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Commissioner:	<u>C. Rechtschaffen</u>
Admin. Law Judge:	<u>K. J. Bemesderfer</u>
CalAdvocates Project Mgr.:	<u>Shelly Lyser</u>
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## **Public Advocates Office**

**California Public Utilities Commission**

# **Public Advocates Office Testimony on Fifth Generation Wireless Service for the Proposed Transfer of Control of Sprint to T-Mobile**

**- PUBLIC -**

San Francisco, California  
January 7, 2019

## MEMORANDUM

This report was prepared by Cameron Reed of the Public Advocates Office at the California Public Utilities Commission (Public Advocates Office or Cal Advocates) under the general supervision of Program & Project Supervisor, Shelly Lyser. Attachment A to this testimony is a statement of qualifications from Cameron Reed. The Public Advocates Office is represented in this proceeding by legal counsel, Travis Foss.

This testimony is comprised of the following chapters:

Chapter	Description
<b>I</b>	<b>Introduction:</b> Background information about the importance of a thorough review of the merger.
<b>II</b>	<b>Fifth Generation Wireless Standards:</b> A discussion about Fifth Generation Wireless technologies, standards, and deployment.
<b>III</b>	<b>Conclusion:</b> A summary of the main points of discussion.

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1 **SUMMARY**

2 An essential part of the required public interest review is an examination of whether the  
3 merger will maintain or improve the quality of service for California customers. The Amended  
4 Assigned Commissioner’s Scoping Memo and Ruling filed October 4, 2018, (Scoping Memo)  
5 makes this requirement clear by asking what new services would arise from the merger,<sup>1</sup> how the  
6 merger will impact service quality,<sup>2</sup> and whether the benefits of the merger exceed any  
7 detriments.<sup>3</sup> In answering these questions, this testimony examined Sprint Spectrum L.P  
8 (Sprint), Virgin Mobile USA, L.P. (Virgin), and T-Mobile USA, Inc., A Delaware Corporation  
9 (T-Mobile) (Collectively “Applicants”) claims of purported service benefits of the merger.

10 **Key Findings:**

11 The key findings of my review of the Applicant’s proposed 5G wireless service include  
12 the following:

- 13 • The International Technical Union’s Radio Telecommunications sector (ITU-R)  
14 outlined performance standards that prospective 5G services must meet by year 2020  
15 which will improve mobile wireless service independent of the merger.
- 16 • Sprint and T-Mobile are independently deploying 5G network equipment in select  
17 markets and both are capable of fully deploying 5G services as stand-alone  
18 companies.
- 19 • New T-Mobile and T-Mobile will have the same amount of low-band spectrum  
20 dedicated to 5G by 2024, <<BEGIN T-MOBILE CONFIDENTIAL>> ■  
21 ■ <<END T-MOBILE  
22 CONFIDENTIAL>>. T-Mobile will also have <<BEGIN T-MOBILE  
23 CONFIDENTIAL>> ■ <<END T-MOBILE CONFIDENTIAL>> of  
24 midband spectrum devoted to 5G by 2024.

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<sup>1</sup> Scoping Memo at p. 2. Question #2.

<sup>2</sup> Id at p. 3. Question #10.

<sup>3</sup> Id a p. 3. Question #14.

- 1 • New T-Mobile plans to aggressively refarm 4G spectrum to 5G spectrum which will  
2 outpace customer demand for 5G service leading to unused 5G capacity and  
3 constrained 4G capacity.<sup>4</sup>
- 4 • 5G handsets are expected to be widely commercially available by year 2020. Low  
5 turnover rates for handsets and an approximately 5-year average life for smart phones  
6 predict that consumer demand for 5G capabilities will not overtake demand for 4G  
7 capabilities until 2025.
- 8 • Both Sprint and T-Mobile's stand-alone 5G networks will rival existing wireline  
9 networks in broadband download speeds by 2024, meeting or surpassing the 100  
10 Megabit per second 5G standard for throughput.
- 11 • New T-Mobile's in-home broadband offering is in its conceptual stages and is lacking  
12 important details regarding customer cost and data usage plans.
- 13 • Sprint is planning to offer in-home broadband service using its 5G network  
14 independent of the merger.<sup>5</sup>
- 15 • Sprint and T-Mobile's concerns about having free spectrum available for a 5G  
16 transition are transient and will abate by 2024.

#### 18 **Key Recommendations:**

19 The harms caused by the loss of a facilities-based provider that is a viable carrier and  
20 competitor does not outweigh the benefits of the merger. The California Public Utilities  
21 Commission (Commission) should deny the merger. If the Commission fails to deny the merger,  
22 it must implement wireless market improvements to mitigate the harms to California customers:

- 23 • Require that New T-Mobile adhere to its commitments to offer in-home broadband  
24 services and to expand and improve service in rural California.<sup>6</sup>
- 25 • Require that New T-Mobile adhere to its commitments to provide wireless speeds in  
26 excess of 100 Megabits per second by 2021 and 400 Megabits per second by 2024.<sup>7</sup>

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<sup>4</sup> When I refer to New T-Mobile's refarming plan, I am referring to the plan holistically to include encumbered 4G LTE spectrum (spectrum used to active support cellular subscribers) which will be gradually refarmed to 5G spectrum and unencumbered 4G LTE spectrum (spectrum not currently supporting cellular subscribers) that is already allocated to 5G spectrum. New T-Mobile's 5G plan for both free and used spectrum outpaces demand.

<sup>5</sup> See <https://www.fiercewireless.com/5g/sprint-may-tackle-market-for-home-broadband-internet>

<sup>6</sup> Application at p. 4.

<sup>7</sup> *Id* at p. 15.

1 **I. INTRODUCTION**

2 The Scoping Memo requires a review of whether a proposed merger is within the public  
3 interest.<sup>8</sup> This review includes in part an examination of whether the merger would maintain or  
4 improve the quality of service and services available to California ratepayers. The Scoping  
5 Memo makes the review requirement clear by asking “[w]hat new services, if any, that are not  
6 currently provided by T-Mobile or Sprint, are contemplated to be provided by the merged entity?  
7 How would the merger impact competition for such services in any metropolitan area or other  
8 geographically distinct market?”<sup>9</sup> and “[h]ow would the merger impact the quality of, and access  
9 to, service to California consumers in metropolitan areas, rural areas, or other geographically  
10 distinct markets?”<sup>10</sup> Further, the Scoping Memo makes it clear that merger impacts on quality of  
11 service or access to new service must have benefits that outweigh the detrimental effects of the  
12 merger by asking “[w]ould the benefits of the merger likely exceed any detrimental effects?”<sup>11</sup>

13 If approved, the proposed transaction will significantly reduce wireless competition in  
14 California and consolidate an already highly concentrated industry.<sup>12</sup> A large majority of  
15 Californians rely on their cell phones as their primary means of voice communication, with  
16 approximately 80 percent of 9-1-1 calls originating from wireless devices.<sup>13</sup> Furthermore, many  
17 low-income families rely on their mobile phones to connect to the Internet at home.<sup>14</sup> If the  
18 merger is approved, New T-Mobile will serve approximately <<BEGIN CONFIDENTIAL>>

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<sup>8</sup> Scoping Memo at p. 2.

<sup>9</sup> *Id* at p. 2. Question #2.

<sup>10</sup> *Id* at p. 3, Question #10.

<sup>11</sup> *Id* at p. 3. Question #14.

<sup>12</sup> Decision (D.)16-12-025 at p. 11. “Mobile broadband markets are highly concentrated” and at p. 74.

<sup>13</sup> See National Emergency Number Association Statistics on Call Volume at:  
<https://www.nena.org/page/911Statistics>.

<sup>14</sup> Approximately 31% of US households that make less than \$30,000 use smart phones as their only connection to the Internet. <https://finance.yahoo.com/news/study-1-5-american-homes-get-broadband-smartphones-192623829.html>.

1 [REDACTED] <<END CONFIDENTIAL>><sup>15</sup> California customers, which means the proposed  
2 transaction will have a significant impact on a large number of Californians.

3 Fifth Generation (5G) wireless service is the next major advancement in the wireless  
4 industry. 5G service is generally expected to focus on breakthroughs that support the  
5 enhancement of mobile Broadband (emBB) and Mission Critical Communication (MCC) along  
6 with expanding to new applications such as Machine-to-Machine (M2M) and Internet of Things  
7 (IoT) communication.<sup>16</sup> 5G standards and expectations are defined by the International  
8 Technical Union – Radiocommunication Sector (ITU-R) in its International Mobile  
9 Telecommunications for 2020 framework (IMT-2020). The specifications and capabilities of  
10 IMT-2020 are discussed in Attachment B to this testimony.

11 In July 2018, the 3<sup>rd</sup> Generation Partnership Project (3GPP) issued release 15 which  
12 included the first 5G stand-alone radio specifications. In addition to the 5G NR air interface  
13 standard for radios, several new infrastructure and antenna technologies will enable 5G's  
14 improved coverage, throughput, and capacity. 5G deployments will also use new millimeter  
15 Wave spectrum (mmWave) to support high density areas; the Federal Communications  
16 Commission (FCC) is making mmWave available to carriers through auctions. 3GPP and  
17 industry groups are still finalizing 5G standards and both 5G equipment manufacture and  
18 customer adoption will take time.

19 The Commission should consider the ability of both companies to implement 5G wireless  
20 deployments absent the merger to determine whether the merger provides benefits to the public.  
21 Furthermore, due to recent advances in 5G New Radio (NR) technology, the Commission should  
22 also distinguish between potential benefits derived from new 5G technologies and benefits  
23 derived solely from the merger. The Commission should adopt the recommendations discussed  
24 in the sections below to ensure that customers' service quality is maintained or improved if the

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<sup>15</sup> Confidential Appendix A to Application (A.) 18-07-011.

<sup>16</sup> Exhibit CR-1: International Technical Union – Radiocommunication Sector (ITU-R) Recommendation M.2083 at p. 11-12.

- 1 Commission fails to reject the merger on the grounds of competitive harms discussed in the
- 2 testimony of Dr. Lee Selwyn.<sup>17</sup>

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<sup>17</sup> Public Advocates Office testimony of Dr. Lee Selwyn at p. viii-xvii.

1 **II. THE BENEFITS OF 5G SERVICE ARE NOT UNIQUE TO THE**  
2 **MERGER**

3 **A. The Capabilities of IMT-2020 Dictate That 5G Services Will Have Faster**  
4 **Broadband Speeds and More Capacity Than 4G Services.**

5 The ITU-R's IMT-2020 framework set forth discrete specifications and use cases that a  
6 5G wireless service needs to meet.<sup>18</sup> IMT-2020 defined eight parameters to consider as key  
7 capabilities of a 5G wireless solution, such as 5G service providing 100 Megabits per second  
8 (Mbps) average broadband speeds and 20 Gigabit per second (Gbps) peak broadband speeds. In  
9 setting forth the key capabilities of the IMT-2020 framework, the ITU-R envisioned that 5G  
10 wireless service should match fixed networks as closely as possible. Many of the merger's  
11 purported benefits can be tied to improvements gained from 5G networks. As discussed further  
12 in the following sections, the stand-alone companies will realize these 5G benefits independent  
13 of the merger. Attachment B to this testimony illustrates the key capabilities of 5G service  
14 compared to the IMT-advanced capabilities that defined Long Term Evolution (LTE) Advanced  
15 wireless services.

16 Several of the Applicant's purported merger benefits of faster speed, more capacity, and  
17 new services are benefits that are enabled by 5G services, and thus not unique to the merger. As  
18 discussed more in the following sections, the Sprint and T-Mobile will deploy 5G technology as  
19 stand-alone companies and many 5G benefits could be realized without the merger. Further, it is  
20 important that the Commission recognize that while the Applicants are beginning 5G infrastructure  
21 deployment, 5G standards are still in the final phases of development and the full scope of 5G's  
22 use cases and impacts are unknown.

23 **B. 5G Wireless Infrastructure Improvements Will Depend Mostly on Network**  
24 **and Cell Site Improvements, Not on Acquiring New Spectrum.**

25 5G NR services are supported by a variety of new technologies or methods to improve  
26 existing technologies. These new infrastructure techniques are key elements of the increased  
27 capabilities that 5G services have compared to 4G and 4G LTE wireless services. There are

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<sup>18</sup> Exhibit CR-1: International Technical Union – Radiocommunication Sector (ITU-R) Recommendation M.2083 at p. 10-14.

1 many individual advancements in physical and frequency transmission methods that combine to  
2 create the basis for 5G NR services, the most prominent technologies including massive Multi-  
3 Input Multi-Output (mMIMO), beamforming, small cell deployments, virtualization, and  
4 millimeter wave spectrum (mmWave). Most of these new technologies depend on cell site  
5 improvements and high frequency spectrum, not existing spectrum portfolios. Attachment B to  
6 this testimony discusses these technologies are discussed in detail.

7 Radio equipment manufacturers have designed the first 5G NR radios using these  
8 technologies. In 2018, Ericsson introduced the Ericsson AIR 6468, which is capable of  
9 supporting LTE services and 5G service.<sup>19</sup> Further, Ericsson radios created after 2015 will be  
10 capable of providing 5G wireless service after an over-the-air software update.<sup>20</sup> The first full  
11 5G deployments are coming in 2019 along with the first 5G capable consumer handsets; the  
12 earliest 5G phones will be released in the first quarter of 2019 with more following towards late-  
13 2019 and 2020.<sup>21</sup> Nokia is also developing 5G radios and has recently partnered with T-Mobile  
14 to facilitate \$3.5 billion in 5G NR system deployments.<sup>22</sup> T-Mobile is already building 5G  
15 infrastructure and plans to deploy it nationwide.<sup>23</sup> Sprint will also be launching 5G services in  
16 the first half of 2019 using its 2.5 GHz Spectrum.<sup>24</sup>

17 While spectrum will be an important aspect of 5G deployment, most of 5G's  
18 improvements will be realized through capital intensive cell site and network management  
19 improvements. Sprint and T-Mobile are committed to deploying 5G services independently and  
20 have adequate spectrum resources to do so, as discussed below. Further, Sprint and T-Mobile  
21 have both committed billions in funds to facilitate 5G deployment, as discussed in the Public

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<sup>19</sup> See <https://www.ericsson.com/en/networks/offerings/5g/5g-nr-radio>.

<sup>20</sup> See <https://www.ericsson.com/en/networks/offerings/5g/5g-radio>.

<sup>21</sup> See <https://5g.co.uk/phones/>.

<sup>22</sup> <https://www.nokia.com/about-us/news/releases/2018/07/30/t-mobile-and-nokia-ink-35-billion-multi-year-5g-network-agreement/>.

<sup>23</sup> Declaration of Neville R. Ray at ¶'s 16-18.

<sup>24</sup> Declaration of John C. Saw at ¶'s 17-18.

1 Advocates Office testimony of Mr. Adam Clark. Absent the merger, Sprint and T-Mobile are  
2 fully capable of deploying 5G as stand-alone companies.

3 **C. New T-Mobile's 5G Deployment Plans Outpace Projected Customer**  
4 **Adoption Rates and Sprint and T-Mobile Are Capable of Independently**  
5 **Deploying 5G Wireless Service.**

6 The Applicants have expressed numerous times that the merger is necessary so that  
7 Sprint and T-Mobile can have the spectrum and scale to quickly build a 5G network.<sup>25</sup> However,  
8 even if it was true that Sprint and T-Mobile needed more spectrum to build their 5G network (an  
9 assumption which I contest below) there are other options besides merging that allow them to  
10 opportunity to acquire more spectrum. Further, New T-Mobile's plan for refarming 5G spectrum  
11 is unduly aggressive and outpaces projected customer demand, exaggerating the need for 5G  
12 spectrum in the next six years.

13 Spectrum refers to the set of frequencies on the electromagnetic spectrum used to  
14 transmit cellular traffic. These frequencies typically range from 600 MHz to 6 GHz. With the  
15 coming 5G wireless service, frequencies viable for cellular traffic will expand into spectrum  
16 bands greater than 6 GHz. Two upcoming Federal Communications Commission (FCC)  
17 spectrum auctions will provide wireless carriers, like the Applicants, an opportunity to bid for  
18 licenses for some spectrum bands in the 28 and 24 GHz frequency range.<sup>26</sup> Auction 101 will  
19 offer county-based licenses for 425 MHz blocks of spectrum. Auction 102 will offer licenses in  
20 Partial Economic Areas, or markets, in seven 100 MHz blocks. Further auctions may be  
21 upcoming, as groups are advocating that the FCC auction portions of the 3.5 GHz midband  
22 spectrum for use in 5G services.<sup>27</sup> These auctions provide an ample opportunity for the  
23 Applicants to acquire new high capacity and high throughput spectrum to support 5G  
24 deployments without merging.

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<sup>25</sup> Application at p. 2-3.

<sup>26</sup> FCC 18-109 released August 3, 2018 *Auctions of Upper Microwave Flexible Use Licenses For Next-Generation Wireless Service*, at p. 5-6 Table 1 and Table 2.

<sup>27</sup> The FCC is considering the option for opening up the 3.5 GHz band for mobile 5G services: Forbes <https://www.forbes.com/sites/fredcampbell/2018/06/28/fcc-action-in-3-5-ghz-band-will-speed-5g/#6ee7cbc91c83>.

1 Further, customers will have to acquire new handsets in order to use 5G wireless  
2 services.<sup>28</sup> As discussed above, 5G capable handsets are going to be released intermittently over  
3 the course of 2019. Early 5G capable phones will require multiple mmWave antennas that will  
4 cause these phones to be bulky, expensive, and have a shorter battery life.<sup>29</sup> As such, consumer  
5 adoption of 5G capable devices will take time. A study conducted in 2015 found that 54 percent  
6 of Americans upgrade their cell phones only when their current phone becomes totally obsolete  
7 and 44 percent upgrade as soon as their cellular carrier allows it.<sup>30</sup> Considering that smartphones  
8 have an average life expectancy of 4.7 years,<sup>31</sup> widespread consumer adoption of 5G handsets is  
9 reasonably expected to take at least 5 years, with approximately 50 percent consumer adoption  
10 expected by 2025.<sup>32</sup> As demonstrated, there is no pressing need to immediately make available a  
11 large amount of 5G spectrum, especially considering that 5G wireless service is more spectrally  
12 efficient than 4G LTE services. Consumers will take years to adopt 5G service, which means  
13 New T-Mobile's plan to refarm encumbered and unencumbered spectrum into 5G spectrum is  
14 unduly aggressive.<sup>33</sup> The Applicants have stated that they will continue to maintain LTE services  
15 going forward, with<sup>34</sup> or without<sup>35</sup> the merger, which is prudent as customers will continue to  
16 use LTE services past 2025. Given that adoption of 5G services are expected to be around 50  
17 percent by 2025, it's reasonable to expect that spectrum assets would be distributed roughly the  
18 same way to accommodate customer use.

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<sup>28</sup> Exhibit CR-2: Sprint Response to Cal Advocates Data Request 001 Question 1-24.

<sup>29</sup> Arstechnica: "Don't buy a 5G smartphone, at least not for a while" at <https://arstechnica.com/gadgets/2018/12/dont-buy-a-5g-smartphone-at-least-not-for-a-while/>.

<sup>30</sup> Gallup Survey: Americans Split on How Often They Upgrade Their Smartphones <https://news.gallup.com/poll/184043/americans-split-often-upgrade-smartphones.aspx?version=print>.

<sup>31</sup> <https://www.cta.tech/News/Blog/Articles/2014/September/The-Life-Expectancy-of-Electronics.aspx>.

<sup>32</sup> The Mobile Economy North America 2018 Report by GSMA which can be found here: <https://www.gsmaintelligence.com/research/?file=1edb46b8f8d86187a7508bad348c3e87&download>.

<sup>33</sup> When I refer to New T-Mobile's refarming plan, I am referring to the plan holistically to include encumbered 4G LTE spectrum (spectrum used to active support cellular subscribers) which will be gradually refarmed to 5G spectrum and unencumbered 4G LTE spectrum (spectrum not currently supporting cellular subscribers) that is already allocated to 5G spectrum. New T-Mobile's 5G plan for both free and used spectrum outpaces customer demand.

<sup>34</sup> Application at p. 3.

<sup>35</sup> Application at p. 27 and p. 29.

1           The Applicants have outlined their spectrum refarming plan<sup>36</sup> in their Public Interest  
2 Statement (PIS). Like many aspects of its proposed business model, the PIS proposed that New  
3 T-Mobile would pursue an “aggressive refarming strategy.”<sup>37</sup> Figure 1 below illustrates the  
4 spectrum refarming and allotment plan that T-Mobile, Sprint, and New T-Mobile expect to  
5 follow:

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<sup>36</sup> Refarming refers to the process for repurposing frequency bands for use with a new generation of mobile technology. In this case, 4G bands would be refarmed into 5G bands.

<sup>37</sup> PIS at p. 32.

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**Figure 1: Spectrum Holdings and Refarming Plan<sup>38</sup>**

**<<BEGIN T-MOBILE CONFIDENTIAL>>**



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**<<END T-MOBILE CONFIDENTIAL>>**

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By 2024, T-Mobile projects that it would have about **<<BEGIN T-MOBILE CONFIDENTIAL>>** [REDACTED]  
[REDACTED] **<<END T-MOBILE CONFIDENTIAL>>**, Sprint would have **<<BEGIN T-MOBILE CONFIDENTIAL>>** [REDACTED]  
[REDACTED] **<<END T-MOBILE CONFIDENTIAL>>** and  
the combined companies would have **<<BEGIN T-MOBILE CONFIDENTIAL>>** [REDACTED]

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<sup>38</sup> Exhibit CR-3: T-Mobile Response to Cal Advocates Data Request 001 Question 1-24.

1 [REDACTED]  
2 [REDACTED] <<END T-MOBILE CONFIDENTIAL>> New T-Mobile plans to use over  
3 <<BEGIN T-MOBILE CONFIDENTIAL>> [REDACTED] <<END T-MOBILE  
4 CONFIDENTIAL>> of its non-mmWave spectrum for 5G service, as compared to about  
5 <<BEGIN T-MOBILE CONFIDENTIAL>> [REDACTED] <<END T-MOBILE  
6 CONFIDENTIAL>> for T-Mobile and <<BEGIN T-MOBILE CONFIDENTIAL>> [REDACTED]  
7 [REDACTED] <<END T-MOBILE CONFIDENTIAL>> for Sprint.

8         Clearly, New T-Mobile plans heavy investment in 5G spectrum refarming. However,  
9 given customer adoption predictions and the increased spectral efficiency of 5G services, New T-  
10 Mobile’s spectrum re-farming plans are unduly aggressive. With its own spectrum refarming  
11 efforts, stand-alone T-Mobile will be able to cover 323 million US Population (POPs) by 2024  
12 with its lowband spectrum and 173.2 million US POPs with its midband spectrum. The  
13 Applicants have suggested that New T-Mobile needs the increased spectrum portfolio to have  
14 spectrum free to transition to 5G. The transition to 5G is a transient problem, one that every  
15 carrier will have to deal with. The Commission should not approve a merger to obviate  
16 temporary issues associated with a technology transition.

17         Projected customer adoption rates and the ability for older radios to be converted through  
18 a software update imply that there is no pressing need for the companies to merge in order to  
19 fully deploy 5G services by 2021 or 2024. The Applicants overestimate the need for refarming  
20 5G spectrum and have underestimated their ability to deploy 5G NR services as stand-alone  
21 companies. Sprint recently affirmed that the company is in a good position to deploy competitive  
22 5G services.<sup>39</sup> The companies do not need to merge to deploy 5G services, especially  
23 considering that upcoming mmWave auctions will allow T-Mobile and Sprint to expand their  
24 spectrum portfolios to supplement 5G deployment in dense urban areas where demand for 5G  
25 services and capacity will be the highest.

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<sup>39</sup> Exhibit CR-4: Sprint 3<sup>rd</sup> Quarter 2017 Earnings Call, “I am very confident in Sprint’s future based on the competitive advantage that we will have with the deployment of 5G on our 2.5 GHz spectrum” at p 4.

1                   **1. Rural Deployment Will Depend on Capital Investment, Not New**  
2                   **Spectrum. T-Mobile Already Has Adequate Spectrum to Serve Rural**  
3                   **Areas.**

4           The Applicants focus on possible benefits that the merger will potentially bring to rural  
5 America and by extension rural California. These possible benefits include increased speed and  
6 in-home broadband options.<sup>40</sup> While rural communities do need faster speeds, the merger is not  
7 the only way to achieve that goal, nor is it the best way. Sprint notes that 2.5 GHz coverage is  
8 limited in its ability to provide coverage, especially in rural areas.<sup>41</sup> Yet, the Applicants claim  
9 that New T-Mobile will rely on this exact spectrum to provide coverage in rural areas.

10           Midband spectrum, such as 2.5 GHz spectrum, has a coverage range of approximately  
11 four miles.<sup>42</sup> Covering rural areas with midband spectrum will require significant capital build-  
12 outs of more cell sites. As discussed in Attachment B, most new technologies enabling 5G  
13 service such as mMIMO and beamforming are infrastructure-related antenna technology, which  
14 will require further investment to upgrade existing antennas and radios. These benefits are not  
15 directly enabled by larger spectrum portfolios, even if more spectrum can benefit 5G  
16 deployments.

17           Further, rural areas have low population densities that do not need as much capacity as  
18 dense, urban areas. As such, carriers need less available spectrum to provide service to rural  
19 areas, especially considering that 5G NR will improve spectral efficiency over 4G. The merger  
20 will lead to portions of spectrum being unused in rural areas. T-Mobile will have <<BEGIN T-  
21 MOBILE CONFIDENTIAL>> [REDACTED] <<END T-MOBILE  
22 CONFIDENTIAL>> available for use in rural areas by 2024 and T-Mobile and New T-Mobile  
23 will have the same amount of available lowband 5G spectrum, <<BEGIN T-MOBILE  
24 CONFIDENTIAL>> [REDACTED] <<END T-MOBILE CONFIDENTIAL>>, to serve rural areas.  
25 Stand-alone T-Mobile already has the spectrum resources to provide high speed 5G services to

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<sup>40</sup> Application at p. 24.

<sup>41</sup> *Id* at p. 28.

<sup>42</sup> Declaration of Neville R. Ray at ¶36.

1 rural areas. T-Mobile can also replace and upgrade its existing 600 MHz radios to provide 5G  
2 service as demand grows in rural areas.

3 **2. New T-Mobile’s In-home Broadband Concept is Neither Fully Planned**  
4 **nor a Unique Benefit of the Merger.**

5 The Applicants claim in-home broadband offerings as a benefit of the merger.<sup>43</sup> While  
6 competition in the in-home broadband market would benefit consumers, the proposed merger is  
7 not the sole, or even the most impactful, enabler of a potential in-home broadband offering.  
8 Further, the in-home broadband offering is not well defined, and the application includes no  
9 material plans to implement this service, how it would be marketed, or what quality of service  
10 could be provided to customers.<sup>44</sup> Several technical issues about network capacity and building  
11 penetration also remain unanswered. Sprint also plans to offer in-home broadband service using  
12 5G independent of the merger.

13 First, the in-home broadband offering is a service enabled by the significant advances in  
14 capacity, coverage, and throughput derived from 5G NR. As discussed in Attachment B, small  
15 cell deployments and mMIMO will enable speeds of 100 Mbps or more, which is comparable to  
16 existing wireline services. The stand-alone deployments of T-Mobile and Sprint in 5G services  
17 are projected to meet or exceed the expected 5G average speeds by 2024, which would enable  
18 the stand-alone companies to provide an alternative to fixed wireline service without needing to  
19 merge.

20 In addition to attributing 5G NR benefits to the merger, the Applicants also lack specific  
21 details about the nature of an in-home broadband option. While New T-Mobile has preliminary  
22 plans to use customer premises equipment such as a wireless router to convert the cellular signal  
23 into a Wi-Fi signal,<sup>45</sup> there is no information on what this device may cost consumers, when the  
24 device will be commercially available, how customers will sign up for service, or even what  
25 areas will have a strong enough signal to be eligible for in-home broadband.

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<sup>43</sup> Application at p. 4.

<sup>44</sup> Exhibit CR-5: T-Mobile Response to Cal Advocates Data Request 002 Question 2-2(g).

<sup>45</sup> *Id.* Question 2-2(b).

1 Critically, wireless data plans typically come with data limits. Even unlimited plans will  
2 have a soft data cap where users will start to be ‘deprioritized’ and face slower download speeds.  
3 These caps tend to be in the 6 to 10 Gigabyte (GB) range; for unlimited plans the soft cap at  
4 which data customers are deprioritized and may receive slower speeds is 50 GB. As such, mobile  
5 users typically tailor their data use around these limitations, as well as the limitations of their  
6 mobile devices which have smaller screens that limit the quality from higher video resolutions.  
7 This user behavior is reflected by T-Mobile’s BingeOn customers, where the largest data  
8 customers consumed on average <<BEGIN T-MOBILE CONFIDENTIAL>> ██████████ <<END  
9 T-MOBILE CONFIDENTIAL>> of data per month to stream video.<sup>46</sup> In 2017, mobile users  
10 consumed on average 7.1 GB of data per month.<sup>47</sup> In home broadband has considerably higher  
11 data limits and data consumption rates than mobile broadband services. In 2016 an iGR research  
12 study found that, on average, US homes use 190 GB of data per month.<sup>48</sup> This number has  
13 undoubtedly risen over the past two years and is nearly four times the soft data cap of most  
14 unlimited plans before deprioritization. Streaming TV and high-resolution video<sup>49</sup> are also very  
15 bandwidth demanding, often using up to 400 to 500 GB of bandwidth a month.<sup>50</sup> Figure 2  
16 summarizes data caps and consumption rates of these various services.

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<sup>46</sup> Exhibit CR-6: T-Mobile BingeOn Statistics.

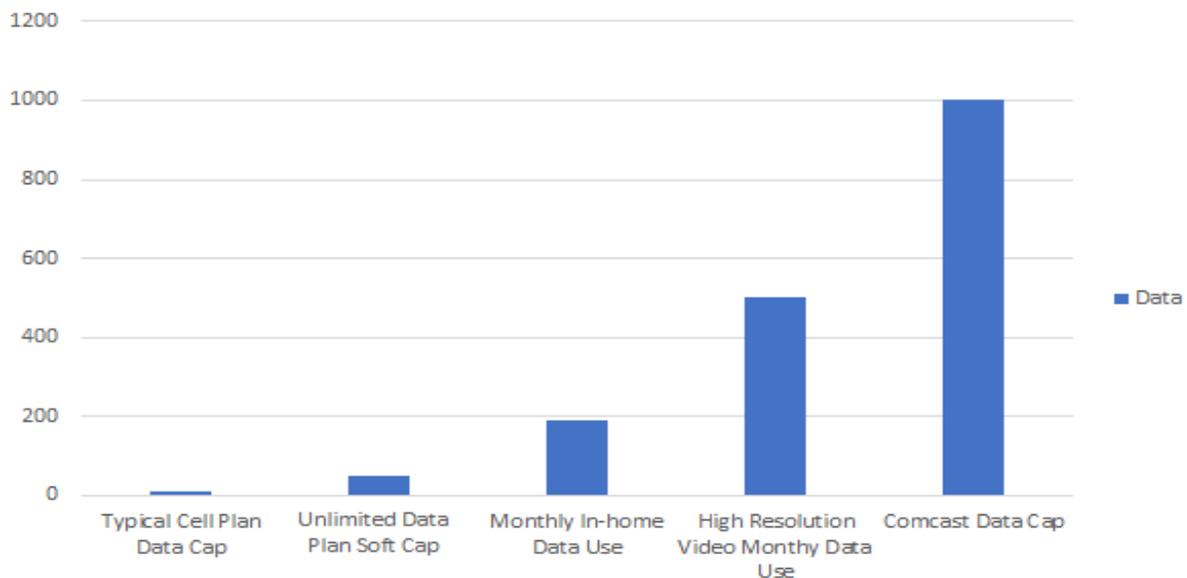
<sup>47</sup> Taken From: <https://www.ericsson.com/en/mobility-report/reports/november-2017/mobile-data-traffic-growth-outlook>

<sup>48</sup> Average data consumption per household taken from: <https://www.telecompetitor.com/igr-average-monthly-broadband-usage-is-190-gigabytes-monthly-per-household/>.

<sup>49</sup> 4K video can use up to 7GB of data per hour.

<sup>50</sup> Information taken from “How much data do different activities use”  
<https://www.whistleout.com.au/Broadband/Guides/Broadband-Usage-Guide>.

1 **Figure 2: Comparison of Data Consumption Rates and Caps for Internet Plans (in GB)<sup>51</sup>**



2  
3 Figure 2 demonstrates the large differences between in-home data consumption and caps  
4 and cellular data caps. Existing information about wireless service suggests that without a  
5 significant change in network management and available customer plans, New T-Mobile’s in-  
6 home broadband offering will not be a substitute for wireline services for the average home.

7 Furthermore, stand-alone T-Mobile will have the same amount of 5G low-band spectrum  
8 that provides adequate coverage and building penetration for in-home service. Stand-alone T-  
9 Mobile will also have a significant amount of midband and mmWave spectrum to provide  
10 capacity in dense environments using small cells and mMIMO deployments. While stand-alone  
11 T-Mobile may not be able to match the projected speeds of New T-Mobile, it can still provide  
12 speeds equal to, or surpassing, existing wireline networks by 2024, as discussed in Public  
13 Advocates Office testimony of Mr. Cameron Reed on Service Quality and Public Safety.<sup>52</sup> Sprint  
14 also announced plans to launch a new 5G mobile smart hub<sup>53</sup> that can support in-home

<sup>51</sup> Comcast’s Data Cap is taken from <https://www.xfinity.com/support/articles/exp-unlimited-limit>.

<sup>52</sup> Public Advocates Office testimony of Mr. Cameron Reed on Service Quality and Public Safety at p. 20.

<sup>53</sup> Sprint and HTC announce innovative new 5G mobile smart hub coming in First Half of 2019: <http://investors.sprint.com/news-and-events/press-releases/press-release-details/2018/Sprint-and-HTC-Announce-Innovative-5G-Mobile-Smart-Hub-Coming-in-First-Half-of-2019/default.aspx>.

1 broadband independently of the merger.<sup>54</sup> The Commission does not need to approve the merger  
2 to improve in-home broadband options for Californians and the Commission should not consider  
3 a loosely defined idea of a potential future service as a benefit of the merger. The Commission  
4 should ensure that Sprint remains as a 5G competitor so that competition can help prices remain  
5 affordable to low-income Californians, and so they can also benefit from 5G services. The  
6 impacts of the merger on low-income customers are discussed more in the Public Advocates  
7 Office testimony of Mrs. Eileen Odell.

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<sup>54</sup> <https://www.fiercewireless.com/5g/sprint-may-tackle-market-for-home-broadband-internet>.

1 **III. CONCLUSION**

2 5G services will bring a host of benefits to the wireless market, including increased  
3 speeds. However, the Commission should not attribute the benefits of 5G deployment as benefits  
4 of the merger, as both companies are fully capable of deploying 5G services independently and  
5 are already doing so in certain markets. The Applicants’ plans for 5G deployment are also  
6 unduly aggressive, moving ahead of projected customer demand and adoption rates for 5G  
7 services. Sprint and T-Mobile independently will have adequate spectrum capacity to deploy 5G  
8 service and will be able to deploy it in a time frame that will meet with projected adoption  
9 figures.

10 5G benefits will also carry through to rural areas and in-home users without the merger,  
11 and the Commission should not consider New T-Mobile’s conceptual in-home broadband  
12 offering as a merger benefit as there are still considerable issues about its viability, pricing, and  
13 availability. Further, Sprint plans to deploy in-home broadband independent of the merger.  
14 While it is true the merger will enable New T-Mobile to refarm more spectrum to 5G faster,  
15 these proposed benefits of the merger do not outweigh the harms of losing a 5G facilities based  
16 wireless provider. If the Commission fails to deny the merger, it should at the very least ensure  
17 that New T-Mobile carries through on its promise to provide in-home broadband services and  
18 deploy infrastructure in rural California through concrete commitments to serve underserved,  
19 unserved, and low-income communities.

# **ATTACHMENTS**

## **ATTACHMENT A**

### **Statement of Qualifications and Experience**

My name is Cameron Reed. I am currently employed by the California Public Utilities Commission (Commission) as a Utilities Engineer assigned to the Public Advocates Office Communications and Water Policy Branch. I have a Bachelor of Science in Mechanical Engineering from the University of California-Davis. My studies included courses in engineering control systems, electrical circuits, experimental methodology, and mechanical systems design. I am a member of the Phi Theta Kappa honor society.

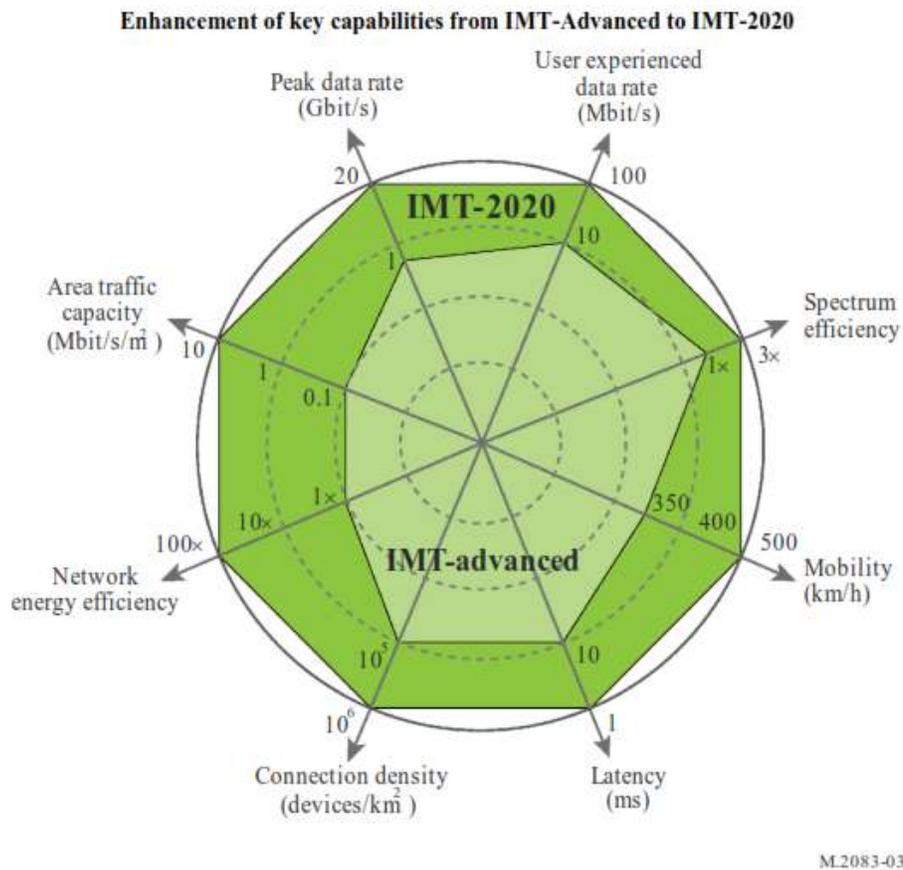
I began work with the Commission on July 5, 2016. I have worked on evaluating California Advanced Services Fund (CASF) Infrastructure and Public Broadband Housing applications. The CASF program funds broadband deployment projects in unserved or underserved areas of California and involves, among other items, evaluating utility financial information, deployment plans, and any existing broadband infrastructure in the area. I have previously submitted testimony concerning Telecommunications Public Safety in the general rate case (GRC) of Sierra Telephone Company (Application 16-10-003), Service Quality and Public Safety in the GRC of Ducor Telephone Company, (Application 17-10-003), Service Quality in the GRC of Foresthill Telephone Company (Application 17-10-004), and Public Safety and Cybersecurity in the Application of Pacific Gas and Electric for a Certificate of Public Convenience and Necessity to become a Competitive Local Exchange Carrier (Application 17-04-010). I reviewed the merger between CenturyLink and Level 3 Communications (Application 17-03-016). I have reviewed thousands of the Federal Communications Commission's Network Outage Reporting System outage reports. During my time at the Commission, I have completed the National Exchange Carrier Association's (NECA) Foundations of Telecommunications Curriculum and completed the 38<sup>th</sup> Western National Association of Regulatory Utility Commissioners (NARUC) Utility Rate School.

## ATTACHMENT B

### Fifth Generation Wireless Service Technical Appendix

The ITU-R's IMT-2020 framework set forth discrete specifications and use cases that a 5G wireless service needs to meet.<sup>55</sup> IMT-2020 defined eight parameters to consider as key capabilities of a 5G wireless solution. In setting forth the key capabilities of the IMT-2020 framework, the ITU-R envisioned that 5G wireless service should match fixed networks as closely as possible. Figure B1 below compares the target capabilities of 5G service to the capabilities of 4G LTE service.

**Figure B1: ITU-R M.2083 Figure 3<sup>56</sup>**



<sup>55</sup> International Technical Union – Radiocommunication Sector (ITU-R) Recommendation M.2083 at p. 10-14.

<sup>56</sup> *Id.* at p. 14.

Figure B1 indicates that the ITU-R expects that 5G wireless service will be faster and more efficient than 4G LTE services. The ITU-R's capability targets are explained more in the following sections.

### **i. Peak Data Rate**

Peak data rate is the maximum achievable data rate under ideal conditions per user or connected device, measured in Gigabits per second (Gbps). IMT-2020 expects that a peak user data rate of 20 Gbps under certain conditions and scenarios, which is faster than the peak data rates that the Applicants are expecting of their networks. Customers will most likely experience 20 Gbps data rates in low traffic or cell site dense portions of the network.

### **ii. User Experienced Data Rate**

The User Experienced Data Rate is the throughput speed that mobile users and connected devices can expect to experience throughout the areas covered by 5G services. IMT-2020 expects that average user will reliably have access to speeds of at least 100 Megabits per second (Mbps) for wide area coverage scenarios, such as urban and sub-urban areas.<sup>57</sup> IMT-2020 standards expect average data rates to reach as high as 1 Gbps in hotspot<sup>58</sup> environments such as inside buildings or in urban deployments with high small cell density.<sup>59</sup>

### **iii. Latency**

Latency refers to the time it takes from when the source, such as a user or connected device, sends a packet to when the destination receives it, typically measured in milliseconds (ms). Regarding 5G wireless networks, Latency refers to the delay contributed by the radio access network. IMT-2020 expects that certain 5G use cases, such as MCC and some M2M communication, will have network Latencies as low as 1ms.

### **iv. Mobility**

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<sup>57</sup> *Id.* at p. 14.

<sup>58</sup> Hotspots are wireless access points created by a hardware device that takes advantage of cellular network data connections. In the context of IMT-2020, a hotspot also refers to use cases in an area with high user density, high traffic capacity expectations, and low user mobility such as user connections within a building.

<sup>59</sup> ITU-R Recommendation M.2083 at p. 14.

Mobility refers to the maximum expected speeds, in kilometers per hour (kmph), where networks can seamlessly transfer connected devices between network radios at cell sites and maintain quality of service. For 5G applications, IMT-2020 expects signal transition to be seamless at speeds up to 500 kmph, or approximately 300 miles per hour (mph). IMT-2020 conceptualized 5G services to handle traffic seamlessly on high speed trains.

#### **v. Connection Density**

Connection Density refers to the number of connected devices per unit of area, defined devices per square kilometers (km). 5G wireless service is expected to support ten times more devices than 4G LTE wireless service, with the possibility of supporting 1 million devices per km<sup>2</sup>. 5G's large connection density will enable large scale IoT and M2M communication services.

#### **vi. Energy Efficiency**

5G wireless services are expected to be more energy efficient for radio access networks and for user devices. Energy Efficiency is represented as the amount of information transmitted in bits per unit of energy consumed to transmit that information in Joules. IMT-2020 expects that 5G wireless service, radios, and devices will be approximately 100 times more energy efficient than services based off the 4G LTE standard. This means 5G services will result in more energy efficiency customer handsets and remote sensors.

#### **vii. Spectrum Efficiency**

Spectrum efficiency refers to the average data throughput per unit of spectrum and cell resource used to provide that data, represented in bit per second per Hertz (Bit/s/Hz). Spectral Efficiency can be represented by the formula below:

$$\text{Spectral Efficiency} = \text{Average Throughput} / (\text{Number of Cell Sites} \times \text{Spectrum Deployed})$$

5G services are expected to be three times more spectrally efficient than 4G LTE services. This means 5G provide more capacity per Hz of spectrum than 4G.

#### **viii. Area Traffic Capacity**

Area traffic capacity refers to the total traffic throughput available per geographic area, measured in Mbit per second (Mbps) per square meter. Area traffic capacity is expected to

increase by 100 times, to 10 Mbps per square meter, or 1 Gbps of capacity for a 100 square meter space in hotspot areas.

IMT-2020 does not expect 5G services to meet all key capabilities simultaneously but that 5G service should be configurable in order to meet the capabilities needed for emBB, IoT, M2M, and MCC applications.<sup>60</sup> The ITU-R outlines the capabilities it expects these use cases will specialize in, which figure B2 represents below:

**Figure B2: ITU-R M.2083 Figure 4<sup>61</sup>**

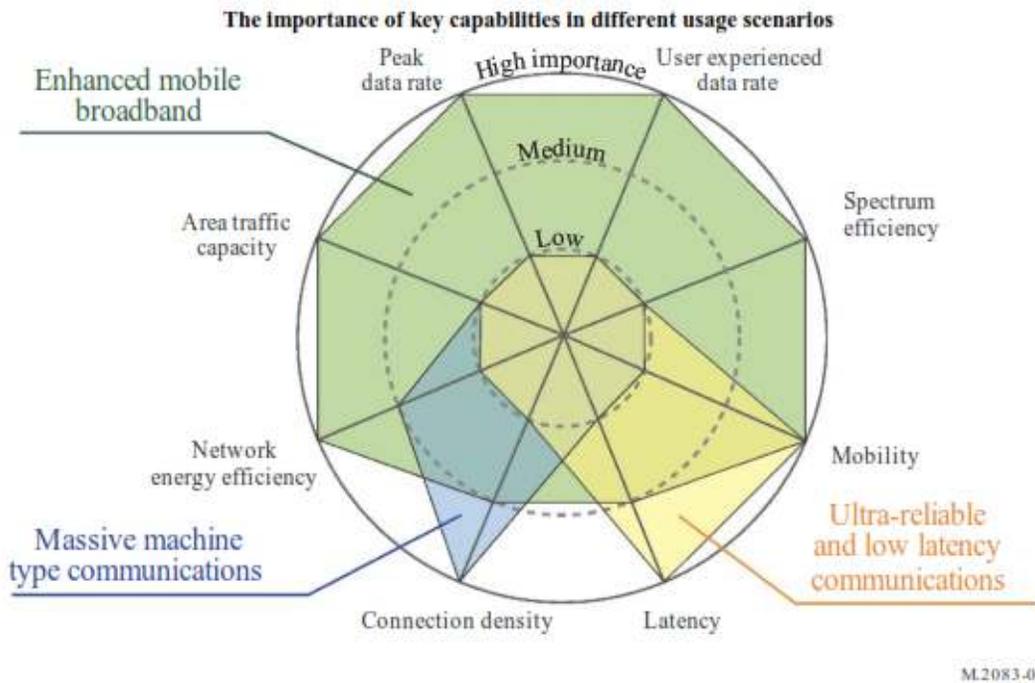


Figure B2 demonstrates that IMT-2020 expects emBB, or consumer 5G wireless service, to meet six of the key capabilities defined for 5G service. Specifically, IMT-2020 expects consumer 5G wireless service to have needs for high throughput, high mobility, and high capacity. Similarly, Massive machine type communications, such as those in M2M or IoT communications will specialize in large communication density and efficiency environments and MCC communications will focus on low latency and high mobility configurations.

<sup>60</sup> ITU-R Recommendation M.2083 at p. 15.

<sup>61</sup> *Id.* at p. 15.

The performance advancements expected from 5G NR services are supported by a variety of new technologies or methods to improve existing technologies. These new infrastructure techniques are key elements of the increased capabilities that 5G services have compared to 4G and 4G LTE wireless services. There are many individual advancements in physical and frequency transmission methods that combine to create the basis for 5G NR services, the most prominent technologies including massive Multi-Input Multi-Output (mMIMO), beamforming, small cell deployments, virtualization, and millimeter wave spectrum (mmWave). Most of these new technologies depend on cell site improvements and high frequency spectrum, not existing spectrum portfolios.

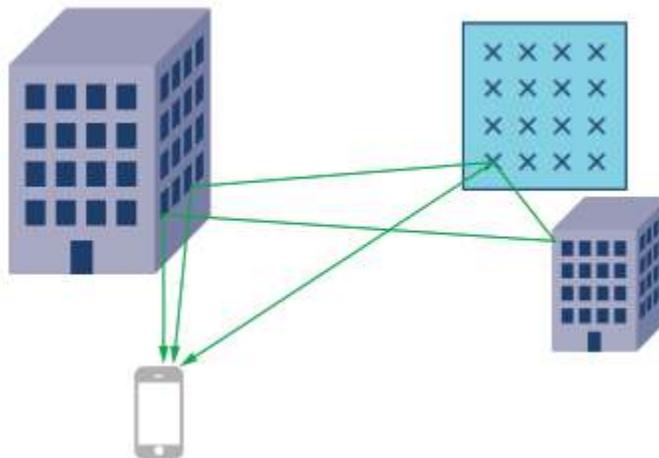
One network technology that 5G will be built on is mMIMO. Massive MIMO is an evolution of 4G's MIMO, in which cell sites have multiple antenna elements that are used to send and receive signals. 4G LTE MIMO used 4 transmission and receiving (4x4) antenna elements. 5G mMIMO will use at least 16 transmission and receiving (16x16) antennas, with the possibility of using hundreds of antennas,<sup>62</sup> to increase capacity, throughput speeds, and spectral efficiency. Nokia, a manufacturer of massive MIMO systems, predicts that mMIMO antennas have the capability to provide services with 5 times more capacity and five times more throughput than 4G services.<sup>63</sup> Accompanying mMIMO infrastructure is a transmission technique called beamforming. Beamforming is a radio signal broadcasting technique that will enable mMIMO and millimeter wave spectrum systems to function. Beamforming refers to the ability of a cell site to use multiple antennas to direct a single band of signal at a cellular end user. This will reduce the interference users experience from other signals and even allow 5G cell sites to reflect signals off structures to reach a nearby user which increases the coverage and signal strength a cell site is able to provide.

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<sup>62</sup> Some manufacturers are making Antennas with 64 transmitting and receiving elements. *See* <https://5g.co.uk/guides/what-is-massive-mimo-technology/>.

<sup>63</sup> *See* <https://networks.nokia.com/solutions/massive-mimo>.

**Figure B3: Beamforming and mMIMO<sup>64</sup>**



Small cells are small cellular antennas site that can be deployed on utility poles or street lights and are used in deployment strategies that compliment mMIMO by increasing the density of cell sites in a geographical area. Small cells typically have a broadcast range of 100 meters or less, depending on the size of the cell. Because small cells are smaller, lighter, and require less power, it is easier for cellular providers to deploy small cells to bolster coverage, capacity, and throughput. Small cells are typically deployed in dense urban environments close to the cellphone users.<sup>65</sup> Small cells and mMIMO will be used in conjunction with mmWave spectrum to greatly increase the capacity and data throughput speeds of 5G wireless networks. MmWaves operate in the electromagnetic spectrum band between 30 to 300 GHz and wavelengths between 1 to 10 millimeters.<sup>66</sup> Because mmWave have shorter wavelengths than traditional cell phone signal bands, mmWave spectrum can transport more data to enable greater capacity and speeds at the expense of reduced coverage and building penetration. This reduction in coverage necessitates network denser deployments that are closer to the customer.

Similar to how small cells will allow carriers to deploy cell sites closer to end users, network virtualization will allow cellular providers to move cellular network nodes closer to end users. Network virtualization allows providers to move from a predominately hardware driven

<sup>64</sup> Exhibit CR-7: Massive MIMO and Beamforming.

<sup>65</sup> See <https://www.verizon.com/about/our-company/5g/what-small-cell-technology>.

<sup>66</sup> [https://transition.fcc.gov/Bureaus/Engineering\\_Technology/Documents/bulletins/oet70/oet70a.pdf](https://transition.fcc.gov/Bureaus/Engineering_Technology/Documents/bulletins/oet70/oet70a.pdf) at p. 1.

network management architecture to a software managed network configuration.<sup>67</sup> Virtualization reduces the amount of time it takes for the network to process user requests for information by bringing more core switching and authentication functions closer to end users. Virtualization will also be used to create cloud-based radio access networks (C-RANs) which use software to centralize call processing for cell sites which increases coordination and performance between cells.

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<sup>67</sup> See <https://business.sprint.com/5g/core-network-virtualization/>.