A Backgrounder on Broadband Technology

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The following report is a backgrounder on some of the issues surrounding rural broadband Internet access in New Kent County Virginia. It was prepared to encourage a common understanding of the broadband Internet technologies available, and some of the technical challenges to be overcome.

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What is broadband?

Definitions

Broadband internet access is now defined by the FCC as 25 Mbps download, 3 Mbps upload. Less than 25/3 is considered under-served; less than 10/1 is considered unserved. Because the FCC data set defines “covered” as any census block with at least one address that has service, the overall broadband coverage data is typically overstated; however, it is the only comprehensive resource available.

There are growing needs to Internet access that will lead to a demand for greater bandwidths in the not too distant future.

- 25MBps download / 3MBps upload – Minimum for modern households, 1-2 people
- USDA gives funding priority to projects supplying 100/100 (3-5 people)
- Many providers are now offering 1G/1G (plenty of room for peak uses)
- A few co-ops are even offering 10GBps service

See Appendix A for some technical concepts and definitions that can help in the understanding of the differences in technologies.

Who needs it?

Rural connectivity is about more than entertainment. Farmers, programmers, and entrepreneurs all need high-speedInternet access. Rural connectivity also supports needed research. It's not just the economy. Rural Internet access can improve health care and education. Nearly 7 in 10 teachers assign homework that requires Internet access. Many rural communities lack access to preventative services and rural communities have higher rates of chronic illness and poor overall health. Telehealth initiatives could alleviate some of these disparities by providing access to routine, preventative care.

Homes

Residential users are realizing more and more uses for Internet access. With increasing numbers of uses comes the need for more bandwidth. Also, many of the newer application demand much more bandwidth that earlier applications (e.g., 4K TV requires up to 40Mbps). Xfinity recently found the average US home data usage to be 151GB/month.

Among the many residential applications are:

- Browsing
- Shopping
- Email
- Smart phone apps for everyone in the house plus visitors
- Smart watch of fitness app
- Voice assistants (Alexa, etc.)
  Entertainment
- Security – webcams, intrusion detection and notification
- Webcam doorbell
- Internet of Things (IoT) – Thermostat, refrigerator, lights, Roomba,
- IoT (Refrigerator, A/C, Secuirty system, Web cams, doorbell)
- Gaming
- 4k TV requires 25M – 40 M
- Multiple TVs
- Kids' homework on KNC school-provided Chromebooks

Businesses

In today's world, it is almost impossible to run any business without reliable access to the Internet. Not only do business operations require access to communications, information and applications, but the customers in many businesses also expect to be able to access the Internet while within the business establishment. Typical business needs include:

- Computers for operations
- Customer communications Email/Facebook/Twitter
- Video conferencing
- Webinars (attending, presenting)
- Large file transfers
- Remote control of servers
- Free WiFi for customers
- Point of Sale (SaaS, or traditional – still need credit auth!)
- TVs for customers (waiting area, restaurant, etc.)
- Security cameras, detection and monitoring

Example: Car dealer

- Computer on every salesperson's desk for research, prospect communications
- Finance director runs credit checks
- Service department tracks appointments, accesses service manuals orders parts
- Customer waiting area has multiple TVs, free WiFi for customers
- WiFi available for employees
- Security cameras and monitoring
- Smart electric usage and HVAC optimization

Example: Restaurant

- Point of sale – payment processing
- Online reservations system
- Online ordering, delivery
- Free WiFI for customers, employees
- Multiple TVs
- Online raw materials ordering, inventory control

Other County uses

- County Administration
- Schools
- Police, Fire, EMS
- Library
- Innovative healthcare services including:
  - Web consultations and telemedicine video sessions
  - Streamlined access to cloud-based applications, including EHRs, payroll, ePrescribing, etc.
  - Remote patient monitoring
  - Store and forward telehealth, big data exchange, and electronic medical imaging transfers
  - Virtual healthcare teams and educational training
  - Internet of Medical Things (IoMT)

Technologies

DSL

DSL is delivered over existing copper telephone lines and offers bandwidth up to 6 or 7 Mbps. Service diminishes with distance from CO. It is considered obsolete, and is being phased out. Upgraded equipment can provide up to 15 Mbps, but, in NKC, **Verizon is not upgrading, they are phasing out**.

Cable

Cable provides broadband through the same coaxial cables that deliver pictures and sounds to a resident's television. Cable TV providers (Cox in NKC) have been providing Internet access by combining several TV channels with a technology called DOCSIS. In NKC they are offering bandwidth of 300 Mbps, but residents say they get far less. The bandwidth is shared, and degrades with distance. In NKC 2/3 of the residents have it but are universally unhappy with the service.

Consumer Reports' latest telecoms survey[i] finds that **people hate their cable company** with the fire of a thousand suns, and that they hate them even more than they did the last time they were asked, which is remarkable, because everyone hated them the last time they were asked.

Mobile wireless (Cell phone service)

The 3G and 4G cellular phone providers offer Internet access through the phones and phone-based "hot spots." They offer bandwidths of up to 10 Mbps (some providers claim higher bandwidths, up to 25 Mbps) and typically have data caps that can make the service very expensive or limit is usefulness. Many factors affect the speed and performance that customers experience, including the programs running on the device, proximity to a cell site, the capacity of the cell site, the surrounding terrain and vegetation (trees), use inside a building or moving vehicle, radio frequency interference, how many other customers are attempting to use the same spectrum resources, the high-speed data allotment, and uses that affect your network prioritization. **Mobile Wireless is not considered an option for fixed broadband Internet needs in homes and businesses.**

Satellite

Current satellite service is delivered by geosynchronous satellites, 23,000 mile above the Earth's surface. There are two providers left, Hughs and Viasat. This is a shared service with monthly data caps. It provides speeds up to 25 Mbbs but with very high latency (signal delay) because the satellites are so far away, and is subject to degradation from weather and RF interference. It requires direct line of sight (free of trees) to satellites in southern sky. Satellite service can be expensive and typically has data caps around 10–50MB/month. It is generally disliked, although I have been hearing from a few people who are quite happy. **The long latency, makes it unusable for many business applications**, such as video conferencing, remote sever maintenance of large file transfers, or for interactive gaming. **It is generally not considered a replacement for a fixed Internet service.**

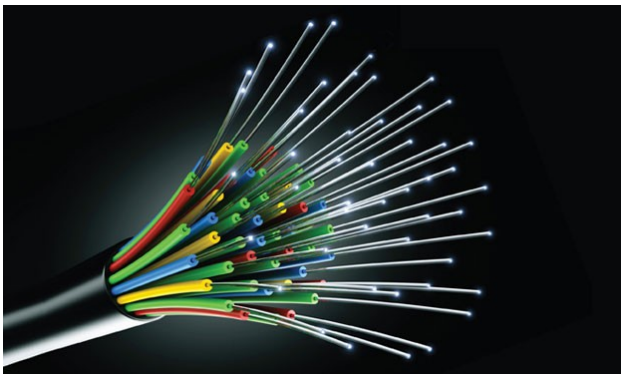
Fixed wireless

Wireless is a type of broadband that connects a home or business to the internet with a radio link between the location and the provider. This means the connection to the Internet does not require a cable, but requires an external antenna. Residential fixed wireless solutions travel through radio waves transmitted by access points which are usually mounted on freestanding towers. Fixed wireless speeds are comparable to DSL or cable. However, the technology requires very high speed back-haul (i.e., fiber to towers), and is highly dependent on local terrain and vegetation (trees). While not as fast as fiber optic cable, it can be a good alternative when there is a low concentration of customers over a larger territory. Contention ratios (oversubscription) are often very high, meaning that many user share a limited amount of bandwidth and will see significant degradation in performance at peak times of the day. **Fixed wireless signal require a clear line-of-sight, so may not perform very well in heavily forested areas, like New Kent County.**

An industry expert puts it this way – "My general rule of thumb on trees is:

- 5ghz goes 20 miles or the distance to the nearest tree.
- 2.4ghz goes 15 miles or through one tree.
- 900mhz goes 12 miles, or through multiple normal trees, or through one spruce tree.
- A chainsaw goes through +2 spruce trees"

Fiber Optic



Fiber optic technology converts the electrical signal carrying data to light and sends the light through glass fibers. The fiber can run from the provider to a home, to a business, to the curb, or a location between the provider and the customer.

Fiber is the most desired internet; it is a relatively expensive last mile solution as it is the fastest form of broadband technology. Most of the backbone and middle mile is deployed using fiber optic cable. Fiber optic cable can offer much faster speeds over longer distances than both DSL and cable. It is also the latest technology and even if broadband speeds increase significantly, a single existing fiber optic connection can still support it.

According to a report[ii] from ILSR, "Fiber networks offer faster, more reliable service than other types of networks. They have been hailed as "future-proof" infrastructure and have long technological lifespans. Additionally, fiber networks support multiple uses for homes and businesses, including Internet service, telephone, video, and security. Fiber networks have high capital costs initially, but **lower operating costs than many other types of networks over the long-term**." Fiber can support signal bandwidths up to 500 THz; test have been carried out transmitting 300 Tbps of data. (Tb are 1,000,000 Mb). So future needs can be met by changing only the electronics at each end of the cable.

Fiber optic cables have a conservative life span of thirty years or more; they are typically depreciated over a 20 year term.

Verizon says that unlike copper, fiber-optic lines are more resilient when it comes to damage from water and lightning and that they have reduced line-related repair dispatches by 75 percent.

5G

The next generation of cell phone service is 5G (5th Generation). It promises wide bandwidth and low latency, but is likely to be costly and come with data caps. Most 5G service is provided by millimeter wave spectrum (28 GHz and 39 GHz); this will give low latency and wide bandwidth (1 Gbps) but the cell sizes are tiny (350-600 ft) and it requires an unobstructed line-of-sight (no trees!). The installation will require thousands of miles of fiber just to serve the 5G tower sites. By the time fiber is strung all along the roads to service the 5G towers, it might as well be serving FTTH/FTTF.

Rural areas will get a form of 5G called "low-band" or "sub-6" 5G that will be delivered on channels in the 2.5-5 GHz range; this will be called 5G, but cannot provide the 1 Gbps bandwidth that they're all talking about. It will have less capacity but still have extremely low latency and be able to work with massive networks of industrial sensors. This 5G service in the sub 6 GHz bands will be of comparable quality to the current 4G service. Everyone seems to agree that 5G will not come to rural locations until many years in the future; the cities will be built out first. And remember that 5G is cell phone service that can be costly, have variable service quality and data caps.

5G also faces resistance from people concerned about health effects of electric and magnetic fields (EMFs), and from the weather-forecasting community. Whether or not EMF can harm human health is a controversial issue. Officials at various agencies, including the Department of Commerce and National Aeronautics and Space Administration, warn that 5G transmissions—specifically those above 24 gigahertz—could scramble nearby readings from the federal weather satellites that meteorologists use to make storm predictions. Regardless of the actual merits of the arguments, the very existence of these objections could result in regulatory proceedings that could take years to resolve, delaying the rollout of 5G services.

Perhaps the biggest unknown about 5G is how it will be monetized. Operators will not be able to keep charging consumers more and more for data. Instead, they are already investigating new business models that will allow them to recoup their investments from partners – whether those partners are providing video content that they want consumers to watch on their wireless devices or car makers that want to differentiate their latest cars from the competition by sending automobile diagnostic info over the 5G network. See Appendix B for some interesting insights into the economics of 5G.

It has been repeatedly stated that 5G will not be a panacea in the quest for rural broadband Internet access; it is a mobile service and not a replacement for fixed broadband access.

LEO Satellites

Low Earth Orbit satellites (LEO) – Several companies are exploring the possibilities of launching a constellation of thousands satellites that would be in constant motion orbiting the earth about 100-1,000 miles up. These next-generation satellite constellations are looking to offer speeds comparable to Earth-bound fiber optic networks. Marketing for internet satellites from the incumbent players, such as SpaceX with its "Starlink" network and SoftBank-backed OneWeb, has largely centered around the opportunity of connecting rural networks.[iii] They include:

- Elon Musk's SpaceX (Starlink – 12,000 satellites)
- Jeff Bezos' Project Kuiper (3,236 satellites)
- Boeing (147-3,016 satellites)
- OneWeb, backed by Japan's SoftBank (720 satellites)
- China (Hongwan – 300 satellites)
- There are several more...

The road is littered with companies that tried, and failed, to pull off a coup in space. Back in 2015, Facebook decided against spending up to $1 billion on a satellite that would provide Internet to under-served regions in Africa and other continents. Microsoft founder Bill Gates helped fund Teledesic, in an effort to build low Earth satellites to provide Internet service. Yet Teledesic closed in 2002, after racking up more than $9 billion in costs.

So there is considerable uncertainty with regard to the LEO's and the time frame for service to customers is likely to be 10 years to the future even if they do succeed.

OneWeb, SpaceX, Telesat, Boeing and now Amazon are the major players developing internet networks with hundreds or thousands of satellites. The race to space for broadband networks is "today's gold rush," an executive said – and its one that is being watched closely.

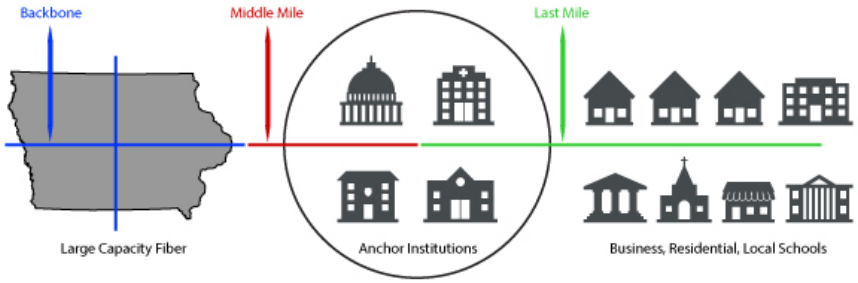
The LEO satellite networks will not solve today's rural broadband problem any time soon, but should be kept in mind as possible competitors or gap fillers in the future 10 or more years out.

Technology Comparison Chart

Technology [Typ. Bandwidth]	Advantages	Disadvantages
DSL [6-7 Mbps]	• Uses existing phone lines • Large coverage area	• Obsolete • Being phased out • High contention • Shared bandwidth • Service diminishes with distance
Cable (Cox) [300 Mbps]	• Available in developed areas • Low latency	• Universal dissatisfaction • High contention • Shared bandwidth • Service diminishes with distance • Uneconomic in rural areas
Mobile [10 Mbps]	• Widely available • Acceptable latency	• Expensive • Data caps • High contention • Service varies with location • Subject to interference • Not considered a replacement for fixed service
Satellite [25 Mbps]	• Universal coverage • Good bandwidth	• High latency • High contention • Shared bandwidth • Requires line-of-sight • Subject to interference
5G [1 Gbps urban]	• Very wide bandwidth • Low latency	• Small cell size • Requires line-of-sight • Can not penetrate trees • Likely to be expensive • May have data caps
Fx wireless [10-50 Mbps]	• Low initial cost • Fast deployment	• Lower bandwidth • Requires line-of-sight • Can not penetrate trees • Subject to interference • Shared bandwidth • High contention • Short useful life (6-7 years)
Fiber [100 – 1,000 Mbps]	• Widest bandwidth • Very low latency • Low contention ratios • Future proof • Immune to interference • Long life (> 30 years) • Lower operating costs	• Higher initial cost • Uneconomic for some cases

Infrastructure

Broadband infrastructure consists of the backbone, the middle mile, and the last mile.[iv]



The **backbone** consists of very large capacity trunks (usually fiber optics) that connect to multiple fiber-optic lines capable of transmitting large amounts of data. It provides a path for the exchange of information that local or regional networks can connect with for long distance data transmission. These data routes and backbone connections are owned by private providers, commercial, government, academic and other network centers.

The **middle mile** links the backbone to the ISP or telecommunications providers' core network or telecommunications exchange. In some communities, the middle mile may connect anchor institutions that enable them to share applications, infrastructure, and other resources.

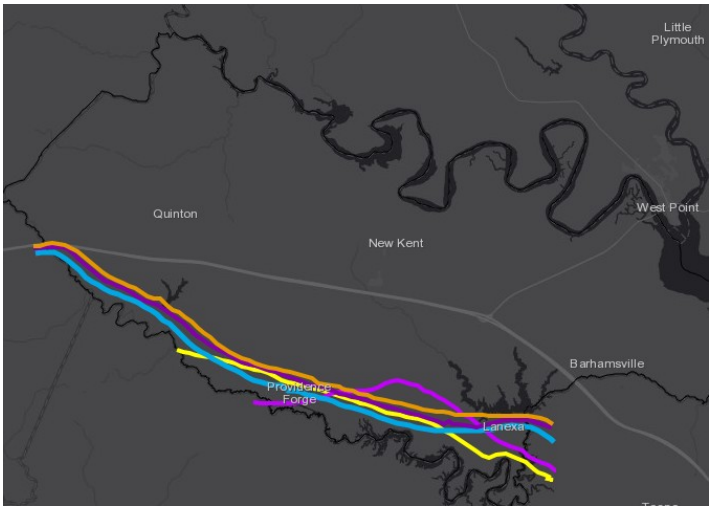
The **last mile** brings the connection to residents' homes and small businesses within the telephone exchange or cable company serving the area. Though all pieces of the broadband infrastructure are important, much focus of the debate and concern on broadband is on the availability (or lack thereof) the last mile connectivity.

What Can New Kent County Do?

Backbone

We already have several backbone fibers running through NK County with Points of Presence (POP) in multiple locations. Some may or may not be open to interconnecting. They include:

- Cox Cable
- Level 3
- Lumos
- Metro Fiber
- Windtream



There is a new company, Tenebris, that is installing a backbone fiber from Virginia Beach (where it can connect to international undersea cables) to Ashburn (where a lot of data centers are located). They plan to support surrounding rural areas for fiber connectivity. They are already working with Fredericksburg and Faquier county.[v]

Middle Mile

The middle mile would typically be a fiber ring connecting "anchor institutions," such as NK County facilities, hospitals, libraries, etc. In NK County this could include:

- County administration offices
- Police, EMS, Fire stations
- Water facilities
- Airport
- Regional Jail
- Schools
- Heritage Public Library
- Cumberland Hospital

In addition, Dominion is in the process of installing fiber links to its facilities, and there is a pilot program to enable them to lay dark fiber along side their cables and make it available for rural broadband efforts. They could be connecting their:

- Substations
- Solar farm

The middle mile is typically the biggest and most expensive part of the infrastructure for providing broadband Internet access. If the county were to take on the construction of a middle mile fiber ring, it could go a long way towards facilitating broadband access to all of the county residents.

Middle Mile Alternatives

County Owned and Operated – An "anchor institution" ring could be owned by the county, which would supply its own needs, and sell access to a last mile provider. After a certain payback period, the county's own Internet access would come at very little to no cost, providing considerable savings. And in fact, it could be come a revenue source because of access fees from one or more last mile providers.

County Owned and Leased – The county could lay dark fiber and simply lease it to a provider that would operate it, proving last mile service to county residents and businesses and well as to the county. The county (and other anchor institutions) would be the provider's biggest customer(s), providing highly desirable economic stability.

Provider Owned and Operated – An independent provider or County Broadband Authority could build, own and operate the middle mile ring, being subsidized by county and or state grants to build it. The county (and other anchor institutions) would be the provider's biggest customer(s), providing highly desirable economic stability. This option would remove any risk from the county

Dominion

Some part of the middle mile infrastructure may be provided by Dominion Energy as part of the pilot program. NK County has already filed a response to Dominion's RFI, indicating the County's interest in participating.

Last Mile

The most important part of the overall Internet access system is the customer-facing "last mile" network. Very few county residents will have any knowledge of, or interactions with, anything but the last mile provider, so it would be highly valuable to have very good technology and high quality customer service.

One way to reduce risk is to build to demand in a phased approach. Following the phased plan proposed by Sandie Terry, only one section of the county would be handled at a time. Further, specific fiber runs could be implemented and prioritized based on customer pre-subscriptions. The streets showing the most demand could be served first, bringing in early revenue and avoiding runs of fiber that will not be used.

There are several possibilities for the last mile provider:

- Extension of the incumbent provider (Cox)
- Other commercial investor-owned ISP
- County Broadband Authority

Extension of the incumbent provider (Cox)

Cox Communications is a cable TV company that already provides Internet access to more than 2/3 of county residents by serving data over their TV cables. They continue to claim to government officials that they are providing 1G service, but the highest bandwidth actually offered is 300/30 Mbps. New Kent County subscribers are universally unhappy with their Cox service, largely because it is a shared service with a high contention ratio, so, in practice users experience much slower service as they compete with their neighbors during peak times. There is also considerable dissatisfaction with the customer service.

Cox has already demonstrated an unwillingness to serve the rural areas as uneconomic; their franchise agreement with the county requires them to provide service to all residents of the county, but only if there are at least 25 residences per lineal mile along a path.

They are agreeing to partner with NKC on a VATI grant application that would extend their existing service to 84 of the county's more than 3,000 unserved locations only because of political pressure.

Cox has very recently started showing interest in serving rural areas, and is preparing a proposal to serve rural NKC. Details are not yet available on their proposal.

Commercial investor-owned ISP

New Kent County could enter into a Public Private Partnership (PPP) with an existing investor-owned provider. There are a few large companies (e.g., Verizon, ATT or big cable companies) that might be interested, and there are some smaller companies that are more likely to be interested in working with us. The county would need to issue and RFI or RFP and see who responds, if anyone. A recent RFP for a nearby county got no responses.

This option would involve finding someone (government grant) to pay for the construction of the network, which would then be owned and operated by the ISP. The advantage of this route would be that many of the medium to large ISP have people on staff that are familiar with the funding and grant-making processes and could prepare grant applications. Disadvantages are higher cost of service for consumers, time until service becomes available, and uncertainties about the quality of service

To wait for the VATI or Federal grants could take several years, since there are only annual grant-making cycles, and currently grants are awarded to about 1/3 of the applicants.

An alternative would be for New Kent County to provide grant money and/or to guarantee a loan for the ISP to construct the network.

Pitfalls to be avoided: There are cable companies that are rebranding to get into the Internet business. For example, recently King William County forged and agreement with Atlantic Broadband to take over their existing cable plant and provide Internet access to the county. Atlantic Broadband is actually the 9th largest cable TV operator in the US, and they plan to provide service to all of KW County except those on streets with fewer than 30 residences per mile. They are a cable company that is cherry-picking the county, not providing rural broadband access to all.

County Broadband Authority

The county could form an "authority" (technically called a Wireless Service Authority (WSA) in Virginia) to own and operate the last mile, or to act as a financing facilitator for a partnership with a private ISP.

A County Broadband Authority could build and own both the middle mile fiber ring and the last mile fiber-to-the-home/farm/business infrastructure. This option provides several advantages because of the local ownership and staffing:

- Lower overhead costs without the need for national advertising or large management hierarchy
- Responsive to community; the entire management and technical team would be local residents
- Flexibility to provide service that citizens desire, not what a large company want to sell them

While many municipal authorities have failed to survive and prosper, there is a highly successful example right here in Virginia, the Eastern Shore of Virginia Broadband Authority (ESVBA). The ESVBA provides connectivity and dedicated internet services to all customers. However, the ESVBA's network is an "Open Access" network, which allows for any certified provider to utilize the ESVBA's network to provide services to end customers. The ESVBA was formed in 2009 and has 9 retail service providers competing to provide Internet and telephone services. Their fiber-to-the-home network is being built to demand, and currently serves select communities.

NKC is fortunate to have ESVBA as an example to follow; we can learn from their experience and avoid the costly mistakes of other authorities. Members of the NKC Broadband Advisory Committee have been in contact with the founders and operators of the ESVBA and have developed unique interpersonal relationships with them, and they have shown an eagerness to help NKC replicate their success.

Steps to Success

A common Vision (Specific and Viable)

We know one common desire of all NKC residents (even those already connected to Cox) is a strong demand for fast, reliable Internet service at a reasonable price.

The BBAC will need to further refine the vision with specific technical characteristics.

One proposed vision is

- A County Broadband Authority owned middle-mile fiber ring providing service to county facilities (schools, police, EMS, fire stations, county administration, water systems)
- A County Broadband Authority proving last mile fiber-to-the-home/farm/business service
- Service levels (symmetric up/down)
  - Economy service: 25 Mbps
  - Standard service: 100 Mbps
  - Premium service: 1 Gbps
- 95% - 97% of residents who want service served with Fiber to the Farm / Home

Assessment of Current Situation

See reports from Rural Broadband Consulting (Sandie Terry) at [https://rbbc-llc.maps.arcgis.com/apps/MapJournal/index.html?appid=94eab617a5684dfca98753bfeaf2b0b8].

Build Community Support

For any broadband project to be successful, it will need subscribers. In NKC, we already have a lot of people clamoring for better service, who would sign up "in a heartbeat." There may be others who are wary of an unknown company without a nationally-recognized brand name. Still other may not even value Internet access, having done without it in the past.

A certain amount of outreach will build support for the proposed solution, and when the solution is adopted, the last mile provider will likely need to do more outreach and marketing to build the subscriber base.

The Value of a Champion

You need to have a “Champion” that will own the broadband initiative.[vi]

Critical to the success of a new broadband enterprise moving from concept to reality is the need for one or more project champions. Boards of directors and broadband enterprise organizers will be project champions. They should have understanding of the broadband service sector with command of the information in the feasibility analysis and understanding of the goals and anticipated operations of the broadband enterprise.[vii]

See Appendix C for Characteristics of a Project Champion

Emphasize Local Decision-Making

Frame the issue in a way that highlights the differences between the motivations of incumbent providers (profits) and community networks (serving the community). Underline the importance of local choice, as opposed to allowing executives in other states determining what services will be available to your community.

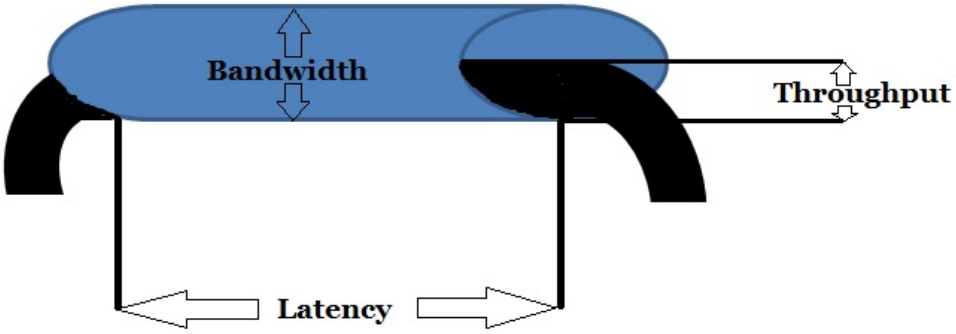
Prepare to Counter Misinformation

Often, misinformation spreads regarding the building of municipal networks, often through well-funded campaigns bankrolled by incumbent providers. These can derail efforts cities make to serve their citizens’ best interests.

Appendix A – Qualities and Definitions

The two figures of merit that define broadband:

- **Bandwidth** – the amount of data that can be transmitted at a time (often mislabelled as speed)
- **Latency** – Latency, also known as delay, is the amount of time from when a data packet is sent to when it is received. For Broadband Internet Access Services, latency is usually expressed as the round-trip time in milliseconds (“ms”) that it takes for a data packet to travel between two end points on the Internet (from point A to point B and then back to point A). Some applications, such as email, can tolerate a substantial amount of latency without any noticeable impact on the application's performance, while other applications, such as real-time video conferencing, require lower latency to function properly.



Line of sight

- “a straight line along which an observer has unobstructed vision.”
- In radio propagation, must also allow for Fresnel zone.
- Low-powered microwave transmitters can be foiled by tree branches, or even heavy rain or snow. The presence of objects not in the direct line-of-sight can cause diffraction effects that disrupt radio transmissions. For the best propagation, a volume known as the first Fresnel zone should be free of obstructions.
- Studies have shown attenuation of 30-80 dB by trees
- One study was done with equipment designed to deliver 300 Mbps with a clear line-of-sight; with propagation through trees the actual bandwidth seen was 23 Mbps – less than 10%.

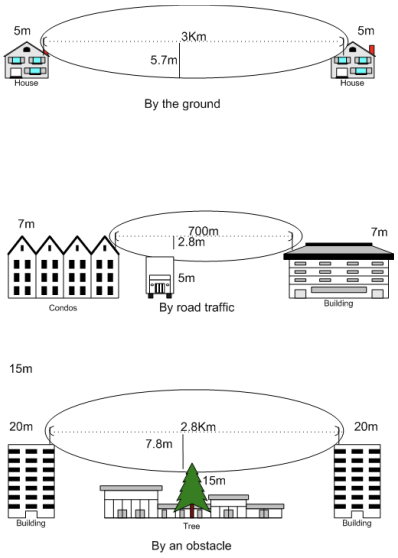
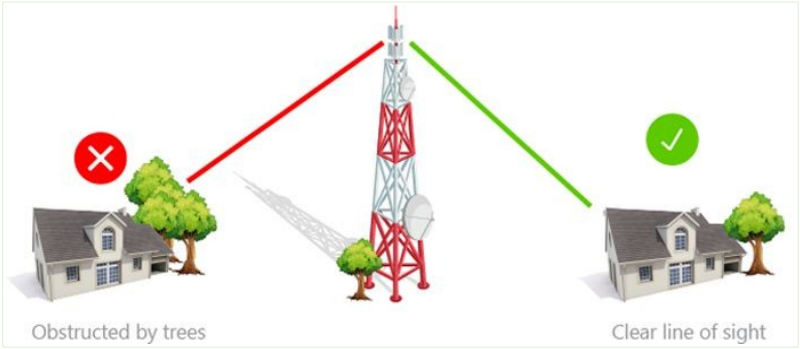
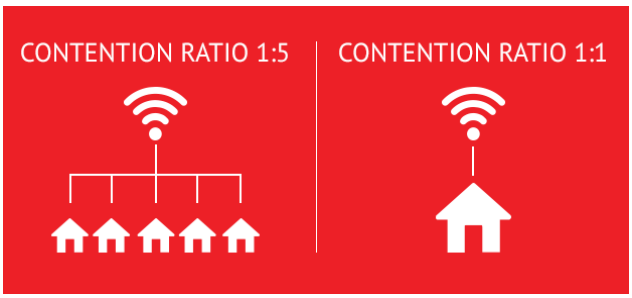


Illustration 1: Fresnel Zone Examples



Contention Ratio



Contention Ratio (or over subscription ratio) is the number of users sharing the same data capacity. The lower the contention ratio the higher the quality of service. A 50:1 contention ratio means that up to 50 broadband customers are sharing the same bandwidth at any one time.

A contention ratio is used in both fixed and mobile broadband wireless access. The use of a contention ratio makes the quality and speed of a broadband connection dependent on the number of users online at any given time. Business broadband services will often have much lower contention ratios to enable the internet server provider (ISP) to give business users a more consistent quality of service. The average contention ratio for a home user internet access connection is 50:1 and 20:1 for a business connection. Many satellite providers have contention ratios that are in the stratosphere, sometimes approaching 400 to 1, making the service often unusable.

If that doesn’t make sense, then look at it like this. You don’t go to a restaurant, pay for your dinner, then have to share that dinner with 9 other people. Sometimes even worse! Imagine having to share your dinner with the entire restaurant; you’d be lucky to get a chip out of a deal like that. But this is essentially what happens with ISPs. No wonder you’re not getting the speeds you pay for! Contention ratio isn't something providers tend to advertise these days.

Fiber-to-the-Premises networks have much higher capacities and typically operate at ratios at or below 4:1. There are many FTTP providers that offer full 1:1 service.

Appendix B – Realities of 5G Deployment

An excerpt from “The realities of rural 5G deployment in the US” (https://www.zdnet.com/article/the-realities-of-rural-5g-deployment-in-the-us/)

The truth is that rural areas are at the bottom of the list of priorities for every major communications carrier. The money just isn't there. They will simply invest where the people are. If a wireless customer generates $50 per month in revenue, and if only 10% of a given population subscribes, the revenue priority is obvious. These geographic areas show some interesting insights into how this will play out, given this conservative formula for revenue:

Geographic area	**Population density** (people/mile^2)	**Household income** (median in 2017)	**Households with broadband**	**Revenue per mile^2**
Manhattan, N.Y.	69,467.5	$85,071	81.9%	$347,337.50
City of Chicago, Ill.	11,841.8	$55,295	73.5%	$59,209.00
Santa Clara County, Calif.	6,327.3	$106,761	89.4%	$31,636.50
City of Palo Alto, Calif.	2,696.5	$147,537	91.3%	$13,482.50
Carbon County, Pa.	171.1	$51,236	74.4%	$855.50
US	87.4	$60,336	78.1%	$437.00
Campbell County, Wyo.	9.6	$80,178	86.4%	$48.00
Loving County, Texas	0.1	$ 80,938	64.5%	$0.50

The money is in the densest populations. The dark-blue areas in this US map will be served first. Early (prestandard) 5G trials are there. The light-green areas will wait -- perhaps for a decade or more. The carriers will spend tens of billions per year building out 5G infrastructure. Naturally, they will prioritize locations that will yield the best returns. Revenue per square mile is the metric to watch. My $50 per month for 5G and 10% penetration rates are very low to make a point that even if it's cheap, there is big money in dense areas.

The whopping 152 people across the 669 square miles of Loving County, Texas -- the most sparsely populated continental US county -- offer the potential for fifty cents per square mile each month! The big telco execs won't even utter that county's name, let alone serve it with 5G! I live in Carbon County, Pa. While a metropolis compared to Loving County -- and technically not considered rural by the US Census Bureau -- my particular "neighborhood" is clearly rural. I barely have 4G, and many in the truly rural areas envy what I have here.

Appendix C – Characteristics of a Project Champion

1. Credibility
    1. Respected for their judgement, common sense perspective
    2. Ability to complete tasks
    3. Ability to have a long-term perspective
2. Financial stability
    1. Viewed as a successful business person in their own right
    2. Have sufficient people to manage their personal business so they are available to spearhead the development of the cooperative
3. Basic knowledge of the broadband sector
    1. Familiarity with the broadband sector
    2. Understanding of marketing trends
    3. Understanding of financed. Ability to learn about the industry or seek out experts
4. A developer
    1. Neither thin-skinned or quick tempered, able to take misplaced criticism and occasional insults, patient
    2. Efforts and actions do not normally receive financial compensation
    3. Sense of humor and sense of the ridiculousness

i See: https://www.consumerreports.org/telecom-services/cord-cutting-continues-high-cable-pricing/

ii Cooperatives Fiberize Rural America: A Trusted Model For The Internet Era By H. Trostle, Katie Kienbaum, & Christopher Mitchell (https://ilsr.org/wp-content/uploads/2019/06/2019-06-Rural-Coop-Policy-Brief-Update.pdf)

iii Sheetz, Mark, Here's why Amazon is trying to reach every inch of the world with satellites providing internet, Published Sun, Apr 7 2019 (https://www.cnbc.com/2019/04/05/jeff-bezos-amazon-internet-satellites-4-billion-new-customers.html)

iv Information from Wisconsin's Broadband Reference Guide produced by: WI Public Service Commission, UW-Extension Madison, and the Center for Community Technology Solutions, January 2014

v See their website (http://tenebrisfiber.com/). Mr Hathaway and I have both spoken with Adam Noll, one of the co-founders, and they are interested in working with us.

vi Terry, Sandie, Broadband Strategies Summary, July 31, 2019

vii Building the Success of the Broadband Enterprise, the Cooperative Experience, Appendix 3.