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# EXAMINING MOBILE BROADBAND TRANSPARENCY

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## Abstract

The 2018 *Restoring Internet Freedom Order* eliminated a number of transparency requirements regarding broadband performance that were introduced in the 2015 *Open Internet Order*. It also eliminated guidance that had been provided in 2016 to assist broadband providers in complying with the transparency rule. In this paper, we examine a number of policy issues that arose in the two Orders and associated guidance, as applied to disclosure of performance of mobile broadband service. We ground this analysis in two datasets of mobile broadband performance.

We examine policy issues about the methodology used to measure mobile broadband performance, the performance statistics that should be measured and disclosed, and the time of day over which broadband performance is measured. We compare the download and upload speed ranges advertised by the largest four mobile broadband service providers in the United States with the distribution of actual measured download and upload speeds. We also analyze the variation of mobile broadband performance over different geographical regions.

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## 1. INTRODUCTION

During 2010 through 2018, the Federal Communications Commission (FCC) has three times promulgated a transparency rule that includes requirements to disclose broadband performance

In December 2010, the FCC issued the *2010 Open Internet Order*.<sup>1</sup> The *2010 Open Internet Order* includes a transparency rule, requiring that broadband Internet access service providers “publicly disclose accurate information regarding the network management practices, performance, and commercial terms of its broadband Internet access services sufficient for consumers to make informed choices regarding use of such services and for content, application, service, and device providers to develop, market, and maintain Internet offerings.”<sup>2</sup> In June 2011, the FCC issued an *Advisory* offering additional guidance to assist broadband providers in complying with the transparency rule.<sup>3</sup>

In March 2015, the FCC issued the *2015 Open Internet Order*.<sup>4</sup> The *2015 Open Internet Order* leaves in place the transparency rule from the *2010 Open Internet Order*, but added several enhancements.<sup>5</sup> In May 2016, the FCC issued an *Advisory* offering guidance regarding acceptable methodologies for disclosure of network performance to satisfy the enhanced transparency requirements.<sup>6</sup>

In January 2018, the FCC issued the *Restoring Internet Freedom Order*.<sup>7</sup> The *Restoring Internet Freedom Order* eliminates the transparency enhancements introduced in the *2015 Open Internet Order*. It also makes some changes to the 2010 transparency rule and to the 2016 guidance regarding its implementation. The *Restoring Internet Freedom Order* is currently under litigation.

In this paper, we examine a number of policy issues regarding transparency requirements under the three Orders and associated guidance, as applied to disclosure of performance of mobile broadband service. Our examination of these policy issues is grounded in two datasets of mobile broadband performance.

One dataset is provided by the FCC’s *Measuring Broadband America* (MBA) program. The FCC has been collecting data since 2013 on the performance of mobile broadband service. Recently, this performance data was made publicly available. It is the first large-scale publicly available dataset on mobile broadband performance in the United States.

Another dataset is provided by Ookla Speedtest®. Ookla makes available both collected data and aggregate statistics on a commercial basis and via research licenses.<sup>8</sup> Ookla Speedtest® collects roughly 50 times the

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<sup>1</sup> *Preserving the Open Internet*, GN Docket No. 09-191, WC Docket No. 07-52, Report and Order, 25 FCC Rcd 17905 (2010) (*2010 Open Internet Order*).

<sup>2</sup> *2010 Open Internet Order*, para. 54.

<sup>3</sup> *FCC Enforcement Bureau and Office of General Counsel Issue Advisory Guidance for Compliance with Open Internet Transparency Rule*, GN Docket No. 09-191, WC Docket No. 07-52, Public Notice, 26 FCC Rcd 9411 (2011) (*2011 Advisory*).

<sup>4</sup> *Protecting and Promoting the Open Internet*, Report and Order on Remand, Declaratory Ruling, and Order, 30 FCC Rcd 5601 (2015) (*2015 Open Internet Order*).

<sup>5</sup> *Id.*, paras. 23-24.

<sup>6</sup> *Guidance on Open Internet Transparency Rule Requirements*, GN Docket No. 14-28, Public Notice, 31 FCC Rcd 5330 (2016) (*2016 Advisory*).

<sup>7</sup> *Restoring Internet Freedom*, Declaratory Ruling, Report and Order, and Order, 33 FCC Rcd 311 (2018) (*Restoring Internet Freedom Order*).

<sup>8</sup> Ookla, *Speedtest Intelligence*® (Ookla Speedtest data), <https://www.ookla.com/speedtest-intelligence>.

number of measurements than does *Measuring Mobile Broadband*, and the largest mobile broadband service providers support Ookla measurement servers.

In section 2, we start with policy issues regarding the methodology used to measure mobile broadband performance. We compare the requirements under the *2015 Open Internet Order* and associated guidance to that under the *Restoring Internet Freedom Order*. We summarize the methodologies used by *Measuring Broadband America* and by Ookla Speedtest<sup>®</sup>, and we compare the download speeds measured by each for one large mobile broadband provider. We consider the policy tradeoffs associated with the decision whether to require a standardized measurement methodology, whether to offer a safe harbor, whether to require that a measurement methodology satisfy certain characteristics, or whether to simply require that the methodology be transparent and that measurements be accurate.

In section 3, we examine policy issues regarding the performance statistics that should be measured and disclosed. We discuss the causes of variation in mobile broadband performance, including capacity, protocols, device, signal strength, and congestion. We examine the guidance provided in the *2016 Advisory* regarding performance statistics in the context of various percentiles of download speed measured for one large mobile broadband provider.

In section 4, we examine policy issues regarding the time of day over which broadband performance is measured. The *2015 Open Internet Order* requires that actual network performance be measured during times of peak usage<sup>9</sup>, but *Restoring Internet Freedom Order* eliminates this requirement. We examine the differences between the download speeds measured during different times of the day for one large mobile broadband provider, and compare these variations to those observed for fixed broadband service.

In section 5, we compare the download and upload speed ranges advertised by the four largest mobile broadband service providers in the United States with the distribution of actual measured download and upload speeds.

Finally, in section 6, we analyze the variation of mobile broadband performance over different geographical regions. The *Restoring Internet Freedom Order* repealed the *2015 Open Internet Order*'s requirement that actual mobile broadband performance be representative of a consumer's experience in the geographical region in which the consumer purchases the service. We examine the variation of mobile broadband performance between various geographical regions for one large mobile broadband provider.

## 2. METHODOLOGIES

### A. Requirements

The *2010 Open Internet Order*'s transparency rule requires that disclosures be of "accurate information".<sup>10</sup> However, the *2010 Open Internet Order* does not require that broadband providers use any specific methodology, explaining that "at this time the best approach is to allow flexibility in implementation of the transparency rule, while providing guidance regarding effective disclosure models."<sup>11</sup> The *2011 Advisory* offers non-exhaustive lists of acceptable methodologies, stating that fixed broadband service providers may use the methodology used by the FCC's *Measuring Fixed Broadband* program, internal testing, consumer

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<sup>9</sup> *2015 Open Internet Order*, para. 166.

<sup>10</sup> *2010 Open Internet Order*, para. 54.

<sup>11</sup> *Ibid.*

speed test data, or other data from third-party sources.<sup>12</sup> Similarly, it states that mobile broadband service providers may use their own or third-party data. With respect to mobile broadband service, the *2011 Advisory* states that providers with access to reliable information on network performance may disclose performance metrics based on such information, and that providers without access to reliable information on network performance may disclose their best approximation of typical ranges of speed and latency that could be expected by most of their customers.<sup>13</sup>

The *2015 Open Internet Order* similarly does not require that broadband providers use any specific methodology, reiterating that “there is benefit in permitting measurement methodologies to evolve and improve over time, with further guidance from Bureaus and Offices—like in 2011—as to acceptable methodologies.”<sup>14</sup> The *2015 Open Internet Order* requires that methodologies be grounded in commonly accepted principles of scientific research, good engineering practices, and transparency.<sup>15</sup> The *2015 Open Internet Order* confirms that participation in the FCC’s *Measuring Fixed Broadband* program is a safe harbor for this requirement.<sup>16</sup> The *2016 Advisory* establishes a similar safe harbor for use of the FCC’s *Measuring Mobile Broadband* methodology.<sup>17</sup> The *2016 Advisory* also explains the characteristics of acceptable methodologies.

The *Restoring Internet Freedom Order* eliminates the requirement that methodologies be grounded in commonly accepted principles of scientific research, good engineering practices, and transparency.<sup>18</sup> The justification is the generic assertion that these “additional reporting obligations unduly burden ISPs without providing a comparable benefit to consumers.”<sup>19</sup> By eliminating the guidance in the *2016 Advisory*, the *Restoring Internet Freedom Order* also eliminates the safe harbor for use of the FCC’s *Measuring Mobile Broadband* methodology.<sup>20</sup>

Neither the *2010 Open Internet Order* nor the *2011 Advisory* explicitly discuss the layer at which broadband performance should be measured. Both give as examples of performance metrics two of the three principal metrics at the transport layer: speed (a colloquial term for throughput) and latency (a technical term for delay). Both the *2015 Open Internet Order* and the *2016 Advisory* put the emphasis on measurement of broadband performance at the transport layer (speed, latency, and packet loss).<sup>21</sup>

The *2011 Advisory* encourages, but does not require, service providers to disclose the methodology used.<sup>22</sup> The *2016 Advisory* states that methodologies should be disclosed. The *Restoring Internet Freedom Order* eliminates the expectation that methodologies be disclosed.<sup>23</sup>

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<sup>12</sup> *2011 Advisory* at 5.

<sup>13</sup> *Id.* at 5. The *2015 Open Internet Order* stated that large mobile broadband providers are now expected to have access to reliable information on network performance; see *2015 Open Internet Order*, para. 166. It is unclear whether or not the *Restoring Internet Freedom Order* has a similar expectation.

<sup>14</sup> *2015 Open Internet Order*, para. 166.

<sup>15</sup> *Id.*, para. 166 n. 412.

<sup>16</sup> *Id.*, para. 166 n. 411.

<sup>17</sup> *2016 Advisory* at 6.

<sup>18</sup> *Restoring Internet Freedom Order*, para. 225.

<sup>19</sup> *Ibid.*

<sup>20</sup> *Id.*, paras. 214 n. 793, 225.

<sup>21</sup> *2015 Open Internet Order*, para. 166; *2016 Advisory* at 3-4.

<sup>22</sup> *2011 Advisory* at 6.

<sup>23</sup> *Restoring Internet Freedom Order*, para. 225.

## ***B. Measuring Broadband America***

Pursuant to the *National Broadband Plan*<sup>24</sup>, the FCC established the *Measuring Broadband America* (MBA) program.<sup>25</sup> The MBA program has been collecting broadband performance measurements on fixed broadband since 2011 and on mobile broadband since 2013.

### ***i. Measuring Fixed Broadband***

The *Measuring Fixed Broadband* program<sup>26</sup> collects, reports, and provides data on the performance of fixed broadband service offered by over a dozen fixed broadband service providers<sup>27</sup> which collectively provide service to over 80% of fixed broadband service subscribers in the United States<sup>28</sup>. Its methodology is implemented in the modems of over 4,000 customers<sup>29</sup> and in measurement test servers hosted by M-Lab and Level 3 Communications<sup>30</sup>.

The routes over which broadband performance is measured are between customer modems and measurement servers.<sup>31</sup> The measurement servers are located in ten cities across the United States near a point of interconnection between the broadband provider's network and the network on which the measurement server resides.<sup>32</sup> The methodology chooses the measurement server with the lowest latency to and from the subscriber.<sup>33</sup>

Broadband performance is measured at all times of the day, but the *Measuring Fixed Broadband* reports focus on measurements during the peak usage period, defined as weeknights from 7:00 pm - 11:00 pm.<sup>34</sup>

Download and upload speeds are measured as the throughput during a 10-second interval (after an initial warm-up period) using 3 concurrent TCP connections.<sup>35</sup> Latency is measured as the average round-trip time of approximately 2,000 packets transmitted during a one-hour interval using a single UDP connection.<sup>36</sup> Packet loss is measured as the fraction of packets in the latency test for which the round-trip time exceeds 3 seconds.<sup>37</sup>

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<sup>24</sup> Federal Communications Commission, *Connecting America: The National Broadband Plan* (National Broadband Plan), March 16, 2010.

<sup>25</sup> Federal Communications Commission, *Measuring Broadband America*, <https://www.fcc.gov/general/measuring-broadband-america>.

<sup>26</sup> Federal Communications Commission, *Measuring Fixed Broadband*, <https://www.fcc.gov/general/measuring-broadband-america-measuring-fixed-broadband>.

<sup>27</sup> Federal Communications Commission, *Technical Appendix to the Eighth MBA Report (Measuring Fixed Broadband Methodology)*, released December 14, 2018, <https://data.fcc.gov/download/measuring-broadband-america/2018/Technical-Appendix-fixed-2018.pdf> at 8.

<sup>28</sup> Federal Communications Commission, *Eighth Measuring Broadband America Fixed Broadband Report (Measuring Fixed Broadband 8<sup>th</sup> Report)*, released Dec. 14, 2018, <https://www.fcc.gov/reports-research/reports/measuring-broadband-america/measuring-fixed-broadband-eighth-report> at 6.

<sup>29</sup> *Measuring Fixed Broadband Methodology* at 10.

<sup>30</sup> *Id.* at 23.

<sup>31</sup> *Id.* at 26.

<sup>32</sup> *Id.* at 24-25.

<sup>33</sup> *Measuring Fixed Broadband 8<sup>th</sup> Report* at 21.

<sup>34</sup> *Ibid.*

<sup>35</sup> *Measuring Fixed Broadband Methodology* at 28.

<sup>36</sup> *Id.* at 29.

<sup>37</sup> *Measuring Fixed Broadband 8<sup>th</sup> Report* at 17.

The FCC has issued reports annually since 2011 summarizing broadband performance as measured by the *Measuring Fixed Broadband* program.<sup>38</sup> The program also annually makes available the underlying data.<sup>39</sup>

Recent reports compare advertised and actual performance, including:

- advertised speeds, by provider;
- median actual speeds, by provider and by service tier;
- the ratio of median actual speeds to advertised speeds, by provider and by service tier;
- the weighted average (across all service tiers) of the ratio of median actual speeds to advertised speeds, by provider;
- median actual latencies, by provider; and
- average packet loss, by provider;

Recent reports also examine the variation of speeds with geography and across time:

- the distribution (across subscribers) of the ratio of median actual speeds to advertised speeds, by provider and by service tier, including the percentage of subscribers whose median actual speed was greater than 95% of the advertised speed; and
- the percentage of subscribers whose median actual speed was greater than 80% of the advertised speed 80% of the time, by provider.

## **ii. *Measuring Mobile Broadband***

The *Measuring Mobile Broadband* program collects and provides data on the performance of mobile broadband service offered by mobile broadband service providers in the United States, using crowd-sourced data gathered from users of the FCC Speed Test App (henceforth, “the app”).<sup>40</sup> The app has been downloaded by hundreds of thousands of consumers.<sup>41</sup> Its methodology is implemented in the app and in measurement test servers hosted by Level 3 Communications.<sup>42</sup>

The routes over which broadband performance is measured are between smartphones and measurement servers.<sup>43</sup> The measurement servers are located in nine cities across the United States near a point of interconnection between the broadband provider’s network and the network on which the measurement server resides.<sup>44</sup> The methodology chooses the measurement server with the lowest latency to and from the subscriber.<sup>45</sup>

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<sup>38</sup> Federal Communications Commission, *Measuring Broadband America Program – Fixed Reports, Data, and Related Materials*, <https://www.fcc.gov/reports-research/reports/measuring-broadband-america/measuring-broadband-america-program-fixed>.

<sup>39</sup> *Ibid.*

<sup>40</sup> Federal Communications Commission, *Measuring Mobile Broadband*, <https://www.fcc.gov/general/measuring-mobile-broadband-performance>.

<sup>41</sup> Federal Communications Commission, *2016 Mobile Measurement Open Data Release Technical Description (Measuring Mobile Broadband Methodology)*, released January 13, 2017, <https://www.fcc.gov/file/15009/download> at 19.

<sup>42</sup> *Id.* at 5.

<sup>43</sup> *Ibid.*

<sup>44</sup> *Ibid.*

<sup>45</sup> *Ibid.*

Broadband performance is measured on devices running the Android operating system using scheduled measurements from 7:00 am - 8:00 pm.<sup>46</sup> Users may also request measurement at any time on devices running either the Android or iOS operating systems.<sup>47</sup>

Download and upload speeds are measured as the throughput over a maximum 15-second interval (after an initial warm-up period)<sup>48</sup> using 3 concurrent TCP connections<sup>49</sup>. Latency is measured as the average round-trip time of approximately 60 packets transmitted during a 30-second interval using a single UDP connection.<sup>50</sup> Packet loss is measured as the fraction of packets in the latency test for which the round-trip time exceeds 2 seconds.<sup>51</sup> Test results are associated with a broadband provider using mobile network and carrier codes and carrier names.

The FCC has not issued reports summarizing broadband performance as measured by the *Measuring Mobile Broadband* program. However, in January 2019 the FCC released a redacted dataset of data collected between the fourth quarter of 2013 and the second quarter of 2018.<sup>52</sup>

### C. Ookla Speedtest®

Ookla Speedtest® collects data on both fixed and mobile broadband performance. Its methodology is implemented in its app and in measurement test servers hosted on many different networks.

The routes over which broadband performance is measured are between smartphones and measurement servers. There are thousands of measurement servers in the United States.<sup>53</sup> Some measurement servers are located within the networks of the four largest mobile broadband service providers, and thus the route often does not cross an interconnection point. The methodology chooses the measurement server with the lowest latency to and from the subscriber.

Broadband performance is measured on devices running either the Android or iOS operating systems upon user request.<sup>54</sup>

Download and upload speeds are measured as the average throughput over a 7.5-second interval<sup>55</sup> using at least 4 concurrent TCP connections.<sup>56</sup> Latency is measured as the minimum round-trip time of 5 packets transmitted using a single TCP connection. Packet loss is measured as the fraction of approximately 200 packets transmitted during a maximum 15-second interval by the client over a single UDP connection which

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<sup>46</sup> *Id.* at 13.

<sup>47</sup> *Ibid.*

<sup>48</sup> *Ibid.*

<sup>49</sup> *Id.* at 8.

<sup>50</sup> *Id.* at 5.

<sup>51</sup> *Id.* at 6.

<sup>52</sup> Federal Communications Commission, *Measuring Broadband America Mobile 2013-2018 Coarsened Data (Measuring Mobile Broadband Data)*, <https://www.fcc.gov/reports-research/reports/measuring-broadband-america/measuring-broadband-america-mobile-2013-2018>.

<sup>53</sup> Ookla, *Comparing Internet Measurement Methods (Ookla methodology)*, <https://www.speedtest.net/about/knowledge/test-methods>

<sup>54</sup> *Ibid.*

<sup>55</sup> The 7.5-second time interval used is the contiguous subset of a maximum 15-second speed test that results in the highest average throughput.

<sup>56</sup> Additional TCP connections are dynamically added as necessary to fully assess the maximum sustainable throughput.

are not received by the server. Test results are associated with a broadband provider using mobile network and carrier codes and carrier names, and mobile virtual network operators (MVNOs) are excluded.

Ookla makes available both collected data and aggregate statistics on a commercial basis and via research licenses.<sup>57</sup>

#### **D. Broadband Provider Disclosures**

In this paper, we focus exclusively on the four largest mobile broadband providers in the United States: AT&T, Sprint, T-Mobile, and Verizon.

These four mobile broadband providers disclose only limited information about the methodology used to measure broadband performance.<sup>58</sup> None fully disclose the methodology used for their disclosures of broadband performance. AT&T states that disclosed actual speed and latency ranges are based on “crowd-sourced speed tests.”<sup>59</sup> Sprint states that its disclosed ranges are based on “a combination of independent third-party testing and Sprint-generated results including actual customer performance results.”<sup>60</sup> T-Mobile states that its disclosed ranges are based on “analysis and projections from third-party, crowd-sourced data.”<sup>61</sup> Verizon states that its disclosed ranges are based on “our internal testing and testing commissioned from third-party vendors”<sup>62</sup>.

None of the four mobile broadband providers disclose the routes over which broadband performance is measured.<sup>63</sup> Crowd-sourced data is likely based on measurement clients in smartphones. However, when measurement is only described as “internal” or “third-party”, it remains unknown whether the measurement client resides in smartphones or in drive-test vehicles. It is similarly unknown where the measurement server resides. Thus, while the route likely contains at least a portion of the path from a consumer device to a cell-phone tower, it remains unknown whether the route contains the portion of the path from a cell-phone tower to an interconnection point, and whether the route contains the interconnection point.

#### **E. FCC Measuring Mobile Broadband vs. Ookla Speedtest®**

Figure 1 displays the median 4G LTE download speed measured on T-Mobile’s network each quarter from 2014 Q1 through 2018 Q2. The orange curve is the median download speed based on data from the *Measuring Mobile Broadband* program, and the blue curve is the median download speed measured by Ookla Speedtest®.

<sup>57</sup> Ookla, *Speedtest Intelligence®* (Ookla Speedtest data), <https://www.ookla.com/speedtest-intelligence>.

<sup>58</sup> AT&T, *Broadband Information Performance Characteristics* (AT&T Current Disclosure), <https://about.att.com/sites/broadband/performance>; Sprint, *Open Internet Information* (Sprint Current Disclosure), <https://www.sprint.com/en/legal/open-internet-information>; T-Mobile, *Policies: Open Internet* (T-Mobile Current Disclosure), <https://www.t-mobile.com/responsibility/consumer-info/policies/internet-service>; Verizon, *Important Information About Verizon Wireless Broadband Internet Access Services* (Verizon Current Disclosure), <http://www.verizonwireless.com/support/broadband-services/>.

<sup>59</sup> AT&T Current Disclosure, at “Mobile Service”.

<sup>60</sup> Sprint Current Disclosure, at “What performance can I expect from Sprint's data networks?”.

<sup>61</sup> T-Mobile Current Disclosure.

<sup>62</sup> Verizon Current Disclosure, at “What speeds and performance can a Verizon Broadband Internet Access Services customer expect, and where are these speeds available?”.

<sup>63</sup> AT&T and T-Mobile both describe the route as “from point A to point B”, but both fail to identify where points A and B reside (AT&T Current Disclosure at “Latency”; T-Mobile Current Disclosure at Latency); Sprint describes the route as “from one designated point to another”, but similarly fails to identify where the points reside (Sprint Current Disclosure, at “Performance”);

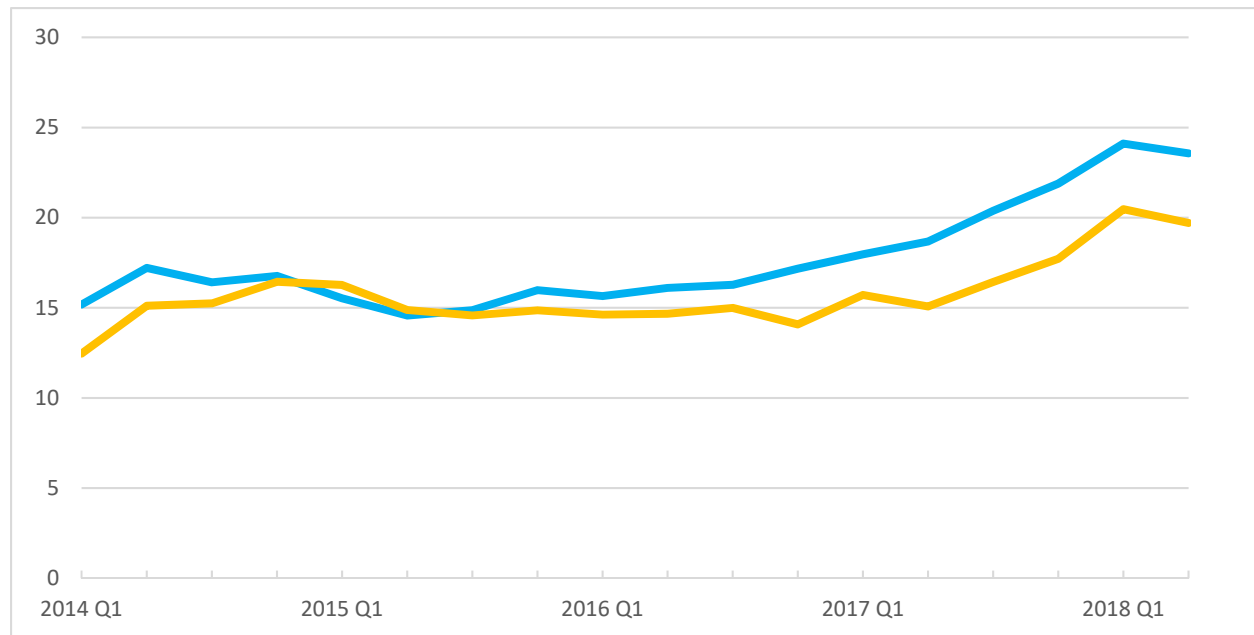


Figure 1: Median 4G LTE Download Speed (Mbps) Measured Using Two Different Methodologies

There are several differences in methodologies between *Measuring Mobile Broadband* and Ookla Speedtest® that could account for the observed differences in measured median 4G LTE download speeds.

First, the two speed tests measure throughput over different routes. For both, one end of the route is the smartphone and the other end is a measurement server. However, *Measuring Mobile Broadband* servers are located in nine cities across the United States near a point of interconnection, while Ookla Speedtest® uses thousands of measurement servers. Thus, the route tested in Ookla Speedtest® is likely to be shorter than the route tested in *Measuring Mobile Broadband*. Since the throughput achieved through a TCP connection is typically decreasing as the distance along a route increases, we expect Ookla Speedtest® to often measure higher speeds than does *Measuring Mobile Broadband*.

Second, the two speed tests measure throughput using a different number of TCP connections. *Measuring Mobile Broadband* uses 3 concurrent TCP connections, while Ookla Speedtest® uses at least 4 concurrent TCP connections. Using a greater number of TCP connections may result in a higher measured download speed, if the mobile broadband provider allocates downstream bandwidth to individual TCP connections rather than to individual devices.

Third, the two speed tests have different approaches to measuring sustained throughput. The TCP protocol continually modifies the throughput from the beginning to the end of a connection. Most notably, the throughput starts very low, and increases rapidly during the first few seconds. To exclude this initial ramp-up period, *Measuring Mobile Broadband* excludes the first 5 seconds of measurements, while Ookla Speedtest® uses the 7.5-second subset of a maximum 15-second test that results in the highest average throughput. The approach used by Ookla Speedtest® could be expected to measure a higher throughput.

Any or all three of these differences are likely to explain why Ookla Speedtest® often measures higher speeds than does *Measuring Mobile Broadband*. There are also a few other differences between the two speed tests that may result in less predictable differences in measured speeds. In this paper, we are only considering *Measuring Mobile Broadband* data from scheduled tests; Ookla Speedtest® uses user-initiated tests. *Measuring Mobile Broadband* only implements scheduled tests on devices running the Android

operating system; Ookla Speedtest<sup>®</sup> collects data from devices running many operating systems, including Android and iOS. Ookla Speedtest<sup>®</sup> collects roughly 50 times the number of measurements than does *Measuring Mobile Broadband*, resulting in smaller confidence intervals for various statistical measures.

#### F. Policy Issues

Neither the *2015 Open Internet Order* nor the *Restoring Internet Freedom Order* require that broadband providers use any specific methodology. There is a tradeoff associated with requiring a specific methodology. Without requiring a specific methodology, mobile broadband providers may use different methodologies, and the differences between such methodologies may result in different measured speeds for the same broadband service, such as those seen in the previous subsection. These differences may fail to assure consumers that the advertised performance is accurate or comparable to the advertisements of other broadband providers. However, measurement methodologies are complex, and there is no single “correct” methodology. The preferred policy option may indeed be to not require a specific methodology, but instead to require that methodologies result in “accurate information”, as the transparency rule requires.<sup>64</sup>

The *2016 Advisory* establishes a safe harbor for use of the FCC’s *Measuring Mobile Broadband* methodology<sup>65</sup>, but the *Restoring Internet Freedom Order* eliminates this safe harbor<sup>66</sup>. It remains unclear why the *Restoring Internet Freedom Order* eliminated the safe harbor, beyond a general approach at eliminating everything related to the transparency enhancements introduced in the *2015 Open Internet Order*. In our analysis, we see no rationale why the *Measuring Mobile Broadband* methodology should not be deemed an acceptable methodology, as is the *Measuring Fixed Broadband* methodology.

If a standardized methodology is not required, this puts the pressure on the validity and accuracy of the methodology. The *2015 Open Internet Order* requires that methodologies be grounded in commonly accepted principles of scientific research and good engineering practices<sup>67</sup>, but the *Restoring Internet Freedom Order* eliminates the requirement, asserting that this places an undue burden on broadband providers without providing a comparable consumer benefit<sup>68</sup>. The *Restoring Internet Freedom Order* presents no analysis whatsoever estimating the consumer benefit, and it is incredulous that there is no significant benefit to consumers that methodologies be grounded in science.

If a standardized methodology is not required, and there is no requirement that methodologies be grounded in commonly accepted principles of science, then the onus is on the FCC to enforce that disclosed broadband performance is indeed “accurate”. The *2016 Advisory* explains the characteristics of acceptable methodologies, but the *Restoring Internet Freedom Order* eliminates this guidance. It is unclear if the *Restoring Internet Freedom Order* disagrees with the guidance or if it believes that no guidance is warranted. In the absence of a standardized methodology or a requirement that methodologies be scientific, we believe that guidance as to the characteristics of acceptable methodologies is clearly warranted. In the absence of a standardized methodology, such guidance lowers the risk that advertised performance is incomparable due to differences in methodologies. Indeed, as we will see in section 5, in the absence of such guidance, advertised speed ranges can be incomparable between competing mobile broadband providers.

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<sup>64</sup> *2010 Open Internet Order*, para. 54.

<sup>65</sup> *2016 Advisory* at 6.

<sup>66</sup> *Restoring Internet Freedom Order*, paras. 214 n. 793, 225.

<sup>67</sup> *2015 Open Internet Order*, para. 166 n. 412.

<sup>68</sup> *Restoring Internet Freedom Order*, para. 225.

Finally, in the absence of a standardized methodology, a requirement that methodologies be grounded in science, or guidance as to acceptable methodologies, the final fallback is transparency. The *2015 Open Internet Order* requires that methodologies be transparent, but the *Restoring Internet Freedom Order* eliminates the requirement. We see no rationale whatsoever for the lack of a requirement that methodologies be disclosed in sufficient detail to ensure that disclosures be of “accurate information”. There is no compelling case to be made for confidentiality at this level of detail. And the current disclosures of mobile broadband providers, e.g. that performance disclosures are based on crowd-sources speed tests but without either explaining the methodology or the entity conducting the speed tests, are clearly insufficient to judge accuracy.

### 3. WHAT PERCENTILES SHOULD BE MEASURED?

#### A. *Variation in Mobile Broadband Performance*

Mobile broadband performance experienced by consumers varies based on many factors.

First, both download and upload speeds may vary based on the capacity available to the broadband provider’s cell site in which a consumer is currently located. This capacity is a function of the amount of spectrum available to the mobile broadband provider in that geographical region. Broadband providers have access to substantially different amounts of spectrum in different geographical regions, and thus speeds may vary substantially by region. It is for this reason that the *2015 Open Internet Order* requires that disclosures of actual performance be reasonably related to the performance the consumer would likely experience in the geographic area in which the consumer is purchasing service<sup>69</sup>, and that the *2016 Advisory* states that disclosure of actual performance metrics for each Cellular Market Area (CMA) in which the service is offered (with some aggregation allowed for CMAs with low population densities) satisfies the geographic disclosure requirement<sup>70</sup>. We discuss geographical variations in Section 6.

Second, mobile broadband providers use a variety of wireless communication protocols to offer mobile broadband service, and different communication protocols are capable of achieving different speeds given the same amount of spectrum. It is for this reason that the *2015 Open Internet Order* clarifies that there should be separate disclosures of mobile broadband performance for each technology (e.g., 4G LTE and 3G).<sup>71</sup> Currently, all four mobile broadband providers support a 4G LTE protocol as well as a number of older protocols (e.g., 4G non-LTE, 3G). Some are also experimenting with newer protocols. A provider may not offer 4G LTE in all of their cell sites. However, today the four largest broadband providers offer 4G LTE to over 90% of consumer connections.<sup>72</sup>

Third, speeds may vary with the make and model of the consumer’s device. In particular, the communication protocols actually used during a connection depends on the protocols supported by the consumer’s device. Today, the vast majority of consumer devices support a 4G LTE protocol. Consequently, over 80% of the connections in the United States use a 4G LTE protocol.<sup>73</sup> However, even

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<sup>69</sup> *2015 Open Internet Order*, para. 166.

<sup>70</sup> *2016 Advisory* at 5-7.

<sup>71</sup> *2015 Open Internet Order*, para. 166.

<sup>72</sup> See e.g. statista, *Proportion of time users have access to 4G networks by country in 2018*, <https://www.statista.com/statistics/635841/4g-time-availability-by-country-worldwide/>.

<sup>73</sup> See e.g. statista, *Global LTE subscribers as share of total mobile connections by region in 2017 and 2018*, <https://www.statista.com/statistics/751468/global-lte-market-share-by-region/>.

using the same protocol, different devices may achieve different speeds based on the implementation of that protocol in the device.

Fourth, both download and upload speeds depend on signal strength. The number of bars displayed on a consumer's device approximates the strength of the signal between the consumer's device and the mobile broadband provider's base station through which the consumer is communicating. The communication protocol typically increases download and upload speeds when signal strength is high, and reduces speeds when signal strength is low. When a user is indoors, signal strength is often low, and correspondingly download and upload speeds are often lower when indoors. It is for this reason that the *2016 Advisory* states that if drive-test data is to be used then it should be combined with "an estimate of the reduction in speed from drive-test locations to user locations".<sup>74</sup>

Finally, both download and upload speeds may decrease when demand for capacity in a cell site exceeds the capacity of that site. When demand for capacity exceeds supply, a mobile broadband provider must reduce download and upload speeds to balance supply and demand. Demand can vary rapidly, but on average demand is higher at peak usage times. It is for this reason that the *2015 Open Internet Order* requires that actual network performance be measured during times of peak usage.<sup>75</sup> For fixed broadband service, the FCC's *Measuring Fixed Broadband* program has, for the purposes of its reports, defined the peak usage period as weeknights from 7:00 pm - 11:00 pm.<sup>76</sup> However, usage patterns are different for mobile broadband service, as we will discuss in Section 4. The FCC has not defined the peak usage period for mobile broadband service, and the *2016 Advisory* clarifies that broadband providers may determine the peak usage period.<sup>77</sup>

### **B. Requirements**

The *2010 Open Internet Order*'s transparency rule requires that disclosures be "sufficient for consumers to make informed choices" and for application providers to "develop, market, and maintain Internet offerings".<sup>78</sup> However, the *2010 Open Internet Order* does not require disclosure of any specific broadband performance metrics.<sup>79</sup> The *2010 Open Internet Order* provides guidance that effective disclosures will likely include "the service technology [and] expected and actual access speed and latency ...".<sup>80</sup> The *2011 Advisory* states that disclosure of expected and actual access speed and latency is sufficient, but not required.<sup>81</sup>

Whereas the *2010 Open Internet Order* and the *2011 Advisory* state that disclosure of expected and actual access speed and latency is sufficient but not required, the *2015 Open Internet Order* requires disclosure of expected and actual access speed and latency.<sup>82</sup> The FCC explains that "actual download and upload speeds [are] the network performance metric[s] of greatest interest to the consumer", and that "[l]atency may affect the perceived quality of highly interactive applications such as phone calls over the Internet, video chat, or

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<sup>74</sup> *2016 Advisory* at 8.

<sup>75</sup> *2015 Open Internet Order*, para. 166.

<sup>76</sup> *Measuring Fixed Broadband 8<sup>th</sup> Report* at 21.

<sup>77</sup> *2016 Advisory* at 5.

<sup>78</sup> *2010 Open Internet Order*, para. 54.

<sup>79</sup> *Id.*, para. 56.

<sup>80</sup> *Ibid.*

<sup>81</sup> *2011 Advisory* at 3.

<sup>82</sup> *2015 Open Internet Order*, para. 166.

online multiplayer games”.<sup>83</sup> The *Restoring Internet Freedom Order* retains the requirement to disclose expected and actual speed and latency.<sup>84</sup>

With respect to fixed broadband service, the *2011 Advisory* states that participants in the FCC’s *Measuring Fixed Broadband* program may disclose the actual download and upload speeds and the actual round-trip latency as determined by the *Measuring Fixed Broadband* program data.<sup>85</sup> The *2015 Open Internet Order* confirms that participation in the *Measuring Fixed Broadband* program and disclosure of the network performance data from that program is a safe harbor for the requirement to disclose actual performance.<sup>86</sup> The *2016 Advisory* establishes a similar safe harbor for disclosure of the network performance data from the *Measuring Mobile Broadband* program.<sup>87</sup> The *Restoring Internet Freedom Order* retains the safe harbor for disclosure of actual performance from the *Measuring Fixed Broadband* program, but eliminates the parallel safe harbor for disclosure of actual performance from the *Measuring Mobile Broadband* program.

Although the *2010 Open Internet Order* provides guidance that effective disclosures will likely include “expected and actual access speed and latency”<sup>88</sup>, neither the *2010 Open Internet Order* nor the *2011 Advisory* discuss what percentiles the speed and latency ranges should represent. In contrast, the *2016 Advisory* offers guidance about when performance should be disclosed as an average, a median, or a range. It recommends disclosing actual speeds as a median when there is little variation, and as a range (e.g., 25<sup>th</sup> to 75<sup>th</sup> percentile) when there is substantial variation (e.g., for mobile broadband).<sup>89</sup> It is unclear whether the *Restoring Internet Freedom Order* eliminated this guidance about when performance should be disclosed as an average, a median, or a range, as well as the guidance on the size of the geographic area.<sup>90</sup>

### C. Measurements of Various Speed Percentiles

Figure 2 displays the mean (i.e., average) and various percentiles of 4G LTE download speeds measured on Sprint’s network each quarter from 2014 Q1 – 2019 Q2. All but the 25<sup>th</sup> and 75<sup>th</sup> percentiles are measured by Ookla Speedtest®. The 25<sup>th</sup> and 75<sup>th</sup> percentiles are estimated by combining data from the *Measuring Mobile Broadband* program and from Ookla Speedtest®.<sup>91</sup>

<sup>83</sup> Federal Communications Commission, *2015 Measuring Broadband America Fixed Broadband Report (Measuring Fixed Broadband 2015 Report)*, released Dec. 30, 2015, <https://www.fcc.gov/reports-research/reports/measuring-broadband-america/measuring-broadband-america-2015> at 7.

<sup>84</sup> *Restoring Internet Freedom Order*, para. 222.

<sup>85</sup> *2011 Advisory* at 4.

<sup>86</sup> *2015 Open Internet Order*, para. 166 n. 411.

<sup>87</sup> *2016 Advisory* at 6.

<sup>88</sup> *2010 Open Internet Order*, para. 56.

<sup>89</sup> *2016 Advisory* at 4.

<sup>90</sup> *Restoring Internet Freedom Order*, paras. 214 n. 793, 225.

<sup>91</sup> Let  $X_i$  be a random variable equal to the download speed as measured by the *Measuring Mobile Broadband* program during quarter  $i$ , and  $Y_i$  be a random variable equal to the download speed as measured by Ookla Speedtest® during quarter  $i$ . Let  $F_{X_i}$  denote the cumulative distribution function of  $X_i$ , and  $F_{Y_i}$  denote the cumulative distribution function of  $Y_i$ . During 2014Q1 – 2018Q2, when we have both sets of data, the estimated 25<sup>th</sup> percentile,  $F_{X_i}^{-1}\left\{.625F_{X_i}\left[F_{Y_i}^{-1}(0.1)\right]+.375F_{X_i}\left[F_{Y_i}^{-1}(0.5)\right]\right\}$ , is an interpolation using the *Measuring Mobile Broadband* data between the 10<sup>th</sup> and 50<sup>th</sup> percentiles as given by Ookla Speedtest®, and similarly the estimated 75<sup>th</sup> percentile,

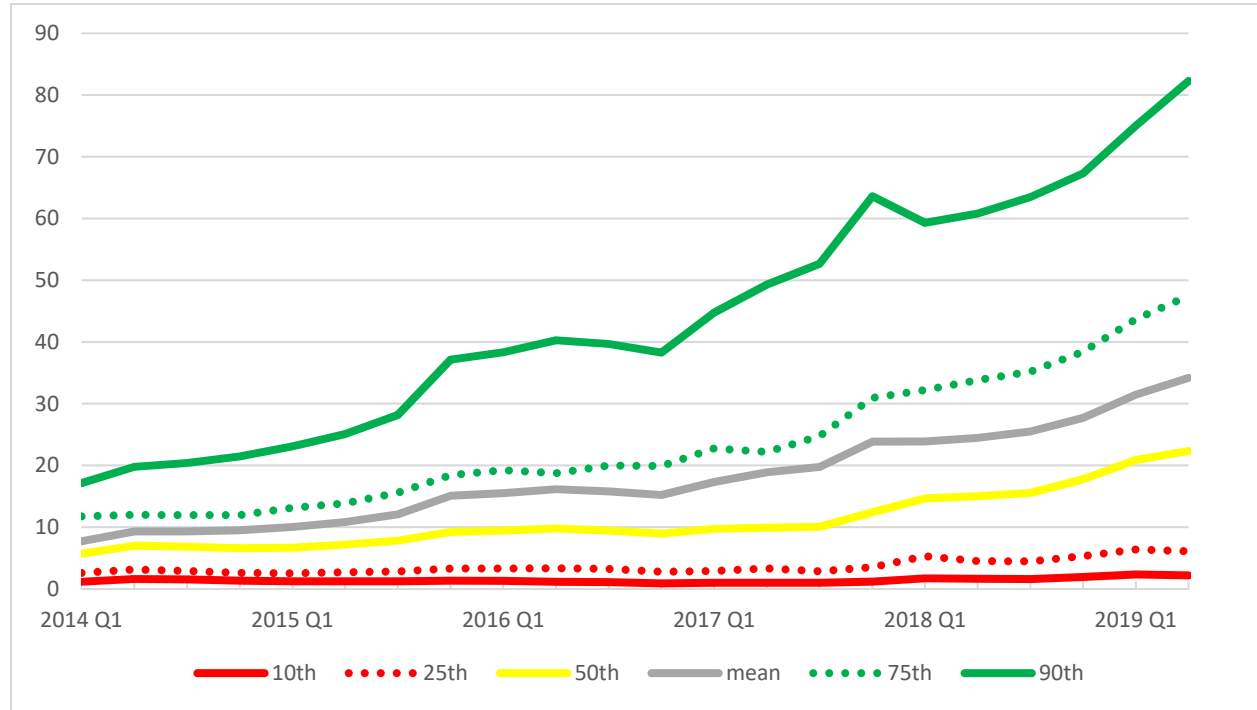


Figure 2: Mean and Various Percentile of 4G LTE Download Speed (Mbps)

During 2019 Q2, the slowest 10% of 4G LTE download speeds measured on Sprint's network (i.e., the 10<sup>th</sup> percentile) were 2.2 Mbps or lower. The slowest 25% of measured download speeds (i.e. the 25<sup>th</sup> percentile) were an estimated 6.1 Mbps or slower. Half of the measured download speeds (i.e., the median or 50<sup>th</sup> percentile) were 22.3 Mbps or lower.

The average download speed was 34.2 Mbps, which is substantially above the median (50<sup>th</sup> percentile) download speed of 22.3 Mbps. Indeed, a relatively large percentage of users experience download speeds below the average download speed.

The highest 25% of measured download speeds (i.e. the 75<sup>th</sup> percentile) were an estimated 47.5 Mbps or higher. The highest 10% of measured download speeds (i.e. the 90<sup>th</sup> percentile) were 82.3 Mbps or higher. A relatively small percentage of users experience download speeds much higher than the average download speed.

$F_{X_i}^{-1} \{ .375 F_{X_i} [ F_{Y_i}^{-1} (0.5) ] + .625 F_{X_i} [ F_{Y_i}^{-1} (0.9) ] \}$ , is an interpolation using the *Measuring Mobile Broadband* data between the 50<sup>th</sup> and 90<sup>th</sup> percentiles as given by Ookla Speedtest<sup>®</sup>. During 2018Q3 – 2019Q2, when only have data from Ookla Speedtest<sup>®</sup>, the estimated 25<sup>th</sup> percentile,  $F_{Y_{i-1}}^{-1} (0.25) [ .625 ( F_{Y_i}^{-1} (0.1) / F_{Y_{i-1}}^{-1} (0.1) ) + .375 ( F_{Y_i}^{-1} (0.5) / F_{Y_{i-1}}^{-1} (0.5) ) ]$ , is an extrapolation from the previous quarter's estimated 25<sup>th</sup> percentile with the rate of change given by a weighted average of the rates of change in the 10<sup>th</sup> and 50<sup>th</sup> percentiles as given by Ookla Speedtest<sup>®</sup>, and similarly the estimated 75<sup>th</sup> percentile,  $F_{Y_{i-1}}^{-1} (0.75) [ .375 ( F_{Y_i}^{-1} (0.5) / F_{Y_{i-1}}^{-1} (0.5) ) + .625 ( F_{Y_i}^{-1} (0.75) / F_{Y_{i-1}}^{-1} (0.75) ) ]$ , is an extrapolation from the previous quarter's estimated 75<sup>th</sup> percentile with the rate of change given by a weighted average of the rates of change in the 50<sup>th</sup> and 90<sup>th</sup> percentiles as given by Ookla Speedtest<sup>®</sup>.

The differences between the 10<sup>th</sup> and 25<sup>th</sup> percentile download speeds are significant. The differences between the 75<sup>th</sup> and 90<sup>th</sup> percentile download speeds are large.

#### **D. Policy Issues**

The *2016 Advisory* recommends disclosing actual speeds for mobile broadband as a range, e.g., 25<sup>th</sup> - 75<sup>th</sup> percentile)<sup>92</sup>, but it is unclear whether the *Restoring Internet Freedom Order* eliminates this guidance<sup>93</sup>. If it did eliminate this guidance, it remains unclear why, beyond a general approach at eliminating everything related to the transparency enhancements introduced in the *2015 Open Internet Order*.

However, as we saw in Figure 2 above, the mean (i.e., average) 4G LTE download speed is substantially higher than the median 4G LTE download speed. The mean download speed does not convey information sufficient for consumers to make informed choices regarding use of such services. Without additional information, a consumer can't know by the average download speed how often she will experience various download speeds. Indeed, a small percentage of users who experience very high speeds disproportionately affect the mean download speed, as is true for any asymmetric distribution with a long upper tail. This pattern is true not only of Verizon, but also of all major carriers. It also holds for upload speeds. As a result, the average speed does not convey anything about the speed typically experienced by consumers.

Furthermore, there are great differences in speed ranges depending on the percentiles used to determine the range. The 4G LTE download speed range from the 10<sup>th</sup> – 90<sup>th</sup> percentiles is much wider than the range from the 25<sup>th</sup> – 75<sup>th</sup> percentiles. And in the absence of a standardized methodology or guidance about the percentiles to use, mobile broadband providers have made very different choices about the percentiles to disclose, as we will see in section 5. In the absence of such guidance, consumers do not have sufficient information to make informed choices.

### **4. PEAK USAGE PERIOD**

#### **A. Requirements**

The *2010 Open Internet Order* makes no mention of the time of day over which broadband performance should be measured, other than that disclosure of such metrics be “sufficient for consumers to make informed choices” and for application providers to “develop, market, and maintain Internet offerings”.<sup>94</sup> The *2011 Advisory* states the disclosure of speed and latency during the peak usage period used in the FCC’s *Measuring Fixed Broadband* program (weeknights 7-11pm) is sufficient, but it does not in general require that disclosures be of performance during any peak usage period.<sup>95</sup>

In contrast, the *2015 Open Internet Order* requires that actual network performance be measured over a reasonable period of time and during times of peak usage.<sup>96</sup> The *2016 Advisory* clarifies that broadband providers “retain flexibility to determine the appropriate peak usage periods for their network performance metrics but must disclose the peak usage periods chosen for such disclosures.”<sup>97</sup>

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<sup>92</sup> *2016 Advisory* at 4.

<sup>93</sup> *Restoring Internet Freedom Order*, paras. 214 n. 793, 225.

<sup>94</sup> *2010 Open Internet Order*, para. 56.

<sup>95</sup> *2011 Advisory* at 4-5.

<sup>96</sup> *2015 Open Internet Order*, para. 166.

<sup>97</sup> *2016 Advisory* at 5.

The *Restoring Internet Freedom Order* eliminates the requirement that actual network performance be measured over a reasonable period of time and during times of peak usage.<sup>98</sup> Its justification consists of an assertion that this “additional reporting obligation[] unduly burden[s] ISPs without providing a comparable benefit to consumers”.<sup>99</sup>

### **B. Measurements**

The statistics given earlier in this paper include measurements taken at all hours, which we refer to as “all day”. The *Measuring Mobile Broadband* program data also makes available more detailed information about the time at which each measurement is collected. Here we aggregate measurements into the three time periods in which the program collects data: 7am-9am, 9am-5pm, and 5pm-8pm. Examining the difference in broadband performance between these three different time periods, and comparing them to the measurements taken all day, allows us to investigate the variation of performance between peak and off-peak usage periods.

The estimated 25<sup>th</sup> and 75<sup>th</sup> percentile 4G LTE download speeds on Verizon’s network during various time periods, as estimated by combining data from the *Measuring Mobile Broadband* program and Ookla Speedtest<sup>®</sup>, are shown in Figure 3.<sup>100</sup>

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<sup>98</sup> *Restoring Internet Freedom Order*, paras. 214 n. 793, 225.

<sup>99</sup> *Id.*, para. 225.

<sup>100</sup> The estimates for 7am-9am and 5pm-8pm use the same interpolations and extrapolations as used in the estimates of all-day 25<sup>th</sup> and 75<sup>th</sup> percentiles (see footnote 91, except that  $X_i$  is now the download speed as measured by the *Measuring Mobile Broadband* program during the corresponding time period. The differences in measured broadband performance between different time periods may depend on the measurement methodology, and we have not examined the variations during the day in the Ookla Speedtest<sup>®</sup> dataset.

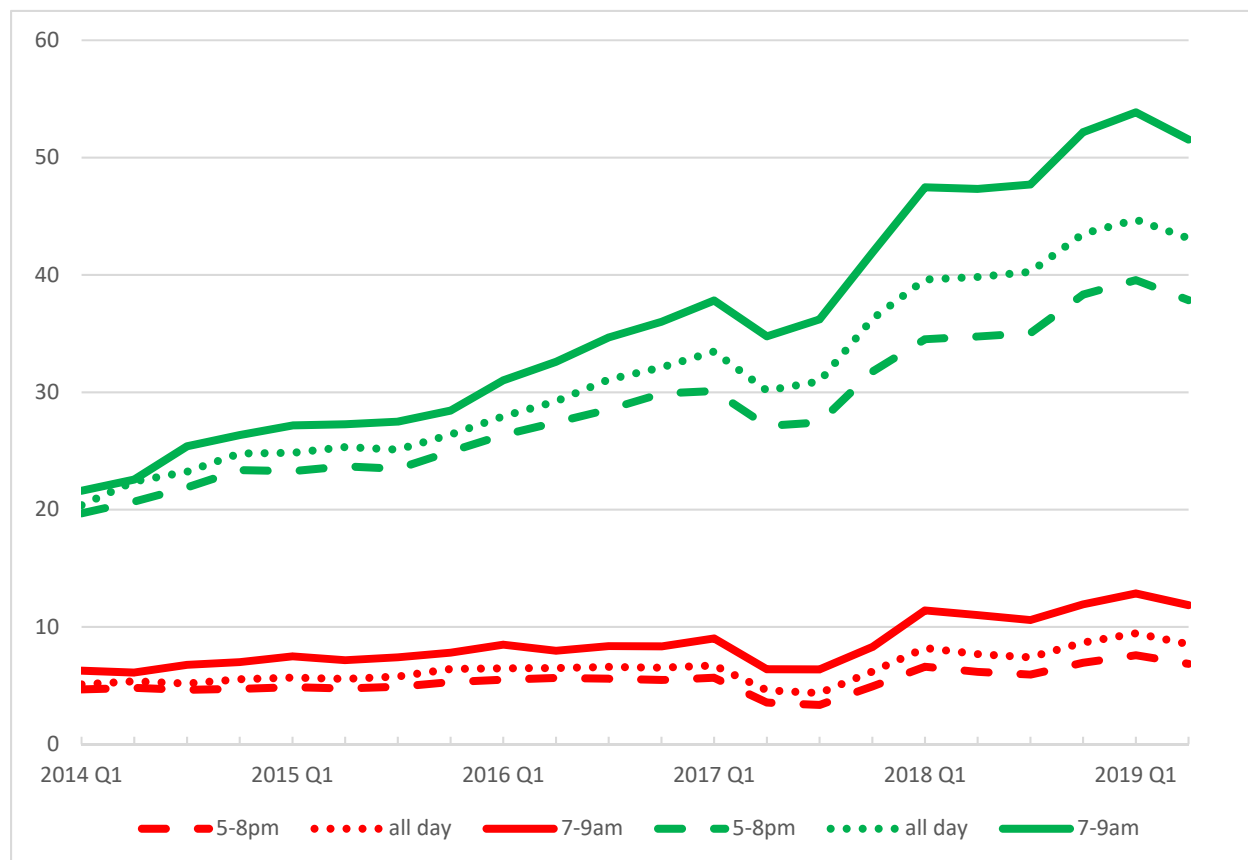


Figure 3: 25<sup>th</sup> and 75<sup>th</sup> Percentile 4G LTE Download Speeds During Various Time Periods

During 2014 Q1, the 25<sup>th</sup> percentile 4G LTE download speed was estimated to be 6.3 Mbps during 7am-9am, and 4.7 Mbps during 5pm-8pm; thus, the 25<sup>th</sup> percentile download speed dropped by 25% during 5pm-8pm. The 25<sup>th</sup> percentile download speed measured over all day was 5.1 Mbps. Similarly, during 2014 Q1, the 75<sup>th</sup> percentile download speed was estimated to be 21.6 Mbps during 7am-9am, but 9% lower (19.7 Mbps) during 5pm-8pm. We expect 25<sup>th</sup> percentile speeds to be more sensitive to congestion than 75<sup>th</sup> percentile speeds, and thus to drop more during 5pm-8pm than do 75<sup>th</sup> percentile speeds.

Although download speeds increased during 2014-2019, the effect of congestion on download speeds also increased. During 2019 Q2, the 25<sup>th</sup> percentile 4G LTE download speed during 7am-9am was estimated to be 11.9 Mbps, up from 6.3 Mbps in 2014 Q1. But in 2019 Q2, the 25<sup>th</sup> percentile download speed during 5pm-8pm was estimated to be 6.9 Mbps; although this is an increase from the 5.1 Mbps it was in 2014 Q1, it is 42% lower than the 25<sup>th</sup> percentile download speed during 7am-9am. Similarly, during 2019 Q2, the 75<sup>th</sup> percentile download speed during 7am-9am was estimated to be 51.5 Mbps, but 27% lower (37.9 Mbps) during 5pm-8pm. Thus, although 25<sup>th</sup> percentile speeds remained more sensitive to congestion than 75<sup>th</sup> percentile speeds, both drop more during 5pm-8pm than they did in 2014.

The reason for this increasing gap between download speeds during morning and early evenings is congestion. However, we cannot identify the location of this congestion.

For fixed broadband service, the *Measuring Fixed Broadband* program has, for the purposes of its reports, defined the peak usage period as weeknights from 7:00 pm - 11:00 pm.<sup>101</sup> In contrast, for mobile broadband, speeds are significantly reduced during a much longer time period, with lower speeds persisting from noon - 8:00 pm. We see these speed reductions on weekends as well as weekdays.

For terrestrial fixed broadband service, the speed reductions during the peak usage period are moderate. The *Measuring Fixed Broadband* reports have routinely shown that the median download speed for terrestrial fixed broadband typically falls by less than 10% from that for off-peak usage periods, and that the median upload speed falls by less than 5%.<sup>102</sup> However, for mobile broadband service, speed reductions during peak usage periods are higher. The download speed reductions for mobile broadband are in the range from 10% - 40%, and the upload speed reductions are in the range from 0% - 10%.

### C. Policy Issues

The 2015 *Open Internet Order* requires that actual network performance be measured during times of peak usage<sup>103</sup>, but the *Restoring Internet Freedom Order* eliminates this requirement, asserting that this places an undue burden on broadband providers without providing a comparable consumer benefit<sup>104</sup>. The *Restoring Internet Freedom Order*, however, provides no estimate of burden or of consumer benefit.

It is incredulous that large broadband providers do not already measure performance during peak usage periods, since usage during peak usage periods is the principle basis for decisions about network capacity upgrades. It is also incredulous that there is no significant consumer benefit. As we observed above in Figure 3, there is a substantial difference in 4G LTE download speed measured during different times of the day, and these differences have increased over the past few years.

There remain important policy questions about the peak usage period. One option would be for the FCC to specify the peak usage period. The upside to such a requirement would be that advertised performance would be more comparable between competing mobile broadband providers. We see little downside, other than that the peak usage period would need to be updated every few years as usage patterns may change.

In the absence of a standardized peak usage period, clearly there is a benefit to the disclosure of the period over which performance is measured. And yet, currently, none of the four largest mobile broadband providers provide such a disclosure.

## 5. DISCLOSURES OF SPEED RANGES

### A. Requirements

The 2016 *Advisory* recommends that expected network performance metrics be disclosed using similar statistics as used for actual performance; e.g., “if *actual* download speed is provided as a range, the *expected* download speed should use a range with the same percentile endpoints.”<sup>105</sup> It is unclear whether the *Restoring Internet Freedom Order* eliminates this guidance.<sup>106</sup>

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<sup>101</sup> *Measuring Fixed Broadband 8<sup>th</sup> Report* at 21.

<sup>102</sup> See e.g. *Measuring Fixed Broadband 2015 Report* at 37; *Measuring Fixed Broadband 2016 Report* at 41; *Measuring Fixed Broadband 8<sup>th</sup> Report* at 33-34.

<sup>103</sup> 2015 *Open Internet Order*, para. 166.

<sup>104</sup> *Restoring Internet Freedom Order*, paras. 214 n. 793, 225.

<sup>105</sup> *Ibid.*

<sup>106</sup> *Id.*, paras. 214 n. 793, 225.

The *2010 Open Internet Order* expects disclosures for each “service technology”.<sup>107</sup> The *2015 Open Internet Order* clarifies that this requires “separate disclosures for services with each technology (e.g., 3G and 4G).”<sup>108</sup>

With respect to the format of disclosures, the *2010 Open Internet Order*’s transparency rule requires that disclosures be “sufficient for consumers to make informed choices”.<sup>109</sup> However, the *2010 Open Internet Order* does not require any specific format.<sup>110</sup>

In contrast, the *2015 Open Internet Order* expressed concern “that in some cases a single disclosure statement may be too detailed and technical to meet the needs of consumers, rather than a separate consumer-focused disclosure.”<sup>111</sup> It therefore offered a voluntary safe harbor for both the format and content of the required disclosure to consumers.<sup>112</sup> An FCC advisory committee developed labels for both fixed and mobile broadband service, which the FCC approved as a safe harbor in April 2016.<sup>113</sup> The labels include expected download and upload speeds, latency, and packet loss.<sup>114</sup>

The *Restoring Internet Freedom Order* eliminates the safe harbor for both the format and content of the required disclosure to consumers.<sup>115</sup> It asserts that “[a]dopting the label could require some ISPs to expend substantial resources to tailor their disclosures to fit the format”.<sup>116</sup>

### ***B. Broadband Provider Disclosures***

The current disclosures (as of June 30, 2019) of speed ranges from the four mobile broadband providers are shown in Table 1.<sup>117</sup>

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<sup>107</sup> *2010 Open Internet Order*, para. 56.

<sup>108</sup> *2015 Open Internet Order*, para. 166.

<sup>109</sup> *2010 Open Internet Order*, para. 54.

<sup>110</sup> *Id.*, para. 58.

<sup>111</sup> *2015 Open Internet Order*, para. 178.

<sup>112</sup> *Id.*, para. 179.

<sup>113</sup> *Consumer and Governmental Affairs, Wireline Competition, and Wireless Telecommunications Bureaus Approve Open Internet Broadband Consumer Labels (Open Internet Label)*, GN Docket No. 14-28, Public Notice, 31 FCC Rcd 3358 (2016).

<sup>114</sup> *Id.* at 4,9.

<sup>115</sup> *Restoring Internet Freedom Order*, para. 231.

<sup>116</sup> *Ibid.*

<sup>117</sup> *AT&T Current Disclosure; Sprint Current Disclosure; T-Mobile Current Disclosure; Verizon Current Disclosure.*

Service Provider	Tech	Advertised Download Speed (Mbps)	Advertised Upload Speed (Mbps)
AT&T	4G LTE	8.2 – 45.9	2.4 – 12.0
	4G	2.0 – 6.3	0.5 – 1.4
	3G	1.5 – 4.8	0.3 – 1.1
Sprint	4G LTE	4 – 35	1 – 5
	Non-LTE	0.6 – 1.4	0.35 – 0.50
T-Mobile	4G LTE	7 – 40	4 – 20
	Non-LTE	1.5	0.23
Verizon	5G UWB	450	50
	4G LTE	5 – 12	2 – 5
	3G Ev-DO Rev. A	0.6 – 1.4	0.5 – 0.8

*Table 1: Current Advertised Speed Ranges*

These disclosures provide advertised broadband performance metrics for a variety of technologies (e.g., 4G LTE, 4G non-LTE, 3G) that are currently supported by each mobile broadband provider. Except where noted, in this paper we focus exclusively on broadband performance of 4G LTE connections. A 4G LTE connection is established when: (1) a 4G LTE capable device attempts to communicate through a cell site that supports 4G LTE, and (2) the device and the cell site agree to communicate using a 4G LTE protocol.

All four mobile broadband providers have chosen to provide a single disclosure wherein the expected and actual speed ranges are the same. Each mobile broadband provider claims that its advertised speed range reflects the speeds that consumers can be expected to experience, and that these speed ranges are based on actual measured speeds.

None of the four mobile broadband providers state the time of day over which broadband performance is measured.

The 2016 Advisory recommended disclosing actual mobile broadband speeds as a range (e.g., 25<sup>th</sup> to 75<sup>th</sup> percentile)<sup>118</sup>, but this guidance was eliminated in the 2018 *Restoring Internet Freedom Order*<sup>119</sup>. Nevertheless, AT&T and T-Mobile represent that their disclosures are based on the 25<sup>th</sup> and 75<sup>th</sup> percentiles of actual measured speeds.<sup>120</sup> Neither Sprint nor Verizon represent what percentiles their speed ranges are based on.

<sup>118</sup> 2016 Advisory at 4.

<sup>119</sup> *Restoring Internet Freedom Order*, paras. 214 n. 793, 225.

<sup>120</sup> AT&T Current Disclosure; T-Mobile Current Disclosure.

Pursuant to the *2015 Open Internet Order*, the FCC approved a label for mobile broadband disclosure as a safe harbor in April 2016.<sup>121</sup> The safe harbor was eliminated in the *Restoring Internet Freedom Order*.<sup>122</sup> Nevertheless, T-Mobile continues to offer such a label.<sup>123</sup>

Table 2 shows the historical speed ranges advertised by the four mobile broadband providers for 4G LTE connections during 2014 Q1 - 2019 Q2, taken from snapshots of their broadband performance disclosures stored on the Internet Archive.<sup>124</sup>

Service Provider	Year and Quarter	Advertised Download Speed (Mbps)	Advertised Upload Speed (Mbps)
AT&T	2014 Q1 – 2015 Q2	5 – 12	
	2015 Q3 – 2017 Q1	5 – 20	3 – 10
	2017 Q2 – 2018 Q2	6 – 29	2 – 11
	2018 Q3 – 2019 Q1	6.2 – 35.4	2.5 – 10.5
	2019 Q2	8.2 – 45.9	2.4 – 12
Sprint	2014 Q1 – 2018 Q2	6 – 8	2 – 3
	2018 Q3 – 2019 Q2	4 – 35	1 – 5
T-Mobile	2014 Q1 – 2016 Q3	6 – 20	2 – 5
	2016 Q4 – 2019 Q2	7 – 40	4 – 20
Verizon	2014 Q1 – 2019 Q2	5 – 12	2 – 5

Table 2: Historical Advertised 4G LTE Speed Ranges

During 2014 Q1 - 2015 Q2, AT&T disclosed only an expected nationwide download speed range (5 - 12 Mbps).<sup>125</sup> Starting 2015 Q3, AT&T updated its download speed range, and added a disclosure of an expected nationwide upload speed range.<sup>126</sup> Starting 2017 Q2, consistent with the *2016 Advisory*, AT&T changed its advertised speed ranges to match what it claims are the actual ranges from the 25<sup>th</sup> to 75<sup>th</sup> percentiles (e.g., to an actual and expected nationwide download speed range of 6 - 29 Mbps).<sup>127</sup> This

<sup>121</sup> *Open Internet Label*.

<sup>122</sup> *Restoring Internet Freedom Order*, para. 231.

<sup>123</sup> *T-Mobile Current Disclosure* at “Consumer Broadband Label”.

<sup>124</sup> AT&T, *Broadband Information (AT&T Archived Disclosures)*, [https://web.archive.org/web/\\*/http://www.att.com/gen/public-affairs?pid=20879](https://web.archive.org/web/*/http://www.att.com/gen/public-affairs?pid=20879) (2014 Q1 – 2018 Q1), [https://web.archive.org/web/\\*/https://about.att.com/sites/broadband/performance](https://web.archive.org/web/*/https://about.att.com/sites/broadband/performance) (2018 Q2 – 2019 Q2); Sprint, *Important Coverage Information (Sprint Archived Disclosures)*, [https://web.archive.org/web/\\*/http://shop2.sprint.com/en/coverage/support/important\\_coverage\\_info\\_popup.shtml](https://web.archive.org/web/*/http://shop2.sprint.com/en/coverage/support/important_coverage_info_popup.shtml); T-Mobile, *Internet Services (T-Mobile Archived Disclosures)*, [https://web.archive.org/web/\\*/http://www.t-mobile.com/Company/CompanyInfo.aspx?tp=Abt\\_Tab\\_ConsumerInfo&tsp=Abt\\_Sub\\_InternetServices](https://web.archive.org/web/*/http://www.t-mobile.com/Company/CompanyInfo.aspx?tp=Abt_Tab_ConsumerInfo&tsp=Abt_Sub_InternetServices) (2014 Q1 – 2016 Q1), [https://web.archive.org/web/\\*/http://www.t-mobile.com/company/company-info/consumer/internet-services.html](https://web.archive.org/web/*/http://www.t-mobile.com/company/company-info/consumer/internet-services.html) (2016 Q2 – 2018 Q3), [https://web.archive.org/web/\\*/https://www.t-mobile.com/responsibility/consumer-info/policies/internet-service](https://web.archive.org/web/*/https://www.t-mobile.com/responsibility/consumer-info/policies/internet-service) (2018 Q4 – 2019 Q2); Verizon, *Important Information About Verizon Wireless Broadband Internet Access Services (Verizon Archived Disclosures)*, [https://web.archive.org/web/\\*/http://support.verizonwireless.com/support/information/broadband.html](https://web.archive.org/web/*/http://support.verizonwireless.com/support/information/broadband.html) (2014 Q1 – 2014 Q1), [https://web.archive.org/web/\\*/http://www.verizonwireless.com/support/information/broadband.html](https://web.archive.org/web/*/http://www.verizonwireless.com/support/information/broadband.html) (2014 Q2 – 2014 Q4), [https://web.archive.org/web/\\*/http://www.verizonwireless.com/support/broadband-services/](https://web.archive.org/web/*/http://www.verizonwireless.com/support/broadband-services/) (2015 Q1 – 2019 Q2).

<sup>125</sup> *AT&T Archived Disclosures*.

<sup>126</sup> *Ibid.*

<sup>127</sup> *Ibid.*

resulted in a significant increase of the advertised download speed range, and a widening of the advertised upload speed range.

During 2014 Q1 - 2018 Q2, Sprint disclosed only an expected nationwide download speed range (6 - 8 Mbps) and an expected nationwide upload speed range.<sup>128</sup> Starting 2018 Q3, consistent with the *2016 Advisory*, Sprint changed its advertised speed range to match what it claims is actual broadband performance (e.g., to an actual and expected nationwide download speed range of 4 - 35 Mbps), but it doesn't disclose what percentiles this range represents.<sup>129</sup> This resulted in a dramatic widening of both the advertised download and upload speed ranges.

During 2014 Q1 - 2016 Q3, T-Mobile disclosed only an expected nationwide download speed range (6 - 20 Mbps) and an expected nationwide upload speed range.<sup>130</sup> Starting 2016 Q4, consistent with the *2016 Advisory*, T-Mobile changed its advertised speed ranges to match what it claims are the actual ranges from the 25<sup>th</sup> to 75<sup>th</sup> percentiles (e.g., to an expected nationwide download speed of 7 - 40 Mbps).<sup>131</sup> This resulted in a dramatic increase of both the advertised download and upload speed ranges.

During 2014 Q1 - 2019 Q2, Verizon disclosed only an expected nationwide download speed range (5 - 12 Mbps) and an expected nationwide upload speed range.<sup>132</sup> The ranges have remained unchanged since 2014 Q1. Verizon has never disclosed whether this expected speed range represents an actual speed range.

### ***C. How Accurate Are Advertised Speed Ranges?***

In this subsection, we compare the advertised broadband performance metrics given above to the measured actual broadband performance metrics.

#### ***i. 4G LTE Download Speed***

For each mobile broadband provider, Figure 4 compares the provider's advertised 4G LTE download speed range to the estimated 25<sup>th</sup> and 75<sup>th</sup> percentile 4G LTE download speeds, for each quarter from 2014 Q1 through 2019 Q2. The advertised download speed range (taken from Table 2) is shown as a grey range; the lower end of the advertised download speed range is shown as a solid red curve, and the upper end as a solid green curve. The estimated 25<sup>th</sup> percentile of all day 4G LTE download speeds is shown as a dotted red curve, and the estimated 75<sup>th</sup> percentile as a dotted green curve.<sup>133</sup> The estimated 25<sup>th</sup> percentile 4G LTE download speed during 5pm-8pm is shown as a dashed red curve, and the estimated 75<sup>th</sup> percentile during 5pm-8pm as a dashed green curve.<sup>134</sup>

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<sup>128</sup> *Sprint Archived Disclosures.*

<sup>129</sup> *Sprint Current Disclosure.*

<sup>130</sup> *T-Mobile Archived Disclosures.*

<sup>131</sup> *Ibid.*

<sup>132</sup> *Verizon Archived Disclosures.*

<sup>133</sup> The estimation method is the same as that discussed in section 3.C; see footnote 91.

<sup>134</sup> The estimation method is the same as that discussed in section 4.B; see footnote 100.

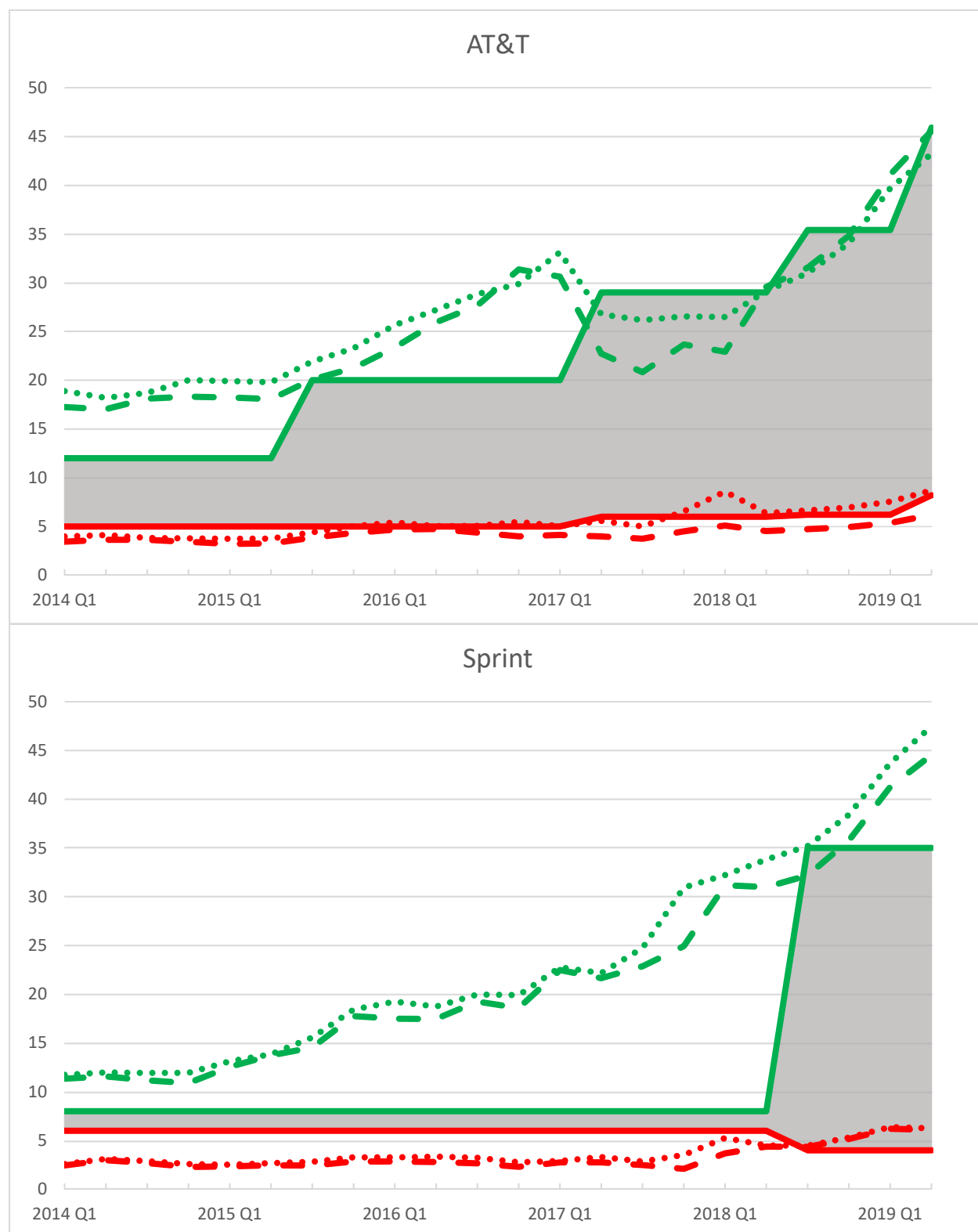


Figure 4: Advertised vs Actual 4G LTE Download Speed Ranges (Mbps), by Year and Quarter

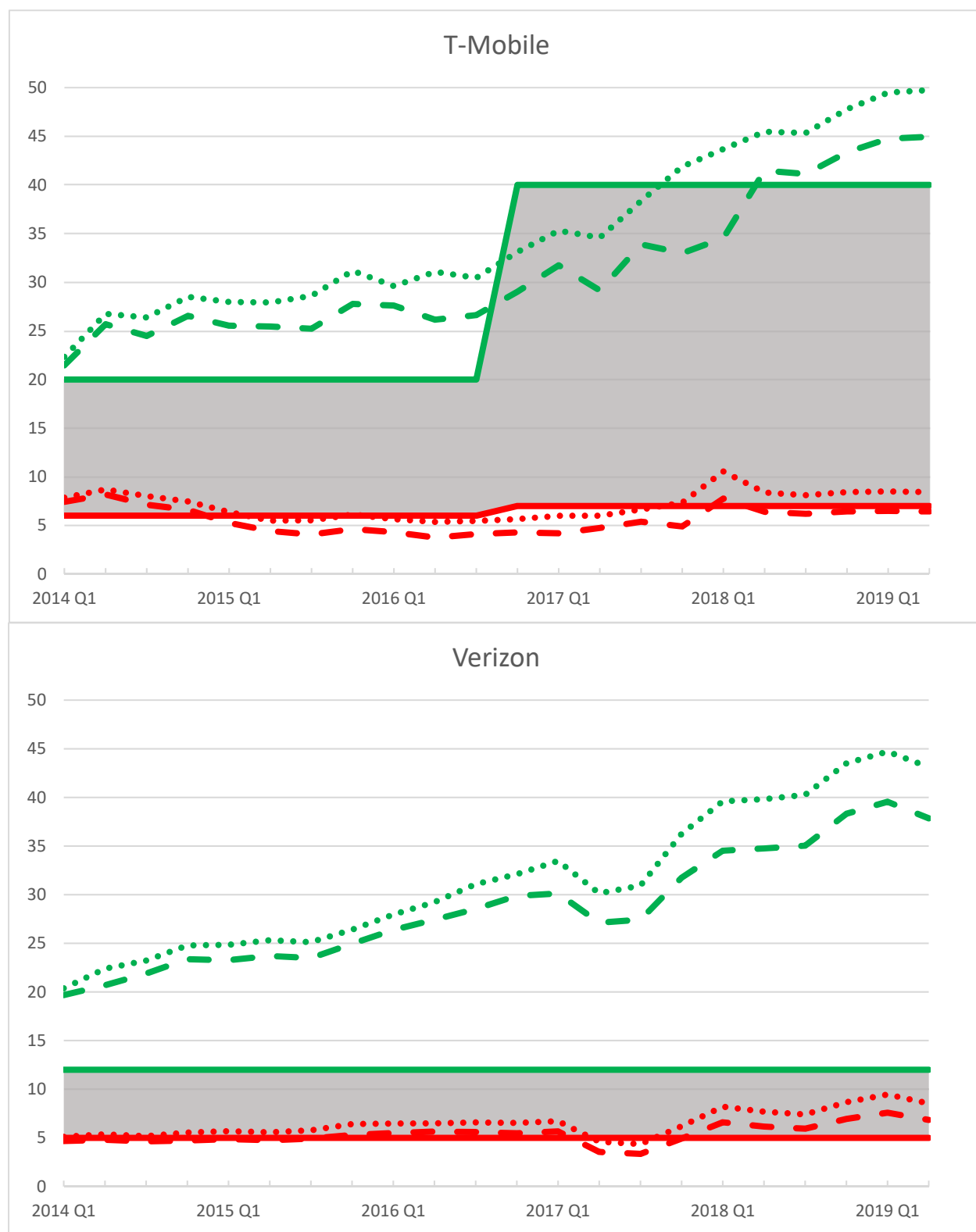


Figure 4 (cont'd): Advertised vs Actual 4G LTE Download Speed Ranges (Mbps), by Year and Quarter

During 2014 Q1 - 2015 Q2, AT&T advertised an expected nationwide download speed range of 5 – 12 Mbps, but did not specify the percentiles that this speed range represents. The estimated all day 25<sup>th</sup> percentile download speed during this time period was  $3.9 \pm 0.2$  Mbps, and the estimated 5pm-8pm 25<sup>th</sup> percentile download speed was  $3.4 \pm 0.2$  Mbps. Thus, the lower end of AT&T's advertised speed range (5 Mbps) significantly exceeded the actual 25<sup>th</sup> percentile. The estimated all day 75<sup>th</sup> percentile download speed was  $19 \pm 1$  Mbps, and the estimated 5pm-8pm download speed was  $18 \pm 1$  Mbps. Thus, the upper end of AT&T's advertised speed range (12 Mbps) was considerably below the actual 75<sup>th</sup> percentile speeds.

During 2015 Q3 – 2017 Q1, following the *2015 Open Internet Order*, AT&T increased its advertised download speed range to 5 – 20 Mbps, but still did not specify the percentiles that this speed range represents. The estimated all day 25<sup>th</sup> percentile download speed increased slightly, mostly to  $5.2 \pm 0.3$  Mbps. The estimated 5pm-8pm 25<sup>th</sup> percentile download speed also increased slightly, mostly to  $4.4 \pm 0.3$  Mbps. The estimated 75<sup>th</sup> percentile download speeds increased steadily during this time period, with all-day speeds increasing from 22 Mbps to 33 Mbps, and 5pm-8pm speeds increasing from 20 Mbps to 31 Mbps. Thus, during 2015 Q3 – 2017 Q1, the lower end of AT&T's advertised download speed range (5 Mbps) was roughly aligned with the 25<sup>th</sup> percentile all-day speeds, and the upper end of AT&T's advertised download speed range (20 Mbps) remained below the 75<sup>th</sup> percentile speeds.

During 2017 Q2 – 2018 Q2, following the *2016 Advisory*, AT&T increased its advertised download speed range to 6 – 29 Mbps, and started explaining that this speed range represents the range from the 25<sup>th</sup> to 75<sup>th</sup> percentile of crowd-sourced measurements. During this time period, the estimated all-day 25<sup>th</sup> percentile download speed was usually  $6 \pm 1$  Mbps, and the estimated all-day 75<sup>th</sup> percentile download speed was usually  $27 \pm 1$  Mbps. Thus, AT&T's advertised speed range was roughly on target. However, the download speeds measured during 5pm-8pm were lower. The estimated 25<sup>th</sup> percentile download speed during 5pm-8pm was usually  $4.5 \pm 0.5$  Mbps, and the estimated 75<sup>th</sup> percentile download speed during 5pm-8pm was  $21 \pm 4$  Mbps.<sup>135</sup> AT&T has never specified a peak usage period during which its measurements are taken.

Since 2018 Q2, AT&T has twice increased its advertised 4G LTE download speed range, first to 6.2 – 35.4 Mbps, and then to 8.2 – 45.9 Mbps. Both times the new advertised speed range was roughly on target with estimated all-day 25<sup>th</sup> – 75<sup>th</sup> percentile ranges.

Sprint's advertisements were too narrow during 2014 Q1 – 2018 Q2. During this time period, Sprint advertised an expected nationwide download speed range of 6 – 8 Mbps, but did not specify the percentiles that this speed range represents. The lower end of this advertised range (6 Mbps) far exceeded the estimated all-day 25<sup>th</sup> percentile download speeds, which started at 2.6 Mbps in 2014 Q1 but only reached about 5 Mbps by 2018 Q2. However, the upper end of Sprint's advertised range (8 Mbps) was far below the estimated all-day 75<sup>th</sup> percentile download speeds, which dramatically increased from 12 Mbps to 34 Mbps. However, in 2018 Q3 Sprint updated its advertised download speed range to 4 – 35 Mbps. It still does not

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<sup>135</sup> There is an anomaly during 2016 Q4 – 2019 Q2 that occasionally results in an estimated 75<sup>th</sup> percentile download speed during 5pm-8pm for AT&T that slightly exceeds the estimated all-day speed. It is likely caused by the inclusion in the *Measuring Mobile Broadband* data during 2016 Q2 – 2017 Q3 of measurements on AT&T's network of some customers of Cricket Wireless (an AT&T MVNO). Some such customers were in plans with download speed caps of 3 or 8 Mbps. This anomaly distorts the shape of the *Measuring Mobile Broadband* download speed distribution. Although the estimated 25<sup>th</sup> percentile download speed during 5pm-8pm is principally based on *Ookla Speedtest data*, the shape of the *Measuring Mobile Broadband* download speed distribution affects the interpolation, and thus distortions in the shape introduce small errors in the estimate.

specify the percentiles that this speed range represents, but it approximately matches the estimated 25<sup>th</sup> – 75<sup>th</sup> percentile speed range in 2018 Q3.

In contrast, T-Mobile’s advertised download speed range in 2014 was far wider. During 2014 Q1 – 2016 Q3, T-Mobile advertised an expected nationwide download speed range of 6 – 20 Mbps, but did not specify the percentiles that this speed range represents. The lower end (6 Mbps) approximately matches the estimated all-day 25<sup>th</sup> percentile download speed during this time period, but exceeds the estimated 5pm-8pm 25<sup>th</sup> percentile download speed during most of 2015 – 2016. In contrast, the upper end (20 Mbps) was far below the estimated 75<sup>th</sup> percentile download speeds, which mostly varied between 25 and 30 Mbps. In 2016 Q4, after the *2016 Advisory*, T-Mobile increased its advertised download speed range to 7 – 40 Mbps and started claiming that this range matches the 25<sup>th</sup> – 75<sup>th</sup> percentile of crowd-sourced measurements of download speed. However, during late 2016 and early 2017, this advertised speed range substantially exceeded the estimated all-day 25<sup>th</sup> – 75<sup>th</sup> percentile speed range, which in 2016 Q4 was 6 – 33 Mbps.<sup>136</sup> T-Mobile also did not specify the peak usage period, but we note that the estimated 5pm-8pm 25<sup>th</sup> – 75<sup>th</sup> percentile speed range in 2016 Q4 was only 4 – 29 Mbps. That said, T-Mobile’s download speeds have steadily increased since 2016 Q4, and eventually exceeded the advertised speed range.

Verizon’s disclosures have followed quite a different pattern. During the entire period from 2014 Q1 – 2019 Q2, Verizon advertised a 4G LTE download speed range of 5 – 12 Mbps. The estimated all-day 25<sup>th</sup> percentile download speed has increased during this time period from 5 Mbps to over 8 Mbps, and the estimated all-day 75<sup>th</sup> percentile download speed has increased from 20 Mbps to over 43 Mbps. Even the 5pm-8pm estimated 25<sup>th</sup> – 75<sup>th</sup> percentile download speeds have exceeded the advertised speed range.

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<sup>136</sup> T-Mobile confirms that the 2016 Q4 advertised 4G LTE download speed range was the range from the 25<sup>th</sup> to 75<sup>th</sup> percentiles, based on analysis and projections from third-party, crowd-sourced data. Determination of the reason for the difference between the advertised 4G LTE download speed range and our estimated all-day 25<sup>th</sup> – 75<sup>th</sup> percentile 4G LTE download speed range requires analysis of the dataset of third-party crowd-sourced data on which T-Mobile bases its analysis and projections, as well as T-Mobile’s analysis and projection methods.

## ii. 4G LTE Upload Speed

Figure 5 compares the provider's advertised 4G LTE upload speed range to the estimated 25<sup>th</sup> and 75<sup>th</sup> percentile 4G LTE upload speeds, for each quarter from 2014 Q1 through 2019 Q2. Since most consumers download more data than they upload, mobile broadband providers offer lower upload speeds than download speeds.<sup>137</sup> Similar to Figure 4 for download speeds, the advertised upload speed range (taken from Table 2) is shown as a grey range; the lower end of the advertised upload speed range is shown as a solid red curve, and the upper end as a solid green curve. The estimated 25<sup>th</sup> percentile of all day 4G LTE upload speeds is shown as a dotted red curve, and the estimated 75<sup>th</sup> percentile as a dotted green curve.<sup>138</sup>

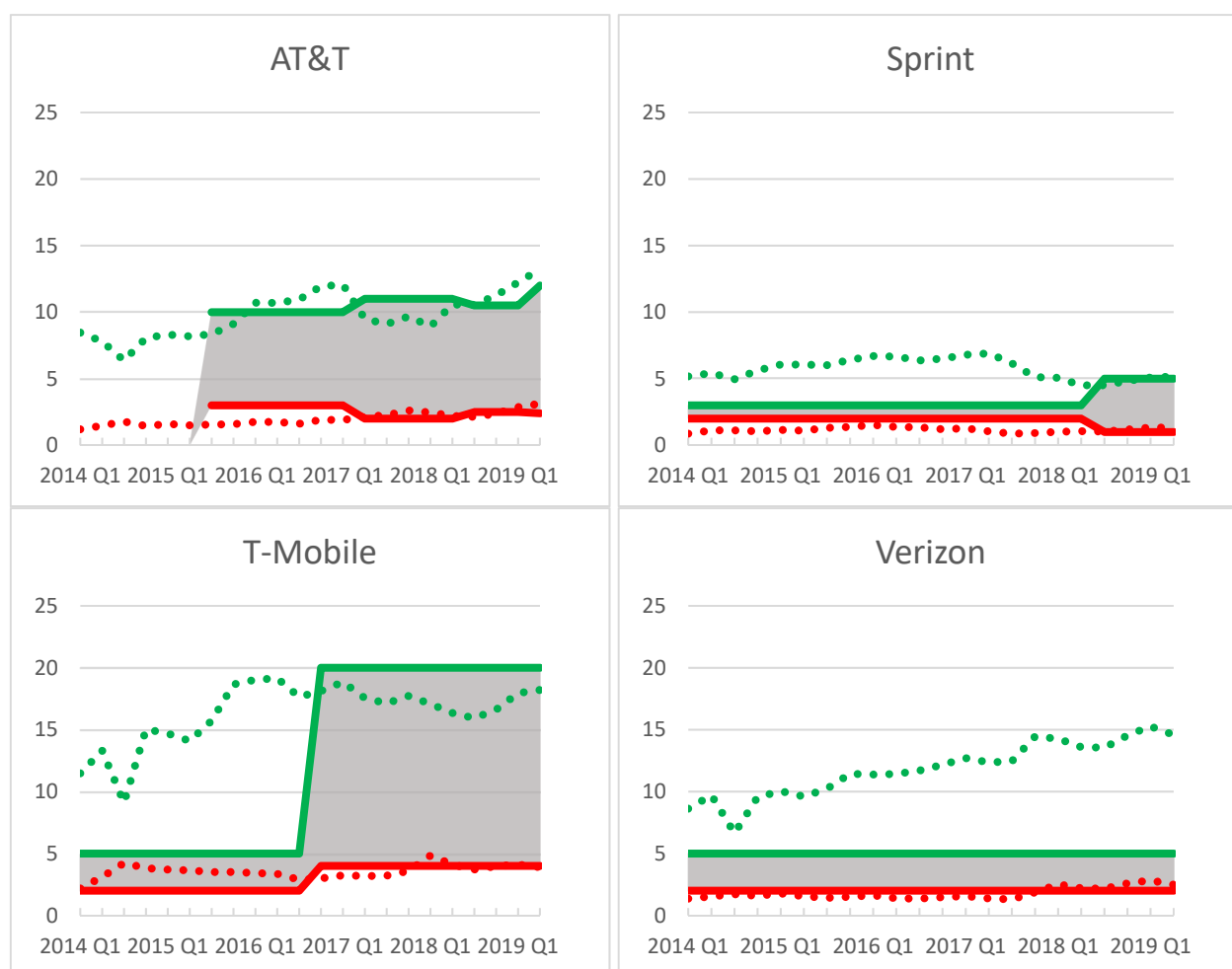


Figure 5: Advertised vs. Actual 4G LTE Upload Speed Ranges (Mbps) versus Year and Quarter.

During 2014 Q1 – 2015 Q2, AT&T did not advertise an expected upload speed range. During 2015 Q3 – 2017 Q1, following the *2015 Open Internet Order*, AT&T advertised a 4G LTE upload speed range of 3 - 10 Mbps, but did not specify the percentiles that this speed range represents. During this time period, the

<sup>137</sup> The ratio of upload to download speeds is in part determined by the frequency bands and the transmission protocol.

<sup>138</sup> The estimation method is the same as that discussed in section 3.C; see footnote 91.

estimated all day 25<sup>th</sup> percentile speed was  $1.7 \pm 0.2$  Mbps, and the estimated all day 75<sup>th</sup> percentile speed increased from 8 to 12 Mbps. During 2017 Q2 – 2018 Q2, following the *2016 Advisory*, AT&T broadened its upload speed range to 2 – 11 Mbps, and started explaining that this speed range represents the range from the 25<sup>th</sup> to 75<sup>th</sup> percentile of crowd-sourced measurements. During this time period, the estimated all day 25<sup>th</sup> percentile upload speed was  $2.3 \pm 0.3$  Mbps, and the estimated all day 75<sup>th</sup> percentile download speed was  $10 \pm 1$  Mbps. Thus, AT&T's advertised upload speed range was roughly on target. Since 2018 Q2, AT&T has twice modified its advertised 4G LTE upload speed range, first to 2.5 – 8 Mbps, and then to 2.4 – 9.6 Mbps. Both times the new advertised upload speed range was roughly on target with estimated all-day 25<sup>th</sup> – 75<sup>th</sup> percentile ranges.

Sprint, during 2014 Q1 – 2018 Q2, advertised too narrow of an upload speed range, just as it did with the download speed range. During this time period, Sprint advertised a 4G LTE upload speed range of 2 – 3 Mbps, but did not specify the percentiles that this speed range represents. The lower end of this advertised range (2 Mbps) far exceeded the estimated all-day 25<sup>th</sup> percentile upload speeds, which were  $1.2 \pm 0.3$  Mbps. However, the upper end of Sprint's advertised range (3 Mbps) was far below the estimated all-day 75<sup>th</sup> percentile download speeds, which were  $5.7 \pm 1.2$  Mbps. However, in 2018 Q3 Sprint updated its advertised upload speed range to 1 – 5 Mbps. It still does not specify the percentiles that this speed range represents, but it approximately matches the estimated all-day 25<sup>th</sup> – 75<sup>th</sup> percentile speed range in recent quarters.

T-Mobile, in contrast, has always advertised a wide 4G LTE upload speed range. During 2014 Q1 – 2016 Q3, T-Mobile advertised an expected nationwide upload speed range of 2 – 5 Mbps, but did not specify the percentiles that this speed range represents. During this time period, both the estimated all-day and 5pm–8pm upload speed ranges far exceeded the advertised speed range. In 2016 Q4, after the *2016 Advisory*, T-Mobile increased its advertised upload speed range to 4 – 20 Mbps and started claiming that this range matches the 25<sup>th</sup> – 75<sup>th</sup> percentiles of crowd-sourced measurements of upload speed. As with its corresponding advertisements about download speed, this advertisement exceeded the estimated all-day 25<sup>th</sup> – 75<sup>th</sup> percentile speed range, which in 2016 Q4 was 3 – 18 Mbps.

Verizon's disclosures have followed quite a different pattern. During the entire period from 2014 Q1 – 2019 Q2, Verizon advertised a 4G LTE upload speed range of 2 – 5 Mbps. The estimated all-day 25<sup>th</sup> percentile download speed has increased during this time period from 1.4 Mbps to 2.5 Mbps, and the estimated all-day 75<sup>th</sup> percentile download speed has increased from 9 Mbps to 15 Mbps.

#### D. Policy Issues

The *2016 Advisory* recommended disclosing actual mobile broadband speeds as a range (e.g., 25<sup>th</sup> to 75<sup>th</sup> percentile)<sup>139</sup>, but it is unclear whether this guidance was eliminated in the 2018 *Restoring Internet Freedom Order*<sup>140</sup>.

As we observed in Figures 3 and 4 above, the comparability of advertised speed ranges between competing mobile broadband providers improved dramatically when AT&T, Sprint, and T-Mobile started disclosing the 25<sup>th</sup> – 75<sup>th</sup> percentiles. Before then, all three typically disclosed speed ranges narrower than the 25<sup>th</sup> – 75<sup>th</sup> percentiles. Sprint, in particular disclosed a 4G LTE download speed range that was far narrower than the 25<sup>th</sup> – 75<sup>th</sup> percentiles, giving consumers an inaccurate representation of the variability in download speed. After they started disclosing the 25<sup>th</sup> – 75<sup>th</sup> percentile speeds, comparability greatly increased,

<sup>139</sup> *2016 Advisory* at 4.

<sup>140</sup> *Restoring Internet Freedom Order*, paras. 214 n. 793, 225.

although Verizon continued to advertise very low percentiles. In the absence of guidance as to the percentiles to advertise, we worry that it would again become impossible to compare the performance among competing mobile broadband providers.

With respect to the format of disclosures, the *2015 Open Internet Order* offers a voluntary safe harbor for both the format and content of the required disclosure to consumers.<sup>141</sup> The *Restoring Internet Freedom Order* eliminates this safe harbor, asserting that the offering of a safe harbor could place a burden on broadband providers<sup>142</sup>. The latter Order is apparently confused about the difference between a requirement (which may impose a cost when outweighed by a corresponding benefit) and a voluntary safe harbor (which may only reduce a provider's cost of compliance).

## 6. GEOGRAPHICAL VARIATIONS

### A. Requirements

Neither the *2010 Open Internet Order* nor the *2011 Advisory* explicitly discuss over which geographical regions broadband performance should be measured and disclosed. This issue is particularly pertinent for mobile broadband service, as access to spectrum and coverage both differ substantially for a particular provider amongst different geographical regions.

The *2015 Open Internet Order* requires that disclosures of actual performance be reasonably related to the performance the consumer would likely experience in the geographic area in which the consumer is purchasing service.<sup>143</sup> For fixed broadband service, the *2016 Advisory* notes that typically “there are few variations in actual BIAS performance across a BIAS provider's service area for a particular combination of technology and service tier.”<sup>144</sup> In contrast, for mobile broadband service, the *2016 Advisory* notes that mobile broadband performance may vary based on a broadband provider's access to spectrum in various geographic areas.<sup>145</sup> On this basis, it states that disclosure of actual performance metrics for each Cellular Market Area (CMA) in which the service is offered (with some aggregation allowed for CMAs with low population densities) satisfies the geographic disclosure requirement.<sup>146</sup>

The *Restoring Internet Freedom Order* eliminates the requirement that disclosures of actual performance be reasonably related to the performance the consumer would likely experience in the geographic area in which the consumer is purchasing service.<sup>147</sup> Its justification is that “[w]eighing the additional costs to ISPs against the limited incremental benefits to consumers, entrepreneurs, and small businesses, we conclude that the net benefits of these additional reporting obligations are likely negative”.<sup>148</sup>

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<sup>141</sup> *2015 Open Internet Order*, para. 179.

<sup>142</sup> *Restoring Internet Freedom Order*, para. 231.

<sup>143</sup> *2015 Open Internet Order*, para. 166.

<sup>144</sup> *2016 Advisory* at 4.

<sup>145</sup> *Id.* at 5.

<sup>146</sup> *Id.* at 5-7.

<sup>147</sup> *Restoring Internet Freedom Order*, paras. 214 n. 793, 225.

<sup>148</sup> *Id.*, para. 226.

### ***B. Broadband Provider Disclosures***

In 2017 Q2, AT&T started disclosing the actual broadband performance (in ranges from the 25<sup>th</sup> to 75<sup>th</sup> percentile) in each Cellular Market Area (CMA), with CMAs with low population density aggregated.<sup>149</sup> For example, AT&T disclosed that the Omaha CMA had an actual 4G LTE download speed range of 4.75 – 21.23 Mbps, whereas AT&T advertised a national 4G LTE download speed range of 6 – 29 Mbps. Such disclosures are consistent with the *2016 Advisory*. Starting 2018 Q4, following the elimination of geographical transparency requirements, AT&T stopped disclosing broadband performance by CMA.<sup>150</sup>

Sprint has apparently never disclosed performance in different geographical regions.

In 2017 Q3, T-Mobile started disclosing the actual broadband performance (in ranges from the 25<sup>th</sup> to 75<sup>th</sup> percentile) in various market areas.<sup>151</sup> For example, T-Mobile disclosed that the Los Angeles - Long Beach – Glendale market had an actual 4G LTE download speed range of 2.8 - 26.8 Mbps, whereas T-Mobile advertised a national 4G LTE download speed range of 7 – 40 Mbps. Such disclosures are partially consistent with the *2016 Advisory*, but they fail to disclose even aggregated data for CMAs with low population density.<sup>152</sup> Despite the elimination of geographical transparency requirements, T-Mobile continues to disclose broadband performance in various market areas.<sup>153</sup>

Verizon has apparently never disclosed performance in different geographical regions.

Among the four mobile broadband providers, only T-Mobile currently discloses actual performance metrics in different geographical markets.<sup>154</sup>

### ***C. Measurements***

We examine the AT&T disclosures.<sup>155</sup> AT&T disclosed the 25<sup>th</sup> - 75<sup>th</sup> percentile ranges of download speed, upload speed, and latency.<sup>156</sup> The speed ranges were based on “crowd-sourced speed test data” between March 2016 and August 2016, and the latency ranges were based on “data compiled by AT&T through drive testing” during the same time period.<sup>157</sup> Consistent with the *2016 Advisory*, AT&T disclosed performance metrics for each CMA in which the service is offered, with data aggregated at the state level among CMAs with a population density below 250 people per square mile.<sup>158</sup>

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<sup>149</sup> AT&T, *Mobility Speed by CMA* (AT&T Archived Geographical Speed Disclosures), [https://web.archive.org/web/\\*/http://www.att.com/Common/about\\_us/files/pdf/Mobility\\_Speed\\_by\\_CMA.pdf](https://web.archive.org/web/*/http://www.att.com/Common/about_us/files/pdf/Mobility_Speed_by_CMA.pdf); AT&T, *Mobility Latency by CMA* (AT&T Archived Geographical Latency Disclosures), [https://web.archive.org/web/\\*/https://www.att.com/Common/about\\_us/files/pdf/Mobility\\_Latency\\_by\\_CMA.pdf](https://web.archive.org/web/*/https://www.att.com/Common/about_us/files/pdf/Mobility_Latency_by_CMA.pdf).

<sup>150</sup> AT&T Archived Disclosures.

<sup>151</sup> T-Mobile, *T-Mobile Network Performance Data* (T-Mobile Archived Geographic Disclosures), [https://web.archive.org/web/\\*/http://explore.t-mobile.com/cityspeeds](https://web.archive.org/web/*/http://explore.t-mobile.com/cityspeeds).

<sup>152</sup> For example, T-Mobile provides no disclosure for anywhere in Nebraska, despite claiming coverage in portions of the state.

<sup>153</sup> T-Mobile Current Geographic Disclosure.

<sup>154</sup> T-Mobile, *T-Mobile Network Performance Data* (T-Mobile Current Geographic Disclosure), <https://www.t-mobile.com/coverage/network-performance-data>.

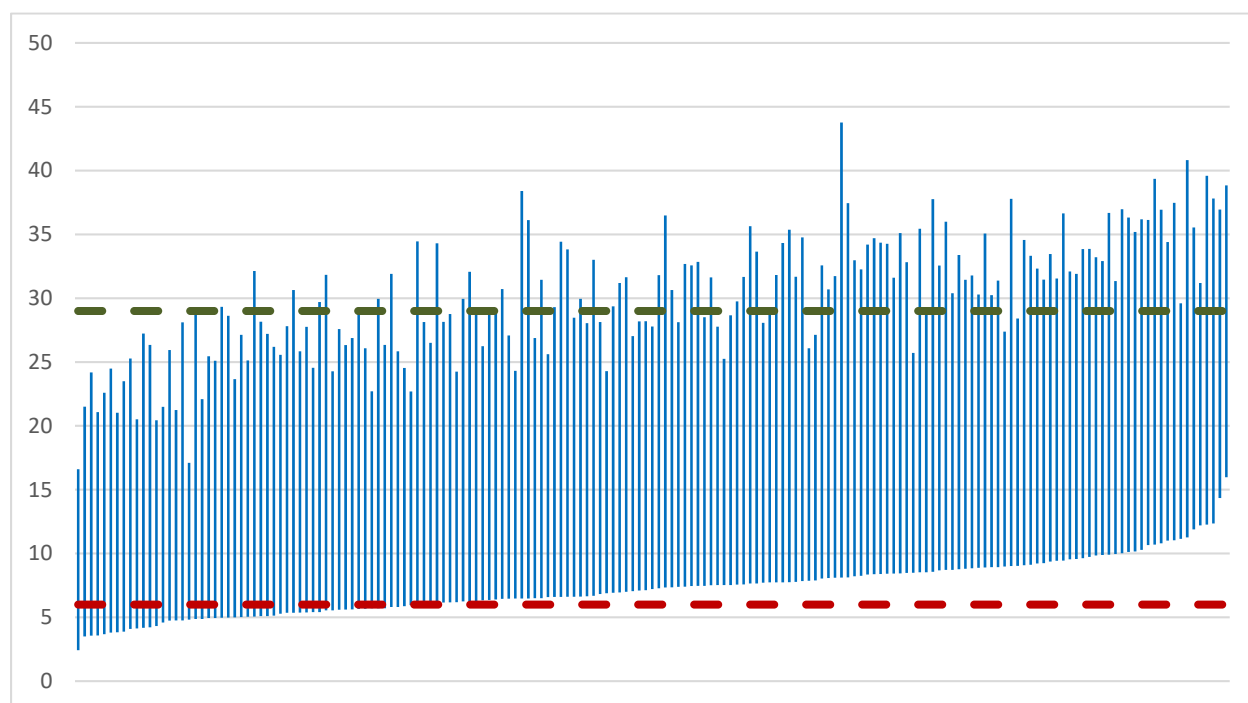
<sup>155</sup> AT&T Archived Geographical Speed Disclosures; AT&T Archived Geographical Latency Disclosures.

<sup>156</sup> *Ibid.*

<sup>157</sup> *Ibid.* Although the information was disclosed during early 2017 to early 2018, the disclosed ranges were based on data collected during March 2016 through August 2016.

<sup>158</sup> *Ibid.*

Figure 6 displays AT&T's disclosed 4G LTE download speed range for each CMA, along with AT&T's advertised nationwide 4G LTE speed range. The CMAs are sorted by the lower end of the speed range, i.e. the CMAs with the lowest 25<sup>th</sup> percentile download speed appear toward the left side of the figure. Each vertical blue bar illustrates the download speed range of one CMA. During the time period in which the CMA-specific data was disclosed (2017 Q1 - 2018 Q2), AT&T advertised a nationwide download speed range of 6 – 29 Mbps, which is illustrated in Figure 6 by the horizontal red and green dashed lines.<sup>159</sup>



*Figure 6: Advertised AT&T 4G LTE Download Speed Range (Mbps) by Cellular Market Area*

Out of the 177 CMAs for which AT&T disclosed a download speed range, 52 CMAs (i.e., 29%) had 25<sup>th</sup> percentile download speeds below the advertised nationwide 25<sup>th</sup> percentile speed (6 Mbps), and 73 CMAs (i.e., 41%) had 75<sup>th</sup> percentile download speeds below the advertised nationwide 75<sup>th</sup> percentile speed (29 Mbps). There were also many CMAs in which the download speed range substantially exceeded the advertised nationwide speed range: 80 CMAs (i.e., 45%) had 25<sup>th</sup> percentile download speeds more than 25% above the advertised nationwide 25<sup>th</sup> percentile speed, and 18 CMAs (i.e., 10%) had 75<sup>th</sup> percentile download speeds more than 25% above the advertised nationwide 75<sup>th</sup> percentile speed.

For CMAs with a population density below 250 people per square mile, AT&T provided data aggregated at the state level.<sup>160</sup> Out of the 47 such states, 20 had 25<sup>th</sup> percentile download speeds below the advertised nationwide 25<sup>th</sup> percentile speed (6 Mbps), and 29 had 75<sup>th</sup> percentile download speeds below the advertised nationwide 75<sup>th</sup> percentile speed (29 Mbps).

<sup>159</sup> We note, however, that during the time period when the data was collected (2016 Q2 - 2016 Q3), AT&T advertised a nationwide download speed range of 5 – 20 Mbps.

<sup>160</sup> *AT&T Archived Geographical Speed Disclosures; AT&T Archived Geographical Latency Disclosures.*

#### D. Policy Issues

The *2015 Open Internet Order* requires that disclosures of actual performance be reasonably related to the performance the consumer would likely experience in the geographic area in which the consumer is purchasing service<sup>161</sup>, and the *2016 Advisory* states that disclosure of actual performance metrics for each Cellular Market Area (CMA) in which the service is offered (with some aggregation allowed for CMAs with low population densities) satisfies the geographic disclosure requirement.<sup>162</sup> The *Restoring Internet Freedom Order* eliminates both the requirement and the corresponding guidance, asserting that the additional costs to broadband providers likely outweighs the consumer benefits.<sup>163</sup> As with other such assertions, it estimates neither the costs nor the benefits.

With respect to the costs, it is implausible that broadband providers do not already today measure broadband performance in various geographical regions, as that is the principal basis for decisions of additional spectrum purchases in various geographical regions. Furthermore, we note that for those providers who subscribe to Ookla *Speedtest Intelligence*<sup>®</sup>, broadband performance is available for a variety of granularities of geographical regions.

With respect to consumer benefit, there is clearly substantial variation among CMAs, and it is difficult to believe the assertion in the *Restoring Internet Freedom Order* that this information is of limited incremental benefit to consumers. Indeed, T-Mobile today continues to provide easy access to similar information by allowing website visitors to simply select their market from a drop-down list.<sup>164</sup>

### 7. CONCLUSIONS

Neither the *2015 Open Internet Order* nor the *Restoring Internet Freedom Order* require that broadband providers use any specific mobile performance measurement methodology. The latitude given to broadband providers to determine the methodology permits measurement methodologies to evolve and improve, as the *2015 Open Internet Order* noted. However, the lack of both a standardized methodology and guidance as to the characteristics of acceptable methodologies resulted during 2014 – 2016 in the four largest mobile broadband providers using incomparable methodologies and/or incomparable disclosures. The end result was that during this time period the advertised speed ranges were incomparable, undermining one of the principal goals of the transparency rule.

There are several options for remedying the problem. First, the FCC could require the use of a specific mobile performance measurement methodology, assuring comparability at the cost of placing a burden on the FCC to periodically update the required methodology as techniques and technology advance.

Second, the FCC could specify (and enforce) the characteristics of acceptable methodologies. The *2016 Advisory* provides scientifically grounded examples of such characteristics, but the *Restoring Internet Freedom Order* largely repeals this guidance. We see no credible rationale for repealing this guidance. In conjunction with specification of characteristics, the FCC could establish a safe harbor for use of a specific methodology, e.g. the FCC's *Measuring Mobile Broadband* methodology. Such a safe harbor was

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<sup>161</sup> *2015 Open Internet Order*, para. 166.

<sup>162</sup> *2016 Advisory* at 5-7.

<sup>163</sup> *Restoring Internet Freedom Order*, para. 226.

<sup>164</sup> *T-Mobile Current Geographic Disclosure*.

established in the *2015 Open Internet Order* but eliminated in the *Restoring Internet Freedom Order*. Again, we see no credible rationale for removing this safe harbor.

Third, the FCC could abstain from specifying either a specific methodology or specific characteristics of acceptable methodologies but simply require that methodologies be grounded in commonly accepted principles of scientific research and good engineering practices. The *2015 Open Internet Order* includes such a requirement, in addition to the guidance later provided about the characteristics of acceptable methodologies, but this requirement was also eliminated in the *Restoring Internet Freedom Order*. We see no rationale whatsoever for removing this requirement.

Personally, we see the second option (specifying and enforcing characteristics of acceptable methodologies) as the best policy option, because it strikes a good balance between evolution and accuracy. Whatever option is adopted for remedying the problem of incomparable advertised speed ranges, we also strongly recommend that methodologies be transparent. The *2015 Open Internet Order* requires transparency, but the *Restoring Internet Freedom Order* eliminates the requirement. We see no rationale whatsoever for the lack of a requirement that methodologies be disclosed in sufficient detail to ensure that disclosures be of “accurate information”.

In addition to issues relating to the mobile measurement methodology, there are several important policy issues relating to disclosures of mobile performance. The *2016 Advisory* recommends disclosing actual mobile speeds as a range (e.g., 25<sup>th</sup> to 75<sup>th</sup> percentile). It is unclear whether the *Restoring Internet Freedom Order* eliminates this guidance. Our analysis shows that there are great differences in speed ranges depending on the percentiles used to determine the range, and that prior to 2016 the four largest mobile broadband providers made very different choices about which percentiles to advertise. Our analysis shows that the guidance provided in the *2016 Advisory* resulted in dramatic improvements in the comparability of the speed ranges advertised by three of the four largest mobile broadband providers.

The *2015 Open Internet Order* requires that actual network performance be measured during times of peak usage, but the *Restoring Internet Freedom Order* eliminates this requirement, asserting (without analysis) that this requirement places an undue burden on broadband providers without providing a comparable consumer benefit. It is incredulous that there is any burden whatsoever, as large mobile broadband providers must already today measure performance during peak usage periods, since usage during peak usage periods is the principle basis for decisions about network capacity upgrades. In addition, our analysis demonstrates that there is substantial consumer benefit, since there is a substantial difference in 4G LTE download speed measured during different times of the day, and these differences have increased over the past few years.

Finally, the *2015 Open Internet Order* requires that disclosures of actual performance be reasonably related to the performance the consumer would likely experience in the geographic area in which the consumer is purchasing service. On this basis, the *2016 Advisory* states that disclosure of actual performance metrics for each Cellular Market Area in which the service is offered (with some aggregation allowed for CMAs with low population densities) satisfies the geographic disclosure requirement. The *Restoring Internet Freedom Order* eliminates the requirement and the associated guidance, asserting (without analysis) that the net benefits of this requirement are likely negative. However, for the four largest mobile broadband providers, the incremental cost is minimal, since mobile broadband performance in various geographical regions is the principal basis for decisions of additional spectrum purchases, and they already have access today to such information. In addition, our analysis shows that there is clearly substantial variation in download speed ranges among CMAs, and it is difficult to believe the assertion that this information is of limited incremental benefit to consumers.