Rhode Island Broadband Analysis

Foreword

In 2022, there is no doubt that access to reliable internet is necessary to work, learn, connect, receive healthcare, and participate in government. Connect Greater Newport – the economic development division of the Greater Newport Chamber of Commerce – has long recognized the importance of broadband to economic development and quality of life, but we have lacked good data about the reality on the ground.

To better understand the existing situation and help plan a path forward, with generous support from the van Beuren Charitable Foundation and the Rhode Island Office of Innovation, we retained Mission Broadband, Inc. and Reid Consulting Group to conduct an analysis of broadband availability in Rhode Island.

The findings are clear: there is a lack of available, adequate broadband (defined according to the new federal minimum standard of 100 Mbps download speed/20 Mbps upload speed) in Newport and Bristol counties, along with other regions in the state. The analysis comes at a critical moment. The federal government has and continues to invest significantly in broadband through the CARES Act, American Rescue Plan Act, and Infrastructure Investment and Jobs Act — which means funding is and will be available to states that want to improve broadband.

We have a very real opportunity and, as this report demonstrates, an urgent need to improve broadband in Rhode Island. We are pleased to share the results of this analysis with our members, public officials, and interested community members and look forward to working together on solutions.

We are grateful to Elizabeth Lynn of the van Beuren Charitable Foundation and Daniela Fairchild of the Office of Innovation for their many contributions, as well as to the additional members of the Greater Newport Broadband Coalition who provided guidance and counsel on this project: Jeff Diehl, Stuart Freiman, Scott Humphreys, Rhonda Mitchell, Elizabeth Tanner, and Matt Wainwright.

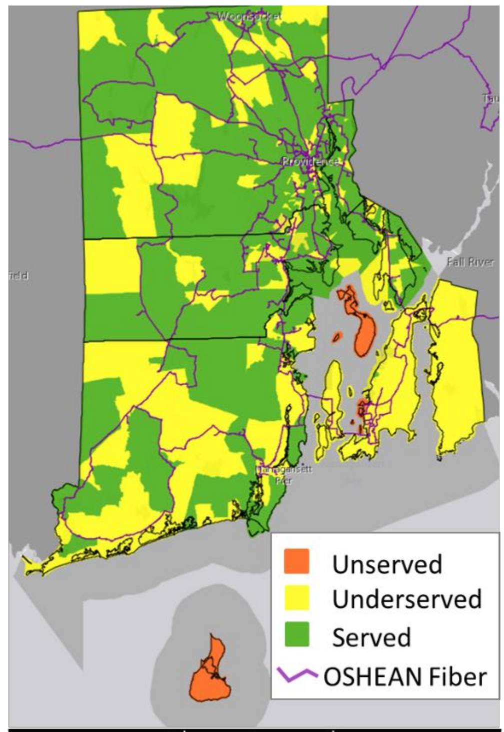
Erin Donovan-Boyle
Executive Director, Greater Newport Chamber of Commerce

Section 1: Executive Summary

Access to reliable high-speed internet has become essential to life in the digital age, central to economic development, education, healthcare and governance. While this reality has been known for years, the COVID-19 pandemic shined a spotlight on the importance of broadband access and the need to improve its impact. The first step in improving the impact of broadband relies on understanding the existing situation. To this end, Connect Greater Newport retained Mission Broadband, Inc. and Reid Consulting Group LLC to analyze broadband availability in Rhode Island. While this report focuses primarily on Newport and Bristol counties, much of the analysis was conducted statewide.

The findings of the study highlight the existing gaps to help focus broadband investment efforts. This report explains the methodology used to arrive at the following key observations.

- 42% of the populated square miles of the state remain unserved[1] or underserved[2] (Figure 1).
    - 134,000 households and small businesses do not have access to broadband that meets the federal definition of "served."[3]
    - Bristol and Newport counties are heavily impacted.
- American Community Survey research shows clearly that poverty and the lack of in-home internet are highly correlated, limiting the ability of the economically disadvantaged to thrive (Figure 2).
- Many small and medium businesses also face broadband capacity constraints impacting their businesses, including tourist-heavy locations such as the Newport waterfront. Large private businesses, institutions of higher education and U.S. Defense locations generally have access to dedicated, high-bandwidth, fiber-optic broadband.
- Greater Newport County and the State have available middle mile fiber resources which can be leveraged to assist in closing last mile gaps, including OSHEAN fiber (Figure 1).



Broadband Status	Populated Sq Miles	Households
Unserved	2%	2,800
Underserved	40%	131,000
Served	58%	307,000

Figure 1: Block-Group Based Analysis

[1] Unserved defined as speeds below 25 Mbps down and 3 Mbps up.
[2] Underserved defined as speeds below 100 Mbps down and 20 Mbps up but above the "unserved" threshold.
[3] Served defined as speeds equal to or above 100 Mbps down and 20 Mbps up.

Having a clear picture of where broadband access is strong and where it is lacking—and why—will be crucial to making the best use of existing and upcoming federal funding programs. Broadband is a complex issue, and access depends on many interrelated factors that involve individual households, government, and the private sector.

This report illuminates different aspects of the broadband landscape in Rhode Island. Future phases of work conducted by Connect Greater Newport will focus on how to close the gaps.

The work started with analysis and mapping of Ookla® Speedtest Intelligence® data , illustrating the on-the-ground experience of Rhode Island households and small businesses. 374,684 speed tests, conducted in RI between January 2020 and August 2021, measured both the download speed (how fast someone can receive information from the internet) and the upload speed (how fast someone can send information through the internet) for users at a specific point in time.

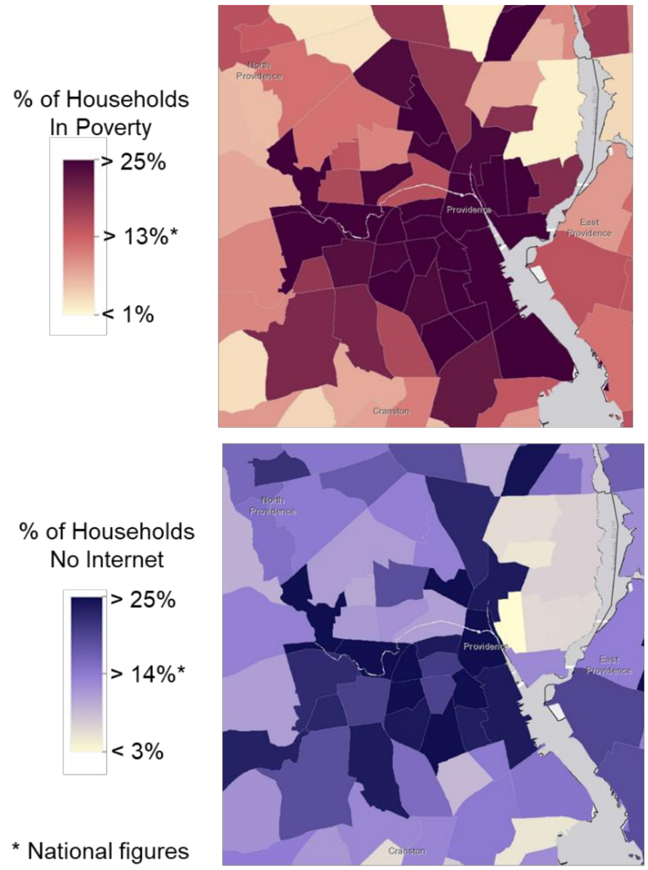


Figure 2: Poverty and Low Rate of Home Broadband

The team also integrated additional data sources to generate insights and create visual overlays, as described in *Section 3 (Methodology)*.

Current data shows there are sufficient broadband networks in many areas of the State to support economic development. In areas identified as lacking adequate and affordable broadband services, there is a risk to economic growth. These specific community areas will need more research to develop plans for increasing broadband services.

Section 2: Introduction to Key Concepts and Terms

To understand the body of this report, it is important to define a few key terms up front. Additional information is available in the *Glossary*, but the following concepts are essential.

Broadband

The term "broadband" has been widely adopted to replace the terms "internet" and "bandwidth," so when the term broadband is used, it is referring to high-speed access to the internet which includes World Wide Web (www)-based resources. The FCC currently considers speeds of 25 Mbps down and 3 Mbps up as the minimum for broadband, while the recent Federal Infrastructure Act increases that minimum to 100 Mbps down and 20 Mbps up.

Available and affordable broadband will have a positive economic impact on Rhode Island communities. Small and medium size businesses are affected when broadband services do not meet their needs. Slow internet, as well as cost prohibitive internet, limits these businesses' ability to sustain client interactions like point of sale transactions, video meetings, data file transfers, and other technology uses. Residential users access more broadband services every day. Remote education and remote work force are critical to today's economy. Aging-in-place as well as increasing telehealth services also rely on adequate broadband.

Affordability can impact residents' decision to have broadband in their homes. Less-populated areas of the state can gain residents by having robust broadband offerings, enhancing the local economies through increases in local spending, tax base, development of businesses and improved educational opportunities.

Ubiquitous affordable broadband has multiple positive effects on economic development:

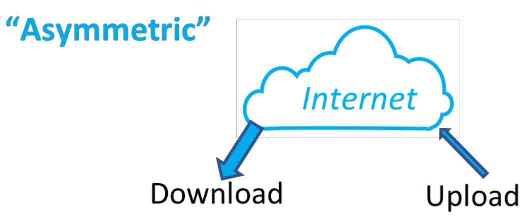
- Increases efficiencies in businesses.
- Provides greater workforce attraction and retention.
- Provides greater remote and virtual access to businesses and talent.
- Benefits the tourism industry.
- Allows the business community to better leverage the global economy.
- Helps in attracting new businesses and stimulating home-based businesses.
- Provides better options for remote training for organizations.
- Improves digital literacy skills over time, enabling a stronger workforce.
- Facilitates remote work and provides easier access to education and new job opportunities for workers.

Speeds

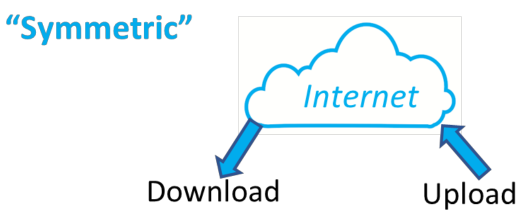
Broadband capacity (bandwidth) generally focuses on two key metrics: download and upload speeds, both quantified in bits per second. The connections may also be asymmetrical or symmetrical, and dedicated or best effort. Figure 3 illustrates the concepts described.

- The "download" speed is the transfer of data from the internet to a device, such as a computer or router.

- The "upload" speed is the transfer of data from a device, such as a computer or router, to the internet.
- A broadband connection is "asymmetrical" when the download and upload speeds are different. As an example, we often hear of "25/3" which means the broadband connection offers speeds of 25 million bits per second download and 3 million bits per second upload, abbreviated as 25 Mbps/3 Mbps or simply 25/3.
- A broadband connection is "symmetrical" when the download and upload speeds are the same, e.g. 25 Mbps download and 25 Mbps upload.
- A "dedicated" bandwidth broadband connection guarantees the promised download and upload speeds every minute of the day, analogous to having your own express lane on the highway.
- A "best effort" bandwidth broadband connection targets a promised speed but will vary in download and upload speeds based on traffic from other subscribers, analogous to the variability of a daily commute in a busy city.



- 25/3 = 25 Mbps down/5 Mbps up
- 100/20 = 100 Mbps down/20 Mbps up
- 1000/200 = 1 Gbps down/200 Mbps up



- 25/25 = 25 Mbps down/25 Mbps up
- 100/100 = 100 Mbps down/100 Mbps up
- 1000/1000 = 1 Gbps down/1 Gbps up

1,000,000 bits per second = 1 Mbps
1,000,000,000 bits per second = 1 Gbps

Figure 3: Broadband Speeds

Unserved, Underserved, and Served Designations

The definitions of what constitutes "unserved" and "underserved" speeds continues to evolve. In 2012, the FCC upgraded its definition, raising the bar to below 25/3 as "unserved" from the previous standard of 10/1. The home-based work and schooling brought on by the COVID-19 pandemic demonstrated the inadequacy of 25/3, particularly on the upload side of the equation. Recent guidance from the US Treasury and the Federal Infrastructure Investment & Jobs Act have raised that bar, defining broadband speeds below 100/20 as "underserved." For the purposes of this report, we adopt the more recent standards that define speeds below 25/3 as "unserved" and below 100/20 as "underserved."[4]

Fiber Optic Networks

Fiber optic networks transmit data via pulses of light using specialized, glass-based cables. Well-engineered, properly deployed fiber optic networks offer high performance, stability, and the ability to meet growing speed requirements for decades to come. The tiny strands of specialized glass, each one thinner than a human hair (Figure 4), have proven to have tremendous capacity. Today, fiber supports speeds as high as 400 billion bits per second in commercial operations, a 40-fold increase in just one decade.

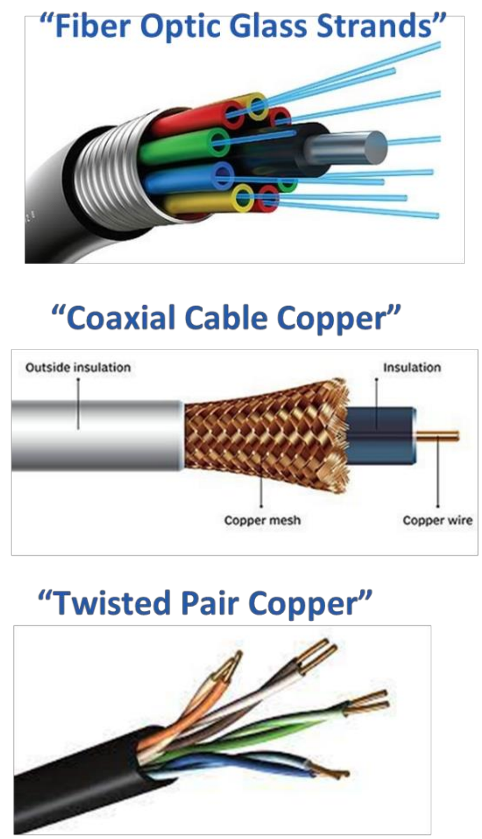


Figure 4: Physical Options for Broadband

Fiber optic networks have become the standard for new deployments due to longevity. While other technologies can cost less in the short term, over the useful life of the technology, fiber costs less to operate and maintain. Thus, fiber-to-the-premise has become the preferred solution in all but the lowest population density areas. Industry trends indicate that the future for Rhode Island broadband rests in fiber-to-the-premise networks that will support expanding requirements for decades to come.

Broadband fiber infrastructure generally falls into three broad categories: backbone, middle mile and last mile, defined as follows.

- "Backbone" fiber extends across continents and under the oceans to connect major hubs called internet exchanges where so-called Tier 1 global networks exchange internet traffic. These backbone networks are generally privately owned and operated by large telecommunications companies.
- "Middle Mile" fiber connects to the internet backbone and extends infrastructure into cities and towns. In Rhode Island, there are multiple middle mile networks.
    - "Closed" middle mile networks are owned and operated by telecommunications companies and are considered "closed" because those companies do not readily provide access to competing providers, nor do they publicly share where their fiber is located.
    - "Open" middle mile networks may be owned and operated by a non-profit, governmental entity or a private company. The Ocean State Higher Education Economic Development and

[4] It is important to note that new federal legislation requires projects undertaken with federal funding to reach speeds of 100/100 Mbps. While this threshold has not been adopted across the board, it is safe to assume that the federal government is signaling their future intentions with these requirements.

Administrative Network (OSHEAN) is an example of an open middle mile network. Generally open networks allow multiple competing entities to utilize their fiber under equitable terms and conditions. Open middle mile providers also generally make their fiber routes public.

- "Last Mile" fiber extends the internet connection from the middle mile into homes, businesses, or community anchor institutions. In today's deployments, last mile connections generally can operate at speeds up to ten billion bits per second (10 Gbps). Upgrades to electronics can expand those speeds to 400 Gbps with technology available today. Last mile fiber is typically owned by the internet service provider although, in a growing number of cases, municipal governments, electrical utilities, and non-profit cooperatives are building last mile networks either to deploy their own services or to lease that capacity to internet service providers.

Cable Modem Networks

Most cable television operators have adapted their networks to deliver broadband. Generally, these cable television broadband networks operate on a hybrid fiber-in-the-neighborhood and coaxial-cable-to-the-premise (Figure 4) infrastructure. Cable modem networks utilize the Data Over Cable Interface Specification (DOCSIS) technology to deliver broadband services. Although recent versions of DOCSIS offer improved speeds, broadband services via cable modem remain constrained, particularly for upload capacity. In many Rhode Island communities, cable technologies represent the highest-speed last mile service available. Although the majority of the underserved areas of Rhode Island have cable modem services available, these services often fail to maintain upload speeds that meet the 20 Mbps threshold for being considered "served." As demand for symmetrical services continues to build, the cable modem approach is likely to fall further behind.

Satellite

Satellite technology, both high earth orbit and low earth orbit, can deliver broadband in areas with no other options; however, the service has significant limitations compared to terrestrial solutions. High earth orbit connections suffer from high latency[5], limited capacity, and interference from local weather and foliage. Low earth orbit satellite service can deliver high speeds with reasonable latency, but it still faces significant issues with foliage and does not scale well.

DSL Networks

Digital Subscribe Line (DSL) networks were the first to offer broadband. While the underlying, landline telephone technology of DSL remains solid, the twisted-pair copper cables (Figure 4) on which it relies have, in nearly all cases, exceeded their useful life. This outdated twisted-pair copper was first deployed in the 1940s and 1950s to provide telephone services and was later re-purposed for broadband. Today, DSL

[5] Latency is the time in milliseconds it takes for data to travel from the user's location to its destination and back. The higher the latency, the more perceived delay there is for an end user. Real-time applications like video conferencing, gaming, and virtual reality require low latency to function acceptably. Fiber networks typically have the lowest latency (10-15 ms) while high earth orbit satellites have the highest, often exceeding 300-500 ms.

services are often the worst performers of the broadband options available in a service area due to the aged infrastructure.

Digital Equity

"Digital Equity" refers to making sure that all citizens can benefit from and contribute to the economic, education, and healthcare benefits enabled by ubiquitous broadband. As an example, Figure 2 (see page 3) highlights the impact of poverty on home broadband adoption. Digital equity generally addresses four key elements:

a. Availability: Is broadband truly available in a particular area?

b. Affordability: Can residents and businesses afford the service? Do broadband providers offer a low-cost package that meets today's bandwidth requirements?

c. Reliability: Does the service deliver as promised? Are the speeds and coverage adequate based on the users' needs in any particular area? Are outages promptly resolved?

d. Adoption: Do residents and businesses have devices and digital literacy needed to utilize the service?

Section 3: Methodology

Broadband availability mapping accuracy continues to be a contentious issue. Historically, the FCC accepted information it received from carriers as fact with no independent verification. Concerted efforts by consumer advocates and third-party verifiers around the country have since proven FCC broadband coverage maps to be highly inaccurate, dramatically overstating the availability of both fixed and mobile broadband services.

The U.S. Congress, in reaction to the overstatements in broadband availability by the FCC, passed legislation in 2019 directing the FCC to generate more accurate maps. The FCC is working to improve its maps with a target date of June 2022; however, the process is ongoing and will likely be subject to challenges by states and carriers. It will be crucial for every state to prepare to participate in this process, as the updated FCC maps will determine allocations of federal funding.

Because of this, states and others have conducted their own mapping. Rhode Island did this during the Broadband Rhode Island era (2010-2015); however, that effort was last updated in 2015. The Reid Consulting Group (RCG) has formulated a well-refined approach to identify broadband realities by melding multiple data sources to reveal the true extent of the digital desert. This report leverages RCG's methodology to create a current assessment of Rhode Island's broadband landscape.

Data Sources

The team integrated multiple data sources to generate insights and create visual overlays, including:

- Ookla® Speedtest Intelligence® records from consumer-initiated measurements.
- Dun & Bradstreet (D&B) business data, which provides addresses of businesses as well as their size and industry.
- Low-income housing locations.
- E-911 data, which show all household addresses in Rhode Island (but not the number of residents).
- U.S. Census data for population counts and area of blocks.
- Federal Communications Commission (FCC) Form 477 records, which describe the availability of internet speeds as reported by all internet Service Providers (ISPs).
- Pew American Community Survey (ACS) findings on rates of poverty and home broadband connectivity.
- FCC Emergency Broadband Benefit (EBB) enrollment, showing where residents have opted into the federal broadband subsidy.
- OSHEAN fiber location data from 2015

These data sources provide key insights into the broadband landscape in Rhode Island. Additional sources of data will further deepen the analysis in future phases.

Ookla Speedtest Intelligence® Analysis

Consumer-initiated speed tests are an excellent way to establish truth-on-the-ground regarding broadband availability. Reid Consulting Group has found Ookla Speedtest Intelligence® to be the richest source of speed test data available, as Ookla is by far the dominant speed test company. Their software and website are the top results when consumers search for speed tests on the web, social media, and on platform-specific app stores.

The speed test analysis in this study looks at fixed broadband services only, as mobile/cellular data availability and speeds can differ significantly from the fixed broadband services that most households and businesses use. Figure 5 (below) illustrates the analytical flow applied to the speed test data and its combination with other sources of information.

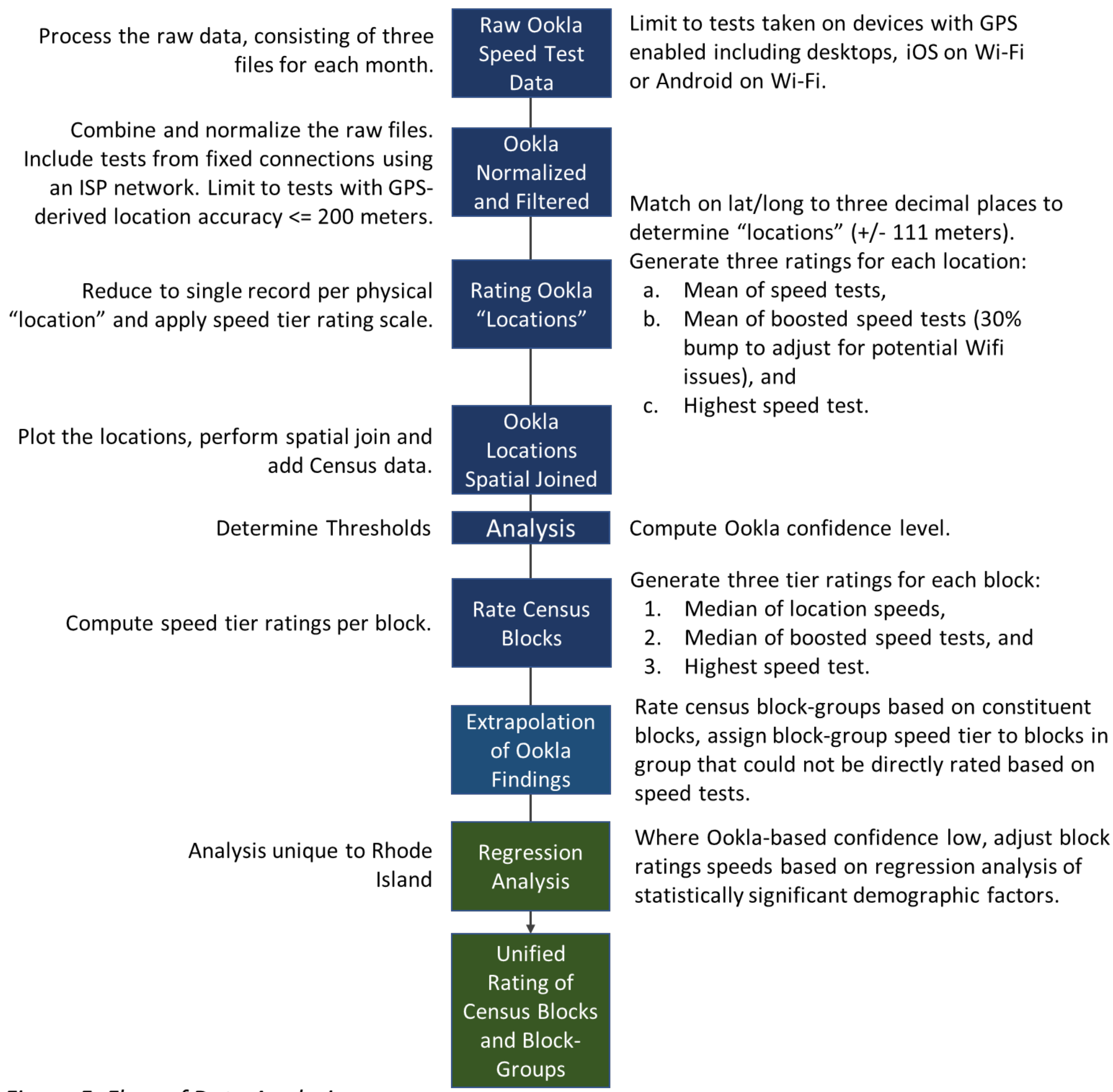


Figure 5: Flow of Data Analysis

Mobile device results (phones, tablets, etc.) are included only if the device reported being connected to Wi-Fi during the test. 4G/LTE/5G mobile data availability is a separate issue and is beyond the scope of this phase of the project.

Before analyzing the raw Ookla® data, we applied location accuracy filters to ensure that the final maps would reflect on-the-ground realities.

While the circumstances of any given test can vary widely, the sheer volume of data (374,000+ results at 39,000 separate locations between January 2020 and August 2021) enables the use of statistical analysis to project broadband speeds across Rhode Island. In many cases, each location contains multiple households because the Ookla data provides three decimal places of latitude and longitude. This level of precision translates roughly to a circle with a diameter of 111 yards. Figure 6 illustrates the average speeds measured at these 39,000 “locations.”

Using the filtered Ookla® results, we rated each 111 x 111 meter location based on the average up/down speed for all tests at that location (Figure 6). We then graded census blocks based on the median up/down speed of all locations within each block. Block group ratings then were calculated based on their constituent blocks.

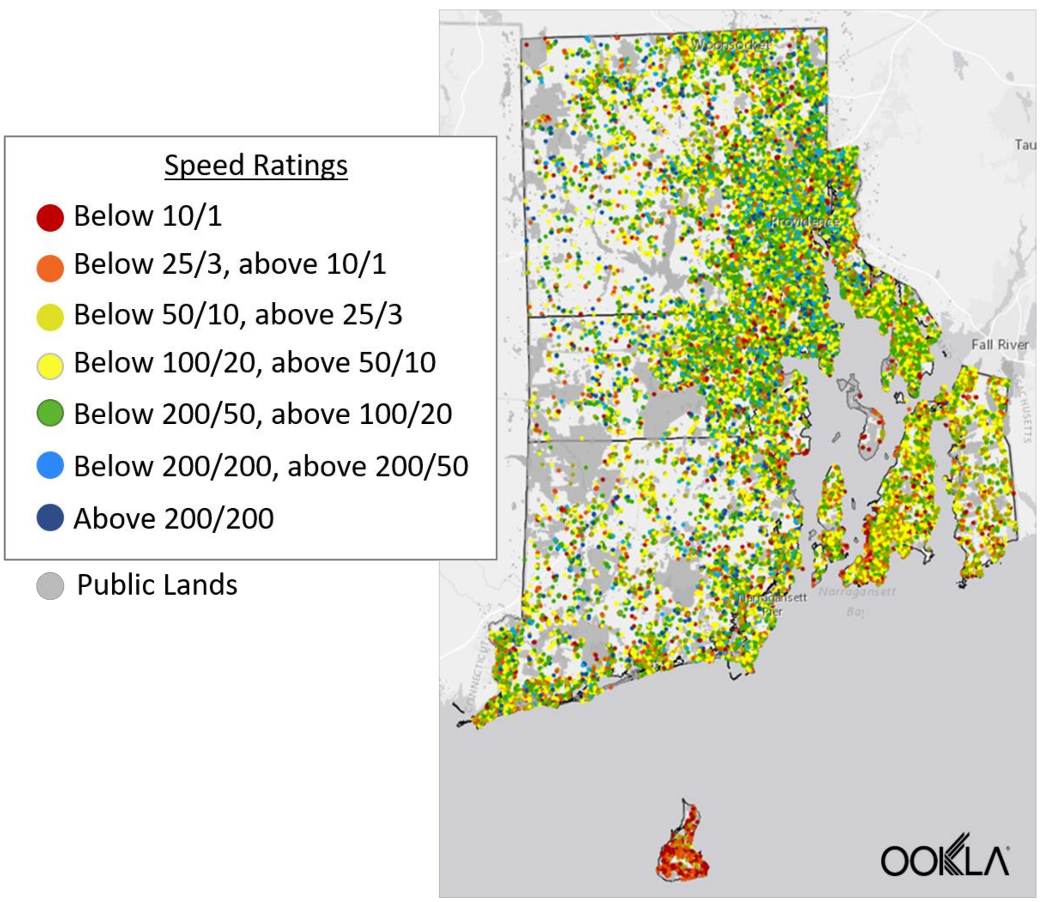


Figure 6: Rated “Locations”

Moving down to the individual census block level, we were able to rate the blocks containing 86% of the households (Figure 7). Yet only 56% of the total number of blocks could be directly rated and nearly half of those contain just a single "location."[6] For blocks with no test results, ratings from block groups were used and then adjusted based on regression analysis with further refinement based on population density and minority composition[7]. These two characteristics were the only attributes that offered statistically valid extrapolation.

Total Ookla Speedtests	**374,000**
Aggregated "Locations"	39,000
Ratable Blocks	**14,000** 56% of blocks 84% of square miles 86% of households
Only 1 Location	47% of the rated blocks
Ratable block-groups	**100%**
Fewer than 10 locations	3% of rated block-groups

Figure 7: Summary of Ookla Speedtest Intelligence Data

At the block group level, enough data was available for a statistically valid rating of all census block-groups in the state with only 3% of those block-groups having fewer than 10 "locations" (Figure 7).

While the block-level results (Figure 8) are compelling, this report recommends focusing on block-group ratings (see Section 5: Key Findings) due to their higher degree of statistical validity. Additional analysis and testing are recommended if block-level results are to be used. Promoting speed testing in under-represented areas could allow for a higher level of confidence at the individual block level in the future.

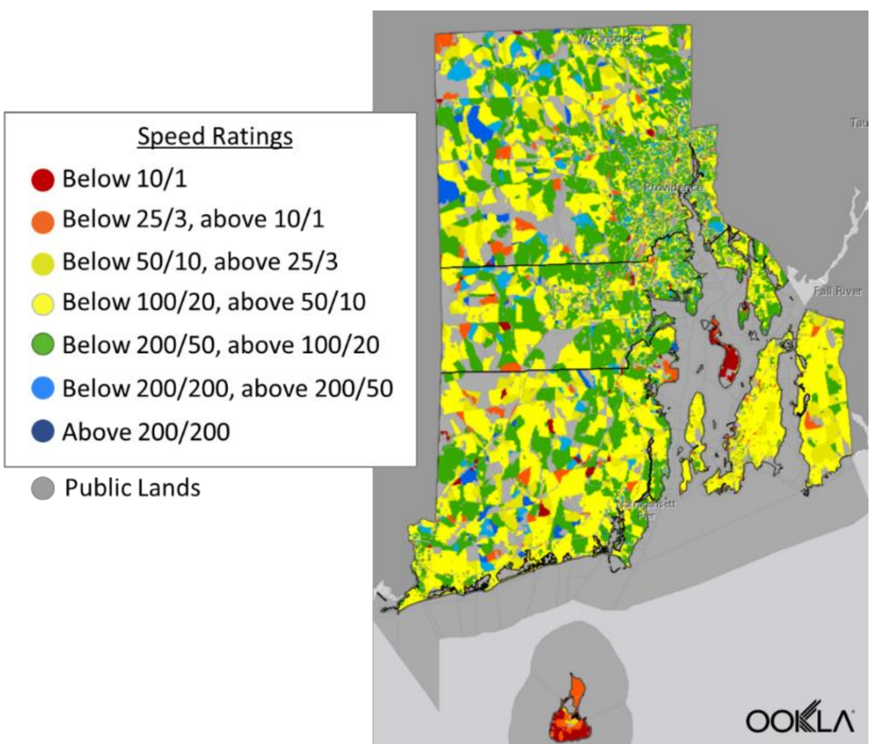


Figure 8: Block-Level Results

[6] If a census block is smaller than Ookla's 111 meter location threshold, then all tests in that block will appear to come from a single location. This effect is most common in densely populated, urban locations.
[7] Lower population density correlates with lower speeds; higher minority household counts correlate with higher speeds.

Critics of speed test data often attribute poor results to consumers choosing lower speed subscriptions or conducting tests on misconfigured or low quality residential equipment. While these are valid concerns, independent market analysis indicates that consumer choice is not the primary determining factor for low-speed results. Reports compiled by the National Rural Electric Cooperative Association (NRECA) from successful rural electric cooperative broadband deployments around the country find that fully one-third of rural households subscribe to the highest speed available to them, mirroring demand in urban areas.

Thus, any truly served populated area should show a mix of high and low speeds. If an area contains no higher tier speed results, the preponderance of evidence demonstrates that higher speeds simply are not available. Likewise, it is unlikely that every single household in an area with uniformly poor speed test results is using faulty equipment.

Business Opportunity Index

To provide insight into business need for broadband, Dun & Bradstreet business data was used to plot the locations of reported businesses in Bristol, Kent, Newport, and Providence Counties (data was not available for Washington at the time of analysis). Each business location was assigned a “broadband opportunity index” by multiplying the number of employees at that location (as reported in Dun & Bradstreet) by a broadband utilization factor between 1 and 5 based on the industry sector of that business. The larger the opportunity index, the larger that business' point appears on the map. This visual analysis facilitates quick identification of business locations and corridors that may need significant bandwidth. Figure 9 shows an example of this approach.

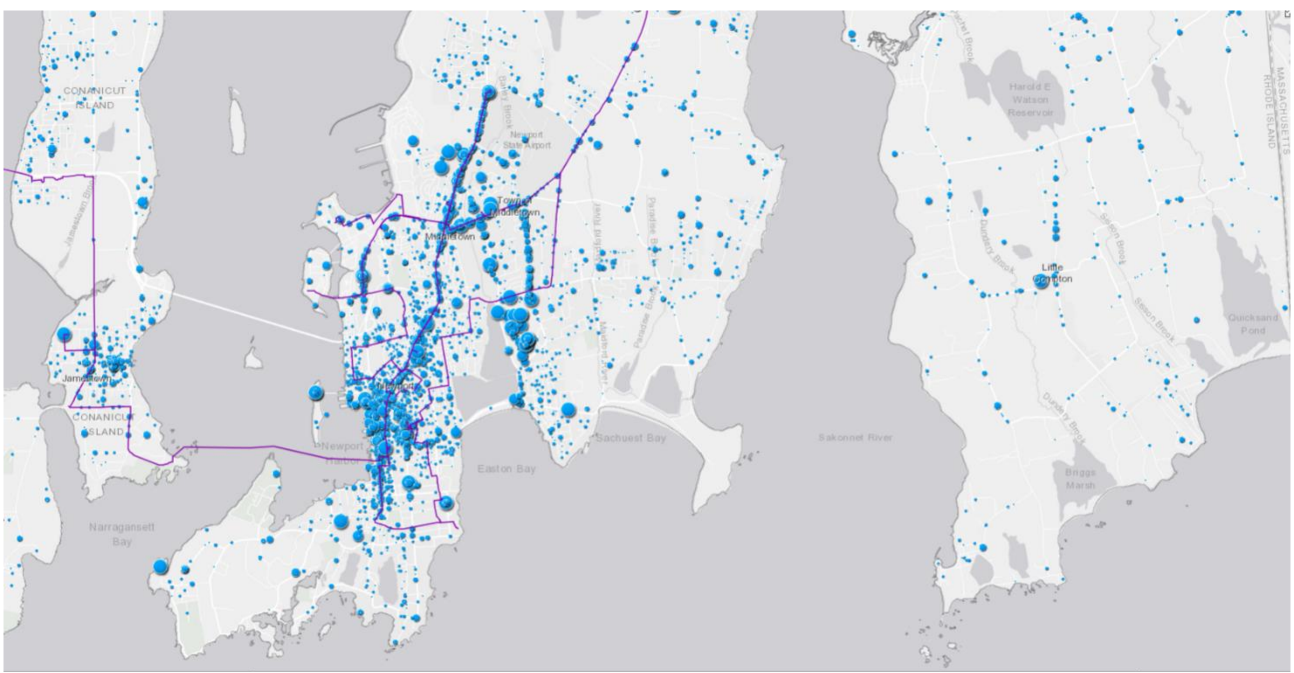


Figure 9: Example of business broadband opportunity index map

Section 4: Overview of Bandwidth Utilization within the Broadband Industry

Projecting Requirements for the Long-Term

Figure 10 shows how residential/small business broadband speeds have increased tenfold every decade from the beginning of the World Wide Web in 1990 through the present day. Rapidly evolving applications will continue to drive higher bandwidth requirements, so this trend is likely to continue for the foreseeable future.

Given that broadband deployments are long-term infrastructure projects, meeting the needs of the next three decades will require careful attention to future speed requirements.

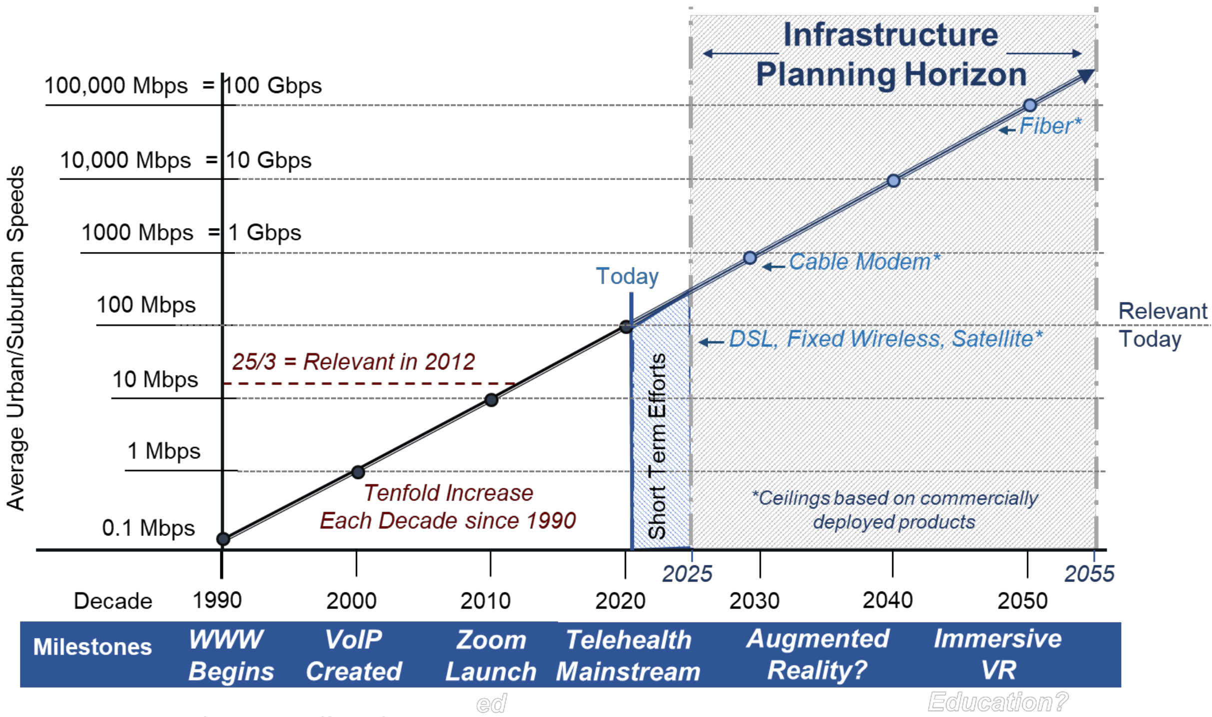


Figure 10: Growth in Broadband Requirements

Only thirty years ago, a 56 Kbps dialup connection was the most common way of connecting to the internet. By 2012, the average speed had risen to 25 Mbps, nearly 500 times faster than a 1990 modem connection. Today's 100 Mbps average speed is almost 2,000 times faster than that original 56 Kbps dial-up connection. While the demand curve may become less steep in the coming decades, we certainly can expect average speeds to reach 1 Gbps by 2030 with continued increases through the end of the planning horizon in 2055.

Historically, residential and commercial broadband usage followed a downstream consumption model where files, content, and streaming media were downloaded to the premises, consumed locally, and deleted. The need to transmit large quantities of data from an individual location or device to the internet was rare, so download speed was considered more important than upload speed. Today that is no longer the case. Remote work, online schooling, and telehealth, combined with social media and other emerging platforms that embed real time interactive voice and video services has made upstream capacity as important as downstream.[8]

Video

The amount of video traffic being uploaded and downloaded on the internet is staggering. This content includes streaming services like Netflix, Amazon Prime Video, and YouTube as well as a plethora of applications that support real time video interaction on traditional and mobile devices like FaceTime, Skype, WebEx, and Zoom. Streaming video already accounts for a high percentage of traffic on ISP networks. As higher quality digital video formats like 4K become more common, faster speeds will be needed. For example, a single 4K video stream requires up to 25 Mbps for seamless playback.

Online education, telemedicine, and telepsychiatry as well as remote work and local government participation all depend on two-way, real time video services. Unlike streaming media where content is downloaded and consumed locally, two-way real time video involves uploading just as much content as is downloaded. Thus, a symmetrical connection with robust upload speeds is necessary for effective online interactions. Even a 25/25 Mbps connection is much more capable than the current FCC standard of 25/3. Personal and commercial use of two-way, real time video services will continue to rise, requiring increased speed and reliability with a greater dependance on upstream capacity. This significant uptick in the use of real-time two-way video places greater importance on the upload speeds available to businesses and consumers.

Transferring High-Capacity Files

Many businesses who operate partially or fully online require high speed, reliable bandwidth to create and publish high density content to the internet or to store and retrieve this content on corporate or cloud servers. Data gathering sessions with the workgroup sectors brought to light several stories from small business owners. One issue outlined was the need to do certain types of their work at home that required the transfer of large files from the business to the internet because the connection at the business was simply not fast enough to do the transfer in a reasonable amount of time.

Migration to the Cloud

Over the past ten years, many business applications that have traditionally run on-premise have moved to cloud-based hosting and service models. Software as a Service (SaaS) has become the predominant business model for major application and software providers such as Microsoft (Office365), Google (Gmail, Google Docs, etc.), and many other firms. Additionally, there are many options for cloud-based software for traditional business functions and services such as HR, Accounting, Inventory, and Customer Service. Cloud services can provide many benefits to businesses and consumers over reliable high-speed internet connections.

Residential Usage

[8] It's also important to note that this demand curve also will mean an overall increase in the total capacity needed for broadband networks - not just speed, but quantity of data transferred.

Residential usage of bandwidth will continue to accelerate. In addition to the residential uses of bandwidth mentioned above, consumers will increasingly use the Internet of Things (IoT) to allow in-home monitoring of virtually any system as well as video cameras capturing home video footage and storing it in the cloud. Some studies estimate that as high as 80% of teenagers and young adults watch or participate in online gaming activities. Gaming presents a unique challenge to broadband providers, because unlike video content, gaming data cannot be cached. The amount of real-time data that must be passed upstream and downstream during a gaming session requires a very robust connection. Residential use also can require broadband for K-12 homework in addition to high school and college online classes.

Throughout the pandemic, it has become evident that affordable and reliable broadband access has become a critical requirement for every community and every citizen across the nation. According to a May 4, 2021 Axios news story,[9] broadband usage increased over 40% during the COVID-19 pandemic, and there is no indication that the level of consumption is going to slow down. The ability to work remotely and receive services such as telehealth, telepsychiatry, and education is transforming the way people live. Robust internet availability is now a factor in home buying. In many regions the digital divide between the haves and have nots is attributable as much to geography in our current environment as socioeconomics.

Emerging Applications and Technologies

Many emerging applications and technologies will require reliable high-speed broadband connections in order to work effectively. Technologies such as Augmented Reality (AR) and Virtual Reality (VR) have the potential to revolutionize teaching and learning models, providing a new level of experiential learning for students from all walks of life. Artificial Intelligence (AI) promises to transform almost every industry, including healthcare (diagnosis, treatments), automotive (autonomous driving), manufacturing (robot assembly), and retail (purchasing assistance). AI technologies are becoming more mainstream and will increasingly be embedded in underlying technologies and systems. Accelerations in the fields of robotics and new technologies like 3D and 4D printing make it clear that some of the technologies being developed will simply not work on existing broadband infrastructure in many parts of the country.

Smart City

A smart city is a city that has digital technology embedded across all its functions to connect, protect, and enhance the lives of citizens. IoT sensors, video cameras, social media, and other inputs act as a nervous system that provides the city operator and citizens with constant feedback so they can make informed decisions. A smart city collects and analyzes data from these IoT sensors and video cameras so that the city operator can decide how and when to take action. Some actions can be performed automatically; however, these innovations and applications depend on access to broadband technology. Smart city technologies include: (1) Smart utility meters attached to buildings and connected to a smart energy grid allowing the utility company to manage energy flow more effectively and to track users' energy consumption; (2) Smart transportation devices to ease traffic pain points and prevent car-related accidents and deaths; (3) Smart grids to help with resource conservation; (4) Smart waste management solutions to monitor how full trash cans are at a given point, send that data to waste management companies, and provide the best waste

[9]Fischer, S. and Harding McGill, M. (2021, May 4). Broadband usage will keep growing post-pandemic. *Axios*. https://www.axios.com/broadband-usage-post-pandemic-increase-32d0858b-9f54-4065-aa9b-b1716dcf6c2f.html

pick-up routes; and (5) Smart air quality sensors to monitor indoor air quality (IAQ), detect pollutants, and inform users via an indicator light or push notifications to one's smartphone or tablet. All of these innovative applications depend on broadband technology to work.

Section 5: Key Findings

Key Finding #1: While much of Rhode Island has access to broadband, under the latest Federal standard half of the populated square miles of the state remain unserved or underserved.

- This means that roughly 130,000 households and small businesses remain without access to broadband that meets the federal definition of served.
- Small businesses on the Newport waterfront and other tourist-heavy locations are underserved for broadband.
- Bristol, Newport, and Washington counties remain poorly connected compared to the rest of the state.

To aid in visualizing availability (Figure 11), block groups have been color coded to reflect their unified speed ratings as calculated by Reid Consulting Group. Areas with speeds below the federal threshold for unserved are shown in orange (below 25/3) and areas below the federal 100/20 threshold for underserved are shown in yellow. Green and blue are used to identify areas with higher speeds. OSHEAN's fiber network has been overlaid to give a sense of middle-mile availability. Upload speeds were the limiting factor in the ratings in many areas of the state.

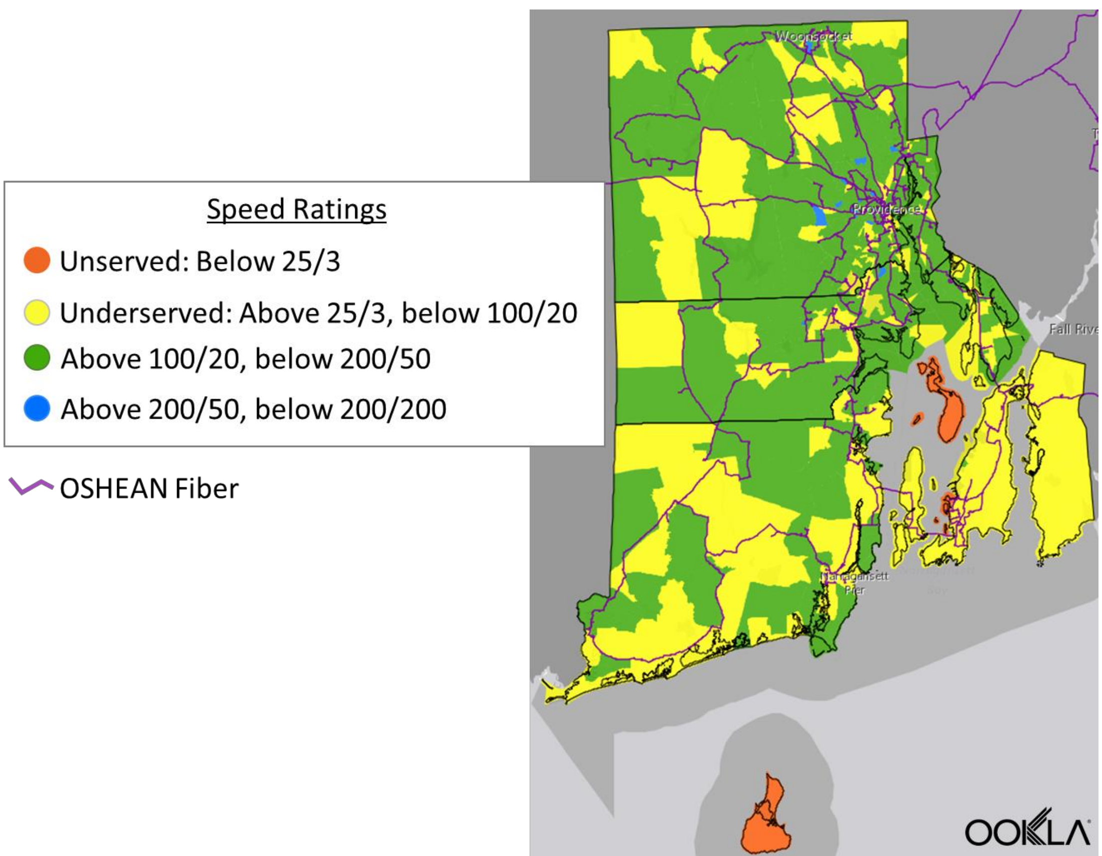


Figure 11: Block-Group Level Results

Geographic Differences

The discrepancies from area to area are easy to see when zooming in to examine two areas in more detail. The experience of subscribers in the Newport area is significantly degraded compared to subscribers in the Providence area (Figure 12). Although both areas are served by the same cable provider, speeds are consistently higher in Providence. Also, Providence users have affordable, high-performance alternatives to cable service that are not available in the greater Newport area. For example, Verizon offers 200/200 Mbps service for $40/month in Providence. This option is not available in Newport.

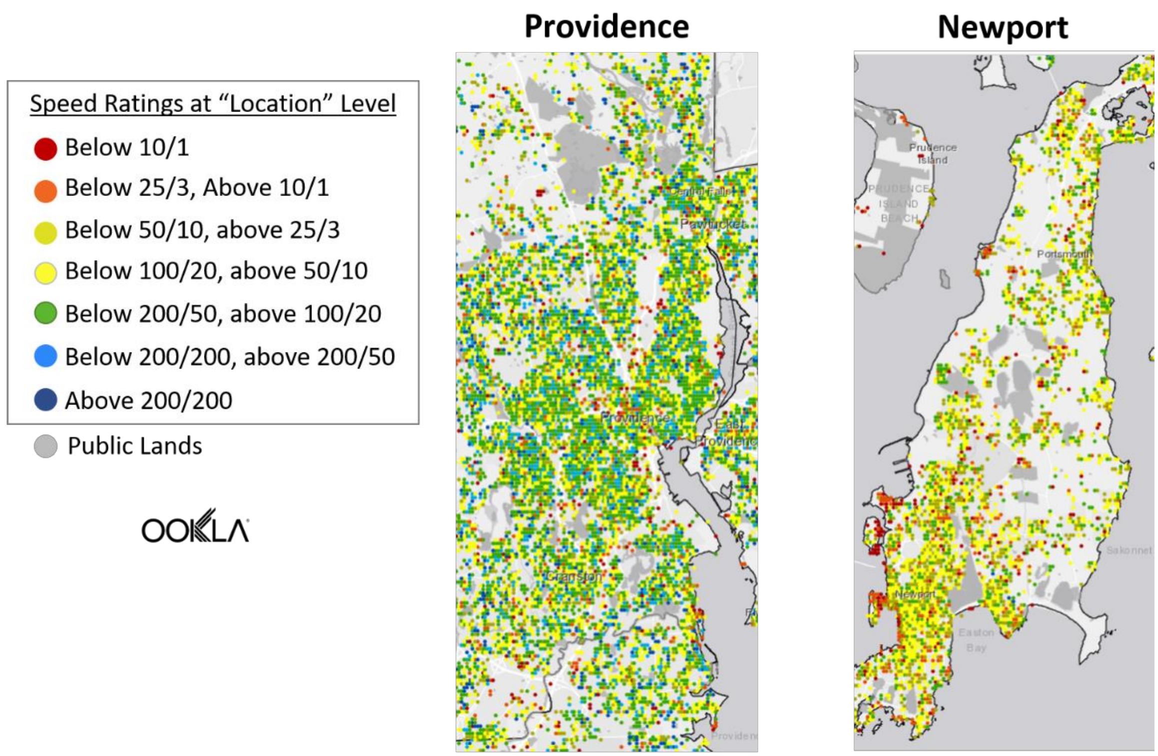


Figure 12: Performance Contrast Between Providence and Newport

Key Finding #2: American Community Survey research shows clearly that poverty and the lack of in-home internet are correlated, limiting the ability of the economically disadvantaged to thrive.

Figure 13 shows an area of Providence that highlights this correlation quite well.

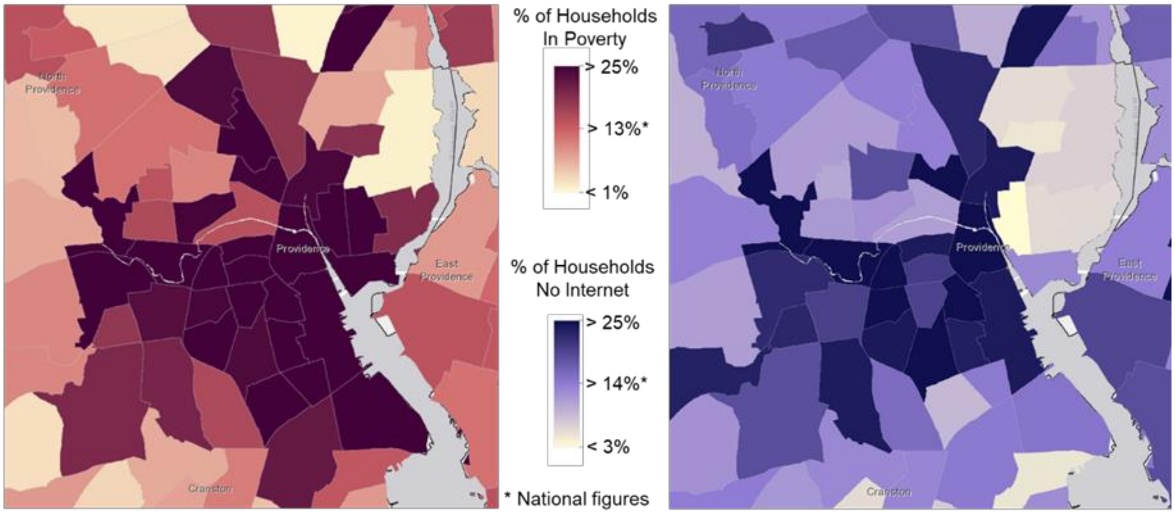


Figure 13: Correlation of Poverty and Low Percentage of Home Internet

Monthly broadband costs can be prohibitive for low-income households, further diminishing the residents' prospects for economic uplift. Figure 14 illustrates that many subsidized housing areas also fall into unserved and underserved areas, relegating these families to poor performance broadband if they can afford it at all.

The analysis also studied enrollment in the 2021 Federal Emergency Broadband Benefit (EBB). Enrollment figures tend to align with low-income housing locations, though those enrollments also mirror population density.

The EBB, enacted in February 2021 as a response to the COVID-19 pandemic, provides up a discount of up to $50/month (shifting to $30/month as of January 1, 2022) for a monthly internet or cell phone data plan.

This program is not a structural solution to access, yet maximizing the use of the EBB would help.

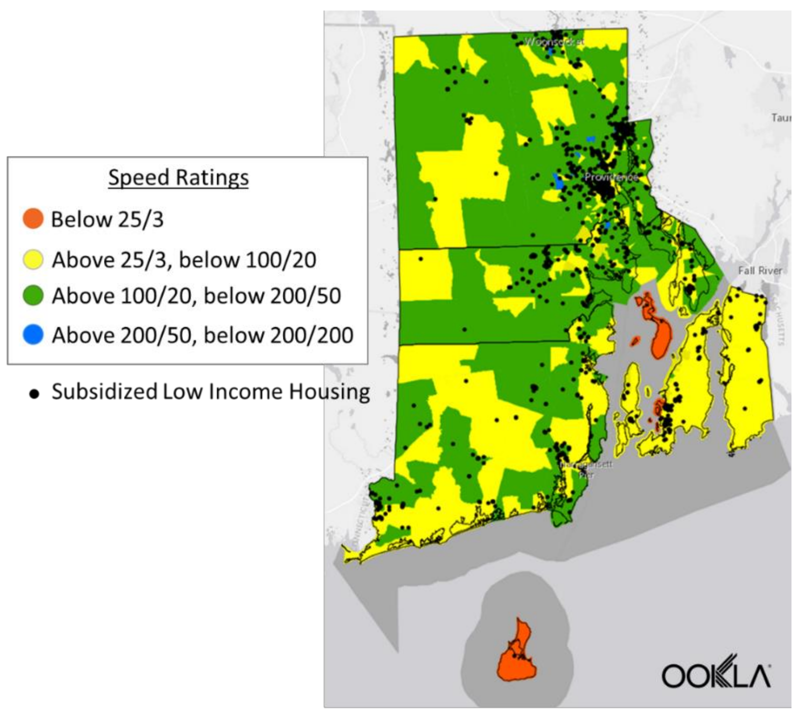


Figure 14: Low Income Housing Locations

Key Finding #3: Small and medium businesses face significant broadband limitations in unserved and underserved areas of the state.

Figure 15 highlights the reality faced by small and medium businesses in the Newport area, with all of the business located in areas where broadband services remain limited. Due to significant capital and operational investments (and in some cases access to OSHEAN middle-mile), private businesses, institutes of higher education, and U.S. Defense locations generally have access to high-bandwidth, fiber-optic broadband technology. In contrast, small and medium businesses generally operate over the same networks as residential subscribers. We can thus project that small and medium business located in unserved/underserved residential areas are also unserved/underserved. Continued research is needed to examine affordability issues for small and medium-sized businesses along with the economic impacts.

In the featured area, we also learned that small businesses on the Newport waterfront and other tourist-heavy locations rely on insufficient broadband capabilities, impacting tourism.

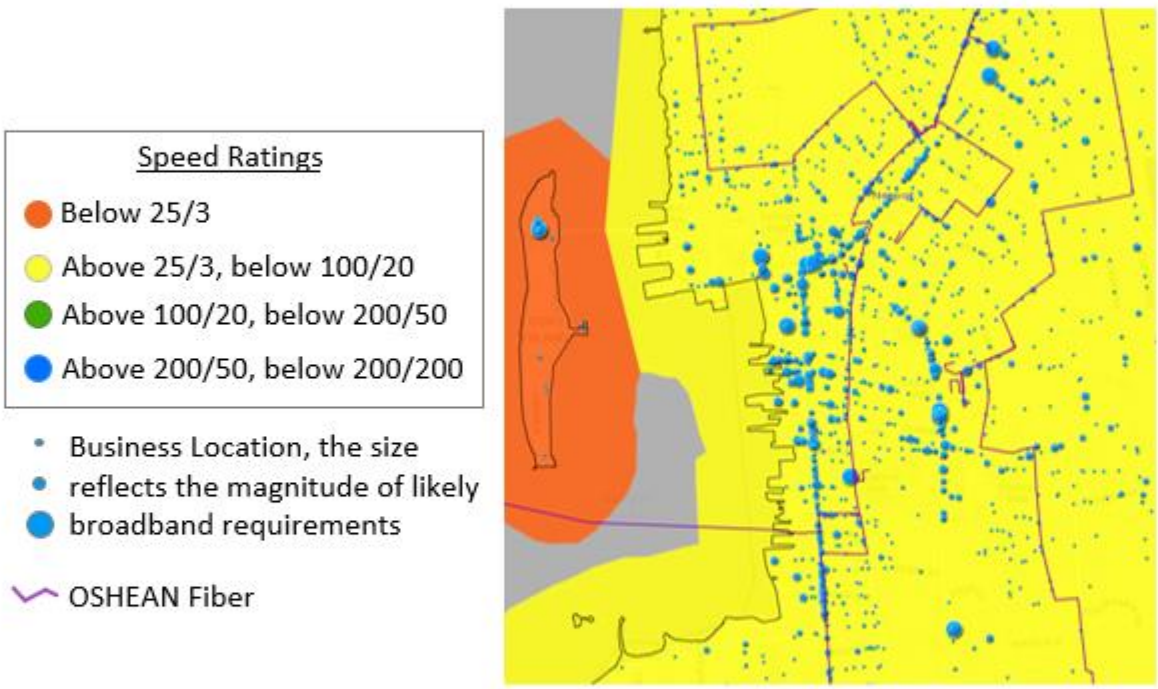


Figure 15: Business Requirements

In Figure 15, business locations are identified by blue dots with OSHEAN middle-mile fiber routes overlaid in purple. Each dot is sized based on a calculated opportunity index that takes into account the number of employees at that location and the relative broadband demand for that business industry sector. The larger the dot, the more bandwidth that business is likely to need. For example, a medical clinic with 50 employees will need more internet capacity than a construction contractor with the same number of employees, since many of the contractor's employees are likely to spend much of their time in the field.

Key Finding #4: Greater Newport and the State have available middle mile fiber resources which can be leveraged to assist in closing last mile gaps, the most predominant being the Beacon 2.0 network operated by OSHEAN.

Rhode Island has multiple assets available to leverage broadband expansion:

- OSHEAN, Inc. (Ocean State Higher Education Economic Development and Administrative Network) has available middle mile fiber throughout the region and the state. While dedicated OSHEAN fiber connections provide extremely high speeds, those connections are only available at participating non-profit anchor institutions. However, the OSHEAN fiber assets do remain available for broadband providers to lease capacity to expand capacity for residential and business uses.

- Cox, Verizon and other private companies own and operate middle mile fiber to support their various broadband and mobile services. Unfortunately, for competitive and security reasons, companies do not share their fiber route maps with the public. Nonetheless, in a public-private partnership, these private companies could leverage their existing fiber assets to improve broadband services.

- The Rhode Island Department of Transportation (RIDOT), the Rhode Island Public Transit Authority (RIPTA), and other public entities have available fiber which may be used to middle mile infrastructure solutions. These department fiber routes include crossing bridges in Bristol and Newport counties which will allow last mile service provider to utilize these fibers in order to gain access to upstream internet infrastructure.

Section 6: Recommended Next Steps

The analysis of data guides the suggested next steps, outlined below.

1. Convene state and local leadership to explore this data, deepen their understanding of conditions on the ground, and develop efficient and coordinated paths toward leveraging federal funding for local solutions in underserved and unserved regions. Engage the public. Share the findings of this report with the public, conduct surveys of residential consumers and small businesses to deepen available information, engage in public forums, and promote speed tests to enhance data.

   Infrastructure investments require careful planning. In a state the size of Rhode Island, it will also require coordination among local and state government and the private sector. As the need for ubiquitous broadband has been made more apparent, a variety of new funding sources have become available including:

   - Approximately $1.1 billion in Coronavirus State and Local Fiscal Recovery Funds (CSFRF / CLFRF, or Fiscal Recovery Funds) were made available in 2021. Broadband is one of the approved spends for Fiscal Recovery Funds under the American Rescue Plan Act (ARPA).
   - In 2021, the U.S. Department of the Treasury authorized the Coronavirus Capital Projects Fund. This fund includes potential allocations of approximately $112 million for broadband expansion in Rhode Island.
   - On November 5, 2021, the Federal government passed the Infrastructure Investment and Jobs Act, which authorizes $65 billion in broadband funding: $42.5 billion for broadband deployment, $14 billion in subsidies for low-income consumers to connect to broadband, $1 billion for middle mile investments, and $2.75 billion for the Digital Equity Act. This bill aims to help lower the price households pay for internet service by requiring federal funding recipients to offer a low-cost affordable plan, by creating price transparency, and by boosting competition in areas where existing providers aren't providing adequate service. It also creates a permanent federal program to help more low-income households access the internet. During the first round, Rhode Island is expected to receive at least $100 million.

2. Perform additional analysis to guide action planning.

   This report provides key insights into the current state of broadband in Rhode Island and highlights the complexity of broadband challenges. Additional data and more granular analysis are needed in order to weigh different options. We suggest that actors in Rhode Island:

   - Prepare the state to challenge FCC maps by encouraging more speed tests and by exploring other sources of broadband performance map data. This should be key step in maximizing Rhode Island's share of federal funding.
   - Explore digital equity for regions and the state as it relates to inclusion, literacy, and available resources including computing devices in the home.
   - Consider extending speed-test analysis to mobile services to identify potential synergies between fixed and mobile broadband infrastructure.

  - Map additional fiber resources like the Rhode Island Department of Transportation's fiber routes, local towns which have installed fiber infrastructure, and internet Service Providers (ISPs) planning expansions.

3. Focus on targeted needs to make an impact. The analysis done to date highlights key areas for improvement. For example:

   - Investigate options and implement a solution for improving fixed and mobile broadband services in areas with high tourism, an issue that is particularly acute in Newport.

   - Cities and towns in Bristol and Newport counties should engage existing ISPs and middle-mile providers to discuss options for improving performance, increasing availability, and addressing affordability. As a result of federal funding guidelines, towns and counties have the opportunity to apply for federal funding through the state to deploy new solutions This federal funding can be utilized for public-private partnerships with existing service providers. This service provider engagement should be scheduled in January of 2022 to prepare for grant funding at a state and federal level.

   - As the state determines the availability of broadband subsidy allocations, issue a Request for Qualification (RFQ) or Request for Proposal (RFP) to solicit interested vendors and technologies to address the needs in target areas. Initiate this process in January of 2022 with an estimated completion timeframe of April 2022 to prepare for upcoming state and federal grant allocations. Bristol and Newport counties can take the lead on a regional RFP approach. The RFP will outline requested parameters for a high-speed broadband network to serve the residential and business community throughout the counties. Outcomes of the RFP will be defining options for service providers, technologies, capital costs, operating costs and end user subscription rates. Additional outcomes will be financial feasibility and owner/operator models. The resulting information will provide leaders updated data to make informed decisions on options to solve the broadband gaps in their communities.

   Current and anticipated future funding sources are directed to States, Counties, Cities and Towns. Traditional funding, such as the Rural Digital Opportunity Fund (RDOF) have been awarded directly to Telecommunication companies and Internet Service Providers. A result of the new direction in funding will allow the State of Rhode Island and Bristol / Newport counties to target monies towards broadband projects that will help solve the digital divide at a community level. By reviewing options such as public-private partnerships, new service providers in markets, infrastructure ownership and operating models as well as technologies to meet today's needs and future broadband expansion, community leaders will have more regulation over federal broadband funding.

4. Inform OSHEAN. The OSHEAN network is a valuable asset to Rhode Island. With significant federal resources available, local leaders should present the findings of this broadband study to OSHEAN’s leadership and discuss opportunities for expansion or upgrade of OSHEAN’s services and/or options for public-private partnerships with ISPs.

Section 7: Glossary

#

3G: The term for the 3rd generation cellular wireless telecommunications standards, usually with network speeds of less than 1 Mbps.

4G: The term for 4th generation cellular wireless telecommunications standards, usually with network speeds greater than 1 Mbps.

5G: The term for emerging 5th generation cellular wireless telecommunications standards, usually associated with network speeds of up to 1 Gbps or more.

A

Asymmetrical Bandwidth: A connection in which the maximum transfer rate is different for download and upload.

Augmented Reality (AR): a technology that superimposes a computer-generated image on a user's view of the real world, thus providing a composite view.

B

Backbone: A major high-speed transmission line that strategically links smaller high-speed internet networks across the globe.

Backhaul: The portion of a broadband network in which a local access or end user point is linked to the main internet network.

Bandwidth: The capacity of an internet connection.

Bond: A fixed-income security in which a borrower borrows money from an investor for a specified period of time at fixed or variable interest rate.

Broadband: The term broadband commonly refers to high-speed internet access that is always on and faster than traditional dial-up access. Broadband includes several high-speed transmission technologies, such as fiber, wireless, satellite, digital subscriber line and cable. For the Federal Communications Commission (FCC), broadband capability requires consumers to have access to actual download speeds of at least 25 Mbps and actual upload speeds of at least 3 Mbps.

C

Central Office: A telecommunication company’s building where consumers’ phone lines are attached to equipment that connects a consumer to other consumers in that central office or other central offices across the globe.

Community Anchor Institutions: Schools, libraries, medical and healthcare providers, public safety entities, institutes of higher education and other community support organizations that provide outreach, access, equipment, and support services to facilitate greater use of broadband service by the entire population and local governments.

Community Needs Assessment: An assessment of the deficiencies that exist in a community that are preventing it from reaching goals or desired results relating to broadband

D

Dark Fiber: Fiber that is in place but not being used for broadband services. ("non-lit" fiber, also see "Lit Fiber").

Digital Divide: The gap between those of a populace that have access to affordable internet and other communications technologies and those that have limited or no access.

Digital Equity: Recognizes that digital access and skills are now required for full participation in many aspects of society and the economy. Digital Equity links Digital Inclusion to social justice and highlights that a lack of access and/or skills can further isolate individuals and communities from a broad range of opportunities.

Digital Inclusion: Implies that individuals and communities have access to robust broadband connections; internet enabled devices that meet their needs; and the skills to explore, create and collaborate in the digital world.

Digital Literacy: The ability to leverage current technologies, such as smartphones and laptops, and internet access to perform research, create content, and interact with the world.

Digital Skills: Any skills related to operating digital devices or taking advantage of digital resources.

DOCSIS (Data Over Cable System Interface Specification): The international telecommunications standard for cable signaling data and spectrum sharing.

Download speed: The rate at which data is transferred from the internet to the user's computer.

DSL (Digital Subscriber Line): A form of technology that utilizes a two-wire copper telephone line to allow users to simultaneously connect to and operate the internet and the telephone network without disrupting either connection.

F

Fiber (Also referred to as Fiber Strand): A flexible hair-thin glass or plastic strand that is capable of transmitting large amounts of data at high transfer rates as pulses or waves of light.

FTTH or FTTP (Fiber to the Home or Fiber to the Premise): The delivery and connection of fiber optics directly to a home or building.

Fixed Wireless Broadband Access: The use of wireless devices/systems in connecting two fixed locations, such as offices or homes. The connections occur through the air, rather than through fiber, resulting in a less expensive alternative to a fiber connection.

G

Grant: A legal instrument reflecting a relationship between a government agency and a recipient. The main purpose of the relationship is to dispense money or resources to accomplish a public purpose. No substantial involvement is anticipated by the government agency during the recipient's completion of the activity.

H

Homework Gap: The homework gap refers to the difficulty students experience completing homework when they lack internet access at home, compared to those who have access.

I

Internet of Things (IoT): The Internet of Things (IoT) is an automated system of interrelated computing devices, mechanical and digital machines, objects, animals, or people that are provided with unique identifiers (UIDs) and the ability to transfer data over a network without requiring human-to-human or human-to-computer interaction.

Internet Service Provider (ISP) or also referred to as just Service Provider: A company that provides users (individuals or businesses) with access (a connection) to the internet and related services.

Interconnection: The linking of numerous telecommunications networks to exchange user traffic.

L

Latency: The time in milliseconds it takes for data to travel from the user's location to its destination and back. The higher the latency, the more perceived delay there is for an end user. Real-time applications like video conferencing, gaming, and virtual reality require low latency to function acceptably. Fiber networks typically have the lowest latency (10-15 ms) while high earth orbit satellites have the highest, often exceeding 300-500 ms.

Last Mile Fiber: The infrastructure, technology and process of connecting the end customer's home or business to the local network provider.

Lit Fiber: An active fiber optic cable capable of transmitting data.

Local Area Network (LAN): A group of network devices that are on a high-speed connection and typically within the same building or location.

LTE (Long Term Evolution): A 4G wireless broadband technology that provides speeds up to 100 Mbps download and 30 Mbps upload.

M

Middle Mile Fiber: The connection between a local network, also called a "last mile" connection, and the backbone internet network.

N

Network Infrastructure: The hardware and software components of a network that provide network connectivity and allow the network to function.

O

Open Access Network: Networks that offer wholesale access to network infrastructure or services provided on fair and reasonable terms with some degree of transparency and nondiscrimination.

OSHEAN, Inc. (Ocean State Higher Education Economic Development and Administrative Network) delivers carrier class optical transport, advanced IP-based networking and innovative cloud solutions to Community Anchor Institutions and the communities they serve. OSHEAN creates trusted connections for peer-to-peer interactions that lead to more efficient, effective and collaborative information technology environments. With an extensive member network consisting of leading healthcare organizations, colleges and universities, K-12 schools, libraries, government agencies, and other community organizations, OSHEAN acts as a key strategic technology partner by facilitating member collaboration and providing best-in-class technology solutions and services that provide operational efficiencies and transform traditional enterprise operating models in support of its members' missions.

https://www.oshean.org/

P

Point of Presence: The particular place or facility where local internet service providers connect to other networks. Distance from the Point of Presence can affect service availability and pricing.

R

Rights-of-Way (ROW): ROW are legal rights to pass through property owned by another. ROW are frequently used to secure access to land for digging trenches, deploying fiber, constructing towers, and deploying equipment on existing towers and utility poles.

S

Service Area: The entire area within which a service provider either offers or intends to offer broadband service.

Smart City: A community which uses different types of electronic internet of things (IoT) sensors to collect data and then uses insights gained form this data collection to manage assets, resources, and services efficiently.

Spectrum: A conceptual tool used to organize and map the physical phenomena of electromagnetic waves. These waves propagate through space at different radio frequencies, and the set of all possible frequencies is called the electromagnetic spectrum.

Symmetric/Synchronous bandwidth: an internet service with the same upload and download speeds.

T

Tax Increment Financing: A public financing method through which future property tax increases can be diverted to subsidize community development and improvement projects. While not discussed in this report, has generated more interest as a potential funding mechanism.

Tier 1 internet Network: A network of internet providers that form a superhighway that allows users access to every other network on the internet.

Tier 2 internet Network: A network of smaller internet providers that allow users to reach some portion of the internet but that still purchase IP transit.

Telemedicine: The use of high-speed, high-capacity internet to support long-distance healthcare services, patient and provider education and enhanced healthcare administration.

U

Upload speed: The upload speed is the rate that data is transferred from the user's computer to the internet.

V

Virtual Reality (VR): The computer-generated simulation of a three-dimensional image or environment that can be interacted with in a seemingly real or physical way by a person using special electronic equipment, such as a helmet with a screen inside or gloves fitted with sensors.

VoIP (Voice over internet Protocol): A technology that allows users to send and receive voice calls using an internet connection instead of a traditional phone line.

W

Wi-Fi (Wireless Fidelity): A technology that uses radio transmissions to enable electronic devices to connect to a wireless local area network (LAN).

WISP: An ISP that provides service through a wireless network.