NTCA THE RURAL BROADBAND ASSOCIATION

July 3, 2023

***Ex Parte* Notice**

Ms. Marlene H. Dortch, Secretary
Federal Communications Commission
45 L Street, NE
Washington, DC 20554

RE: ***Connect America Fund*, WC Docket No. 10-90; *ETC Annual Reports and Certifications*, WC Docket No. 14-58; *Telecommunications Carriers Eligible to Receive Universal Service Support*, WC Docket No. 09-197; *Connect America Fund – Alaska Plan*, WC Docket No. 16-271; *Expanding Broadband Service Through the A-CAM Program*, RM-11868**

Dear Ms. Dortch:

On Friday, June 30, 2023, the undersigned on behalf of NTCA-The Rural Broadband Association ("NTCA") spoke with Marco Peraza, wireline advisor to Commissioner Nathan Simington, regarding matters in the above-referenced proceedings.

During the conversation, NTCA reiterated support for targeting funds to enable network deployment so that providers can reach the remaining unserved locations in their areas. At the same time, and particularly as the Federal Communications Commission (the "Commission") considers the future of universal service, NTCA highlighted the need for reasonable and sufficient ongoing support for all locations that are currently served to ensure rates remain affordable and prior loans and private investment capital can be repaid and recovered. NTCA therefore encouraged the Commission to seek in any order to strike a balance in directing resources needed to promote new deployments while also not forgoing the broader mission of universal service by failing to provide additional long-term support for operating expenses and recovery of prior investment moving forward – and specifically to view these objectives of deployment and sustainability as co-equal priorities in a final decision.

NTCA further asked the Commission to ensure that, prior to adjusting support due to the asserted presence of competitors, proper assessment is made of the capabilities of such would-be competition. In particular, sound policy should not sacrifice a meaningful and realistic assessment of *technological capability* under the mantra of technological neutrality. Regardless of technology, if certain platforms and services have not shown widespread capability to perform consistently at a certain level of performance in rural areas, such claims of coverage should not be accepted on their face. Moreover, NTCA asserted that if the Commission were to establish any challenge process that permitted parties to assert coverage beyond what they have reported on the Broadband Data Collection ("BDC") – a process that NTCA would oppose – the Commission should then ensure such a challenge process is "two-way" and allow for corrections to BDC data for overstated claims as well. *See Ex Parte* Letter from Michael R. Romano, Executive Vice President, NTCA, to Marlene H. Dortch, Secretary, Commission, WC Docket No. 10-90, *et al*. (filed June 16, 2023); *see also* National Telecommunications & Information Administration ("NTIA"), *Bead Challenge Process Policy* (available at: https://internetforall.gov/bead-challenge-process-policy) (allowing for challenges based not only upon mere availability, but also based upon asserted levels of performance). NTCA also responded in the conversation to questions regarding the reliability of unlicensed fixed wireless services specifically, and in that part of the conversation referenced a paper attached hereto recently submitted by NTCA to NTIA.

Finally, NTCA noted recent announcements regarding target dates for the completion of work under the Broadband Equity, Access, & Deployment ("BEAD") program and urged the Commission to aim for comparable network deployment schedules in its own programs – while also incorporating flexibility with respect to specific timeframes given the still evolving nature of BEAD initiatives and the work now just getting underway in states to implement the program. *See Fact Sheet: Biden-Harris Administration Announces Over $40 Billion to Connect Everyone in America to Affordable, Reliable, High-Speed Internet* (available at: https://www.whitehouse.gov/briefing-room/statements-releases/2023/06/26/fact-sheet-biden-harris-administration-announces-over-40-billion-to-connect-everyone-in-america-to-affordable-reliable-high-speed-internet/) ("With these allocations and other Biden administration investments, all 50 states, DC, and the territories now have the resources to connect every resident and small business to reliable, affordable high-speed internet by 2030.")

Thank you for your attention to this correspondence. Pursuant to Section 1.1206 of the Commission's rules, a copy of this letter is being filed via ECFS.

Sincerely,

/s/ *Michael Romano*
Michael Romano
Executive Vice President

Enclosure

cc: Marco Peraza

June 2023

Unlicensed Wireless Networks Should Not be Considered Reliable for Purposes of BEAD Funding

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Executive Overview

The emergence of the Broadband Equity, Access, and Deployment (BEAD) program has supercharged a national conversation around connecting unserved and underserved Americans, primarily in rural areas. A key part of this debate involves the question of which technologies are the best long-term investment of public funding. In this discussion some parties make arguments that are based on speculative claims that ring more of marketing spin than sound engineering principles. Some of these arguments are also based on a fundamental misunderstanding with respect to the laws of physics, the costs of various technologies, and the capabilities of certain technologies. This paper addresses recent claims made specifically about unlicensed wireless technology in relation to the stated goals and policies of the BEAD program.

An economist, Dr. William Lehr, recently published a white paper[1] arguing that the National Telecommunications and Information Administration's (NTIA's) Notice of Funding Opportunity (NOFO)[2] for the BEAD Program is based on bad policy regarding unlicensed wireless services. Among other things, Lehr argues that NTIA's "fiber-only" or "fiber-first" policy unfairly disregards other technologies, especially unlicensed fixed wireless broadband technologies.[3] He also argues that NTIA's policy does not promote competition and will increase the total cost of reaching un/underserved consumers with broadband "while offering no compensating advantage."[4] Lehr suggests that ". . . States should endeavor to learn as much as they can about the cost of providing service to all locations in the State using different technologies."[5] I agree with the latter sentiment; when the States complete their evaluations, however, a data-driven analysis of unlicensed wireless will yield a different perspective than Lehr. As we will see, Lehr's conclusions miss the mark on the technologies' varying capabilities and take an artificially limited view of the costs to deploy and operate them.

BEAD is intended to connect unserved and underserved areas, many of which are rural. So when determining the best broadband technology to be used in BEAD-eligible areas, it must necessarily be well-suited for overcoming the many challenges that come with serving sparsely populated rural areas.[6] These areas present unique challenges both when deploying and then operating broadband networks, and thus technology choices that may be reliable and cost-effective in an urban environment may not always be the best choice for rural areas. Many have declared that the BEAD program is likely to be a "once in a generation" opportunity to reach un/underserved rural consumers, and as such the States should ensure that networks built leveraging BEAD funds are the most cost-effective and sustainable networks that can deliver robust service for generations to come. Given the public resources at stake, BEAD funds should not be used to deploy networks that will quickly reach the end of their useful life and/or that are incapable of serving each and every customer that steps forward seeking broadband at the committed level of service, since doing so could strand customers on the wrong side of the digital divide for many years – possibly forever.

There are a variety of wireline and wireless technologies that can deliver broadband, and many factors must be considered when selecting the best technology for achieving the goals of a given deployment and factoring in the characteristics of the area in question (rural or urban, flat or mountainous, etc.). When determining the suitability

[1] Getting to the Broadband Future Efficiently with BEAD Funding, William Lehr, MIT, January 2023 ("Lehr Paper").
[2] "Notice of Funding Opportunity: Broadband Equity, Access, and Deployment Program", NTIA, May 13, 2022 ("BEAD NOFO")
[3] Lehr Paper, page 3.
[4] ibid
[5] Lehr Paper, page 5.
[6] FCC Broadband Map (https://broadbandmap.fcc.gov/)

of a technology, key factors include speed, quality (latency, jitter, and capacity), the capital cost (both short-term and long-term), operational expense, mobility, transferability, scalability, sustainability, and reliability.[7]

Considerations for Selecting Broadband Technology

- Speed
- Quality
  Latency, jitter, capacity
- Capital Cost
  Short-term and long-term
- Operational Expense
- Mobility
- Transferability
- Scalability
- Sustainability
- Reliability

Fixed wireless networks have the advantage of limited transferability – that is, the ability to move some portion of broadband capability between subscribers. Considering every relevant factor, however, it becomes readily apparent that fiber is the preferred technology for transporting Internet traffic whether that be for backhaul for wired or wireless solutions or connecting specific end user locations. When compared to the other technologies, fiber is capable of much faster broadband speeds, and offers unmatched quality, scalability, sustainability, reliability, and a lower total cost of ownership – the latter of which is an essential economic perspective to adopt when considering investments in networks intended to last decades.[8] Moreover, both wireline and wireless providers alike clearly realize the benefits of fiber as most have been replacing much of their networks with fiber over the last 15 to 20 years.

The laws of physics dictate two fundamental and unalterable truths for wireless networks: First, the broadband speed of a wireless system is primarily determined by the amount of available spectrum. Second, the quality of a wireless signal degrades as the distance between the customer and the tower increases – especially at higher frequencies, where obstacles such as trees, buildings, or hills can block the radio frequencies used for broadband. As it relates to fixed wireless service that may be utilized by BEAD awardees, much of the currently available spectrum – especially the unlicensed wireless spectrum – is in a high frequency band referred to as "high-band" or millimeter wave (mmW) band. Unfortunately, the propagation characteristics of these frequencies are poor (they do not travel far) and are also significantly degraded by weather – each of these factors makes them not well-suited for use in rural areas. The effects of distance, obstacles, and network congestion can be offset to some extent, as towers can be located closer to the end user customer – this is especially true at higher frequencies. However the cost of these towers, along with the increased fiber backhaul costs from these towers, often offsets the expected savings of a wireless network. In addition, the ongoing costs of a wireless network are significantly higher than a fiber network, as will be discussed more later – this factor demonstrates the importance of taking into account the "total cost of ownership" and looking beyond a near-term time frame alone.

The Infrastructure Investment and Jobs Act (Infrastructure Act) and the NTIA BEAD program require deployment of networks that can offer speeds of at least 100/20 Mbps. Congress also directed NTIA to establish "priority

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[7] Broadband Speed Characteristics, Larry Thompson, PE, Nathan Weber, PE, Brian Enga, PE, June 2018.

[8] Comparing Wired and Wireless Broadband, Broadband Communities Magazine, Larry Thompson, PE, Brian Bell, PE, Brian Enga, PE, and Warren Vande Stadt, June 2015.

broadband projects" that "can easily scale," as it would be short-sighted to use once-in-a-generation public funds on networks that are perhaps able to meet customers' needs today but may be unable to scale to meet customers' broadband needs in the next few years (or certainly over decades).[9] Today, the median fixed broadband speed according to OOKLA is roughly 200 Mbps[10] and the average speed is over 300 Mbps according to the FCC.[11] This means that, as a matter of "reasonable comparability," deploying networks that can deliver only 100 Mbps would *already* be behind the times. Moreover, if demand continues to increase as it has over the past 20 years (and we have no reason to believe that it will not), policymakers must prepare for gigabit speeds in just the next few years. There is no spectrum available in sufficient quantity to allow a fixed wireless network to deliver these speeds, as identified by OOKLA, practically and economically throughout a rural environment – and there are no foreseeable wireless technology advances on the horizon that will change that. It should come as no surprise then why fiber has been rightly prioritized in using the valuable resources made available under the Infrastructure Act and through NTIA's BEAD program.

The challenges are even greater when it comes to dependency upon *unlicensed* fixed wireless service specifically to satisfy and keep pace with the ever-increasing demand for higher-speed and more reliable broadband service in rural America. Indeed, it is difficult for rural broadband networks that rely on unlicensed wireless to deliver world-class broadband service *today*. Apart from some very limited circumstances presenting ideal conditions as summarized herein, the technical and related economic hurdles to doing so going forward will be substantial, if not insurmountable. Making the wrong technology choices now will result in much more investment required in the coming years just to meet increasing customer demands, and denying funding to areas in need of better broadband based upon the availability of services that depend in whole or in part upon unlicensed spectrum would resign many to be left on the wrong side of the digital divide for many years to come.

As discussed further herein, the NTIA NOFO reached an efficient, well-grounded, and data-backed decision in treating unlicensed wireless network access as unreliable under the BEAD program. Unlicensed frequencies are crowded, stemming from their unlicensed nature, and therefore suffer reliability issues. In fact, such networks should not only be viewed as unreliable when it comes to determining which areas are eligible for BEAD funding, but I would contend that networks that rely in whole or in part upon unlicensed spectrum should not be awarded BEAD funds as they will not be able to keep pace over time, leaving all stakeholders wondering in less than a decade why the substantial investments made are not yielding long-term results.

[9] Infrastructure Investment and Jobs Act (Infrastructure Act), SEC. 60102 (2) (I) (ii)
[10] https://www.speedtest.net/global-index/united-states#:
[11] FCC's Twelfth Measuring Broadband America (MBA), Fixed Broadband Report, January 6, 2023.

Unlicensed Fixed Wireless Limitations

To put Lehr's assertions about efficiency into the proper context, it is important to take a step back and understand the basics of wireless network engineering. Factors that hinder the reliability of wireless broadband networks include terrain (trees, hills, buildings, etc.), distance (how far the customer is from the tower), limited spectrum, and interference (other users in the same spectrum). Many of these factors are outside the control of the wireless operator and, depending on the frequency spectrum being used, could result in the network being unreliable or even unusable. When considering unlicensed spectrum in particular, congestion (too many customers using the service) must be added to the list and is a major concern.

Factors Affecting Wireless Broadband

- Terrain – *Trees, hills, buildings, etc.*
- Distance – *How far a customer is from the tower*
- Limited Spectrum
- Interference – *Other users in the same spectrum*
- Congestion – *Too many customers using the service*

Speed Limits on Wireless Networks

Spectral efficiency is a measure of how many bits of information in "bits per second" (or broadband speed) per Hz of frequency spectrum used. Recent advances in wireless technology such as Multiple-Input and Multiple-Output (MIMO) have improved spectral efficiency. Modern wireless networks can typically achieve a spectral efficiency of 2 to 4 bps/Hz across their coverage areas. If a wireless network, for example, were able to achieve a spectral efficiency of 5 bps/Hz when using 40 MHz of spectrum it would have a total capacity of 200 Mbps (5bps/Hz * 40 MHz) per antenna or beam. This capacity is not dedicated to a single customer but shared by all customers served by that antenna or beam for both upload and download.

Most wireless providers "oversell" the network capacity of each antenna (or sector or beam) many times over. This is referred to as oversubscription and helps wireless carriers spread their investment over more customers to reduce their cost per customer. Oversubscription is a legitimate and appropriate aspect of engineering a network – but it then cannot be ignored when making apples to apples comparisons of networks' capabilities and efficiencies and identifying optimal investments. Oversubscription is defined in terms of the ratio of the total bandwidth sold to the total bandwidth available. For example, if the wireless provider has sold 100 Mbps download service to 8 customers (800 Mbps sold capacity) and has 200 Mbps of available download capacity, this would be an oversubscription of 4:1. These 8 customers may each believe they have the full 100 Mbps of capacity they purchased but would actually have much less, since only 2 of the 8 customers could operate at full speed at any given time. Too much oversubscription can result in poor network performance since the number of customers attempting to use the network would far exceed its capacity. As the wireless carrier increases the offered broadband speed to keep up with user demands, the oversubscription ratio increases and the broadband performance for each customer degrades.

Understanding the concept of spectral efficiency and oversubscription will be important later when we evaluate Lehr's specific claims.

Unlicensed Spectrum – A Scarce Commodity

The two most significant factors when determining a wireless network's broadband capability (both in terms of the broadband speed, but also the number of customers it can accommodate) are the amount of spectrum available and the frequency properties of that spectrum. There are three basic groupings of frequency bands used for broadband: low-band (below 1 GHz), mid-band (from 1 GHz to 6 GHz), and high-band (above 6 GHz). The relative size of these bands can be seen in Figure 1.

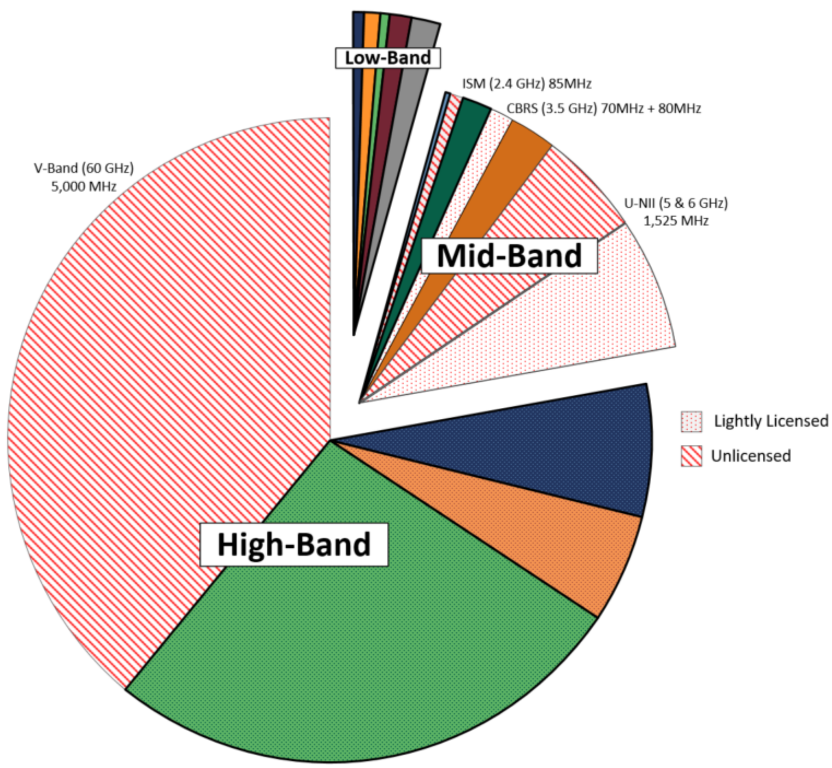

Figure 1. Broadband Spectrum

Most of the unlicensed spectrum available for broadband use is in the high-band. Unfortunately, high-band frequencies do not travel far (often only a few hundred feet), cannot penetrate obstacles such as buildings or trees, and are very susceptible to weather effects (rain, snow, fog). Because of this, wireless networks that use high-frequency bands are not well suited to provide rural broadband services where the distances between customers can be large and the countryside is often covered with hills and trees. The low-band frequencies work over large distances (often many miles) and can better penetrate obstacles. However, there is only 26 MHz of unlicensed broadband spectrum in this band, and it is shared with many other customer devices (such as cordless phones, baby monitors, and two-way radios). This sheer lack of spectrum in the low-band makes it difficult to offer merely 25/3 Mbps broadband service on a reliable basis – even if there were no other users of the band. Because of the severe limitations associated with the frequencies in the high-band and low-band when delivering broadband to rural customers, these bands tend not to be used in commercial real-world settings for rural broadband and we will not consider these bands any further.

This leaves mid-band spectrum. There are three unlicensed or lightly licensed (sometimes referred to a "licensed by rule") bands in the mid-band that could be usable for unlicensed broadband delivery. These are:

- **2.4 GHz (ISM) Band** – The 85 MHz of spectrum available in this band is used by many devices, including nearly every Wi-Fi router and microwave ovens. The limited amount of spectrum and the crowded nature of this band frequently makes it difficult and often impossible to deliver reliable broadband.
- **3.5 GHz (Citizens Broadband Radio Service or CBRS) Band** – Although there is 150 MHz of spectrum available, 70 MHz is licensed; and the 80 MHz remaining is for general use referred to as "lightly licensed" or "licensed by rule." There are incumbent users of this spectrum and broadband providers must give preference to these users so the amount of spectrum available for broadband service could be much less. The 80 MHz of lightly licensed spectrum, or General Authorized Access (GAA), is made available on a secondary basis using a Spectrum Access System (SAS). A device must receive authorization from the SAS before using the spectrum. As users of the spectrum in an area increase, the amount of spectrum available to each wireless provider decreases.
- **5&6 GHz (U-NII) Band** – This band has 1,525 MHz available for unlicensed use. The FCC is still in the planning stages with this spectrum but intends to allow a portion of this band (850 MHz) to be used outdoors in a GAA mode. While the frequency is almost twice that of CBRS, the power allowed in the 6 GHz band is lower, the signal does not travel as far (often only a couple miles) and is worse at penetrating objects such as buildings and trees.

Under optimal conditions, the mid-band could be used to deliver 100/20 Mbps broadband but is much less reliable and scalable than a fiber network. As users demand higher speeds these mid-band networks will no longer be able to keep up with user demand. This will be discussed in detail in the following sections.

Unlicensed Wireless Network Reliability Concerns

Fixed wireless providers using unlicensed and lightly licensed (GAA) spectrum must share the spectrum with any other broadband wireless provider in the area. As new unlicensed wireless providers enter the market, their signals can interfere with the existing wireless services in the same frequency band, which often requires them to reduce the amount of spectrum used and therefore reduce the speed. In the case of GAA, the SAS would divide the spectrum amongst all the providers that request access, which could result in a provider not being able to meet their customer speed and capacity commitments due to their loss of usable spectrum. The amount of available spectrum could be cut in half from one day to the next.

Other factors that impact wireless providers using mid-band spectrum – factors outside of their control – include tree growth or the construction of new buildings. As with all wireless networks, storms and wind can also cause the customer's wireless antenna to become misaligned resulting in degraded performance or a complete service outage.

Unlicensed Wireless Network Scalability Concerns

Less than 10 years ago, the FCC's definition of broadband was 4 Mbps download and 1 Mbps upload (4/1 Mbps). The Twelfth Measuring Broadband America (MBA) Report[12] recently released by the FCC shows that in October 2021 the average fixed broadband speed was 307.7 Mbps for download and an average of 58.4 Mbps for upload. Both download and upload speeds have been increasing by an average of over 38% annually since the FCC started publishing the MBA reports. If the broadband speeds continue at this rate – and we have no reason to believe that they will not – the average broadband download speed will be nearly 6 Gbps by 2030 as shown in Figure 2.

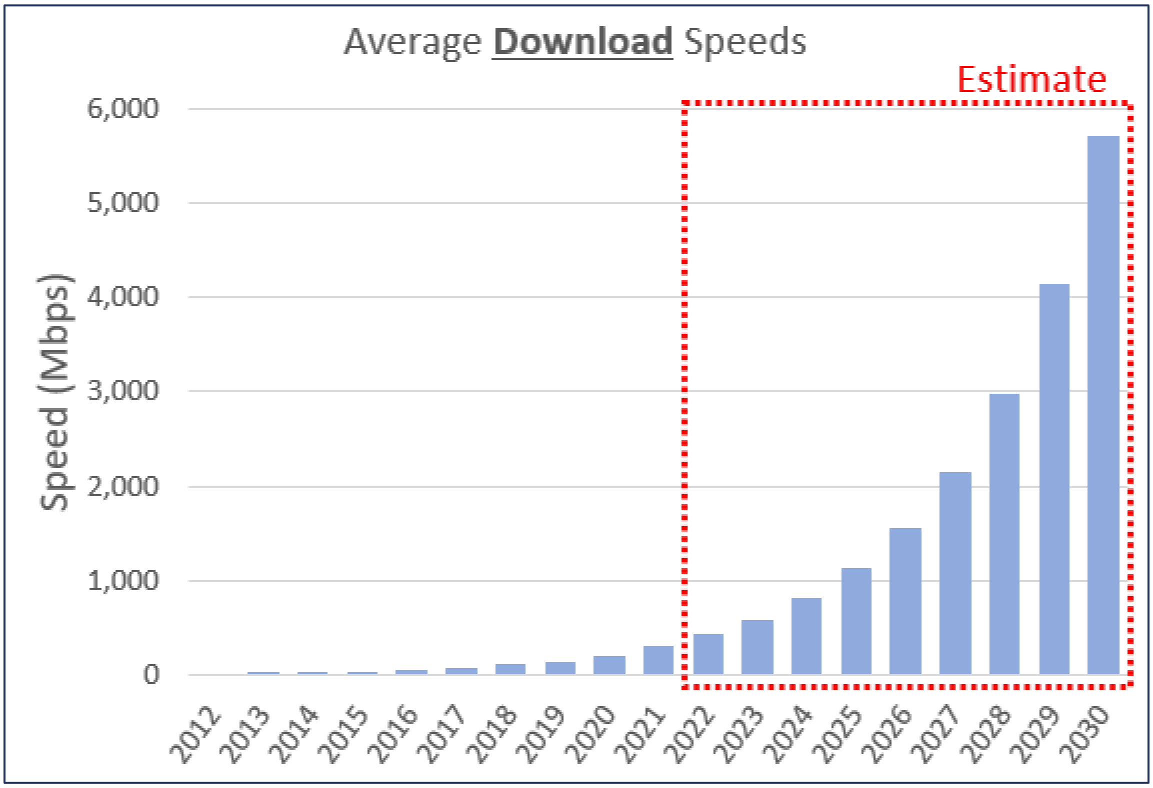

Figure 2. Average Download Speeds – Based on FCC MBA Reports

The Infrastructure Act defines a "priority broadband project" as one designed to (1) "provide broadband service that meets *speed, latency, reliability, consistency in quality of service*, and related criteria as the Assistant Secretary[13] shall determine" and (2) "ensure that the network built by the project can *easily scale speeds over time* to … meet the evolving connectivity needs of households and businesses" and "support the deployment of 5G, successor wireless technologies, and other advanced services."[14] (italics added)

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[12] FCC's Twelfth Measuring Broadband America (MBA), Fixed Broadband Report, January 6, 2023.

[13] In this context, the "Assistant Secretary" refers to the Assistant Secretary of Commerce for Communications and Information.

[14] Infrastructure Act § 60102(a)(1)(I).

Interpreting the Infrastructure Act, NTIA defined "Priority Broadband Projects" as those that use "end-to-end fiber-optic architecture."[15] It is clear from the BEAD NOFO that NTIA, in interpreting Congressional intent, determined that end-to-end fiber is needed to "ensure that the network built by the project can easily scale speeds over time to … meet the evolving connectivity needs of households and businesses" and "support the deployment of 5G, successor wireless technologies, and other advanced services."[16] This was correct, because in order to easily scale speeds over the long term, a broadband network must be able to deliver speeds *faster* than the 100/20 Mbps that Congress considered "served" today. If a wireless network struggles to achieve 100/20 Mbps today, a marginal increase to 200/25 Mbps could quickly make the wireless network inadequate and again leave these customers on the wrong side of the digital divide.

To deliver 200/25 Mbps[17] over a broadband wireless network, approximately 65 MHz of spectrum would be needed for a single customer.[18] In order for the wireless network to be practical and economical, more than a single customer is needed to spread their common costs across. A wireless operator would require all 80 MHz of the CBRS GAA spectrum to deliver today's average broadband speed to just a few customers. The instant a second provider enters the area, the first operator would only be able to rely upon half of the band (40 MHz) and could no longer reliably meet the service level commitments to its customers. As broadband demand continues to grow as shown in Figure 2, there is no unlicensed wireless technology that is suitable for rural applications that will be able to keep up. The unlicensed wireless network will become obsolete relatively soon after installation due to the factors noted above – namely distance, limited spectrum, interference, and congestion.

Because wireless spectrum is a scarce commodity and it is becoming much harder for the FCC to find additional spectrum for wireless broadband, the only hope for a wireless provider to be able to offer faster speeds and higher capacities over time is through future technology advances. Better modulation schemes and more spectrum from the FCC have helped improve wireless speeds in recent years. However, considering how rapidly customer demand for broadband is increasing, it is unlikely that technology advances will be able to keep up, and any specific promises or pledges along these lines must be seen as speculative – and certainly not worth betting billions of federal dollars or the broadband future of millions of customers upon.

To summarize: All wireless networks face challenges outside the control of the wireless operator. For unlicensed networks in particular, those challenges include congestion and reliability. Low-band and high-band spectrum do not have properties appropriate for rural broadband deployments; midband frequencies face crowding, lack of control and reliability, and inadequate power. Spectral efficiency and oversubscription further weaken the capability of unlicensed wireless networks, while also limiting their ability to scale to meet future broadband demands.

With background information on the properties of unlicensed wireless established, we turn now to addressing specific recent arguments regarding using unlicensed wireless for BEAD-funded broadband networks.

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[15] BEAD NOFO § IV B 7 b I (1)

[16] ibid

[17] Median speed for fixed broadband in the United States in February 2023 was 198/23 Mbps per Ookla Speedtest Global Index (https://www.speedtest.net/global-index/united-states#fixed)

[18] Assumes a 30% coding overhead and a spectral efficiency of 5 bps/Hz.

NTIA Should not Consider Unlicensed Wireless to be Reliable Broadband as Dr. Lehr Proposes

Dr. Lehr's white paper argues that NTIA's determination that fixed wireless service delivered over unlicensed spectrum is not a "reliable broadband service" violates the principle of technical neutrality. He asserts that this supposed violation of the technical neutrality principle will (1) lead to poor service quality of BEAD supported services, (2) distort competition, and (3) increase regulatory costs. He further argues that excluding unlicensed wireless technologies will increase the cost of deploying broadband. Each of these claims misses the mark. I will discuss each claim and put them into the proper context as a professional engineer involved in the design and deployment of both fiber and wireless networks for more than 30 years.

1. The Policies of the BEAD NOFO Do Not Violate the Principle of Technological Neutrality

Lehr begins his paper by asserting that the principle of technological neutrality was mandated by Congress in the Infrastructure Act.[19] He goes to great lengths to describe scenarios where the preference of a specific technology may be appropriate, but his arguments against NTIA's fiber preference are unpersuasive. In fact, while their explicit technological neutrality requirements can be found in the middle mile and digital equity portions of the IIJA, Congress notably omitted any such requirement with regard to BEAD funding. Regardless, even if such a principle were to apply, preferring fiber to the end user over an unlicensed fixed wireless network does not violate the principle of technical neutrality – it is not as if all wireless technology is being excluded, and it is also not the case that all wireline networks can meet the criteria necessary to be prioritized.

To be clear, attempting to be consistent with the principle of technological neutrality is appropriate in certain circumstances; for example, when choosing between two or more solutions, each using different technologies that are, in fact, functionally similar. For example, choosing between an electric vehicle (EV) and an internal combustion engine (ICE) vehicle could be considered technologically neutral under the right circumstances. If the required vehicle only needs to carry two passengers, travel 100 miles a day, have good acceleration and braking, have a Bluetooth radio, and expected to last more than 10 years and 100,000 miles then both vehicles could meet the requirements. Selecting between the EV and the ICE vehicles could be considered technologically neutral.

However, we can consider another scenario where the EV manufacturer requests quotes from two battery manufacturers. The first battery manufacturer could provide high quality lithium-ion batteries whereas the second manufacturer could provide copper and aluminum electrodes in a mason jar of saltwater. The battery made from saltwater would be much less expensive and may even be faster to deploy, but it would not be functionally equivalent to a lithium-ion battery. No one could credibly argue that the EV manufacturer was not being technology neutral when selecting the lithium-ion batteries even though the saltwater batteries may provide the same voltage.

When considering the capabilities of various types of broadband networks, and in attempting to apply the principle of technological neutrality, the difference between fiber and unlicensed wireless is much greater than the difference between the lithium-ion battery's ability to power the EV compared to the saltwater in a mason jar. As discussed previously, one of the largest determining factors for broadband speed over an unlicensed

[19] Lehr Paper, page 4.

wireless network is the available frequency spectrum. Under a best-case scenario, there is only about 1,600 MHz of unlicensed spectrum in the mid-band – much of which is so congested as to be unusable. However, the laser frequencies on a fiber network can range from 179 THz to 238 THz (59 THz total) using technologies that are common today. *Fiber has more than 36,000 times more spectrum* available to deliver broadband services compared to unlicensed wireless. A preference for fiber over an unlicensed wireless network does not violate technological neutrality when policymakers compare technologies and conclude that they are not functionally equivalent in terms of capacity, how they differ in the ability to serve every consumer in a given area with a committed and reliable level of capacity as new customers subscribe, and their respective abilities to meet communities' needs both immediately and over the long term life of the asset in which the federal investment is being made. In this case, policymakers attempting to close the stubborn digital divide have a responsibility to avoid repeating the mistakes of prior programs that aimed for short-term solutions and to ensure instead that public dollars deliver a long-term return in terms of the ability to serve these areas.

Lehr argues that there are instances where technological neutrality does not apply, and in these instances "technical specificity" could apply instead. For example, Lehr claims, "There are benefits to technical specificity in certain cases that may include (i) when a technology is well-understood and relatively unchanging . . . "[20] To support his argument, Lehr contends that FTTP broadband network designs and technologies are unsettled and rapidly changing. However, such arguments fail to grasp the well-structured engineering and evolution of FTTP networks. Lehr attempts to support his argument by pointing to the fact that there are two types of fiber (multimode and single mode) as if the evolution from multimode fiber to single mode fiber somehow impacted the design of FTTP networks. Although there have been numerous advances in FTTP technology, Dr. Lehr appears to mistake technological advancement and continuous improvement for unsettled experimentation. I have designed hundreds of thousands of miles of outside plant cable over the last 30 years and have never seen multimode fiber used in local FTTP networks. Multimode fiber was designed to be used for in-building and campus environments, not the local loop architectures of a broadband provider. Single mode fiber is not an advanced form of multimode fiber – manufacturers still make both fiber types for different applications. Even though there have been advances in fiber cable performance, many broadband providers are still using fiber optic cables that were installed in the 1980's or earlier without service degradation or failure. Indeed, highlighting their scalability and resilience, fiber cables from the 1980's still have many thousands of times more capacity than all the unlicensed wireless spectrum available today.

To further argue that fiber technology is "unsettled and changing" Lehr states, "FTTP last mile networks are complex and there are lots of ways to layout such network that balance dedicated vs. shared cables and how much passive v. active optical and other networking equipment should be located in the last-mile access network (e.g., remote service terminals, splitters, etc.)."[21] Again, this argument is a red herring. Lehr's attempt to paint FTTP technologies as unsettled and rapidly changing fails to comprehend the distinction between structured advancement and chaotic and disruptive reinvention. Although FTTP architectures allow flexibility of design, they have been standardized for many years. The passive optical network (PON) architecture in common use today is standardized by the ITU-T Study Group 15 as part of their G.984 standards. These standards were originally ratified 20 years ago (2003) and new deployments are still based on these same standards. Modern fiber electronic technologies such as XGS-PON continue to work on these fiber networks as did FTTP electronics from 20 years ago. There are some fiber broadband providers that use active ethernet (AE) rather than PON architectures, but

[20] Lehr Paper, page 10.
[21] Lehr Paper, footnote 22.

these are also based on standards – IEEE 802.3. Fiber outside plant networks designed for AE will also work for PON FTTP electronics.

Lehr also asserts that the "the question of what technology is best for providing broadband access in a given area at a given time is far from settled."[22] There are undoubtably some very rural locations in the United States that are difficult to reach with fiber, but many of these same locations are also very difficult to reach with wireless technologies because they are often located in mountainous areas or areas with significant tree cover. However, in most instances, fiber is both the most economical (over the long term) and best performing of all broadband technologies.[23] Since all broadband networks, including wireless, satellite, and CATV, already use a lot of fiber, the fiber debate is really only about the last few hundred or few thousand feet to the customers. These other non-fiber broadband technologies simply introduce a broadband bottleneck that significantly limits the amount of broadband that can be delivered to the end user customer. Extending fiber all the way to the customer where possible using FTTP technologies eliminates this broadband bottleneck introduced by other broadband technologies.

Lehr also argues that NTIA's fiber preference will increase the regulatory costs because the government funded network will be a monopoly.[24] Here, it must be remembered that these areas are currently unserved by adequate broadband providers because there is no economic case to build and operate a reliable broadband network. For a network to be sustainable in these areas and continue to meet the ever-increasing customer demand, the network must be supported by more than simply end user revenues. Precisely because BEAD aims funding to serve unserved areas first and foremost, any network built leveraging BEAD funds – regardless of whether it is FTTP or wireless – will likely be a monopoly, at least initially, in the area in which it is being deployed. Put another way, if his criticism carries weight at all, it hits equally regardless of technological choice.

2. Excluding Unlicensed Wireless Will Not Increase Cost of Broadband

The BEAD program is a "once-in-a-generation" opportunity to close the broadband gap in the United States.[25] The program will be a failure if the networks that are funded through the BEAD program are not sustainable (i.e., able to meet the bandwidth needs of consumers now and in the future) and a new round of capital is needed in relatively short order to rebuild the networks only recently constructed using BEAD funds. Policymakers inarguably recognized this, as the Infrastructure Act, and the BEAD NOFO demonstrate a clear preference for high-quality and sustainable networks as the best use of public funding. Selecting the broadband solution that has the lowest initial cost but will soon be outdated is not the most sustainable choice, and in fact likely will cost more over time.

In his discussion on the comparative costs of deploying fiber versus fixed wireless networks over unlicensed spectrum, Lehr makes a number of unsupported statements regarding the additional costs to deploy FTTP. As one example, Lehr claims that it will increase the total cost of achieving our national goal by ". . . tens of billions of dollars!"[26] if fixed wireless over unlicensed spectrum is not taken into account in the BEAD program. Even assuming as true that the initial costs of FTTP deployment are higher as compared to an unlicensed fixed wireless

[22] Lehr Paper, page 11.
[23] Can Unlicensed Wireless Solve the Rural Digital Divide, Vantage Point Solutions, March 2023
[24] Lehr Paper, page 9.
[25] Global speed indexes don't have the United States in the top ten countries with respect to broadband speeds.
[26] Lehr Paper, page 4.

network, a FTTP network is almost always less expensive when considering the cost over the entire life of the asset.[27] Lehr oddly never acknowledges this longer-term perspective.

While much has already been written, by Lehr and others, on the fact that the initial capital investment can be lower for a wireless network, this advantage often disappears when considering the increased operational expenses of wireless and the ongoing capital investment required.[28] To be clear, the intention herein is not to rehash those issues, but to focus on the suitability of unlicensed wireless to provide fixed broadband service in rural areas and under what circumstances public funds should be used to deploy such networks. That said, it is worth reiterating this point on a cost factor that Lehr ignores.

For example, if we were to consider two refrigerators with the first one being $500 and the second one being $1,500, one may be tempted to believe that the first refrigerator represents the most cost-effective solution to keeping food cold in a kitchen. However, if the first refrigerator is expected to last only 5 years and can only cool to 50 degrees Fahrenheit and the second refrigerator will last 20 years and can cool to 40 degrees Fahrenheit, a different conclusion would obviously be reached. When considering that the first refrigerator must be replaced four times (totaling $2,000) during the life of the second refrigerator and adding the food spoilage due to the poorer cooling capabilities, it becomes clear that the second refrigerator is the wiser choice.

Similarly, most of the cost of a fiber network is the fiber and initial fiber construction (placing it underground or on poles), and the fiber itself typically lasts 40 years or more, whereas much of the cost of a wireless network is electronics which will last only 5 to 7 years before needing to be replaced/upgraded. Like the better cooling capabilities of the second refrigerator, the fiber network is also capable of offering better performance in the form of much faster speeds. Arguing that fiber is a "technology choice that is much more expensive to deploy"[29] ignores such basic factors and does not consider the potential cost savings over the life of the asset – the "total cost of ownership."

Beyond breezing past these intersecting technical and economic considerations, Lehr's comparison of the cost of FTTP to an unlicensed wireless network is based upon an incomplete understanding of how networks are built and broadband services delivered. First, a fiber network's "cost to serve" requires that the fiber cable be placed at or near each location. A location is not considered "served" until the customer can be connected to the fiber network by simply installing a short fiber drop (typically no more than 500 feet) and some inexpensive electronics. However, a wireless customer may be considered "served" by simply installing a radio on a nearby tower. The operator often does not consider obstacles such as terrain or trees that may block the wireless signal at some of the locations nor the cost to provide service to these customers. In fact, it can be the case that the customer is thought to be "served" by a wireless network right up until the point when a field visit indicates that some obstacle renders that impossible (or only at a reduced level of performance or much higher cost after all). Second, a fiber network is designed to serve all customers that the network passes, while a wireless network is often designed for (and only has the total capacity to serve) just a small fraction of the customers in its footprint.

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[27] Future Proof: Economics of Rural Broadband, Comparing Terrestrial Technologies & Investment Considerations to Meet Increasing Consumer Broadband Demands, Foundation for Rural Service, Larry Thompson, PE, Brian Enga, PE, and Brian Bell, PE, March 2021 (https://www.ntca.org/sites/default/files/documents/2021-05/Future%20Proof%20--%20Economics%20of%20Rural%20Broadband%20FINAL_0.pdf) ("Future Proof")
[28] Future Proof
[29] Lehr Paper, Page 3.

Lehr also states that "the models that purport to show that FTTP is more cost effective over a twenty- or thirty-year horizon do not account for the expected Moore's Law-like improvement in the price-quality performance of fixed wireless technologies."[30] He bases his assertion on a theory advanced by Gordon Moore, the founder of both Fairchild and Intel, who postulated that the number of transistors in an integrated circuit would double every two years. What Lehr misses is that the increase in broadband speeds over a wireless network is nowhere near doubling every two years and has been unable to keep up with even average customer demands (which double approximately every 3 to 4 years). Of greater concern is Shannon's law that defined the theoretical limit of the amount of information that can be sent over a network. Wireless networks are likely approaching their theoretical limits with respect to their capacity for delivering data to consumers which may hinder future improvements – FTTP networks, on the other hand, are nowhere near their theoretical limit.

The fact remains, when analyzed over a longer period of time — a decade, or the longer useful life of the network asset — fiber network deployments have been shown to be the most economical choice for rural fixed broadband networks. The promises of wireless solutions to deliver Gigabit service in rural applications have not materialized and may never be economical to deploy.[31] Apart from some very limited circumstances and putting aside marketing claims, the technical and related economic hurdles remain substantial for wireless networks.

3. Disregarding Unlicensed Wireless Networks Will Accelerate, Rather Than Delay, Meaningful Broadband Benefits

Dr Lehr argues that unlicensed wireless networks can be deployed faster than FTTP and, therefore, consumers can enjoy the benefits of broadband sooner. Even as this may be the case in some instances, the time it takes to deploy a FTTP network does not always differ significantly from deploying an unlicensed wireless network. This is true for several reasons:

- Wireless networks needed to deliver speeds required by BEAD will require perhaps tens of thousands of new towers to be built, often requiring the construction of new fiber to these towers. Indeed, even if it were true that fiber construction takes longer than a wireless network, the latter cannot effectively serve many customers without the former, and thus a basic comparison of the time involved with tower construction vs fiber is of little value without touching on this fact.
- The construction of these facilities relies on the same labor pool as the construction of fiber for a FTTP network. Both are currently suffering from labor shortages.
- Materials needed to construct both wireless and fiber facilities are experiencing supply chain issues. Availability of equipment, especially wireless equipment, is also being hindered because of Buy American requirements. This will likely slow deployment of both wireless and fiber networks.

[30] Lehr Paper, Page 31.

[31] Evaluating the Capabilities of Fixed Wireless Technology to Deliver Gigabit Performance in Rural Markets, February 2021 (https://www.fcc.gov/ecfs/file/download/Letter%20and%20technical%20whitepaper%20on%20Gigabit%20standards%20020121.pdf?folder=10201387611048)

- The construction of fiber and towers needed for wireless networks still requires permits and approvals from local, state, and federal agencies. This may include city and town permits, Department of Transportation, railroads, Bureau of Reclamation, Bureau of Land Management, US Forest Service, US Park Service, Department of Natural Resources, Army Corp of Engineers, and others. Even in instances when the network may require less time to build, the permitting process can be a significant part of the construction timeline.

Furthermore, to keep an unlicensed fixed wireless network operational, it is necessary to make a significant investment in electronics every 5 to 7 years as the equipment becomes outdated or manufacturer discontinued. If the wireless operator does not have the capital to invest in the network or the economics cannot justify this level of investment, the network performance will decline and eventually fail altogether. Alternatively, since the bulk of the investment in a FTTP network is in the fiber cable and the inexpensive electronic equipment can normally be upgraded over a longer time horizon, there is a much higher probability of the network being sustainable.

Investing in a network, such as FTTP, that has a much higher probability of being sustainable over the next 30 or 40 years is better use of public funds. This benefit of fiber was recognized by NTIA when the agency stated, "End-to-end fiber networks can be updated by replacing equipment attached to the ends of the fiber-optic facilities, allowing for quick and relatively inexpensive network scaling as compared to other technologies."[32] By contrast, relying on a network that requires significant periodic investment introduces a significant risk of not being sustainable long term – justifying disregarding networks that are not proven to be reliable in delivering broadband over wide geographies over longer stretches of time.

4. FTTP is not Complementary to Fixed Unlicensed Wireless

In general, *mobile* wireless service is properly considered complementary to a FTTP service. Consumers desire mobile voice and small-screen video, but also want a high-speed fixed broadband service at their home and business for large-screen video, remote work, eHealth, security systems, Internet of Things (IoT) devices. Mobile wireless networks also rely on fiber backhaul networks from their towers. When a mobile call is made from a customer in New York City to Los Angeles, only a small portion of that call is carried on a wireless network (probably less than a couple miles). The vast majority of that call is carried on a fiber network – more than 99.9% of the call.

Despite this fact, Lehr misses the mark in arguing that *fixed* wireless and wireline services are complementary in the same manner. Fixed unlicensed wireless networks and FTTP networks both deliver broadband services to a fixed location. These two network types perform similar functions and purport to fulfill similar demands, even if one performs at a far higher level than the other. If anything, the most that could be said is that fiber is complementary to fixed wireless networks in that most of the latter rely on fiber for their backhaul. In this sense, "Wireless Needs Wires," but the converse is not true. Except for the use of Wi-Fi networks within a customer premise, a FTTP network does not rely on an unlicensed wireless spectrum to deliver broadband services.

[32] BEAD NOFO § IV B 7 b I (1)

Lehr’s Arguments with Respect to Sufficient Speeds are Telling

Lehr asserts that not including unlicensed fixed wireless within the definition of “reliable broadband service” will result in a “misdirection of funds to overbuild locations that already have ISPs offering 25/3 Mbps or better service.”[33] Our national policy for using an unprecedented infusion of capital for broadband funding should not be based, however, on setting the standards so low that all technologies can meet the standard for funding or disallow deployment where the bare minimum is available today. Instead, NTIA has rightly approached the rules to fulfill the congressional call for prioritizing scalable projects and focusing on what is needed to ensure that our citizens can participate in a digital world today and long into the future.

Lehr’s statement of the desired end state is telling: “However, at 25/3, there are no important Internet-accessible application for which the broadband access connection is the relevant bottleneck component today (in a technical sense, at least).”[34] Not long ago, some questioned why we would ever need 1 Mbps; in 2010, the National Broadband Plan projected that 4 Mbps should be sufficient for millions of rural consumers and communities for at least a decade to come. Today such speeds are reminiscent of dial-up, just as 25 Mbps will seem not long from now (and possibly already). More importantly, Lehr’s argument neglects that broadband connections must serve a location, not a single device. Many devices may be active at a single location; in fact, most streaming services recommend 25 Mbps for a single Ultra High Definition (UHD) video stream.[35] A single UHD video stream that may be used for education, entertainment, or medical reasons could use the entire download capacity of a 25/3 Mbps broadband service and leave nothing for any other device or user at this same location. As in the past, the next generation of video will consume even more.

Lehr’s suggested solution for this is not to invest in scalable and reliable networks, but instead to suggest that users “change their behavior by avoiding simultaneous use of limited broadband capacity” or that some users “move to alternate locations.”[36] What Lehr proposes would certainly be poor public policy – why would any policymaker support funding networks that are inadequate (even by today’s standards) and then propose that the users move to, say, the library to access adequate internet speeds (particularly when one of the very reasons this public funding was made available to ensure that no American is forced to go to the library or other public place simply to access basic online applications and services)? Indeed, the fact that Lehr feels compelled to make such an argument would seem to concede the limitations of the very types of networks he argues should be deemed reliable enough or even funded.

It is important not only to close the broadband gap, but to keep it closed. Too much funding is being deployed at this time to entertain the thought of needing to do this all over again in just a short period of years. Deploying highly reliable networks that have fast speeds (both upload and download) will help close that gap today, but these networks must also be scalable and sustainable to keep this gap closed in the future. Congress recognized this in the Infrastructure Act where it defined “Reliable Broadband Service” as “. . . broadband service that meets performance criteria for service availability, adaptability to changing end-user requirements, length of serviceable life.”[37] The Infrastructure Act also required the Administrator to “. . . ensure that the network built by the project

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[33] Lehr Paper, page 4.
[34] Lehr Paper, page 13
[35] https://www.highspeedinternet.com/resources/how-much-speed-do-i-need-to-watch-netflix-and-hulu
[36] Lehr Paper, footnote 33
[37] Infrastructure, Investment, and Jobs Act (Infrastructure Act), SEC. 60102 (2) (L)

can easily scale speeds over time."[38] As discussed later, restrictions on the use of spectrum and the laws of physics make it difficult, if not impossible, for unlicensed wireless networks to meet these requirements of the Infrastructure Act.

[38] Infrastructure Act, SEC. 60102 (2) (I) (ii)

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Larry Thompson is a licensed professional engineer and has been designing satellite, wireless, and broadband wireline networks for more than 35 years. Larry received his bachelor's degree in physics from William Jewell College and his bachelor's and master's degrees in Electrical Engineering from the University of Kansas. Prior to founding Vantage Point Solutions in 2002, Larry held several engineering and management positions with TRW's Space and Defense sector, CyberLink Corporation, and Martin Group. Larry is currently the CEO of Vantage Point Solutions, which has over 400 employees and is a national provider of engineering and consulting services. Over the years, he has assisted many wireless and wireline companies successfully manage their technical, regulatory, and financial challenges.

Larry was a two-term member of the FCC's Broadband Deployment Advisory Committee (BDAC), is a frequent speaker at state and national conferences, and a frequent expert witness at utility commission and legal proceedings relating to telecommunication technology and regulatory matters.

About Vantage Point Solutions

Better Broadband means Better Lives. Vantage Point Solutions, Inc. helps providers bring this promise to life through comprehensive engineering and consulting solutions tailored to the unique needs of the companies, Cooperatives, and communities we serve.

Headquartered in Mitchell, South Dakota and with six additional offices across the country, Vantage Point works with broadband and telecom providers in more than 40 states. Our 400+ employees include ten licensed professional engineers, three attorneys, and industry leaders in technology and advocacy. With professional engineers and regulatory experts under the same roof, we are able to understand the big picture for any individual company decision or broader industry policy.

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