FILED
12/07/23
04:59 PM
R2302016

R. 23-02-016

Tarana Wireless, Inc.

Attachment A
To Reply Comments of Tarana Wireless, Inc. on BEAD Staff Proposal

December 7, 2023

Re: Comments of Tarana Wireless on California's BEAD Initial Proposal

Dear Commissioner Houck and President Reynolds,

We are writing to you as 19 PhD's with more than 250 years of combined academic and professional technological experience. Throughout our careers, we have passionately committed ourselves to addressing the Digital Divide in California, the United States and around the world. It is with profound respect but deep concern that we are writing to provide a fact-based response to the characterization of fixed wireless access ("FWA") broadband technology by the California Public Utilities Commission's (CPUC) staff.

Tarana Wireless, Inc. ("Tarana") would like to take the opportunity to comment on the California Public Utilities Commission's ("CPUC") characterization of fixed wireless access ("FWA") broadband technology, as represented in Volume I of the BEAD Initial Proposal published on November 7, 2023. Several technical inaccuracies in its depiction of FWA hinder meaningful consideration of wireless alternatives that California could use to significant benefit in achieving 100% universal broadband service across the state, as called for in the Governor's 2020 Executive Order.

On page 9 of Volume 1, the CPUC states its intent to modify the FCC National Broadband Maps count of BEAD eligible broadband serviceable locations (BSLs) by opting to change the status of BSLs served by "low-speed fixed wireless" from underserved to unserved. As part of the justification for this change, the CPUC states the following about fixed wireless.

> *As a technical matter, fixed wireless speeds fluctuate heavily; given this, speeds that barely qualify as underserved will likely be below 25/3 service during peak usage times. This is especially true of older fixed wireless deployments that struggle to reach higher speeds and mitigate interference and line of sight issues. In fixed wireless networks, service performance can be affected by a customer's proximity to a base station, the capacity of the cell site, the number of other users connected to the same cell site, the surrounding terrain, and radio frequency interference. Additionally, fixed wireless networks require a clear line-of-sight. Therefore, obstructions, such as trees, can block radio signals and impact the reliability of fixed wireless networks. Poor weather conditions, including rain, can affect the availability and quality of a customer's fixed wireless service.*

The characterization of fixed wireless technology in Volume I is outdated and does not reflect proven technologies currently available to California ISPs and consumers. Although certain characteristics described by the CPUC may have been true three or more years ago, ongoing technology progress has delivered robust and resilient fixed wireless solutions, demonstrated through thousands of successful deployments across California and around the world.

Tarana is a next-generation Fixed Wireless Access ("ngFWA") broadband technology company. It was founded 14 years ago in the San Francisco Bay Area by three U.C. Berkeley PhDs who were committed to developing a solution to bridge the digital divide. Tarana's Gigabit 1 (G1) platform is the result of more than $400 million invested in a decade of ground-up R&D, exclusively focused on perfecting Fixed Wireless Access. G1 offers all the fast-deployment advantages of wireless, but now with the performance, capacity, and interference rejection required to deliver reliable fixed broadband connections for homes and businesses at large network scale. This includes overcoming challenging non-line-of-sight (NLoS) conditions, utilizing both licensed and unlicensed spectrum, to provide a fully-formed wireless alternative to last-mile fiber for the long term. 100% of Tarana's intellectual property is held in California, and all of our manufacturing is performed by two California-headquartered companies, all in North America. Most of our 400 employees, including 26 PhDs, are also based in California.

Each of our G1 base nodes, which are mounted on vertical assets such as cell towers, water towers, or tall buildings, can effectively serve up to 250 homes spanning line-of-sight distances of up to 18.6 miles and non-line-of-sight distances up to 3 miles, all while delivering speeds of up to 800 Mbps per connection which can be flexibility allocated to downlink or uplink. With an upcoming software upgrade, G1 nodes will soon be able to provide up to 1.6 Gbps to each household.

In just 2.5 years since we introduced our technologies to the market, we are proud to be serving unserved and underserved families and communities in 21 countries and 45 US states. Partnering with over 200 Internet Service Providers ("ISPs"), we have extended our reach to more than 10 million homes passed. With a growing subscriber base that now numbers in the tens of thousands, we are now adding 1,500 to 2,000 new subscribers every week. Notably, 98% of ISPs that have tested Tarana's technology have chosen to adopt it. Why? The answer is straightforward: It works.

Tarana believes it is important to address the CPUC's depiction of fixed wireless with clear characterization of the state-of-the-art in fixed wireless, ngFWA, and the

well-proven performance the technology is demonstrating in hundreds of commercial networks today:

High Network Capacity

- The CPUC states that service performance in fixed wireless networks can be impacted by the capacity of a cell site and the number of users connected to it. This is true of all access technologies (including fiber) and hence is not specific to wireless or FWA. Rather, it is a design choice. For example, Tarana Wireless' G1 technology is designed with enough per-sector capacity to easily serve 200 end customers with reliable 100/20 Mbps service. This properly engineered network capacity ensures the ability to support all customers with dependable high-speed broadband service with room for growth.

Non-Line-of-Sight:

- The CPUC characterizes fixed wireless as requiring a clear line of sight for reliable broadband service. Tarana's ngFWA technology, however, is designed to operate not just line of sight ("LoS"), but also near line of sight ("nLoS"), and full non-line of sight link conditions. Tarana's base nodes ("BNs") and remote nodes ("RNs") leverage multiple paths in each channel, ensuring a seamless connection despite obstructions that might hinder a clear line of sight. Each BN currently utilizes up to 80 MHz of spectrum, spread across two adjacent or separated channels, with up to 40 MHz in each, flexibility that improves overall performance. Outdoor remote nodes are placed at residential and enterprise subscriber locations and automatically align with the best available BN. Tarana's technology utilizes two wave-propagation phenomena, reflection and diffraction, to overcome obstacles to line-of-sight links. Reflection involves radio waves bouncing off solid objects, similar to light reflecting off a mirror, while diffraction is comparable to water waves spreading out after passing an obstruction. Operating in midband spectrum (3.5, 5, and 6 GHz), Tarana can fully leverage these reflection and diffraction phenomena to navigate around line-of-sight obstructions, such as trees, buildings, vehicles, or other obstacles.

Interference Cancellation:

- The CPUC states that fixed wireless struggles to mitigate interference. It is true that one of the challenges in fixed wireless technologies is managing both "self-interference" and interference from external sources but the state-of-the art has evolved. Tarana's ngFWA fully cancels all self-interference for better operation even in licensed spectrum. Further,

ngFWA cancels bursty interference as well (e.g. Wi-Fi) that might crop up during a transmission in unlicensed bands. This is accomplished through a unique asynchronous burst interference cancellation ("ABIC") algorithm. The fundamental principle of ABIC involves processing multiple mixed-signal inputs to isolate the signal of interest from the chaotic interference in the radio channel. Unlike conventional methods that focus on finding a clean channel, ABIC stands out in canceling undesired signals at the receiving end of the link, ensuring a connection free from interference. Consequently, Tarana's ngFWA delivers reliable broadband service whether in lightly licensed CBRS spectrum, or the traditionally interference-prone unlicensed 5 and 6 GHz spectrum.

Inclement Weather

- The CPUC states that fixed wireless' ability to deliver broadband service is impacted by poor weather conditions such as rain. While traditional fixed wireless systems, such as those utilizing 3GPP or WiFi technologies, may struggle to maintain reliable broadband service in inclement weather, Tarana's ngFWA technology has effectively overcome these challenges. Legacy fixed wireless systems often face issues like absorption and attenuation, where shorter wavelengths are absorbed or scattered by water molecules and atmospheric moisture. Additionally, rain, snow, and fog can cause scattering and reflection, particularly in higher millimeter-wave bands like 60 GHz, leading to signal deviation and degradation. The molecular resonance of oxygen in the air further contributes to attenuation at 60 GHz. Tarana addresses these limitations by operating in the 3, 5, and 6 GHz bands, thereby avoiding the adverse effects associated with higher frequencies. In high-wind situations, broadband service delivered by traditional FWA technologies is often compromised by additional signal disturbance from moving obstacles like tree branches waving in the wind or debris flying through the signal path. Continuous, rapid optimization of our beamforming technology ensures that our BNs maintain the strongest signal and connection to the RNs on a customer's homes or businesses. Our system rapidly calculates alternative paths around these obstructions at a rate of 5,000 times per second, ensuring seamless adaptation to changes without the subscriber even realizing anything has occurred.

Proximity to a Base Station

- The CPUC states that the performance of fixed wireless in delivering broadband can be impacted by proximity to the base node. Tarana's G1 platform is capable of offering line-of-sight coverage of up to 18.6 miles, near

line-of-sight coverage up to 10 miles, and non-line-of-sight coverage up to 3 miles. When addressing the digital divide, the commonly used phrase "last mile" often underestimates the significant distances that many communities face in accessing broadband infrastructure. Tarana's ngFWA technology can aptly be described as a "last 18.6-mile technology," emphasizing its capability to bridge considerable distances and provide reliable broadband connectivity where it is needed most.

High Speeds

- The CPUC states that fixed wireless service struggles to meet and provide higher broadband speeds. As part of the BEAD program, the National Telecommunications and Information Administration ("NTIA") mandates that states and territories fund broadband projects with a minimum service speed of 100/20 Mbps. Tarana's G1 technology surpasses this requirement by delivering 800 Mbps of aggregate throughput to a single RN at a customer's home or business. This capacity can be flexibly allocated between upload uplink and downlink, accommodating customer preferences or ISP network performance goals. Furthermore, with a planned software upgrade in early 2024, Tarana's current hardware will double its throughput, reaching an impressive 1.6 Gbps for end users.

Low Latency

- Tarana's ngFWA stands out for its exceptional capability to deliver high broadband speeds to households along with low latency in long-range connections. Our ngFWA boasts a one-way latency, measuring the transmission of data packets from source to destination, of less than 5 milliseconds.

Numbers of users from a cell tower site

- The CPUC states that fixed wireless performance can be impacted by the number of users connected to the cell site. Whether operating in 3.5 GHz, 5 GHz or 6 GHz, a single Tarana base node is capable of supporting up to 250 remote nodes. Each base node has 90° coverage. To achieve 360° coverage in a cell, four base nodes are required in each frequency band. Therefore, four base nodes can support up to 1000 remote nodes. Additional base nodes can be added to increase density per tower location as needed.

In conclusion, Tarana appreciates the opportunity to provide insights and corrections regarding the California Public Utilities Commission's characterization

of fixed wireless access broadband technology, as outlined in Volume I of the BEAD Initial Proposal. It is evident from our detailed analysis that the CPUC's portrayal of fixed wireless technology contains technical inaccuracies and misconceptions. We have thoroughly addressed these inaccuracies here, reporting from our ISP customers' real-world experiences with the G1 platform that Tarana's ngFWA technology is fully capable of overcoming the challenges mentioned by the CPUC.

Our technology operates effectively in non-line-of-sight conditions, utilizing innovative methods like asynchronous burst interference cancellation to mitigate interference in unlicensed spectrum. Contrary to traditional fixed wireless systems, our ngFWA technology is resilient in inclement weather, ensuring reliable broadband service even in challenging conditions. The proximity to a base station is not a limiting factor, as our ngFWA can serve customers up to 18.6 miles away. With high speeds greatly exceeding the NTIA's recommended threshold, low latency, and the ability to support multiple users from a single cell tower site, Tarana's technology outperforms the limitations described in the CPUC's depiction of fixed wireless and has been proven in doing so in thousands of deployments around the world.

Furthermore, we want to emphasize that the CPUC's characterization appears outdated and fails to recognize the significant advancements in fixed wireless technology achieved over the past few years. Tarana, with its G1 platform, represents the forefront of such technological progress, providing reliable, high-speed broadband solutions to underserved families and communities across the globe. We urge the CPUC to reconsider its depiction of fixed wireless technology and acknowledge the capabilities demonstrated by current ngFWA technology. By embracing accurate and up-to-date information, the CPUC can make more informed decisions that better align with the goal of achieving 100% universal broadband service in California, as called for in Governor Newsom's Executive Order and in the federal Bipartisan Infrastructure Law, appropriately entitled "Broadband for All.".

Why are these factual corrections important to make? Employing and using accurate information is crucial for the CPUC to develop a clear understanding of the various technologies at its disposal - which meet and exceed the reliable, high-speed, low latency standards called for in the IIJA - in pursuit of universal service for California families. Erroneous information and the resulting conclusions lead to an Initial Proposal that is overly dependent on fiber deployment. California does not have the time or money to universally implement fiber. The current CPUC proposal jeopardizes leaving hundreds of thousands of Californians on the losing side of the digital divide. An alternative approach, encompassing a spectrum of broadband technologies, which - again - meet and preferably exceed reliable, high speed

standards, is imperative to guarantee that all Californians have the broadband access they require and rightfully deserve.

Thank you for your attention to these critical matters. We remain committed to contributing to the advancement of reliable and efficient broadband solutions that bridge the digital divide. In fact, we have committed our lives to this goal.

Sincerely,

Sergiu Nedevschi, PhD
Computer Science
University of California, Berkeley
Chief Strategy Officer & Co-founder

Rabin Patra, PhD
Computer Science
University of California, Berkeley
Chief Software Architect and Co-founder

Omar Bakr, PhD
Computer Science
University of California, Berkeley
Co-founder

Ligang Ker, PhD
Electrical Engineering
University of Arizona
Principal DSP Engineer

Eric Rebeiz, PhD
Electrical Engineering
University of California, Los Angeles
VP of Systems Engineering & Architecture

Arvind Raghavan, PhD
Electrical Engineering
Clemson University
Director of Product Management

Yongmin Zhang, PhD
Electrical Engineering
University of Houston
Vice President of Engineering

Jun Chen, PhD
Electrical and Electronics Engineering
University of Notre Dame
Senior Staff Systems Engineer

Hua Liu, PhD
Artificial Neural Networks and Intelligent Control
Tianjin University
Director of Integration & Diagnostics

Yu-Yu Lin, PhD
Electrical Engineering
University of California, Los Angeles
DSP Software Engineer

Neeran Karnik, PhD
Computer Science
University of Minnesota
Principal Architect

Junha Im, PhD
Electrical Engineering
Yonsei University
Senior Staff Systems Engineer

RJ Honicky, PhD
Computer Science
University of California, Berkeley
Director of Engineering

Hemachandra Reddy Gorla, PhD
Electrical Engineering
Southern Illinois University
Staff Antenna Engineer

Steve Bruzone, PhD
Electrical, Electronics, and
Communications Engineering
University of Minnesota
Senior Director, Algorithms

Srinivas Sivaprakasam, PhD
Electrical Engineering
University of Kansas
VP of Hardware and NPI

Thomas Svantesson, PhD
Electrical Engineering
Chalmers University of Technology
Senior Principal Systems Engineer

Nadeem Akhtar, PhD
Mobile and Wireless Communications
University of Surrey
Staff Product Manager

Yatish Patel, PhD
Computer Science
University of California, Berkeley
Director of Engineering