Public Interest Benefits of Expanding Fiber Networks

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Executive Summary

Bridging the rural-urban digital connectivity gap is a top priority for the Federal Communications Commission (the "Commission"). The goal requires ensuring more rural homes receive high quality broadband services that are dependent on fiber backhaul. Importantly, in addition to providing superior last mile connectivity, policies that facilitate fiber deployments deeper into rural networks to support home broadband connections also produce significant additional benefits that would not otherwise occur if the same funds were used to support satellite broadband service. Positive spillover benefits include high-bandwidth, low-latency 5G and Internet of Things (IoT) deployments that rely on robust backhaul networks reaching further into rural areas. Such benefits include boosts to economic activity, improved access to education and healthcare, connected cars and road safety, smart cities and pollution reduction, smart grids and reductions in electricity outage, among other benefits. Additionally, the automatic and real-time communications between IoT-enabled devices are expected to drive productivity increases through greater automation. Of specific importance for rural communities, supporting anchor institutions and advanced agricultural applications will bring economic benefits from digitization and the knowledge economy that are mostly enjoyed by urban communities.

The Commission's latest efforts to close the rural-urban digital divide include the Rural Digital Opportunity Fund (RDOF) which will subsidize rural broadband deployments through a reverse auction process. The bidding process is designed to balance the sometimes competing desires for high quality and low cost broadband by giving more weight to bids that provide higher quality broadband services. The policy preference built into the auction for fast speeds and lower latency recognizes that terrestrial networks – regardless of the last mile technology – will require fiber deployments deeper into the network, with the concomitant spillover benefits additional fiber backbones will bring.

I. Background on Rural Digital Opportunity Fund Auction

Closing the rural-urban digital divide is a top priority for the Commission. In this pursuit, the Commission has enacted a series of policies that allocate funds to support new high-speed broadband infrastructure in rural America.[1] The latest, the RDOF, builds on the Connect America Fund Phase II (CAF II) reverse auction by committing an additional $20.4 billion over ten years to support the construction of high-speed broadband networks throughout rural America.[2] In designing the RDOF auction, the Commission proposes maintaining the preference for higher speed broadband and increasing the weight given for lower latency offerings.[3] In doing so, the Commission correctly recognizes the importance of terrestrial broadband deployments, including the significant positive spillover effects of additional fiber deployments in rural areas.

A. Auction Format

The Commission outlined its vision for the Fund in its July 2019 Notice of Proposed Rulemaking (NPRM). Based on the CAF II experience, the Commission has designed the RDOF subsidies to target both unserved and underserved areas using a multi-round, reverse, descending clock auction

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1 FCC, "Rural Digital Opportunity Fund," Notice of Proposed Rulemaking (NPRM), ¶ 1, WC Docket Nos. 19-126, August 2, 2019, https://docs.fcc.gov/public/attachments/FCC-19-77A1.pdf, ("RDOF NPRM").

2 FCC, "RDOF NPRM," ¶ 3.

3 "Latency is the time it takes for a data packet to travel from one point to another in a network." See FCC, "Eighth Measuring Broadband America Fixed Broadband Report," p. 8, December 14, 2018, accessed October 19, 2019, https://www.fcc.gov/reports-research/reports/measuring-broadband-america/measuring-fixed-broadband-eighth-report, ("Eighth Measuring Broadband America Fixed Broadband Report").

that would favor "faster services with lower latency" while encouraging "intermodal competition".[4] The Commission proposes a budget of $20.4 billion available to subsidize service for approximately 3.9 million locations identified as between the high-cost and extremely high-cost funding benchmarks in the Connect America Model (CAM) of providing service to high cost areas.[5] The Commission emphasizes that its fundamental objective is to provide universal, affordable, high-speed broadband service to all Americans.[6]

The Commission plans to use a multi-round, descending, clock auction to identify the Eligible Telecommunications Carriers (ETCs) that will receive support, and the magnitude of that support.[7] Mirroring the structure of the CAF II auction, the RDOF auction will consist of sequential bidding rounds: bids for different areas will be compared to each other based on area reserve prices (the maximum price the Commission is willing to provide for support to the area) and weights corresponding to the quality of service offerings that bidders propose, based on speed/data allowance tiers and latency levels.[8] Bids in all tiers will be considered simultaneously, so that bidders will be competing across geographies and performance standards (service tiers).[9] Similar to CAF II, each qualified bidder will "select the performance tier and latency combination(s) for which it intends to bid" in each state/geographic area where it seeks RDOF support.[10] In each

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4 FCC, "RDOF NPRM," ¶ 3.

5 The budget is based on the CAM cost of deploying a high-speed broadband network to all locations in wholly unserved price cap census blocks that exceed the existing high-cost threshold of $52.50 per-location per-month, and with that cost capped at $198.60. See FCC, "RDOF NPRM," ¶ 16.

6 FCC, "RDOF NPRM," ¶ 13.

7 The Commission has put forward a variety of deployment obligations to be imposed on all support recipients that are intended to promote efficacy and accountability such as service and subscription milestones, and reporting and non-compliance measures. See FCC, "RDOF NPRM," ¶¶ 28, 30, 38, 40.

8 FCC, "RDOF NPRM," ¶¶ 19-20.

9 FCC, "RDOF NPRM," FN 27. Also see "CAF II Order on Recon," ¶ 4.

10 FCC, "Connect America Fund Phase II Auction Scheduled for July 14, 2018," Notice and Filing Requirement and Other Procedures for Auction 903, ¶ 64, FCC 18-6, February 1, 2018, https://www.fcc.gov/document/fcc-takes-final-steps-next-phase-rural-broadband-expansion-1. ("CAF II Notice and Filing Requirement")

round of the auction, a bidder will be able to submit a bid indicating the performance tier, latency and the support amount it is willing to accept to provide service to an area.

Thus, the Commission will determine an implied annual support amount for a bid by adjusting the area-specific reserve price for the bid percentage and the weights of that bid, with implied support not exceeding that reserve price.[11] If the CAF II methodology is followed, then the winning bids will be picked "based on the percentage each bid represents of its respective area's reserve price and determines support amounts that take into account the performance tier and latency specified in the bid."[12]

B. Technology Weights

A key feature of the RDOF auction will be the use of technology weights, as was used in the CAF II auction. The Commission, however, is proposing to increase the latency weights such that lower latencies are favored.[13] Such weights express the policy preferences of the Commission in the trade-off between better quality and lower price. For the short-term, the least cost or most efficient technology solution for the mountains of Colorado may not be the ideal solution for the plains of Kansas. Fortunately, not all broadband is created alike, and a well-crafted auction can efficiently determine the technology appropriate for a given area. For example in CAF II, a majority of the locations in Kansas plains were covered by low latency technologies, while the mountains in Colorado were covered with high latency technologies.[14] Even as the CAF II latency weights may serve the Commission's shorter-term goals, given the future need for higher speeds,

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11 FCC, "RDOF NPRM," ¶¶ 19-20.

12 FCC, "CAF II Notice and Filing Requirement," ¶ 205.

13 The proposed latency weight will increase the weight from 25 to 40. *Also see,* FCC, "RDOF NPRM," ¶ 25 and "Table on Proposed Performance Tiers, Latency and Weights," p. 10.

14 FCC, "Connect America Fund Phase II: Auction 903 Results," August 28, 2018, accessed October 14, 2019, https://www.fcc.gov/reports-research/maps/caf2-auction903-results/. *Also see* FCC, CAF II Public Reporting System, https://auctiondata.fcc.gov/public/projects/auction903/static_files/prs_all_bids.zip, ("CAF II Auction 903: PRS").

greater capacity and lower latency technologies, the Commission is also addressing the longer horizon when deciding on performance tiers and latency weights by encouraging fiber deployments deeper into rural networks.

Typically, low latency technologies are terrestrial technologies that reach the customer premises using copper, fiber, and fixed wireless for the last mile connection, while high latency technologies are typically satellite-based.[15] As the FCC itself has stated, "Satellite technologies inherently experience longer latencies since packets must travel approximately 44,500 miles from an earth station to the satellite and back."[16] The terrestrial technologies all share the feature that they rely on significant fiber deployments deep into the terrestrial networks. The weights in CAF II were constructed such that there were incentives for providers to cover areas by deploying high speed and low latency technologies, but at the same time also deploy broadband to other areas using a lower speed and higher latency technology when the higher quality solutions were not economical. If the Commission adopted a single technology standard, at whatever level that standard was set, the auction would inherently favor some bidders over others. Allowing a diverse set of bidders in the auction, while maintaining the policy goal of deploying high speed, low latency broadband to unserved and underserved rural areas, brings the Commission closer to achieving its goal of technological neutrality and universal broadband service.[17]

The Commission, in the interest of garnering participation from a variety of service providers, has chosen to adopt *technology-neutral* standards, meaning that authorized support recipients are permitted to use any fixed broadband technology to meet their performance obligations and

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[15] European Commission, "Comparison of Wired and Wireless Broadband Technologies," accessed October 14, 2019, http://ec.europa.eu/information_society/newsroom/image/document/2018-17/comparison_of_broadband_technologies_table_75B12AE2-FC37-D44B-C75B5885D383A0FE_51503.pdf. Fiber as a last mile technology has certain advantages. See, https://www.eff.org/wp/case-fiber-home-today-why-fiber-superior-medium-21st-century-broadband.

[16] FCC, "Eighth Measuring Broadband America Fixed Broadband Report," p. 16.

[17] FCC, "RDOF NPRM," ¶¶ 17, 23.

service milestones.[18] However, as the Commission itself has recognized, it has a 'preference' for high-speed, low-latency and higher usage allowances.[19] The RDOF NPRM proposes increasing the latency weight, from 25 to 40, compared to the CAF II auction.[20] This will not only advance the Commission's goals of deploying high-speed, low-latency broadband to rural areas in the shorter term, but will also lay the groundwork for a robust future-oriented broadband deployment by incentivizing fiber deployments throughout rural America. The Commission needs to incentivize the deployment of technologies that will serve as the foundation for the next generation of services and be the catalysts for future innovation. Increasing the latency weights achieves this goal.

II. Positive Externalities from Extending Fiber Deeper Into the Wireline Terrestrial Network

The effect of extending fiber deeper into the network has positive externalities that are not immediately captured by the short-term performance metrics of service provision at a certain speed and latency and do not necessarily enter the calculus of private actors in deciding when and where to deploy broadband. For example, while certain bidders (e.g. those providing satellite broadband) may only focus on the last mile connection, other bidders must also consider backhaul and extending fiber increases the potential for 5G deployment in rural America and enhances the connectivity options for anchor institutions such as hospital and libraries. Such positive externalities can drive a wedge between the policy makers' objectives and private decision-making.

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18 FCC, "RDOF NPRM," ¶ 23.

19 FCC, "RDOF NPRM," ¶ 25.

20 Viasat CommentsFCC, "RDOF NPRM," ¶ 25, "Table on Proposed Performance Tiers, Latency and Weights," p. 10.

A regulator's objective should be to maximize total (private and social) benefit from a policy, i.e. take externalities into account. For the current proceeding, this means that the Commission should recognize the positive externalities from fiber deployments in rural communities that go beyond provision of broadband to residences and small businesses. High-speed and low-latency technologies will not only provide better internet connection for consumers, but will also indirectly improve social welfare, by incentivizing the extension of fiber deployments deeper into rural networks with the added benefits of supporting the U.S.'s 5G development and enhanced education, health and agricultural resources. Below we discuss some externalities of extending fiber deployments deeper into rural networks, which when taken into account, support a higher weight for lower latency technologies.

A. The Benefits of 5G and the Internet of Things (IoT)

The most important positive externality of extending fiber deployments deeper into rural networks is the support the enhanced networks will provide to 5G deployments in rural areas. The expected benefits of 5G are well known; seeing that rural communities share in those benefits is important. To do so, rural communities need the high-capacity fiber infrastructure necessary to provide the backhaul to 5G and IoT networks. Such infrastructure is key to providing the high capacity and low latency that provide so much of the benefits from these new, next generation networks. Simply put, if fiber is not sufficiently extended into rural America, these communities may not have adequate access to 5G and IoT capabilities that Americans in urban areas experience, and the universal service objectives of Congress will not be met. [21]

[21] 47 U.S.C. § 254(b).

1. Direct Benefits of 5G and IoT

5G and the Internet of Things (IoT) are game-changers for our times. Simulations by Qualcomm have predicted download speed improvements from 71 Mbps for the median 4G user to 1.4 Gbps for the median 5G user (a 2,000 percent gain) and reduced latency from 115 milliseconds to 4.9 milliseconds.[22] In addition to faster data speeds and ultra-low latency, a 5G network is envisaged to have other key capabilities, including increased density of throughput (as high as 10 Mbps per square meter); and increased connection density (as high as one million devices per square kilometer).[23] The evolution of 5G networks is expected to facilitate the deployment of new applications including the IoT, which refers to the linking of and communication between physical objects, such as roadways and bridges with cars or between agricultural sensors and farm management systems, using wired and wireless networks.[24] Ericsson estimates that worldwide, there could be over 30 billion connected devices by 2023, with nearly 20 billion of those being IoT devices.[25]

By 2035, 5G is expected to generate $12.3 trillion of global economic activity, $2.2 trillion in GDP for the global economy and 22 million jobs.[26] For the United States, 5G is expected to result in

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[22] Qualcomm, "Qualcomm Network Simulation Shows Significant 5G User Experience Gains", February 24, 2018, accessed October 17, 2019, https://www.qualcomm.com/news/releases/2018/02/25/qualcomm-network-simulation-shows-significant-5g-user-experience-gains.

[23] The other three key capabilities listed by the ITU are: increased spectrum efficiency; increasing mobility; and increased network energy efficiency. See "IMT Vision," ITU, Figure 3, p. 14.

[24] Michael Chui, Markus Löffler, and Roger Roberts, "The Internet of Things," McKinsey Quarterly, March 2010, accessed October 17, 2019, http://www.mckinsey.com/industries/high-tech/our-insights/the-internet-of-things.

[25] "Ericsson Mobility Report," Ericsson, June 2018, accessed October 17, 2019, p. 16, https://www.ericsson.com/assets/local/mobility-report/documents/2018/ericsson-mobility-report-june-2018.pdf.

[26] IHS Economics and IHS Technology, "The 5G Economy: How 5G Will Contribute to the Global Economy," p. 4, January 17, 2017, accessed October 17, 2019, https://cdn.ihs.com/www/pdf/IHS-Technology-5G-Economic-Impact-Study.pdf ("The 5G Economy"). For GDP estimate see: GSMA, "Study on Socio-Economic Benefits of 5G Services Provided in mmWave Bands," The WRC Series, p.

$719 billion of gross output, and generate 3.4 million jobs by 2035.[27] Beyond the direct economic impacts, there are a number of other quality related benefits that will come from improved access to education and healthcare, connected cars and road safety, smart cities and pollution reduction, smart grids and reductions in electricity outage, among others. Additionally, the automatic and real-time communications between IoT-enabled devices will also likely drive productivity increases through greater automation.[28] There is no guarantee that the jobs and economic benefits described above will accrue to rural Americans unless policymakers make an intentional and concerted effort to ensure they do.

All of these benefits depend on low latency services powered by fiber backhaul connectivity. Therefore, wherever possible, policies should be developed that increase the reach of terrestrial fixed networks in to rural America, which the Commission has recognized in the RDOF NPRM.[29] The Commission's proposed RDOF latency weights have sparked comments from various parties. The Buckeye Hills Regional Council, for example, is in favor of eliminating the high latency option entirely so as to eliminate RDOF funds being spent on satellite-based options.[30] Viasat, a satellite provider, argues that the 40 percent weight on high-latency technologies is unwarranted and a

11, December 2018, accessed October 17, 2019, https://www.gsma.com/spectrum/wp-content/uploads/2019/10/mmWave-5G-benefits.pdf.

27 IHS Economics and IHS Technology, "The 5G Economy," p. 19.

28 Bureau of Communications and Arts Research, "Impacts of 5G on Productivity and Economic Growth," The Australian Government, Working Paper, p. 6, April 9, 2018, accessed October 17th, 2019, https://www.communications.gov.au/departmental-news/impacts-5g-productivity-and-economic-growth.

29 FCC, "RDOF NPRM," ¶ 23.

30 Buckeye Hills Regional Council, "Comments on NPRM for the Rural Digital Opportunity Fund," accessed September 20, 2019, https://ecfsapi.fcc.gov/file/10919596025806/Buckeye%20Hills%20Regional%20Council%20comments%20on%20RDOF%2019%20Sept%202019.pdf.

more reasonable weight would be closer to 5 percent.[31] Viasat's comments, however, understate the benefits that low-latency technologies offer to consumers.

For the latency-sensitive applications in the context of 5G, latency is an important component of gauging the quality of experience for broadband users. Many new technologies with the potential to greatly benefit society require the speed and capacity of 5G networks, and fiber in particular. 5G is expected to decrease end-to-end latency by 10 times, thereby improving user experiences for current technologies and providing an opportunity for innovation.[32] In particular, IoT technologies, such as robotic surgery, autonomous vehicles, and drones will require extremely low latency. 5G will also enhance the online gaming experience as small lags can drastically alter a game.[33] There are a fair number of applications that would benefit significantly from low latencies.[34] As the Commission itself has recognized, the "higher latencies of geostationary satellite-based broadband services may impair the perceived quality of such highly interactive applications."[35] Thus, the tradeoff should not be evaluated just in terms of current uses of broadband technology, but also with an eye towards building in potential capacity for future needs.

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31 Comments of Viasat, Inc., "Rural Digital Opportunity Fund and Connect America Fund," WC Docket No. 19-126, September 20, 2019, accessed September 30, 2019, https://ecfsapi.fcc.gov/file/1092075048414/Viasat%20Comments%20on%20RDOF%20NPRM%20and%20Auctionomics%20Report%20(9-20-19).pdf, ("Viasat Comments").

32 Mohammed Al Khairy, Qualcomm Technologies, "How 5G Low Latency Improves you Mobile Experiences," accessed September 19, 2019, https://www.qualcomm.com/news/onq/2019/05/13/how-5g-low-latency-improves-your-mobile-experiences, ("How 5G Low Latency Improves you Mobile Experiences").

33 Mohammed Al Khairy, Qualcomm Technologies, "How 5G Low Latency Improves you Mobile Experiences."

34 Cable Labs, "Cable Broadband Technology Gigabit Evolution," Fall 2016, accessed October 14, 2019, https://www.cablelabs.com/insights/cable-broadband-technology-gigabit-evolution.

35 FCC, "Eighth Measuring Broadband America Fixed Broadband Report," p. 8.

2. The Need for Backhaul

In the context of the RDOF, the FCC has stated that, "[t]o encourage the deployment of higher speed services, and in recognition that terrestrial fixed networks may serve as a backbone for 5G deployments, these proposed weights favor higher-than Baseline speeds and low-latency services."[36] Examining technologies that will support this new ecosystem will be critical in understanding how to maximize its value to the U.S. economy. The two load-bearing pillars in the architecture of 5G networks and IoT are (i) spectrum in a variety of different bands for connectivity and bandwidth needs, and (ii) reliable low-latency backhaul. While there are strong Commission initiatives on bringing mid-band and millimeter wave spectrum to the market quickly, there is not as much focus on the second pillar – backhaul. The extension of fiber deeper into the network to provide the necessary backhaul for 5G and IoT will unlock the full potential of these emerging technologies.

In rural areas that are already at a competitive disadvantage compared to their urban counterparts when it comes to broadband connectivity, the Commission needs to pay special attention so that these areas are not at a further disadvantage when it comes to 5G. Incentivizing operators to extend fiber into rural areas and closer to the users will provide the groundwork for 5G in rural America and help narrow the digital divide. According to one study, the U.S. requires between $130 billion and $150 billion of fiber infrastructure investment over the next five to seven years, to "adequately support broadband competition, rural coverage and wireless densification."[37] Such massive amounts of funding will have to come from multiple sources, and RDOF, with its $20.4 billion budget, can provide a part of this investment.

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[36] FCC, "Rural Digital Opportunity Fund NPRM," ¶ 25.

[37] Deloitte, "The Need for Deep Fiber," p. 4, July 2017, accessed October 17, 2019, https://www2.deloitte.com/content/dam/Deloitte/us/Documents/technology-media-telecommunications/us-tmt-5GReady-the-need-for-deep-fiber-pov.pdf, ("The Need for Deep Fiber").

On the critical issue of the need for wired backhaul for wireless, NTCA-The Rural Broadband Association writes, "policy makers cannot overlook that 'wireless needs wires:' mobile wireless facilities—and the IoT and other application they enable—depend upon adequate, wired backhaul capabilities to realize their full potential.[38] With millimeter wave spectrum coming online, carriers will deploy many more small cells and hotspots with a much smaller coverage radius than traditional cell towers. According to a Deloitte report, without more fiber, "carriers will be unable to support the projected four-fold increase in mobile data traffic between 2016 and 2021."[39] Previous generations of wireless technology such as 3G and 4G, are fundamentally different from 5G. The critical ingredients for 3G and 4G were larger lower frequency blocks and improved spectral efficiency.[40] 5G and IoT will rely more heavily on the use of higher frequencies and densification, including more macro and microcell builds, requiring fiber backhaul.[41] Deploying fiber closer to the customers will enable carriers to take advantage of these technologies and encourage 5G deployment.[42] For example, carriers are deploying small cells closer to customers to improve the quality of service and coverage and fiber-based backhaul is the preferred solution wherever possible.[43] While the densification calculations and timelines are different in rural areas than in urban areas, without the appropriate investments in fiber today, rural areas will be left out of those decisions in the future. The significant positive externality of enhanced 5G deployments

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[38] Comments of the NTCA- The Rural Broadband Association, 84 Fed. Reg. 49, 9078, https://www.ntca.org/sites/default/files/federal-filing/2019-04/04.01.19_NTCA_Comments_Spectrum_Farm_Service_Agency_84_Fed.Reg_.49-9078.pdf.

[39] Deloitte, "The Need for Deep Fiber," p. 4.

[40] Deloitte, "The Need for Deep Fiber," p. 9.

[41] L-Com Global Connectivity, "The Role of Fiber in 5G Networks," Cabling, July 1, 2019, accessed October 12, 2019, https://www.cablinginstall.com/home/article/16468526/the-role-of-fiber-in-5g-networks, ("The Role of Fiber in 5G Networks").

[42] L-Com Global Connectivity, "The Role of Fiber in 5G Networks."

[43] Brian Lavellee, "5G Wireless Needs Fiber, and Lots of It," Ciena, accessed October 17, 2019, https://www.ciena.com/insights/articles/5G-wireless-needs-fiber-and-lots-of-it_prx.html. *Also see*, Ron Tellas, "3 Reasons Why Fiber is the First Choice to Support 5G Networks," February 7, 2019, accessed October 17, 2019, https://www.belden.com/blog/smart-building/why-fiber-support-5g-networks.

from extending fiber deeper into rural America is one of many reasons the Commission is correct to adopt a policy preference for high-speed, low-latency broadband service.

B. Access for Anchor Institutions

Community anchor institutions (CAIs) – schools, libraries, healthcare clinics, etc. – are vitally important to residents in rural areas as they serve as a means to connect people to the rest of the world. Yet, often CAIs in rural areas are deprived of high-capacity, low-latency broadband, preventing them from providing quality services to community members, whereas those are the areas they are needed the most. According to the latest FCC data, in 2017, only 73.6 percent of the rural population had access to 25/3 Mbps broadband compared with 98.3 percent in urban areas.[44] Rural schools are four times less likely to have a fiber optic connection than urban schools.[45] Similarly, the median speeds at urban and rural libraries were 30.5 Mbps and 9 Mbps, respectively, according to a study conducted by the University of Maryland.[46] Fiber backhaul extended deeper into rural areas to connect homes through the RDOF will have the add-on benefit of making such backhaul available to providers who can extend higher quality broadband to CAIs.

Libraries are particularly important institutions in rural areas. Government and nongovernmental agencies alike have recognized the importance of rural libraries and have provided support to such institutions. The 1956 Library Services Act, which provided funding to rural public libraries, was an initial step to increase the role of public libraries in rural areas.[47] More recently, the *Rural*

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[44] FCC, "2019 Broadband Deployment Report," Figure 1, p. 16, GN Docket No. 18-238, May 29, 2019, https://docs.fcc.gov/public/attachments/FCC-19-44A1.pdf.

[45] Tom Koutsky, "Rural Broadband Programs and Community Anchor Institutions," The Schools, Health, & Libraries Broadband Coalition (SHLB), accessed September 19, 2019, https://www.shlb.org/uploads/9.RuralBroadband_SHLBActionPlan.pdf, ("Rural Broadband Programs and Community Anchor Institutions").

[46] Tom Koutsky, "Rural Broadband Programs and Community Anchor Institutions," p. 3.

[47] Deanne W. Swan et al., "The State of Small and Rural Libraries in the United States," Institute of Museum and Library Services, accessed October 4, 2019, https://www.imls.gov/assets/1/AssetManager/Brief2013_05.pdf.

Library Sustainability Project, funded by the Bill and Melinda Gates Foundation, has provided workshops and trainings to thousands of library staff across 42 states.[48] The Commission also recognized the need for libraries in rural communities in developing the Universal Service Fund.[49] However, in the RDOF, the Commission does not explicitly discuss the benefits of covering areas with anchor institutions. The Schools, Health and Libraries Broadband (SHLB) Coalition expressed its concerns with the language adopted by the Commission in the NPRM, writing that the NPRM "repeatedly refers to the 'homes and small businesses' that will be served by the RDOF, without any mention of anchor institutions."[50] Often, libraries are the only provider of broadband access to the public, so making sure libraries have coverage is critical to rural community members.[51] Moreover, health clinics in rural areas need bandwidth to provide quality services and connect patients with medical specialists around the country.[52]

The SHLB also recognizes the importance of schools and health clinics to rural communities. Many schools, including rural and community colleges, are designing curricula around internet applications, smartphones and tablets, which all require sufficient bandwidth at affordable rates.[53] These applications depend on high-speed broadband which is greatly enhanced if there is sufficient nearby fiber. While the RDOF will not directly connect schools or libraries or other CAIs, the RDOF, if it sufficiently prioritizes terrestrial broadband connectivity and the fiber necessary for such services, will indirectly benefit CAIs. Thus, increasing access to education and the quality of education is another example of the public benefits of extending fiber into rural areas. The

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48 Rural Library Sustainability Program, https://www.webjunction.org/explore-topics/rlsp.html.

49 FCC, "Connect America Fund," Report and Order and Further Notice of Proposed Rulemaking, ¶¶ 3, 124. FCC 11-161, WC Docket No. 10-90, November 18, 2011, accessed October 8, 2019, https://docs.fcc.gov/public/attachments/FCC-11-161A1.pdf.

50 Comments of the SHLB Coalition, "Rural Digital Opportunity Fund and Connect America Fund," p. 3, WC Docket No. 19-126, September 20, 2019, "https://ecfsapi.fcc.gov/file/1092161917953/SHLB%20et%20al%20Comments%20-%20final%20-%20Sept%2020%202019.pdf, ("Comments of the SHLB").

51 "Comments of the SHLB," p. 5.

52 "Comments of the SHLB," p. 5.

53 "Comments of the SHLB," p. 4-6.

Commission should consider these externalities associated with covering areas containing anchor institutions when establishing the auction parameters.

C. Advantages to Agriculture

With a growing world population and changing climates, new agricultural practices are being developed to meet the rising global demand for food. Major developments are being made in automating farming processes using the IoT. Yield monitoring, micro-climate monitoring, precision seeding, connected equipment, remote diagnostics, storage monitoring, herd monitoring and field scouting are some of the applications in this area. For example, a farm in the United Kingdom is utilizing technologies, such as autonomous tractors and drones, to plant and harvest crops without human labor.[54] Such technologies will help meet the increasing demand for food as "the planet will need to grow 70% more food in 2050 than it did in 2009."[55] Precision agriculture will make several aspects of farming more efficient. Namely, IoT in agriculture will allow farmers to collect better data on weather conditions, soil quality, crop's growth, and cattle's health.[56] Data tracking technologies are already developed. Many farms are starting to implement weather stations, whereby smart sensors are placed throughout the farm and collect data from the environment and send it to the cloud for further processing. Similarly, there are sensors to monitor crop and soil health, and cattle behavior. Farms can use productivity management systems to take in this data and use it to make more informed decisions and increase efficiency.[57]

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54 Spencer Feingold, CNN, "Field of machines: researchers grow crop using only automation," accessed September 25, 2019, https://edition.cnn.com/2017/10/07/world/automated-farm-harvest-england/index.html.

55 Neil Lewis, Max Burnell, and Angelica Pursley, CNN Business, "How 5G will change the future of farming," accessed September 19, 2019, https://www.cnn.com/2019/04/01/business/5g-farming/index.html.

56 Mary Aleksandrova, Easterm Peak, "IoT in Agriculture: 5 Technology Use Cases for Smart Farming (and 4 Challenges to Consider)," accessed October 1, 2019, https://easternpeak.com/blog/iot-in-agriculture-5-technology-use-cases-for-smart-farming-and-4-challenges-to-consider/.

57 James Taylor, "3 Ways Digital Transformation Shapes Rural Quality of Life," July 1, 2019, accessed October 17, 2019, https://www.isemag.com/2019/07/fiber-rural-broadband-healthcare-education/.

However, in order for new precision agriculture technologies to be effective, there needs to be adequate fiber infrastructure. As NTCA states, a farmer looking to modernize operations "could not use precision agriculture until the company put down fiber."[58] According to a USDA study, fiber is a better choice than satellite due to the latter's "unpredictability of service caused by high latency, capacity limitations, and costs for securing high volumes of data flows."[59] Especially in rural areas, which may have lots of trees and foliage, satellite broadband is not as reliable as wired systems.[60] With precision agriculture technologies estimated to contribute between $18 billion to $23 billion annually, an enabling technology such as fiber, will have an immense impact in realizing such gains.[61] The RDOF's auction weights should thus incent technologies such as fiber that can adequately support such agricultural advances into the future.

III. Viasat's Comments and the Auctionomics Report

Viasat argues that the auction weights for high latency bids should not be increased from 25 to 40, as the FCC suggests in the NPRM and, if anything, should be reduced.[62] They make two primary economic arguments for their position. The first is that high latency of the type experienced by satellite broadband users is perfectly acceptable for most users and therefore should not be penalized much if at all. The second argument is that increasing the latency weight in the

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58 Comments of the NTCA- The Rural Broadband Association, 84 Fed. Reg. 49, 9078, https://www.ntca.org/sites/default/files/federal-filing/2019-04/04.01.19_NTCA_Comments_Spectrum_Farm_Service_Agency_84_Fed.Reg_.49-9078.pdf.

59 USDA, "A Case for Rural Broadband: Insights on Rural Broadband Infrastructure and Next Generation Precision Agriculture Technologies," p. 7, April 2019, accessed October 17, 2019, https://www.usda.gov/sites/default/files/documents/case-for-rural-broadband.pdf, ("A Case for Rural Broadband").

60 Natalie Gagliordi, ZDNet, "How 5G will impact the future of farming and John Deere's digital Tranformation," accessed September 19, 2019, https://www.zdnet.com/article/how-5g-will-impact-the-future-of-farming-and-john-deeres-digital-transformation/.

61 USDA, "A Case for Rural Broadband," Table 1, p. 24.

62 "Viasat Comments", pp. 4, 10.

upcoming auction will prevent Viasat from being an effective competitor, leading to worse auction outcomes. They illustrate this second point with analysis from Auctionomics of a counterfactual analysis of the CAF II auction. Both of their arguments have internal inconsistencies that undermine their conclusions.

A. Viasat's Arguments about Latency

In Viasat's response to the NPRM, they urged the Commission to alter the auction rules to allow geosynchronous-orbit ("GSO") satellite providers to be more successful in the auction. GSO providers' bids are penalized because their high-latency technologies have "the small latency inherent in the round trip transmission of a radiofrequency signal to the satellite and back to earth," as Viasat explains.[63] Viasat does not discuss any factors that may affect satellite coverage such as weather, foliage, line of sight and the like. Their attempt to diminish the importance of latency and these other quality dimensions fails.

As noted above, the reason for quality weights in the CAF II and RDOF auctions is to allow bidders using different technologies or different levels of planned investment to compete with each other for subsidies to provide broadband service to unserved and underserved areas. If the Commission adopted a single quality standard, at whatever level that standard was set, the auction would inherently favor some bidders over others. For example, if quality was set high (high throughput, low latency) then only bidders who had technologies that could meet those standards would be able to bid. The auction would be less competitive because the lower quality bidders would not be able to participate. Conversely, if a lower quality standard was set (lower throughput, higher latency) the higher quality network providers would likely not be able to compete on cost against operators whose networks are designed or optimized to provide lower quality service. The quality weights in the auction are designed to express the trade-off between quality and value that allows

[63] "Viasat Comments," p. 4.

bidders offering different levels of quality to compete against each other. How they are set reflects the policy maker's (here the Commission's) preferences.

Viasat argues that there are only a small number of use cases where low-latency is required and a small number of users care about latency, suggesting that its importance is overrated in the previous and proposed FCC weights of 25 and 40, respectively.[64] Their argument misses the point. The auction weights are not based on a numerical calculation of some proportion of users who report caring about latency. Rather the auction weights reflect the quality trade-off policy makers want. That at most 5% of users are estimated to value low latency in no way suggests that the auction weight should be 5.[65] Rather it should be set to reflect the social value of lower latency when compared to deploying a greater amount of lower quality broadband. This social value reflects that the cost of low latency may be disproportionate to the percentage of times latency is critical as well as the likely increased sensitivity to latency that will come with future 5G services and the positive externalities described in the previous section. The Commission's proposal in the NPRM is a reflection of resetting this relative value trade-off.

Beyond latency, a satellite broadband user's experience differs from a terrestrial broadband user's experience. Uplink capacity is significantly more constrained for satellite users. In fact, Viasat discusses using a hybrid terrestrial/satellite system where the satellite component is only used larger downloading, suggesting that satellite's advantages over terrestrial are limited.[66] Satellite coverage requires line of sight to provide broadband and factors such as foliage are also significant hindrances to service availability.[67] None of these other factors are considered in Viasat's advocacy for lower latency weights.

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64 "Viasat Comments," pp. 4, 17, 18, 20.

65 "Viasat Comments," p. 20.

66 "Viasat Comments," pp. 4, 5, 26.

67 Broadband Now, "Satellite Internet in the United States – Limitations," accessed October 18, 2019, https://broadbandnow.com/Satellite.

Viasat argues that the Commission should take into account factors such as jitter and packet loss, and should not be focusing on latency alone.[68] In fact they argue that "jitter and packet loss have at least as great (if not greater) impact than latency on the typical consumer's usage of broadband services," and have a greater impact on consumer experience than latency.[69] This argument fails to account for the fact that latency and packet loss are positively correlated. A greater latency implies greater packet loss.[70] The Eighth Measuring Broadband America Report, that Viasat itself quotes, shows that satellite had the highest packet loss compared to other technologies.[71]

Viasat makes several additional arguments in favor of lower latency weights. I address each here:

- Marginal costs. When Viasat reports that it bid on the most locations in the CAF II auction, it is reflecting that as a satellite provider it has very low marginal costs. Given how satellites function, the marginal cost of satellite is lower. In fact, Viasat bid on most of the CAF II locations (over 890,000 locations) and the price-point bids were identical in all locations.[72] Viasat has an incentive to bid close to its lower marginal cost because the more customers it can sign up, the more it can spread its fixed costs and lower its average costs. This dynamic does not exist nearly as strongly with terrestrial bidders, who have a much larger proportion of their costs incurred as they incrementally expand their network. Consequently, satellite bidders have a built in advantage in a large nationwide auction driven by their cost structure (high fixed costs, lower marginal costs) that is independent of their total cost of service. Since the auction is attempting to find the lowest total costs

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68 "Viasat Comments," p. 17.

69 "Viasat Comments," p. 17.

70 Jacques du Toit, "Latency and Packet Loss Metrics – The Unsung Heroes of Network Reporting?" Iris Network Systems, October 14, 2015, accessed October 20, 2019, https://www.irisns.com/latency-and-packet-loss-metrics-the-unsung-heroes-of-network-reporting/.

71 FCC, "Eighth Measuring Broadband America Fixed Broadband Report," p. 18.

72 FCC, "Connect America Fund Dashboard," All Bid (zipped), accessed October 11, 2019, https://auctiondata.fcc.gov/public/projects/auction903/static_files/prs_all_bids.zip.

of expanding broadband coverage (after taking into account quality differences) a truly level playing field for bidders would take this difference into account. A higher weight for high-latency broadband achieves this objective.

- Equivalency of coverage. Viasat argues that it was the only bidder in many areas and if the latency weight was increased from 25 to 40 it would not have been successful in any of these areas and they would have remained unserved and prices would be higher.[73] Similar to the CAF II auction, the RDOF also targets fostering cross-geography competition that would allow bidders to bid against each other when they were bidding for different territories.[74] This, in large part, would allow competition to force bidders to bid lower even in places they were the only bidder.[75] However, the goal of the RDOF is not just deploying broadband to rural unserved areas. It is to deploy high-speed, low-latency broadband to rural areas – which is not answered by naively counting the locations where they were the only bidder.
- Intermodal Competition. Viasat argues that lowering the latency weights promotes the Commission's objective to create enhanced intermodal competition.[76] This line of argument appears to equate the functionalities of a high latency satellite service with low latency fixed technologies such as fiber. Additionally, references to consumers being interested primarily in the download and upload speeds are misleading, as it is used as an indirect argument about why latency should not be an important metric of performance evaluation in intermodal competition.[77] The Eight Measuring Broadband America report clearly calls out "two other key network performance metrics" - latency and packet loss - that "can significantly affect the overall quality of Internet applications."[78] With latency

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73 "Viasat Comments", pp. 2, 7, 10.

74 "Viasat Comments", pp. 4, 12.

75 CAF II Order, ¶ 22, 28.

76 "Viasat Comments", pp. 4, 14.

77 "Viasat Comments", pp. 16-17, FN 32.

78 FCC, "Eighth Measuring Broadband America Fixed Broadband Report," p. 8.

being directly related to throughput, i.e. speed, a lowering of latency weights may adversely impact speeds, a metric Viasat itself claims consumers care about.[79]

- Externalities. Viasat argues against taking externalities into account, except when they benefit satellite providers. They argue that the RDOF is a retail program and it is inappropriate to consider the wholesale impacts of subsidizing retail services, *i.e.*, any benefits from the potential provision of backhaul and a fiber backbone for 5G should not be a decision parameter.[80] However, their own quote from the Commission talking about universal service funds "specifically focused on increasing access to evolving services for consumers living in rural and insular areas" contradicts their position.[81] 5G is an evolving service to consumers, and if a fiber deployment provides the necessary backhaul for such a service, then this goal should fall within the universal service goals of the Commission. Additionally, they also argue that there are network deployment benefits to satellite, so they are, in essence, claiming the same benefits they are arguing against.[82]

B. Auctionomics Counterfactual Analysis

The Auctionomics analysis submitted with the Viasat comments provides a counterfactual analysis of the CAF II auction and concludes that the supply of fixed broadband services would be worse without Viasat's participation. It does so by assuming the actions of other bidders in the auction would have played out as it had without Viasat's participation. The analysis then recalculates the auction outcome in this hypothetical world and finds that fewer households would have been covered by the auction, and the Commission would have paid higher prices for the households

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79 Tim Keary, "Latency vs Throughput – Understanding the Difference," "How to Measure Latency and Throughput," Comparitech, January 23, 2019, accessed October 20, 2019, https://www.comparitech.com/net-admin/latency-vs-throughput/.

80 "Viasat Comments," p. 20.

81 "Viasat Comments," FN 55.

82 "Viasat Comments," FN 26.

that were covered. The Auctionomics report determines that since Viasat was the only provider to bid on many areas, the majority of these areas would have been left unserved if not for Viasat's participation. Specifically, the report finds that "of the 190,595 locations covered by Viasat, only 26 would have had coverage if Viasat did not participate, so 190,569 additional locations were covered due to Viasat's participation."[83] Therefore, based on the Auctionomics analysis, Viasat concludes that by increasing the latency weight from 25 to 40 in the RDOF, there is a large risk that several areas will remain uncovered after the auction.[84] The Auctionomics analysis concludes that this is an unambiguously worse outcome.[85] Such a conclusion is unwarranted on both analytic and policy grounds.

A key underlying analytic assumption that allows for the counterfactual analysis performed by Auctionomics is that Viasat did not bid strategically in the auction.[86] This seems a highly suspect assumption given the size of Viasat in the auction and the fact that they bid in almost 900,000 locations and was a significant winner of CAF II support.[87] Given their impact on the auction, it would be naïve of them to think they were price-takers and that by bidding strategically they could not influence the auction outcome. The implication of this is that the remaining bidders would have faced different information in the auction and they too would not likely have bid the same. Consequently, simply assuming the auction would have played out as it did absent Viasat is unwarranted and the analysis of their impact on the auction is incomplete, at best.

Absent Viasat's participation in the CAF II auction, the remaining bidders would have faced a different competitive environment. This starts at the planning phase for the terrestrial bidders and

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83 "Viasat Comments," FN 3.

84 "Viasat Comments," p. 4.

85 "Viasat Comments," p. 34.

86 "Viasat Comments," p. 36.

87 "Viasat Comments," p. 2. *Also see* FCC, "CAF II Auction 903: PRS" and FCC, "FCC Connect America Fund Phase II Auction. Winning Bidder Summary," Attachment A, DA-18-887A2, August 8, 2018, accessed October 20, 2019, https://docs.fcc.gov/public/attachments/DA-18-887A2.pdf.

includes the determination of areas those remaining bidders would target. Knowing that such a large bidder as Viasat with lower marginal costs would not be participating, or that Viasat's economic advantage in the auction was balanced by weights for low latency, would likely lead to the terrestrial bidders contesting more areas than they in fact did. The Auctionomics analysis assumes the only places the terrestrial bidders would bid absent Viasat are the same locations they bid with Viasat in the auction.[88] Although it would be difficult to accurately estimate how bidding would have played out in this alternative world, the Auctionomics assumption of no increased bidding clearly underestimates the incremental areas that terrestrial bidders would have won in this hypothetical world. In essence, they assume away benefits of increased latency weights by assuming the remaining terrestrial bidders would not be more aggressive absent Viasat's competition. With significantly more geographic coverage of terrestrial broadband networks, fiber deployments deeper into rural networks would provide significant additional benefits of the type discussed in the prior section.

Perhaps more important than the technical problems with the Auctionomics analysis, it misses the larger policy point about why there are technology weights in the first place. The Auctionomics analysis assumes that there is no difference between different ways customers can receive broadband. If that were true, there would be no weighting for higher latency or other quality differences between modes of providing broadband. In a fuller modeling of a counterfactual analysis that estimates the impact of Viasat on the CAF II, some accounting for the lower quality of demand Viasat brings to auction would be needed, in addition to estimating their strategic impact on the auction. The Auctionomics analysis does neither as it assumes away the very question being analyzed – is it appropriate for the Commission to design an auction that explicitly prefers lower-latency broadband connections. Having assumed away the central issue under consideration, the Auctionomics analysis does not provide guidance to the Commission in its quest to appropriately express its preferences for differing quality of broadband.

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[88] "Viasat Comments," p. 8, 12, 35.

IV. Conclusions

The latency weights for broadband services proposed in the RDOF are a proper expression of the Commission's policy preferences. These preferences include higher quality (greater throughput, lower latency) broadband service that will drive more fiber deployments deeper into rural areas. Such deployments will have significant spillover benefits related to closing the digital divide that range from enabling more rural deployments of 5G and IoT networks to supporting anchor institutions and advanced agricultural services. These benefits are expected to create millions of jobs, many of them in rural America.

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