The Rural Broadband Industry

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Acknowledgments

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FAQ

Following are a few of the questions answered by this paper:

Q. Who provides broadband in rural America?

A. For purposes of this paper, rural America is defined as places outside of cities and county seats. Broadband is delivered to rural areas by a diverse group of internet service providers (ISPs):

- The largest broadband providers in rural America are still the big telephone companies, or telcos, like AT&T, CenturyLink, Frontier, Windstream, Consolidated Communications, and a few others that provide DSL delivered over copper lines.
- Cable companies mostly provide broadband in towns, but there are places where cable companies serve small towns, subdivisions, or densely populated unincorporated rural areas.
- Over 800 wireless ISPs (WISPs) are members of WISPA, the trade association for this industry. These companies provide broadband in rural areas using fixed wireless technology.
- There is a growing amount of fiber in rural areas that has been built by small, regulated telephone companies.
- The newest entrants into the rural broadband market are electric cooperatives that are building fiber.
- All three major cellular carriers have recently upgraded to more generous rural cellular broadband plans, but coverage is still spotty.
- Stationary satellite broadband is available from Viasat and Hughes.net.
- We're on the verge of seeing broadband from low earth orbit satellites with Starlink in beta test mode.

But even with all of these potential options, a giant percentage of rural homes still don't have the option to buy a broadband product that meets the FCC's definition of broadband of speeds of at least 25/3 Mbps.

Q. What are some challenges for rural broadband deployment?

A. Most of the issues of bringing fast broadband to rural areas are a direct result of the low density of housing in most rural areas. Low housing density translates into high cost for any land-based broadband technology. This means that finding funding is almost always the biggest challenge in funding a rural broadband network. But there are numerous other kinds of challenges:

- Companies that have never sold in a competitive environment often have problems with marketing and selling broadband. There are also demographic issues that affect the ability to sell, such as the age and income of the customer base.
- Operational risks arise from ISPs that don't execute the original business plan well. Operational risks can vary widely and include issues such as bundling the launch of products, cost overruns, losing the faith of the public, or encountering external issues such as problems in the supply chain.

- Competitive risks arise as the result of the reaction of competitors. Competitors can cut prices or try to lock customers into long-term contracts. Competitors can also react by upgrading technologies to offer faster broadband.
- Finally, there are political risks. While rare, we've seen state governments change the laws to block a municipal broadband launch. Laws and ordinances can change at any time that can negatively impact an ISP. For example, local governments may refuse to grant franchises or rights-of-way.

Q. What technologies are used to bring broadband to rural America?

A. A wide range of broadband technologies is deployed in rural America today. The largest number of households in rural America can buy broadband from DSL from telcos, fixed wireless, or geostationary satellites. None of these technologies generally offers fast broadband speeds and most customers using these technologies can't get broadband that meets the Federal Communications Commission's (FCC) definition of broadband at 25/3 Mbps.

There are newer technologies coming to rural America. A growing number of rural homes have fiber broadband provided by small telephone companies or electric cooperatives. Fixed wireless technology has improved significantly over the past few years. And small numbers of rural homes get home broadband from cellular connection; this is a technology that is poised to explode as cellular carriers are all expanding home broadband capabilities in rural markets. We are now seeing beta tests of low-orbit satellite broadband from Elon Musk's Starlink, and two other satellite providers are likely to serve customers over the next few years.

Some technologies are rarely seen in rural America. Although there are a handful of rural communities with cable company broadband, this technology is generally being deployed in towns and cities. The cellular carriers will be beefing up cellular networks in urban areas using 5G technology, but that may never come to rural America in the same manner; the key characteristic of 5G is to take advantage of multiple closely placed cell sites, something not likely to be cost-effective in areas with low housing density. Verizon has been building fiber-to-the-curb, which brings fiber in front of homes and then beams the broadband to homes with millimeter-wave spectrum, but this technology makes no sense in a rural setting. Finally, there are ISPs in urban areas that beam wireless broadband to buildings, but the technology also makes no sense in rural America.

Q. How are rural broadband projects funded?

A. Most new terrestrial landline broadband networks need grant funding to make any sense in a rural area; the cost of construction generally is too high to justify without some help from grants. Over and above grant funding, most entities finance in the simplest normal form of financing available to each type of ISP:

- Municipal ISPs tend to finance using revenue or general obligation bonds that are repaid from broadband project revenues. There are a few municipal broadband providers that are making bond payments using property taxes, sales taxes, or some other non-broadband revenue source. Such projects are typically 100% debt and don't include any municipal cash or equity.

- Electric and telephone cooperatives tend to finance by borrowing from boutique banks that cater to cooperatives such as CoBank or the Rural Telephone Financing Cooperative (RTFC). Some cooperatives borrow from the Rural Utility Service (RUS), the federal broadband lender that is part of the Department of Agriculture. It's not unusual for cooperatives to contribute equity to broadband projects.
- Large telcos tend to finance infrastructure using corporate bonds, although they might also use traditional bank financing. Large telcos might also fund directly with equity and generally have a sizable annual capital spending budget.
- Small, regulated telephone companies tend to borrow from the RUS, CoBank, or from traditional bank loans. Project funding might include equity.
- Non-publicly traded fiber overbuilders tend to use traditional bank financing.
- In partnerships, it's typical that each partner finances its portion of funding in the traditional ways mentioned above, with the caveat that it's sometimes difficult to marry different sources of financing.

Some ISPs have more complicated capital stacks. This could mean including non-traditional sources of funding such as customer contributions, federal loan guarantees, opportunity zone funds, or other non-traditional funding.

Q. What are the federal government and state governments doing to support broadband expansion in rural America?

The federal government has been providing grant funding for a number of years to help cover the cost of deploying faster broadband in rural areas. This includes programs like:

- The FCC has funded rural broadband using money from the Universal Service Fund. There have been several large grants funded including ACAM, which funded faster broadband for smaller independent telephone companies; CAF II, which was a grant provided to only the largest regulated telephone companies to bring rural DSL; and most recently several reverse auctions such as the Rural Digital Opportunity Fund (RDOF) that provided $9 billion for rural broadband. The FCC has also provided major subsidies for rural healthcare, schools and libraries, and low-income households through the Lifeline program.
- In 2020, the Coronavirus Aid, Relief, and. Economic Security (CARES) Act provided funding for broadband needs associated with the pandemic.
- The recent American Rescue Program Act (ARPA) is providing many billions in federal subsidies that can be used for broadband or other infrastructure.
- The federal government has offered grants to fund infrastructure, digital inclusion, and broadband training, and broadband loan guarantees through various agencies. The National Telecommunications and Information Administration (NTIA) publishes a list every year that details the current subsidy programs.[1]

Roughly two-thirds of states provided some kind of broadband infrastructure assistance in 2020 in the form of infrastructure grants, matching funds for federal grants, or loans.

[1] https://broadbandusa.ntia.doc.gov/resources/federal/federal-funding

I. The Rural Broadband Market

This section takes a generic look at the players in rural broadband and then looks at the various operating models in most common use in rural areas today.

A. ISPs in Rural America

The following entities provide most of the broadband in rural America.

Large Incumbent Telephone Companies

The FCC distinguishes between large and smaller telephone companies. Several large telephone companies are regulated under a different set of regulations than other telephone companies. This regulation is referred to as price cap regulation and applies to AT&T, CenturyLink, Frontier, Verizon, Consolidated Communications, Cincinnati Bell, Windstream, and the telephone companies that serve U.S. territories such as Puerto Rico and Guam. These telephone companies collectively serve a large majority of the broadband available in rural America. These telcos are in rural America due to having been monopoly telephone companies for as long as a hundred years. Some of the properties owned by Frontier, CenturyLink, Windstream, and Consolidated have changed ownership several times.

The dominant technology in use in the rural parts of properties is DSL, although there are examples of faster technologies deployed in some county seats in rural communities. Rural DSL outside of towns is generally extremely slow; while there could be the stray rural subdivision that has 25 Mbps DSL, most of rural America has DSL speeds under 10 Mbps.

Small Incumbent Telephone Companies

There are over 900 smaller telephone companies that the FCC refers to as rate-of-return carriers. It's still possible to create new monopoly telephone companies and several Native American tribes have done so in recent years. There are four common forms of ownership for small telcos – cooperatives, family-owned, holding companies that own multiple small telephone companies, and telephone companies owned by venture capitalists. This group of telephone companies ranges from tiny companies with barely more than 100 customers to a few companies that have almost 200,000 customers.

Over 400 telephone cooperatives are owned by customers of the business. Cooperatives tend to be some of the larger independent telephone companies, with a few cooperatives with more than 100,000 members. Although there are a few family-owned telephone companies with almost 100,000 customers, this category also includes the tiniest telephone companies, some with only a few hundred customers.

There are holding companies of various sizes. The largest holding company is TDS Telecom from Madison, Wisconsin, which owns over 100 telephone companies. Most holding companies own 10 or fewer telephone companies.

The phenomenon of venture capital firms buying telephone companies started perhaps 20 years ago but has picked up steam in the past few years. One of the most recent sales of a telephone company to a venture capital firm was the sale of Ritter Communications in Arkansas to Grain Management.

For the most part, independent telephone companies were created to serve rural areas where AT&T or some other larger company constructed the networks in the county seat and left the rural areas to tiny mom and pop companies often started by farmers. Over time the industry consolidated, and AT&T purchased many of the smaller companies while other small companies merged. A large percentage of the small telcos have used money from the FCC's Universal Service Fund in recent years to build fiber in their service areas. Many of these small telcos have also expanded beyond their historic exchange boundaries, using a wide range of different technologies.

<u>Incumbent Cable Companies</u>

Incumbent cable companies are mostly found in county seats and in some smaller towns in rural areas. Most of the big cable companies, including Comcast, Charter, Mediacom, Altice, Cox, etc., serve some rural towns. There are also some smaller independent cable companies still in business. It's rare for cable companies to build into rural areas surrounding towns, but there are places where this has been done. Recently, Charter won a federal RDOF grant and has pledged to build rural networks to pass over a million households. That is the first major cable company foray into rural America. Not all rural communities have a cable provider and there are county seats where the only incumbent provider is a telephone company.

<u>Electric Cooperatives / Commercial Electric Companies</u>

Electric companies are a natural candidate to be a rural ISP because they own the existing poles and rights-of-way that are needed to build a fiber network. A few electric companies got into the broadband business 15 years ago, but most of the activity in this industry segment has been recent. Some states have laws that prohibit electric cooperatives from offering broadband.

In addition, numerous electric cooperatives have partnered with telephone cooperatives or commercial telcos to offer broadband.

<u>Fiber Overbuilders</u>

Some fiber overbuilders aren't associated with telcos or cooperatives. Most independent fiber overbuilders are competing in towns and cities, and only a handful of independent fiber builders operate in rural America outside of towns.

Several kinds of entities fit into this category:

- <u>Municipal fiber overbuilders</u>. Perhaps 200 communities have built residential fiber-to-the-premise. It's rare to find these networks serving sparsely populated rural areas, but there are a few examples of municipal ISPs that also serve some of the areas surrounding a town. Municipalities that serve outside of the city boundaries often do so because the municipality already serves the water or electric utility in surrounding areas. However, a few municipalities have expanded for the sole purpose of growing larger and gaining economy of scale. An example of this is the Lafayette Utilities Service of Lafayette, Louisiana, which has built fiber into several surrounding suburbs of the city.

- Newly formed broadband cooperatives. A few newly formed cooperatives have built rural broadband.
- Commercial fiber overbuilders. These range from tiny companies that construct fiber from the back of a pick-up truck to giant fiber overbuilders like MetroNet, Ting, and Google Fiber. I know of only one commercial fiber overbuilder, IdeaTek in rural Kansas, that builds only in rural markets.
- Tribes. At least a dozen tribes have built broadband and taken over telecommunications on Native American tribal lands. A few of these got into the business by buying the property from a telco, while others have overbuilt. A lot of tribes are considering this model.

WISPs

These ISPs deploy fixed wireless broadband, meaning they put transmitters on towers and beam broadband wirelessly to customers.

The quality of WISP networks varies widely. A high-quality WISP uses towers that are fiber-fed and use a full range of spectrums to reach customers. The technology today can deliver speeds of over 100 Mbps within a mile and speeds of 50 Mbps up to 5-6 miles. However, many rural WISPs are deploying older technology, using poor backhaul and limited spectrum that are delivering broadband speeds that can be as slow as rural DSL.

Fixed Cellular Providers

AT&T, T-Mobile, and Verizon have all introduced new cellular broadband products in 2021. Until these newer products, rural fixed cellular was generally referred to as a hotspot. The hotspot products had small monthly data caps and charged a lot for going over the data limit. I've heard numerous stories during the pandemic of families working or schooling from home and seeing monthly bills of $500 to $1,000.

The new fixed cellular plans are generally faster and offer larger data caps up to unlimited data. The speed received by any customer on this technology is a function of how far that customer lives from the nearest cell tower. Speeds for customers near a cell tower can be as much as 50 Mbps, but speeds drop quickly, and are slow in much of rural America.

Satellite Providers

There are two distinct types of satellite broadband, geostationary and low-orbit. The two geostationary providers are HughesNet and Viasat. The fastest speeds are on Viasat, which has launched some new satellite, with speeds up to 40 Mbps. But the problem with geostationary satellites is the vast distance (over 22,000 miles) from Earth. The time delay in the signal (latency) is so high that the high-orbit satellites have a difficult time maintaining a real-time web connection that would be used for things like Zoom calls, voice over IP, connection to work or school servers, or even using shopping web sites.

Three new entrants to the field put satellites at much lower orbits, between 200 and 500 miles above the earth. The only operational provider is Starlink, owned by Elon Musk. The company is still in beta test mode. Starlink recently started taking deposits for service and got 500,000 deposits of $99. Starlink has launched over 1,300 satellites and needs many thousands more to have ubiquitous coverage. Beta test download speeds have ranged from 50 Mbps to 150 Mbps. Some detractors believe that speeds will bog down when a lot of customers are using the network.

OneWeb plans to launch 648 satellites that are larger than Starlink's and are basically floating data centers. The company recently launched 36 satellites, bringing it to a total of 182 satellites in orbit. The company says it will be able to start serving the U.K., Alaska, northern Europe, Greenland, Iceland, and northern Canada after two more launches and plans to be able to serve the whole planet by the end of 2022.

The latest player is Project Kuiper, owned by Jeff Bezos. The company has contracted with United Launch Alliance, a joint Boeing-Lockheed Martin venture, for the first nine broadband satellite launches.
Project Kuiper plans to launch 3,236 satellites and the company says it will need 578 satellites to begin offering limited service. Project Kuiper is taking a different strategy than Starlink and is launching larger, and more capable satellites rather than constellations of smaller satellites. It will be interesting to see what this difference means in terms of customer coverage and bandwidth.

<u>Middle-mile Fiber Providers</u>

Middle-mile fiber providers own the longer fiber routes that stretch between towns and counties. Backhaul fiber is vital to any rural broadband network since the long-haul fibers are needed to carry traffic to and from the internet.

A number of different kinds of middle-mile providers crisscross the country:

- <u>Big telcos</u>. AT&T, CenturyLink (Lumen), and Verizon all own extensive middle-mile networks. For many small towns in the country, these providers are the only option for buying transport. In some parts of the country, there are also extensive middle-mile networks owned by large cable companies.
- <u>Other commercial providers</u>. Middle-mile providers like Zayo only sell fiber transport and are not retail ISPs. Some of the most extensive rural middle-mile networks are owned by smaller telephone companies. These are often referred to as statewide networks. There are also middle-mile networks owned by investor-owned electric utilities and electric cooperatives. More recently, we're starting to see middle-mile networks owned by cellular companies.
- <u>ARRA middle-mile networks</u>. A number of rural middle-mile networks were built using funding from the ARRA stimulus grants in 2009. By definition, all ARRA networks must be open-access and must sell transport at reasonable prices to anybody that wants rural transport, whether to reach cell towers or to provide last-mile broadband. The only

exception to this middle-mile characteristic of being open-access is the ARRA network in West Virginia, which the state gave to Frontier to operate.

- Proprietary networks. Some entities build fiber networks for their own exclusive use. Some of these are large networks like the one built by Duke Power, a commercial electric utility, which has elected to not share fiber with any other entities. Facebook, Google, and Microsoft have built some middle-mile networks for their own use. Many networks owned by school systems are prohibited from sharing bandwidth with anybody else due to restrictions placed upon the systems by state law and the form of financing used to fund the networks. Also, some proprietary networks are owned by private corporations; for years Ford owned an extensive network connecting factories in and around Detroit. In many states, the networks built to support highway systems can't be used for commercial purposes. There are also other state-owned fiber networks that can't be used for commercial purposes, like the network in Minnesota that connects to most city halls in county seats, but which is unavailable to ISPs.

There are numerous different business arrangements with middle-mile fiber networks:

- The rural networks owned by the big telcos and cable companies in rural areas generally have the most expensive transport, which seems to be a way for these big companies to squelch competition.
- However, most middle-mile networks charge market rates for transport, regardless of the entity that owns the network. In any part of the country where there are multiple options for transport, the rates between competing networks tend to become similar over time. It can still be expensive to buy transport going to rural places where there is only one middle-mile provider. The cost of transport is very much a route-by-route issue—the more fiber options the less expensive the transport.
- There are numerous examples of middle-mile networks building fiber jointly with other entities. This is generically referred to as cost-sharing, with each partner getting access to some negotiated number of fibers on the jointly built fiber routes. The partners that engage in cost-sharing run the gamut from school systems to cellular carriers, municipalities, electric companies, universities, and data centers (Microsoft, Google, Facebook).

Although the owners of fiber networks vary widely, the operational aspects of sharing fiber are almost the same everywhere. Generally, fiber owners don't allow customers to touch the fiber network and all work is done by the fiber owner or its agents. There are somewhat standard ways for customers to physically tie into and meet middle-mile networks. While rates vary widely, rates generally have only a few components – a rate based upon the bandwidth utilized, a rate based upon the miles of transport, and a rate for connecting to the network.

B. Operating Models

Following is a look at the most common operating models for building and operating a rural broadband ISP.

Retail Model: Build-Own-Operate

In this operating model, the network is built, owned, and operated by a single entity. This could be a commercial ISP, a municipality, or a cooperative. The vast majority of ISPs in the country use this operating model, from the smallest municipal ISP to the large ISPs like Comcast.

Two primary factors affect the cost and profitability of a build-own-operate ISP. The factor with the biggest impact in rural America is customer density. The cost of providing any kind of network to customers is a lot higher, on a per-customer basis, when the customers are scattered and live far apart.

The other important factor for ISPs is economy of scale. In general, the larger the ISP the higher the operating margins. This is due mostly to larger companies being able to spread joint and common overhead costs across larger numbers of customers.

Advantages

> Profits. A single owner/operator can make all of the profit from operating an ISP business.
>
> Control. The owner-operator is solely in charge of making every decision related to operating the business.
>
> Flexibility. A single owner/operator can make quick decisions, within the restrictions from governance rules, to respond to changes in the market or to respond to competition.

Disadvantages

> Risks. The flip side of the ability to make all of the profits is that a single owner/operator also takes all of the risks. If the business doesn't succeed, an owner-operator can lose its investment.
>
> Financing. The ability of a sole owner-operator to fund the business relies entirely upon the creditworthiness of the entity. Small ISP owners often have a hard time raising the money needed to build or extend a network. Every business has a natural credit limit, and this often makes it difficult for ISPs to reach goals.

Open-Access

In an open-access operating model, a network owner (generally a government) offers fiber connections to multiple ISPs, which would then provide retail products to customers. The network owner's only source of revenue is fees collected from the ISPs, which pay for access to the fiber network. ISPs have the relationship with customers—ISPs sell, provide services, bill, and provide customer service.

The open-access model thrives in Europe but has had a more difficult time succeeding in the US. Europe has seen success with open-access networks because a significant number of the large ISPs there are willing to operate on a network operated by somebody else. This came about due to the formation of the European Union. Before the European Union, each country on the continent had at least one monopoly telephone company and a monopoly cable TV company. The formation of the European Union resulted in a change in law that opened up existing state-run monopolies to competition. All of the state-owned telecoms and ISPs found themselves in competition with each other and most of these businesses quickly adapted to the competitive environment. This contrasts drastically with the U.S. market, where there is no example of any large cable company competing with another and only limited competition between large telephone companies.

When a few cities in Europe considered the open-access operating model they found more than a dozen major ISPs willing to consider the model (large companies that would be equivalent of getting Comcast, AT&T, or CenturyLink agreeing to use the new fiber network). There are now open-access networks in places like Amsterdam and Paris as well as in hundreds of smaller towns and cities. The biggest networks have over a hundred ISPs competing for customers—many of the ISPs with niche businesses going after a specific tiny slice of the market. Due to that level of competition, the European fiber networks get practically every customer in their market since even the incumbent providers generally jump to the new fiber network.

That hasn't happened in the US. There is not one example in this country of a large telco or cable company agreeing to operate competitively on somebody else's network to serve residential customers. The large ISPs in the US will lease limited amounts of fiber outside of their footprint to serve large business customers, but the big ISPs have never competed for smaller businesses or residents in each other's monopoly footprints.

This means that open-access networks in the US must rely on small ISPs. These small ISPs are generally local and mostly undercapitalized. The small ISPs have all of the problems inherent to small businesses. They often don't have the money or expertise to market well. They often have cash flow issues that put restraints on their growth. In addition, many of them don't last beyond the career of their founder, which is typical of small businesses in general.

Open-access network operators have struggled in this country due to the nature of the small ISPs on their network. Consider the example of Provo, Utah. The city was required by Utah law to use the open-access business model if it built fiber. The city had originally attracted eight ISPs, but they were small. The city had to help some of these ISPs succeed. Over time, the small ISPs folded or consolidated, and the city ended up with only two ISPs. It's hard to make an argument that a network with so few choices is open-access—because the whole purpose behind open-access is to provide customer choice. The ISPs on the Provo network didn't spend much money to sell or market and Provo was losing a lot of money on the network. The poor success and dwindling number of ISPs eventually prompted the city to cut its losses and sell the fiber network to Google Fiber for $1.

<u>Examples of Open-Access Networks</u>. Following are some of the municipal open-access networks in the country.

- The public utility districts (PUDs) in Washington state. These are countywide municipal electric companies. The PUDs are restricted to offering open-access due to state legislation passed a number of years ago. The PUDs are tackling the open-access business model in a number of unique ways. The largest open-access fiber networks are in Chelan County PUD, Grant County PUD, and Douglas County PUD.

- Utah has a similar law that applies to municipalities. This led to the creation of an open-access fiber business in Provo and another network called Utopia that brings fiber to many small towns. As mentioned above, Provo found the financial model to be unsustainable. Utopia struggled for many years and was recapitalized several times and is still operating a wholesale business.
- A similar law was passed in Virginia after Bristol Virginia Utilities (BVU) built a retail fiber network. The legislation grandfathers BVU as a retail provider but allows other cities to operate only open-access networks. So far, the wholesale model has been adopted by only a few cities, the largest being Roanoke, which offers open access on a limited basis to parts of the city.
- Tacoma, Washington, chose an open-access model where the city was the retail provider of cable TV, but connections to the network for telephone and broadband were sold wholesale to ISPs. The city recently elected to lease the network to a commercial ISP.
- Ashland, Oregon, operates an open-access network, but the city also operates as a retail ISP on the network and competes against a few local ISPs that sell on the network.
- At least several hundred cities have built fiber rings and are promoting open access to carriers. For the most part, these networks serve only carriers and business customers. There are numerous examples such as a lit fiber network in Davis, California, a dark fiber network in south Los Angeles operated by the South Bay Council of Governments, a fiber ring in downtown Cincinnati, a dark and lit fiber ring in Seattle, and an extensive fiber network in Gainesville, Florida.
- Other communities have tried to build open-access networks but then were unable to find any ISP partners. For example, Longmont, Colorado, tried to launch an open-access network, but when it was unable to find ISP partners, it decided to offer full retail services directly to residents.
- One of the most interesting open-access network stories is in Ammon, Idaho. The project is funded by asking homeowners to contribute $3,500 upfront to pay to connect to the network. These fees have largely funded the network construction, making it easy to provide access to multiple ISPs. Not having to pay for the network means that ISPs can offer low rates. I don’t think this model is easily replicable. The downside to this model is that only homes that can afford the payment are connected. This model would not work in most communities because it would exclude low-income homes, most renters, and any other home unwilling or unable to pay the upfront fee. In most communities, this would result in neighborhoods of fiber haves and have-nots, something most cities reject.

Advantages

Customer choice. The most appealing aspect of an open-access network for a community is that it offers a variety of choices to customers over the same fiber network. The further hope on an open-access network is that having greater competition will lead to lower prices and better customer service. The reality of the market is that most open-access networks have only one or two residential ISPs, and prices are often high. It’s not unusual on open-access networks for residential prices between competitors to be close. There are some ISPs that offer services like cable TV that may not be offered by other ISPs, but the appeal of cable as a differentiator is quickly fading.

Lower operating expenses. There are some cost savings for the owner of an open-access network. The owner doesn't have to provide the triple-play products, which bundle internet, television, and phone service. It doesn't have to sell, bill customers, or provide customer service. But it's still extremely difficult for the network owner to be profitable with open-access because the network owner still has to cover the full cost of building and financing the network, plus maintain the fiber network and provide the core electronics. In most scenarios, the network owner has to continue to install fiber drops and/or customer electronics. The primary factor that matters to an open-access network owner is the overall customer penetration rate. From a financial perspective, it doesn't matter to the owner if there is one residential ISP or several as long as the ISPs get enough customers for the network owner to cover costs.

Disadvantages

Retail/wholesale revenue gap. There is a big difference in the revenue stream between collecting the retail revenue stream from customers versus collecting only the fees charged to ISPs. For example, the average retail revenues on a fiber network serving residential customers might be over $100 per customer per month. The average revenues on an open-access network are far smaller, at perhaps $35 per customer per month. The networks needed for open-access are almost identical to the networks needed for an owner-operator ISP. Most municipalities operating an open-access network do not generate enough revenue to repay the cost of building the network.

Not many quality ISPs. Every open-access network that has been tried in the US has had trouble finding and retaining ISPs. The ISPs willing to operate in this environment are generally small and undercapitalized. Open-access forces these ISPs to compete against other small competitors, which holds down end-user rates, but then also puts pressure on ISP earnings. Not only is it hard to find ISPs, but it's hard to keep them. Many ISPs on open-access networks tend to sell out to other ISPs on the network.

Leads to cherry-picking. The open-access model, by definition, leads to cherry-picking (ISPs only pursuing customers willing to pay a lot). If ISPs are charged a fee to use the network, then these fees will generally lead them to not want to sell to low-margin customers. The only way to get broadband to everybody in an open-access network is for the network owner to lower their fees—and that makes it impossible to pay for the network. The cherry-picking leads to lower penetration rates, and CCG Consulting has never seen an open-access network that has a customer penetration rate as high as would be expected if the same community was a municipal retail provider.

No control over sales performance. The network owner in an open-access network has no control over the customer sales process. That means it only does as well as the ISPs on the network. In CCG's experience, having talked to many of the ISPs that operate on open-access networks, the ISPs tend to not have the resources for major marketing efforts or else only want to serve a niche market and don't try to mass market. An owner-operator, by contract, will continually try to sell to everybody—but that never happens on an open-access network.

Public/Private Partnership (PPP)

A broadband public/private partnership is formed when a municipality and a commercial ISP somehow work together to bring broadband. Numerous variations of partnerships can be formed.

PPPs initially arose internationally as a way to finance infrastructure needs that local, regional, or national governments could not fund from taxes, bonds, or other traditional methods of raising government monies. There are estimates that the U.S. has an infrastructure deficit of many trillions more than can be financed by the combined borrowing power of all of the state and local governments added together. This has increased the discussion of public/private partnerships as a way to build needed infrastructure.

There are three major ways that a fiber PPP can be structured depending upon who pays for the network. A fiber network could be mostly funded by the government, mostly funded by a commercial entity, or funded jointly by both.

> PPP funded mostly by a government. There are not many examples of this in the U.S. This scenario means that a government takes all of the financial risk of building a network and then hands the operation of the network to somebody else. This seems to be the arrangement that is in place in the Google Fiber partnership with Huntsville, Alabama. Reports are that Google Fiber is responsible for the costs inside the customer premise and the city for the rest. There are similar partnerships between Ting, an internet service provider, and Charlottesville, Virginia, and Westminster, Maryland.
>
> PPP funded mostly by the commercial provider. There are many examples where a commercial provider has built a fiber network and doesn't consider the venture to be a PPP. Generally, an ISP that uses the normal avenue of obtaining rights-of-way and then adheres to the franchise and permitting processes in a city is free to build fiber.
>
> It's also not a PPP if a government gives concessions to attract an ISP. To be considered as a PPP, a municipality would have to get something in return for the concessions they make to an ISP. This could be almost anything that is perceived to be of permanent value. It might be free or reduced telecom prices provided to government buildings or fibers connecting government locations. It could also be the ISP agreeing to help the city meet some social goal, such as building out to poorer parts of the city, that a normal commercial ISP might otherwise not have considered.
>
> PPP funded jointly. When a municipality and an ISP both contribute cash or hard assets to a venture then it's clearly a true partnership. There are a number of examples of telecom PPPs working in the country today. Such partnerships are structured in many different ways and the following are a few examples.
>
> - Zayo partnered with Anoka County, Minnesota. This is a suburban county just north of Minneapolis and St. Paul. Each party contributed money to build a fiber network together. The county received access to a 10-gigabit network connecting all of its facilities and Zayo received connections to all of the major business

districts. Zayo owns the network, but each party has affordable access to the whole network as needed. Each party is also allowed to build outward from any point on the jointly built network at its own cost.

- Nashville, Tennessee, partnered with a commercial fiber provider to build fiber to city locations as well as to commercial districts. Both parties made capital contributions. The city eventually sold its interest in the network but still retains fiber to most city buildings.
- Dozens of small cities built an initial fiber network to connect to schools, water systems, etc., and allow commercial providers to build spurs from the city-owned ring. The financial arrangements for this vary widely. Sometimes the two parties just swap access to various locations on each other's network and in other cases, they each pay to lease access on the other's network. However, both parties share the same network, portions of which each has funded.
- In Sibley and Renville counties in Minnesota, the counties, cities, and townships together contributed an economic development bond that is being used to fund 25% of the cost of a fiber-to-the-premise network, which is operated by a newly formed commercial cooperative.
- Google Fiber recently reached an agreement with West Des Moines, Iowa, where the city will build empty conduits to the side of each home and business, and Google Fiber will install fiber and offer service to everybody in the city. The network will also be open to other ISPs and is the first example we know of a dark conduit open-access network.
- There are hundreds of examples of government entities that have built fiber routes jointly with some commercial enterprise. This is referred to in the industry as fiber sharing and generally, each contributor to the fiber route will get some specific number of pairs of fiber. This is a common practice when a school system builds fiber networks.
- A fairly new kind of partnership is between communities and the incumbent telephone company. In the past few years, there have been such partnerships formed by Consolidated in New Hampshire and by CenturyLink in Missouri. It seems likely with the influx of ARPA funding that many more such partnerships will be formed. In these partnerships, the city generally bears the cost of building the network and the telco promises to pay for some or all of the cost of the network over time as long as the network gets enough customers.

There are several kinds of contributions that a government can make to somebody else's fiber network. These could include cash, real estate, excused fees, or sweat equity. Governments can allow a commercial provider to use parcels of lands or give it an existing building. Excused fees might mean not charging for something that would normally be due, such as permitting fees or property taxes. The government could excuse payments for poles, conduit, existing fiber, or towers. It could mean the commercial provider might not need to pay taxes or fees for some time, as is often done in many economic development projects. Sweat equity is assigning a value to the time contributed by the city. For example, we've seen a city assign extra employees for tasks like the permitting process during a major fiber construction project.

There are almost unlimited ways to model and form a public-private partnership. The underlying requirement is that the business must be profitable for the private commercial partner. Commercial providers expect a healthy rate of return on any investment they make in the business.

Following are the advantages and disadvantages of public/private partnerships, from the government perspective.

Advantages of a PPP

Lower investment needed. Any network costs provided by a private partner reduces the investment and borrowing needed by the government entity. A private equity partner can bring cash toward building a fiber network that might be hard to raise elsewhere.

Disadvantages

Matching goals and expectations. One of the primary reasons why there are not a lot of telecom public-private partnerships is that it's often difficult to reconcile the differing goals of the two sides. The commercial partner is generally going to be focused on the bottom line and returns while the community part of the business often has goals like community betterment and lower rates. One of the biggest sticking points in creating PPPs is that cities want fiber to pass every home, while ISPs prefer to build to only selected neighborhoods. It's often difficult to put together a structure that can satisfy all of the different goals.

Expensive money. Commercial partners often have a goal to make at least a 20% return on equity, and that makes external equity an extremely expensive source of funding.

Tax-free funding issues. It's difficult to obtain tax-free bond funding to support a PPP. Tax-free financing can't be used for a project that provides tangible benefits to a commercial entity.

Length of partnership. Many commercial investors only make investments with the intent to eventually sell the business to realize the cash value. This may be difficult to reconcile with the long-term desires and goals of a community-based fiber optics project that might want to own the network forever.

Governance issues. It's a challenge to develop a governance structure for a competitive business that can accommodate the government decision-making process. Governments generally have to go through a defined deliberative process including holding open meetings to make any significant decisions. This does not match well with the decision-making process and the timeline for a commercial partner. A commercial partner might want to make decisions in days when the public process might not be able to resolve issues for weeks or months.

Maintaining local control. One of the biggest issues faced by any municipality that enters into a broadband partnership is maintaining control. If a community is going to spend millions to finance a fiber network, it's natural that the community wants to be able to control things like setting broadband rates or determining policies intended to provide broadband to low-income households.

ISPs will automatically assume that they are going to get to call all of the shots related to operating the business—and most ISPs are not going to be interested in entering into a partnership where that is not the case. ISPs have a natural mistrust of government entities because they assume that government will make decisions based on political goals or pleasing the public, and not based upon being profitable. Municipal ISPs operate with different goals than commercial ISPs. There are numerous examples of municipal ISPs with super-low rates or with policies that provide big discounts to disadvantaged households—things that commercial ISPs are not easily willing to do.

Other Operating Alternatives

There are other operating options for communities that don't want to operate an ISP or form a public/private partnership. A few examples include:

Operator for hire. An operator for hire is just what it sounds like. A municipality could build a fiber network and hire an ISP to operate the business. An operator for hire would have no ownership and would be a vendor and not a partner. The operator is paid to operate the business in a way directed by the municipal owner. This is not a unique concept and there are small communities that have hired outside firms to operate the municipal electric or water business.

The challenge with this concept is that there aren't many ISPs willing to accept this role. Most ISPs want a partnership where they can share in upside profits. Unfortunately, if an ISP wants to share profits, it won't want a municipal partner setting policies that cut profitability.

Partner with other municipalities. A more common option is to partner with other municipalities in some sort of consortium. States have laws that allow local governments to join together to tackle projects that benefit multiple communities. It's common for communities to band together to tackle regional issues like water systems, school boards, transportation, etc.

There can be upsides for communities to work together to create a broadband business. The broadband business is an economy of scale business, meaning that the more customers served by the business the lower the cost per customer. It's a lot easier to justify creating an ISP for half a dozen small communities creating one ISP business than it would be for each small community to tackle this individually. Having the economy of scale from serving multiple communities also makes it easier to fund the network.

The one downside in a municipal consortium is that any member will not have the same kind of control that would be in place with operating an ISP directly. However, a consortium is likely going to have policies that the member municipalities will like.

Cooperative. A broadband cooperative is owned by customers of the business. Every state allows cooperatives in general, but there are states with prohibitions against cooperatives that offer broadband or telephone service. (This is a rapidly changing list because a lot of states passed laws in 2020 to allow electric cooperatives to offer broadband.) The cooperative business structure is more common in some parts of the country. For example, in the upper Midwest, half of the businesses in a rural community might be operated as a cooperative. We've seen several new broadband cooperatives in recent years like the RS Fiber Cooperative in Minnesota. There are a few benefits that a cooperative has over a municipal structure.

Funding is a major plus for cooperatives. It's easy to assume that municipalities can fund projects easily with bonds, but many communities cannot support bond issues large enough to pay for a broadband network. Municipalities are just like every business in that each city has a natural lending limit based on its ability to raise the revenues needed to repay a bond issue.

Cooperatives can have access to funding sources that aren't available to municipalities. For example, it has often been challenging for municipalities to win state or federal broadband grants, but much easier for cooperatives. While municipalities can theoretically borrow money from federal lending sources like the Rural Utility Service, these loans have rarely gone to municipalities due to banking requirements that municipalities can't accept. But these funds are easily available to cooperatives. There are also CoBank, itself a coop that lends to telephone and electric cooperatives, and RTFC that lends to telephone cooperatives. Cooperatives have also been known to solicit equity infusions from members of the community, which is a challenge for a municipal project.

<u>Non-profits</u>. Establishing a non-profit corporation is another alternative business structure. Non-profit corporations are similar to cooperatives, but with a few key differences:

- Non-profits are not taxable while most cooperatives pay income taxes. The profits made by a non-profit must be invested back into the community, while the profits at a cooperative must be rolled back into the cooperative.
- Every customer of a cooperative gets a vote to choose the Board that governs the business. A non-profit Board can be established in almost any manner and the public probably gets little or no say in how the business is operated.
- Non-profits don't have the same access to funding sources that are available to cooperatives.

These differences have resulted in cooperatives being a more popular structure and there are not many non-profit ISPs.

C. Feasibility Studies

This section of the report discusses the first step that anybody that wants to launch an ISP in a new market must take: doing enough research to make sure that the new ISP or new market will be profitable. A new broadband venture always starts with a feasibility analysis. Municipalities tend to hire outside experts to conduct the feasibility analysis while existing ISPs tend toward undertaking the analysis internally, but in both cases, the analysis tries to answer the same question: Is it possible to profitably operate an ISP in the market we are considering? An analysis of a potential broadband market will include the following:

<u>Market Research</u>

Market research typically includes the following types of research:

Market prices. The ISP will analyze the current broadband and related prices in the target market. It's a common misperception that the big ISPs charge the same rates everywhere; we've seen big differences between markets in the willingness of ISPs to offer promotional discounts, bundling discounts, negotiated discounts, etc. Price research can be done in several ways. First are web searches to determine the products and prices of existing service providers. It's also typical to talk to local providers who are sometimes willing to share their pricing. Ideally, it's beneficial to gather a sample of customer bills.

Online survey. An online survey is a great tool for understanding sentiment and to find out how the public feels about the current broadband available. The keys to a good survey are to ask simple, unambiguous, and unbiased questions and to keep the survey manageably short. There is no standard format for online surveys. I've seen surveys as short as four to five questions and others that are pages long. Online surveys are best at measuring sentiment questions: Do people like their current ISP? Are people happy with prices or customer service? Would people like to see somebody bring a new alternative to the community.

Online surveys for businesses are generally different than residential surveys. Every business has a unique broadband story because every business uses broadband in unique ways. This means business surveys generally ask businesses to tell their broadband story in essay form rather than by answering multiple-choice questions. Surveys want to learn if the current broadband is restricting the business from conducting business in an ideal way. We generally also want to know what a business might tackle differently if it got faster broadband.

Statistically valid telephone survey. A statistically valid survey is the only way to reliably quantify findings about the market. For example, if a community wants to know the number of homes that don't currently have broadband, a statistical survey is the best tool for measuring numerical facts.

Most business surveys are designed to provide an accuracy of 95%, plus or minus 5%. That means that if you were to ask the same questions to 100% of the people in the survey population that the results should not vary by more than 5% from what was obtained in the survey.

There are a few important factors that must be present to get that degree of accuracy. First, the questions asked must be unbiased and can't lead respondents to answer in a given way. Probably the most important factor is that a survey must be conducted randomly to represent the whole community. It's impossible to overstress the importance of a random survey. To give an example, if a survey wants to answer the question of how many households would consider switching service to a new fiber network, then only a random study can provide a believable answer. It's just as important to find the people who are not interested in broadband as it is to find those that would prefer fiber.

Another key issue is that to keep the survey reasonably short. There is a well-known phenomenon called survey fatigue and a large percentage of people will hang up or walk away from a live survey if they feel it's taking too long. We've found that a survey should not last more than ten minutes, and hopefully for less time.

There are only two ways to administer a random survey: by telephone or by knocking on doors. It's extremely challenging to administer a door-to-door survey over a large geographic area. An important consideration when doing a telephone survey is that it no longer makes any sense to do a telephone survey if the survey doesn't include cellphones.

Speed tests. Another useful research tool is to ask residents and businesses to take a speed test. Speed tests are the best tool we know of to get a qualitative analysis of existing broadband networks in the community. Or, in other words, are ISPs delivering what they are selling?

Interview key stakeholders. Feasibility studies often include interviews with key stakeholders. These interviews can go a lot deeper than surveys to understand the issues being experienced by customers in a given market.

Contacting ISPs. Another useful market research tool is to talk to current ISPs in the market. The larger incumbent ISPs often won't talk to somebody doing a feasibility study. The goal of these calls is severalfold. It's good to know if ISPs have any plans to improve or expand broadband. It's also good to explore if there is any potential for the community and an ISP to partner to find a solution.

Engineering Analysis

An engineering analysis must be performed to estimate the cost of building a broadband network in the community. The goal of an engineering analysis is to perform enough engineering investigation to be able to get within 5% of the cost of building a network in the community. Feasibility engineering analysis generally involves the following tasks:

Data gathering. Most communities today have GIS mapping data that is invaluable for creating an engineering estimate. GIS data generally includes, at a minimum, the location of every property plot and building in the community as well as details about the locations of streets, roads, and alleys. Sometimes GIS data contains even more data. For example, the data might note the number of living units in an apartment building or the number of businesses in a strip mall. The GIS data might include details on utility poles – who owns them and how tall each is.

Engineers have learned to not rely solely on GIS data and will also look for corroborating evidence that can support what is found in the GIS data files. For example, getting a count of electric and/or water meters is a good way to double-check the accuracy of the GIS data.

One of the hardest things to count is the number of potential businesses in a market. Communities will often have a count of the number of business entities in the community, but that would include shell companies that might own real estate or companies started by people working from home. It can be a big challenge to identify the number of businesses that might become customers of an ISP.

The other kind of data often gathered is demographic. Does the community already have a long-range plan for the location of future housing or business growth? Demographic investigations might also help to quantify the number of low-income homes that might have problems paying the full price for a broadband connection.

Field site investigation. An engineer also will want to visit the community to look around to identify factors that might affect the cost of fiber construction. Local factors can have a big impact on the cost of building fiber. For example, the most important is the conditions of existing utility poles – is there room to add fiber? Are there impediments that might provide a reason to build fiber along a specific side of the street? Does it look better to bring utility into homes from alleys rather than from the front of a home? The field engineer will make specific recommendations about the most sensible way to construct a new network.

Choose Design Criteria.

There are many design criteria that will affect the cost of the network. Before creating the design, an engineer will determine the following aspects of the design:

- Whether to use buried fiber, aerial fiber, or some mix of the two.
- Whether to put aerial fiber in the communications space or the power space. An electric utility can save money by putting fiber near the power lines instead of lower on the pole with other utilities.
- The technology to be used. Fiber uses two different primary technologies, passive and active. Each can be the best choice for a specific community.
- The specific electronics design philosophy. There are different ways to design a network that mostly has to do with the size of the community and the shape of the network. As an example, in smaller communities the electronics might be placed at one central hub, while in larger communities there might be a series of hubs built around the area to hold electronics.
- Redundancy. This looks at ways to design fiber rings that can reduce network outages to neighborhoods caused by a future fiber cut.
- Connectivity to the outside world. It's always important to understand where the network will connect to the outside world.
- Accounting for growth. The design must be robust enough to handle future growth.

High-level design. Once all of the facts are gathered, an engineer will create a high-level design of the network. Most engineering firms today use design tools that can automatically place some of the key network elements on a map. For example, if the engineer chooses the locations for the various electronic hubs, the software will determine the size of fibers needed to reach out into the community. Engineers will then review the design in detail and make modifications as needed based upon earlier research. As an example, the engineer might force the design to use alleys instead of frontage streets in some parts of the network.

A high-level design results in a 'parts' list. It will describe the units of various types of construction that are needed, such as the number of feet of 48-count fiber versus 96-count fiber, along with the various other network devices like cabinets, handholes, etc., that are needed to complete the design.

Pricing the network. The last major task is for the engineers to assign pricing to the design units. Engineering firms maintain price lists for common raw material components. The harder number to estimate is labor costs. Engineers will maintain lists of regional labor rates, but they usually also talk to several construction firms that work nearby to understand local construction rates and conditions.

Estimating other costs. Engineers will layer on other costs of building a network including:

- Engineering fees. This is an estimate of the field engineering costs that will occur during construction.
- Construction management. This is the function of looking over the shoulder at the construction vendors to make sure that they are building according to specifications and are reporting accurate construction units.
- Rights-of-way, permitting, etc. There is a cost to comply with local permits to use streets and rights-of-way and to obtain any needed private rights-of-way. Construction projects of any size also are likely to include special efforts to obtain the rights to build on bridges, around interstate highway overpasses, and across railroad tracks.
- Contingency. It's a standard feasibility practice to add a contingency cost to a project to add a cushion of financial safety. We often see contingencies between 5% and 15% of construction costs depending upon how sure the engineers are about the underlying assumptions.

Financial Models

The goal for financial modeling is to understand the financial ramifications of any given business plan. The first goal is to see if a given operating model can be profitable – and if not, what it might take to become profitable.

The financial business analysis should look in-depth at the organization, operating costs, overheads, equipment, and materials required to operate the proposed business. For example, a business plan should assume the staffing positions needed and the likely salaries and benefits.

It's typical for business plan analysis to include a sensitivity analysis. This will test each of the most important variables to understand how each changes future cash flow and financial results. It's typical, for example, for key variables like the customer penetration rate, interest rates on debt, or prices to influence the financial results.

Funding and financing analysis. ISPs need to understand how broadband networks and projects might be funded. It would be typical to include an analysis of all of the likely sources of funding that might apply to a given community. This might include things like bond funding, grants, bank financing, federal loan guarantees, contributions from customers, direct funding by tax revenues, or other esoteric financing mechanisms like Qualified Opportunity Zone financing.

Add-ons

It's common for communities to ask consultants to answer questions other than the financial viability. There are often topics that are of local concern that they want to see addressed in broadband studies. This could include topics like:

- The benefits of fiber broadband. How does having fiber benefit a community?
- The risks of tackling broadband. What are the financial, operational, and other risks of launching a new broadband market or business?
- The likely competitive response of incumbents. How will the incumbent telephone and cable companies respond to competition?
- Regulatory analysis. What's the burden of regulation?
- Impacts of other technologies. How might alternate technologies like Starlink satellite, 5G, or cellular broadband affect a new broadband network?
- Industry trends. What industry trends are likely to have the biggest impacts on this specific project?
- How to find a partner. How can a government entity find a partner?
- A timeline. What's the likely timeline for building and launching a network?

Written Report

A feasibility study should address the following big-picture issues:

- The cost of building the desired network.
- The amount of money that must be invested to build the network and start the broadband business in the community. This might come with specific recommendations such as the amount of grant funding that is needed to make the project work.
- The market demand for broadband: How many people in the community might buy service from a new network?
- Specific hurdles that the community faces in launching a new business.
- Depending upon the various other topics that were included in the feasibility study, the report might also describe market prices, the competition, legal and regulatory issues, etc.
- A strategic plan to move forward.

Municipal clients almost always want a formal written report that describes the study process and that describes the findings. Such reports are rarely under 100 pages long and can be much longer.

D. Implementation Timeline

Once a feasibility study has been delivered, an ISP can begin the process of deciding if it should move forward with the new market. The typical steps that we see taken after completion of a feasibility study is something like the following:

- Conduct more research. This generally means digging deeper into local issues than was done during the feasibility study.
- Overcome any hurdles. Every ISP will have a different list of hurdles. This could be something as simple as identifying and assigning staff needed to move forward. Hurdles

can also be a lot more complicated, such as finding a way to work around state barriers to broadband deployment for a municipality.
- Decide to build fiber. I've seen the deliberative process take years. The decision to move forward with a costly fiber project is not an easy call.
- Raise money. This might be straightforward for a municipality that can issue bonds without a referendum or for a commercial ISP that already has a sufficient line of credit. For everybody else, this likely is the hardest hurdle to overcome.
- Build the network and launch the business.

It's impossible to predict the time required for the first four steps. Every situation is different. It's possible to go quickly through the first four steps, but I've also seen these steps take many years. The longest example I can think of that eventually resulted in a fiber network was seven years for the first four steps. The two steps that are often the hardest are making the decision to move forward and funding the network. Funding might be straightforward for a municipality that can issue bonds without a referendum or for a commercial ISP that already has a sufficient line of bank credit. For everybody else, funding is likely the hardest hurdle to overcome.

Conduct More Research

It's routinely expected that more research will be needed after the completion of a broadband feasibility study. It's impossible to imagine a feasibility study that is so thorough that it answers every question an ISP might have.

Research can be for almost any subject imaginable, but the following are the most common kinds of research that we normally see being done after a feasibility study, assuming the feasibility study recommends moving forward:
- <u>Market research</u>. If a feasibility study didn't include detailed market research, this is often the next step. It's always important to get a trustworthy estimate of how many homes in a community will buy broadband from a new network.
- <u>Legal/regulatory research</u>. It's routine to look closer at any legal hurdles that might be a barrier to entry and to understand the level of regulation that will apply to providing broadband.
- <u>Understanding barriers to market entry</u>. This could cover a wide range of hurdles that must be overcome to bring broadband to a community. For example, if government funding will be contributed to a broadband solution there might need to be a public referendum. There might be state or county ordinances that add difficulty to creating a broadband solution. There might be a limit on the amount of money a local government or a commercial ISP can borrow. There might be an incumbent that is likely to respond fiercely to competition. Understanding barriers means delineating and grasping every issue that might hinder a broadband solution.
- <u>Funding</u>. A feasibility study should quantify the cost of building the needed network. Having a concrete number in mind for broadband makes it possible to start looking at possible sources of funding that can finance a network.
- <u>Exploring grants</u>. In today's environment, an area of specific funding that needs attention is the availability of grant funding. This means exploring potential grants, understanding

eligibility to request the grant, and understanding the timeline for applying for grant funding and using any awarded monies.

- Choose an operating model. A feasibility study might have explored different options such as an entity tackling broadband alone versus the creation of a public/private partnership. Before moving forward, an operating model must be adopted.
- Local staffing. Another logical step is to determine the immediate staffing required to move a broadband project forward and to determine how to pay for it.
- Community outreach. Municipal projects almost always require community outreach to explain to the public what was found in a feasibility study and to ask how the community feels about moving forward.
- Local ordinance review. This is a good time to review local ordinances that affect broadband construction—tasks like permitting, rights-of-way, fiber locating, construction inspection, etc. Whether a community is thinking of building a network or attracting a commercial ISP to do so, it makes sense to remove any barriers that add unneeded costs to broadband construction.
- Looking for partners. If a feasibility study recommends a partnership structure, the next step is to find and interview potential partners.
- Tackling broadband gaps. As part of seeking a broadband solution it makes sense to look at issues like bringing broadband to low-income families, students, and other stakeholders that might be left out of a broadband solution.
- Understanding unique local issues. Almost every community has local conditions that affect finding a broadband solution. For example, a college town might need to consider how to effectively bring broadband to student housing and how to market to college students.
- Gaining political consensus. Many communities have to put effort into building a political consensus. This might mean things like holding workshops to answer elected officials' questions about broadband. It might mean visiting other communities that have already found a broadband solution.

Overcome Any Hurdles

This is the stage of a project that I refer to as making mini decisions. Before the big decision is made to move forward it is first necessary to focus the project by resolving many of the above issues. For example, a decision might be made that the project must be some form of a public/private partnership. It might be determined that a public referendum is needed to move forward. It might be clarified that a grant of specific dollar magnitude will be needed to make the project work. This stage means coming to conclusions on many of the steps listed above.

Decide to Build Fiber

Once all of the above research is concluded, and assuming that ways have been identified to overcome any hurdles, the decision-makers must formally decide to move forward. This might be done by a city or county board or council, or the board of directors for a commercial ISP or a cooperative.

Project Implementation

Implementation is a broad-brush phrase that covers all of the tasks that must be accomplished from the time that a decision is made to move forward until the new broadband network has customers.

We strongly recommend using a Gantt chart process (or some equivalent) for the implementation. This is a systematic approach that means defining every task that is needed, entering the tasks onto a timeline, assigning who is responsible for each task, and tying the tasks together so that if a task is finished early or late that the entire timeline can be adjusted. One of the most important outcomes of using a structured approach is that the critical path—the chain of events that must be done on time in order for the project to keep on schedule—can be identified. This puts the emphasis on the critical tasks.

The following are the largest categories of tasks that much be accomplished. The first few tasks are listed first because they are typically tackled early, and the natural order for tackling tasks is a natural product of using the Gantt chart process.

Find a partner. Finding and reaching a deal with a partner must be one of the first steps if a partner will be part of the solution. It's likely that if the project needs to have a partner that preliminary discussions likely happened during the research stage above. But if not, then finding a partner is a key step. A big part of cementing a partnership is to negotiate a partnership agreement that clearly defines the roles and expectations for both parties. There are many factors to consider when contemplating a public-private partnership:

- Incompatible goals. It's not unusual for a municipality and a commercial ISP to have significantly different goals that may not be compatible. An easy example might be the desire of a commercial partner to maximize profits while the municipal partner might want to subsidize large numbers of low-income households. It's essential for both parties to fully specify their goals up-front.
- Decision-making process. Commercial partners are often frustrated by the slow deliberative decision process required by most municipalities. Even ordinary decisions might require several council meetings to decide.
- Public records requirements. Many commercial ISPs are uncomfortable with the fact that anything given to a municipality might be discoverable and made available to the public.
- Meshing the financing. It's not easy to mesh two different types of financing. For example, it might prove impossible to satisfy the collateral requirement for both a bond issue and a bank loan for a jointly funded project. The new network can be pledged as collateral to only one lender.
- Unpredictable leadership. Commercial ISPs are also uncomfortable that municipal administrations can change with a new election, meaning that the relationship between the two parties can change drastically.

Raise the funding. If the exact source of funding is not known, then determining funding is usually the other early key step in the process. It can be a waste of time to undertake any other implementation steps until it's clear that the project can be funded. If funding is simple, such as issuing municipal bonds that don't require a referendum, then this process can be easy, but it rarely is simple. The funding process more often relies on multiple sources of funding, including things like grants. We've always recommended not moving too far until funding is secure. The funding step is often the longest time hurdle to overcome, and I've seen projects take years to cement the funding.

Define the construction process. Will the project be turnkey with a design/builder that designs and builds the network? Will there be separate engineers, contractors, and inspectors?

Identify the project team. The final key step is to identify the implementation team. This is likely to be a combination of existing staff, staff yet to be hired, consultants, external engineers, construction vendor(s), material vendors, etc. If some of the external team members haven't already been identified, this step might include issuing requests for proposals (RFPs) or otherwise interviewing candidates for external team member positions like consultants, engineers, and construction vendors.

Choose technology. If it wasn't already done in earlier stages, an early step would be to finalize the choice of technology, which is often followed by identifying the preferred vendors of technology. To the extent that technology cost is an issue, this process might also include getting bids from vendors as a way to make the needed choice.

Preliminary network design. While many projects are initially launched based upon high-level feasibility engineering, an early step for many projects is to undertake more detailed engineering sufficient enough to receive competitive bids for construction.

Organizational readiness. Organizational readiness means getting the business structure in place. It means obtaining business licenses, logos, websites, the basics. One of the most challenging tasks for a new ISP is to define the public name of the business that will be marketed.

Outsourcing should be defined. Decisions should be made about what functions will be outsourced instead of performed by staff. This could include a wide variety of areas like building customer drops, network monitoring, providing ISP routing, etc. Outsourced vendors should be identified and integrated into the implementation team as needed.

Hiring process. If the new business will add employees, the process of creating job descriptions, defining benefits, determining salaries, determining the interview process should be established.

Procurement readiness. A list of needed purchases should be made. Even if the construction contractor buys network materials, the company will likely need to purchase vehicles, computers, furniture, office equipment, test equipment, etc. Any needed real estate should be identified and procured. The formal purchasing process should be defined (low-cost bids, RFPs, etc.) if it will be used. If the company is going to buy construction materials, then specifications need to be created, quantities determined, and vendors selected.

Regulatory readiness. A new ISP may need to be certified by a state regulatory authority. ISPs need to register with the FCC. Tariffs might need to be filed with the state. There is a list of regulatory steps that must be taken by every ISP such as registering with the Universal Service Fund, registering with the FBI to define processes for assisting with wiretaps, etc. There are additional regulatory steps required if the ISP plans to sell voice or cable TV products. There are industry processes that must be implemented to exchange traffic with the outside world.

Contract readiness. A new ISP often needs several contracts such as interconnection agreements, pole-attachment agreements, franchise, and rights-of-way agreements. If the business will have contracts with customers a shell agreement should be created.

Product readiness. Specific products and prices should be developed. All vendors needed to provide any product should be selected.

Software readiness. ISPs use software to enable the customer care process from order taking to billing (OSS/BSS system). There are other kinds of software often used such as sales software, mapping software, etc. that should be purchased, and training provided for staff.

Sales and marketing plan. Possibly the biggest key to success in launching a fiber business is a successful sales and marketing plan. You want two plans – one for selling to residents and another for selling to businesses. If sales involve door-to-door selling, there will be training on the consultative sales process. The sales plan also includes the development of things like product literature that explains your products to customers, a sales-oriented website, customer documents like price lists and terms of service. You'll also want to develop an advertising plan and strategy. You'll need a compensation plan if there will be sales commissions.

Building readiness. There may be buildings to be built or modified. This could include employee office space and retail public space. There will typically be a network core area to include electronics that must be air-conditioned. There often must be emergency generators for electric outages. Most networks include numerous huts and cabinets that need to be sized, equipped, and placed in service.

Business office readiness. The business will have to identify, secure, and prepare the retail business office where the public can interface with the business. Processes need to be established to accept payments and safely accept cash.

Accounting readiness. The business must be prepared to account for a huge number of invoices and transactions during the construction process. An accounting auditor should be selected. Accounting software should be defined and purchased. A chart of accounts and the budgetary process should be established. The process for internal approval of invoices and other payments should be established.

Construct the network. Define timeline and responsibilities for constructing the network. Be ready to store construction materials and to provision daily to crews as needed. Have all processes in place for construction such as permitting, rights-of-way, traffic control, utility locating, etc. Define who inspects and approves construction. What's the testing process to approve and accept completed segments of the network?

Customer location procedures. Define the standard installation process. Do electronics go inside or outside of premises? Where are you willing to place electronics inside of premises? When do extra fees get invoked for a non-standard installation? Determine steps and timeline for building drops, adding electronics, turnup, testing, and customer training.

ISP readiness. The servers, switches, and other devices used to provide ISP services should be purchased. IP addresses should be purchased. ISP functions such as email services, DNS routing, and security readiness against malicious software and hacking should be defined and implemented.

Network security plan. There should be a plan in place for disaster recovery should the network crash. There should be both physical and electronic barriers created around key electronics, buildings, software, etc.

Customer process readiness. Every process for interfacing with customers including sales, order taking, provisioning, installation, taking payments, etc., should be clearly defined and tested. Every person in the customer care chain should know their role and responsibilities and should know what to do if an expected process doesn't work. Processes for screening customers such as credit checks or requiring deposits should be defined.

Billing readiness. Define bill format. Determine customer payment options: cash, credit card, checks, live payments, bank debits. Determine billing cycles. Determine late payment and disconnection processes. Make sure the first bill is correct.

Provisioning process. Make sure customers get the products they ordered. Connect the services in time for installation. Make sure that needed hardware is given to the installer for each customer. Test each customer's product before hand-off.

Network monitoring process. Equipment alarms should be enabled to notify if there are problems with electronics or the network. The process of monitoring the network 24/7 should be defined. There should be an escalation process so that the right people are alerted for various levels of trouble and outages. There should be a process for issuing trouble tickets and tracking and closing them as troubles are resolved.

Customer trouble process. Define how customers can interface with the business (live, telephone, text, website, etc.). Define who takes customer trouble calls. Define first-tier maintenance to try to resolve problems over the phone. Define how to escalate and to dispatch repair technicians to the customer's premise. Prioritize and track every customer outage to make sure all are handled.

Connect the first customer. Whew!

This was about as short as this list could be made. There are dozens of important steps and hundreds of smaller tasks not included in the above, which illustrates the complexity of creating a new ISP, or even of launching a new market. It's not unusual for a full Gantt chart for a network launch to have two to three thousand separately identified tasks that much be completed.

Typical Broadband Network Deployment Timeline

It only makes sense to talk about the timeline for what occurs after a broadband project is funded. The timeline needed to reach funding is unique to every situation, and funding could happen as quickly as months or take many years.

There is also a big difference in a timeline when comparing a newly formed ISP building its first network and an existing ISP adding a new market to an existing business. This is easy to see by looking at the list of major categories of tasks just above – an existing ISP is already going to be doing many of the needed functions, while a new ISP needs to find a solution for every step of entering the new business.

Another issue that has a big impact on the timeline is how the ISP handles funding. An ISP that doesn't want to start tackling the above list of tasks until funding is in hand has a much longer timeline than an ISP that is willing to get many of the tasks completed before funding is in hand. For example, an ISP can save a lot of time if it has already tackled the regulatory readiness tasks and has taken the big steps of having already engaged with the engineer, construction vendors, and electronics vendors.

The last issue that has a big influence on the timeline for an ISP launch is the purchasing process. A builder that has to go through formal RFPs to make significant capital expenditures is going to take a lot longer than an ISP that can call and negotiate directly with these vendors. As a common example, there might need to be an RFP process to first hire the engineer before the process can be started to choose the construction contractors and the electronics vendors. Another important purchasing decision is if the ISP will buy all of the material or if they will allow one of the other vendors like the construction contractor to make such purchases. In many cases, a builder may be able to get a substantial discount from manufacturers that would not be available for the network owner.

The following discussion of the timeline assumes the ideal situation. It assumes that the engineer and construction company are on board on the day that funding is closed. For any project where that is not the case, the time needed to identify and hire these two primary vendors would have to be added to the beginning of the timeline. It's also important to have the key staff on board at the onset of a new network launch. If this means hiring a new general manager, hopefully all the legwork needed to do so will have been tackled early.

The following discussion will identify the order in which tasks are usually tackled in a network launch. One important idea that is often the focus of a network launch is the critical path. A delay in any task on the critical path will translate into a delay in the launch of the new market (which is often measured by the day when the first customer can get service on the new network).

Earliest Tasks

Note that the following breaks tasks into steps defined as early and subsequent. In a small network build, all of these tasks are tackled quickly, while in larger projects that might take multiple years to build, the timeline looks more like what is discussed below. The earliest tasks are almost always the following.

- Regulatory readiness. A network owner must be a certified carrier to interface with other carriers and related entities in the industry. For example, a utility that owns poles will often require that a network owner be a registered carrier before allowing any discussions on pole-attachment agreements. The time required to be a certified carrier varies widely by state, and also tends to vary according to the workload at the regulatory agency in the state. We see times of two to six months to achieve the needed regulatory status, assuming there is no controversy in the process. Note that occasionally a large incumbent telco or cable company might intervene in requests for certification of a government entity as a way to delay the process.

- Backoffice readiness. This includes tasks like starting the accounting process, creating budgets, and defining the cash flow process and approvals needed to use cash.

- Contract readiness. An early step is to take care of any paperwork and fees needed to get rights-of-way or franchises needed to build along public rights-of-way in the construction footprint. Rights-of-ways to cross customers' properties are done later in the process during construction – the early permits are ones signed with local governments if needed. There may also be needed contracts like pole-attachment agreements with the local utility or pole owner.

- Procurement readiness. In today's environment where both fiber and electronics have supply chain issues, the ISP should address procurement as soon as possible. Procurement may start with choosing the engineer and construction vendor. It will mean choosing the technology and the primary electronics vendors. But building a network also requires buying a large amount of hardware and the many components needed to build a network. It also involves things like vehicles, computers, etc. The specific procurement process should be defined, including the needed approvals to buy things. To the extent possible the ISP should consider steps to make procurement more efficient.

- Field engineering. It's critical to get engineers into the field as early as possible to start the detailed design of the network. Preliminary engineering usually focuses on creating a list of materials to be purchased for the first phase of construction. The engineers also should focus on whatever issues might require the longest timeline. That would include starting the process of an inventory of poles to begin the process of requesting make-ready approval, and also looking at the permitting process for anything that might take longer, such railroad crossings, bridges, state and federal parklands, sensitive environmental areas, and interstate highway crossings. Early engineering steps also might include identifying parcels of lands needed for buildings, huts, or other devices. Finally, if not already done, the engineer and the network owner will choose the technology and vendor to be used for electronics.

- Define the construction roles. It's vitally important to have a clear hierarchy established for who can make day-to-day decisions during the construction process—who specifically can say yes or no to a proposed design change. It's also important to define the roles: What specifically are the engineer and construction contractor expected to do? This will define how the two firms work together and the tasks each will assume. For example, does one of these entities order materials and maintain and monitor the inventory of construction materials? How do the permitting and rights-of-way work? What role does the staff of the network owner play?

- Creating the construction schedule. The engineers will decide the best place to start network construction. An overall construction plan is created. For instance, will the network start at one hub and try to add customers as the network is built? Or alternately, will backbone fibers be built first connecting the various parts of the network? A schedule should outline the number and type of construction crews needed – a process that is coordinated with the construction contractor.

- Hiring plan. The network owner should hire needed early staff at this stage, or else develop a plan of when to hire in the future.

Subsequent 'Getting Ready' Tasks

These are the tasks that are tackled during the construction process and leading up to the time of adding live customers to a new network.

- Construction management. A large number of tasks must be coordinated to have an efficient construction process. Materials need to be in place for each new section of the network. The right kinds of crews need to be scheduled for each stage of construction. Crews must be told daily where and what to build. Permits and paperwork must be complete and in place. The public must be notified of upcoming construction. Existing utilities must be located and marked for buried construction. The daily process of inspecting work that has been completed should be in place along with a way to count and reconcile the billing units completed each day. The purchasing and inventory management process must continue to purchase needed materials. Remediation practices must be put into place to return streets and rights-of-way to the condition they were in before construction.

- Building readiness. While fiber is being built, the various hub buildings and huts should be placed and made ready for electronics. This could range from buying pre-configured structures or else using an architect and building new structures. Site preparation means land acquisition, arranging for power, providing fencing and other security, pouring concrete pads, and whatever other steps are needed to have the huts ready by the time fiber is ready.

- Drop readiness. A separate construction process needs to be undertaken to prepare to build fiber drops for customers. The staffing or contractors available to do the work must be notified. Materials must be purchased. The process of notifying customers and getting permission to cross private property must be in place. Somebody must quantify the number of drops that can be completed per day or per week. The vast majority of fiber projects build drops over time as customers are added to the network. Very few ISPs charge customers for drops, except perhaps in situations where a customer has an extremely long drop.

- Customer readiness. All of the processes needed to sell and install customers must be put into place. Most important of all, since these steps often require the same ISP personnel for multiple tasks, an assessment must be made whether there is enough staff to be ready for the planned customer launch date.
  - Create process flows. The step-by-step process of onboarding a new customer should be specified and responsibilities for each step defined. The ISP should determine the number of days that the business can quote to customers for a normal installation.
  - Qualify customers. Any steps that will be required to qualify customers such as doing credit checks or requiring deposits must be specified and honed.
  - Product readiness. As early as possible, the ISP should define primary products, services, and prices. It's worth noting that most ISPs sell nearly identical products that are differentiated by the pricing and packaging. One of the biggest challenges for ISPs is creating a broadband product for low-income homes. If an ISP sells too many low-price products early, they may have trouble breaking even. We've found that one of the pre-requisites for offering a low-income product is that the ISP must first be selling enough full-priced products to break even.
  - Marketing. Marketing normally starts before the sales process to notify the market that a new network and broadband products are on the way. The company needs to be ready to take orders, or at least pre-orders when the marketing begins.
  - Sales process. The specific sales process must be defined. Sales staff or vendors need to be identified and scheduled. The sales process needs to be synced with the construction staff so that sales aren't made before the network is ready in any given part of the market.
  - Software readiness. If the ISP doesn't already own the suite of software needed to operate the business (OSS/BSS software), then the software vendor needs to be selected, the software installed, and staff trained. This is also the time to decide if the business needs other software such as mapping software, sales software, construction management software, etc.
  - ISP readiness. Define the steps needed to activate each product. For broadband, this means everything from buying servers to defining network security, identifying external vendor relationships, buying the internet backbone, etc.
  - Define the trouble process. How will the company receive reports from customers about troubles? How will the ISP react?

  - Billing readiness. Design the bill format. Define the process of calculating, collating, and sending bills. Define the process for taking payments. Define the process when customers don't pay.
  - Provisioning process. Define every step that must be taken between the time that somebody takes an order from a customer until the time that the first bill is sent.
  - Pre-selling. Will the ISP take early orders before the network is built? If an ISP does this there should be a way to keep customers informed of the progress of the network construction.

- Network security plan. A smart ISP will be planning how to handle fiber cuts or network outages. It should arrange for outside vendors that might be activated in major fiber cuts.

- Business office readiness. Create the public business office space.

Launch Tasks

The final steps are the actual launch of the business. This includes steps like:

- Network testing and acceptance. Most construction contracts require that an ISP accept segments of the network as it is completed. This should always include testing to make sure the network is operating to specifications. It should involve a visual inspection to make sure that the construction contractor has done the needed clean-up and restoration work.

- Starting the marketing process. ISPs differ significantly about when to start marketing. Some fear that marketing too early alerts the competition, while others start taking orders well in advance of a network launch.

- Kicking off the sales process. As portions of the network are available for use, the ISP should activate the sales process. Many ISPs accept a few beta customers and test the network and all of the processes before going to the full sales process. The ISP should be prepared to implement whatever sales methods it is using, such as door hangers during construction, knocking on doors, etc.

- Taking orders and activating the provisioning process. Almost every ISP decides in the days of early sales to modify the provisioning process as it sees the reality of how company staff really interacts. This is the time to fine-tune the process before sales volumes get large.

- Activating and testing the products. The ISP should test each product to make sure that what is being sold can be delivered.

- Fine-tuning the installation process. This is also time to look hard at the installation process to be able to make realistic estimates of the time needed to install a customer. Define what an installer will and will not do for a standard installation. How much time is allotted for customer training?

- Installing the first customer. This means having all paperwork in place that might include contracts, product information, basic information about the ISP, etc. This includes discussing installation options with a customer. It usually involves training on how to use the new broadband.

- Sending the first bill. The first bill for every new customer should be reviewed before it is sent to make sure it's accurate. An incorrect bill is a terrible first step for an ISP.

Typical Timeline

For most ISPs, the most important date when launching a new network or a new market is the date when the first paying customer is added to the network. There is no 'typical' timeline for this, but there are some generalities to keep in mind when trying to estimate the time this ought to take for a given project.

- The funding process can take a long time for any ISP and there is no standard timeline for working through funding. Established ISPs with an established line of credit might be funded to build a new neighborhood with little more than a telephone call, while my most persistent client took seven years to get funded. Because of this, we normally talk about timelines that start as of the day of funding. Any ISP that starts accruing interest expense will want to get the construction process started immediately.
- You can never forget seasonality. There are many places in northern states where construction is not done in cold weather if there is to be buried construction due to the ground freezing. There are places like the Pacific Northwest where certain months are avoided if possible due to reasonably expected rainy months. Along the Gulf Coast, many ISPs try to launch new projects after the end of hurricane season to avoid costly early delays. Communities with huge influxes of tourists tend to want to tackle projects in the off-season, and a few places in the West now try to work around fire season.
- Existing ISPs can open a new market and get customers much faster than a new ISP building its first market. This makes sense because an existing ISP already has all of the processes in place for dealing with customers like the sales and marketing process, the provisioning process, the billing process, the installation process, etc. A new ISP has to work through every task listed above to serve the first customer, while an existing ISP already does many of the tasks on this list.

  The time it takes an existing ISP to add the first customer is going to depend mostly upon the construction timeline. If an ISP is adding a tiny market, say a village of 100 homes, it might be billing customers a few months after starting the process. When building larger markets, it's likely to take six to nine months to get the first customer. The extra time for a larger market is due to the extra steps having to tackle make-ready work for aerial construction, having to often obtain land and build neighborhood huts, obtaining a building and creating the network and business office hub, etc.

  There are always exceptions to this. For example, in a market of any size with a noncooperative pole owner, it could take a year or more to get make-ready work done for aerial construction. Special circumstances like unusual rights-of-way such as federal parkland can add time to any project.

- We rarely see new ISPs get the first customers in less than 15 to 18 months from the day the project is funded and launched. This can be faster if the first market is tiny, but that's a typical time expectation for most market launches by a new ISP.

II. Broadband Technologies

This section of the report will discuss the most common technologies that are being used to expand rural broadband.

A. Understanding Oversubscription

Before talking about any technology, it's important to understand the concept of oversubscription and how this affects broadband performance on various technologies. Oversubscription comes into play for any technology where customers share bandwidth somewhere in the network. Oversubscription is a way to quantify the number of customers that share a given portion of the network.

The easiest way to understand the concept is with an example. Consider a passive optical fiber network. The most commonly deployed technology is GPON, where up to 32 homes share 2.5 gigabits of download data in a neighborhood fiber passive optical network, or PON.

If an ISP sells a 100 Mbps download connection to 20 customers on a PON, then in aggregate, those customers can use as much as 2 gigabits of download data, meaning there is still unsold capacity – meaning that each customer is guaranteed the full 100 Mbps connection inside the PON. However, if an ISP instead sells a gigabit connection to 20 customers, then there are 20 gigabits of potential customer usage that have been pledged over the same 2.4-gigabit physical path. The ISP has sold more than eight times more capacity to customers than is physically available, and this particular PON has an oversubscription ratio of eight.

When people first hear about oversubscription, they are often aghast. They think an ISP has done something shady and is selling people more bandwidth than can be delivered. But ISPs understand how customers use bandwidth and they can take advantage of the real behavior of customers in deciding oversubscription ratios. ISPs know that a home subscribing to a gigabit connection rarely uses the bandwidth capacity purchased. A home isn't using much bandwidth when people are asleep or away from home. The residents of a gigabit home might spend the evening watching a few simultaneous streaming videos and barely use any bandwidth. The ISP is banking on the normal behavior of its customers in determining a safe oversubscription ratio. ISPs have come to learn that households buying gigabit connections often don't use any more bandwidth than homes buying 100 Mbps connections.

I recently checked, and most of my clients using GPON tell me that they average about 40% utilization, meaning all of the customers on a PON collectively only use about 40% of the 2.4 gigabits of capacity. This means that an ISP could provision 100% gigabit products on the PON and still deliver full speeds to customers far more than 99% of the time. An oversubscription ratio of eight on a fiber network is an extremely high-quality broadband product.

Even if the PON in this example ever get too busy, the issue is likely temporary. For example, if a few doctors lived in this neighborhood and were all downloading big MRI files at the same time, the neighborhood might temporarily cross the 2.4-gigabit available bandwidth limit. Since transactions happen quickly for a gigabit customer, the overuse of the bandwidth would not last long, and even when it was occurring most subscribers to the PON wouldn't see a perceptible difference.

It is possible to badly oversubscribe a neighborhood using some technologies. Anybody who has used a cable company for broadband can remember back a decade ago when broadband slowed to a crawl when a home's occupants first started watching Netflix in the evening. The cable company networks were not designed for steady video streaming and were oversubscribing bandwidth by factors of 200 to 1 or higher. It became routine for the bandwidth demand for a neighborhood to significantly surpass network capacity, and when that happened, the whole neighborhood experienced a slowdown. Since then, the cable companies have largely eliminated the problem by decreasing the number of households in a neighborhood node, which lowers the oversubscription ratio.

As an aside, ISPs know they have to treat business neighborhoods differently. Businesses might engage in steady large bandwidth uses like connecting VLANs to multiple branches, using software platforms in the cloud, using cloud-based voice over internet protocol (VoIP), etc. An oversubscription ratio that works in a residential neighborhood is likely to be too high in some business neighborhoods.

To make the issue even more complex, the sharing of bandwidth at the neighborhood level is only one place oversubscription comes into play. Any other place inside the ISP network where customer data is aggregated and combined will face the same oversubscription issues. The industry uses the term 'chokepoints' to describe places in a network where bandwidth can become a constraint. There is a minimum of three chokepoints in every ISP network, and there can be many more. Bandwidth can be choked in the neighborhood as described above, can be choked in the primary network routers that direct traffic, or can be choked on the path between the ISP and the internet. If any chokepoint in an ISP network gets over-busy, then the ISP has oversubscribed that portion of the network that feeds into the chokepoint.

The Upload Speed Crisis

Oversubscription became a big issue during the pandemic. Networks that were functioning fine before the pandemic saw big slowdowns when everybody started working or attending school from home. I heard from numerous people about cable company networks slowing down in the middle of the day – a time when networks historically were at some of the fastest speeds. I heard about DSL networks that slowed to a crawl when hit with the extra demand from the pandemic.

The major oversubscription issue during the pandemic was with upload broadband speeds. Adults and students who formerly only cared about downloading video suddenly were at home simultaneously trying to connect to remote work and school servers. People who were happy with their broadband speeds pre-pandemic suddenly found their broadband connection to be inadequate.

It's not hard to understand the upload speed crisis. Customers served by DSL often have upload speeds of 1 Mbps to 3 Mbps. Customers served by fixed wireless are a little higher. Even people in cities using big cable companies thought they had great broadband but came to realize that the typical 10 Mbps to 15 Mbps upload from the cable company was not fast enough.

People suddenly wanted to grab an upload data connection to connect to a work or school server or to connect to a Zoom call and maintain the connection for a long time. The typical school or work server requires at least a 2 Mbps to 3 Mbps constant connection. Zoom calls require 1 Mbps or more in each direction. Such connections completely overwhelmed DSL networks, resulting in lost or frozen connections.

My consulting firm CCG does residential broadband surveys and during the pandemic, about 30% of customers using cable company networks said the upload connection was inadequate for allowing multiple people to share the connection at the same time. This isn't hard to understand.

First, cable company upload connections are of low quality with a lot of noise, so that even if a speed test says a connection is 10 Mbps, the quality varies and can result in freezing or kicking off customers trying to upload. Most cable systems deploy upload broadband using the frequencies on the cable system between 5 MHz and 42 MHz. This is a relatively small amount of bandwidth and it also sits at the noisiest part of cable TV frequency. I harken back to the days of analog broadcast TV and analog cable systems when somebody running a blender or a microwave would disrupt the signals on channels 2 through 5 – the cable companies are now using those same frequencies for upload broadband. The DOCSIS 3.0 specification assigned upload broadband to the worst part of the spectrum, because before the pandemic almost nobody cared about upload broadband speeds.

The second reason that upload speeds were poor during the pandemic is due to oversubscription. While there might be enough download in a neighborhood to accommodate 100 homes watching video in the evening, there is not enough upload bandwidth to accommodate all of the residents trying to work or attend school from home. The cable company networks were cramming a lot of users onto a small and noisy portion of the network. Even a home with only one student during the pandemic might have suffered a poor connection because of all of the neighbors trying to use the same limited amount of bandwidth.

B. Common Broadband Technologies

Fiber Technology

The gold standard of broadband technology is fiber. With today's technology, fiber can deliver 10 Gbps connections to customers in the newest networks. No other technology comes close to this. The following looks at the common kinds of fiber technology being deployed for customers today.

Passive Optical Network (PON**)**

PON technology makes use of optical splitters so that as many as 64 customers can share the same core laser. A PON network can be designed in numerous configurations, but all designs include the same key elements. At the network core are electronics knows as an Optical Line Terminal (OLT), which is the device that contains the lasers that provide the light source for customers. These OLTs can be in the same location as the fiber core or else can be spread around the network, generally in huts or large cabinets.

There is one fiber leaving the OLT for each PON, which is the term used to describe a cluster of customers in a neighborhood that all share the same core laser. PON technology allows for adding as many as 64 customers to a PON, but most ISPs limit this to 32 customers. The fibers from the OLT terminate into a splitter cabinet where each fiber is then split into the 32 separate fibers that go to customers. Most ISPs put the splitter cabinets deep into the network close to customers. This drastically lowers the number of fibers needed in the network since the customer fibers connect only between the splitter and the customer. The designation of 'passive' for the technology comes from the fact that the splitter site doesn't require electronics or power; the splitting is just what it sounds like, one fiber is spliced into 32 individual paths.

The latest version of fiber technology is XGS-PON. This configuration of PON provides 10 Gbps speeds downstream and 2.5 Gbps speeds upstream, to share among the 32 customers. This technology has come into recent widespread use after being deployed by AT&T in the U.S. and Vodaphone in Europe. For the past several years this technology was more expensive than the commonly used GPON, but that price difference has largely closed in 2021.

The most widely deployed PON technology is GPON (Gigabit PON). This technology delivers a download path to a PON (32 customers) of 2.4 Gbps and an upload of 1 Gbps. ISPs like Google Fiber and others have used this technology to provide a symmetrical gigabit product to every customer.

There is a third PON technology, NG-PON2. This technology is mostly used by Verizon to bring broadband to small cell sites. The technology uses multiple lasers at the core to transmit different 'colors' of light to individual customers. The lasers are tunable to different light frequencies. For now, this technology is a lot more complex than XGS-PON, plus it still costs more because manufacturers have not made enough of it to achieve economy of scale.

The current vendors for PON equipment include Alcatel-Lucent, Adtran, Zhone, Nokia, and Calix.

There are many benefits of PON technology, which explains why this has become the preferred technology for providing residential and small business broadband:

- No electronics in the field. PONs use passive splitters to distribute the bandwidth over the fiber to the customers. There are only two active components in the PON Distribution Network – the Optical Line Terminal (OLT) at the network core and the Optical Network Terminal (ONT) at the customer premise. Everything else in the network is passive, meaning no need for field power.
- Less field maintenance and more reliability. Since a PON uses passive splitters there are fewer powered network elements. This means less maintenance, fewer field personnel required, more reliability and fewer managed network elements in the distribution network. A PON also means less land and right-of-way since there is no need for larger active powered sites.
- Less fiber needed. A PON network uses significantly less fiber than an active system. A single fiber between the OLT and the splitters can carry 32 customers; an active network would require 32 separate fibers for the same path. Less fiber means lower capital costs, less loading on poles, quicker fiber installations, and smaller fiber management systems.

- High-density electronics. Since PON electronics need only one laser at the core to communicate with 32 customers, the core electronics are far smaller and denser. This means less power is needed, less air conditioning, and less floor space.
- Allows some active ethernet. PON technologies allow an active Ethernet card to be added to the chassis, meaning an ISP can serve larger customers using active Ethernet. This just means designing a few extra fibers on each route.
- Flexible OLT placement. The OLTs that light the network can be migrated into the field as needed. Manufacturers make small PON chassis systems that can be placed strategically to further reduce the size of fibers. This would be especially useful for future growth, such as if a new subdivision is built at the edge of the network.
- Most cost-effective way to provide big bandwidth. With XGS-PON, an ISP could offer 10-gigabit bandwidth for less than the cost of deploying active ethernet. PON typically costs 10% to 15% less than active ethernet.

Active Ethernet

An active ethernet network provides a direct fiber connection from the core electronics to each customer. This means there is one laser in the core communicating with one laser at the customer premise.

Historically, active ethernet was able to provide greater bandwidth than PON technology, but with XGS-PON that advantage has largely evaporated – although only active Ethernet can provide a customer with a 10-gigabit upload link. Active ethernet is most appropriate for large business customers that want dedicated electronics and bandwidth that is not shared with any other customers. This is the technology most commonly used to serve cellular sites, schools, and other large-bandwidth customers.

The primary downside to active ethernet is that more fibers are required in the network since fibers are not shared between customers. Electronic costs are generally also higher since there is a dedicated laser at both ends of the connection to every customer.

The primary vendors in the active ethernet equipment market are Cisco, Calix, Adtran, and Nokia-Alcatel-Lucent. The primary advantages of active Ethernet:

- Carries a greater distance. Where a PON has a 12-mile (20 kilometer) limit between the core electronics and the customer, active Ethernet can reach over 50 miles. The passive elements in a PON network contribute to accumulated loss in signal strength.
- Less engineering and planning. Since every fiber run is a direct connection between the core electronics chassis and the customer, there is less engineering and planning needed to design and deploy an active network.
- Dedicated bandwidth. The bandwidth delivered to each customer is not shared in the last mile (although it could be shared elsewhere in the network). Dedicated bandwidth means each customer gets 1 to 10 Gbps of data stream under all circumstances.
- Dedicated fiber to each customer. Cutting one fiber puts only one customer out of service. The flip side of this is that cutting a fiber bundle of active Ethernet customers might mean a lot of splicing to put back into service. But note that it's extremely rare to cut only one fiber.

- Can upgrade a single customer. Upgrades can be done on a one-by-one basis for customers needing more bandwidth.

Hybrid Fiber Coaxial Network

Hybrid fiber coaxial (HFC) is the technology that has traditionally been deployed by cable companies. Hybrid refers to the fact that an HFC network uses a fiber backbone network to bring bandwidth to neighborhoods and a copper network of coaxial cable to deliver service to customers. HFC networks are considered lean fiber networks (meaning relatively few fiber strands) since the fiber is only used to deliver bandwidth between the headend core and neighborhood nodes. At each node, the fiber broadband signal is converted to operate over copper coaxial cable to reach homes and businesses.

HFC has rarely been deployed as a rural technology. But in the recent federal RDOF auction, Charter won grants for large rural where it might use the technology in rural settings.

An HFC system delivers customer services differently than an all-fiber network. For example, in an HFC network, all of the cable television channels are transmitted to every customer and various techniques are then used to block the channels a given customer doesn't subscribe to.

In an HFC network, all of the customers in a given node share the broadband in that node. This means that the number of customers sharing a node is a significant factor—the fewer the customers, the stronger and more reliable the broadband signal. Before cable systems offered broadband, they often had over 1,000 customers on a node. But today, the sizes of the nodes have been "split" by building fibers deeper into neighborhoods so that fewer homes share the fiber connection for a given neighborhood.

The amount of bandwidth available to deliver internet access that is available at a given node is a function of how many "channels" the cable company has dedicated to broadband. Historically, a cable network was used only for television service, but to provide broadband, the cable company had to find ways to create empty channel slots that no longer carry TV programming. Most cable systems have undergone a digital conversion, done to free up channel slots. In a digital conversion, a cable company compresses video signals and puts multiple channels into a slot that historically carried only one channel.

The technology that allows broadband to be delivered over an HFC system follows a standard called DOCSIS (Data Over Cable Interface Specification) that was created by CableLabs. Over a decade ago the big cable companies updated to the DOCSIS 3.0 standard that allows bonding together enough channels to create broadband speeds as fast as about 250 Mbps download. A few years ago, cable companies began upgrading to the latest DOCSIS 3.1 standard that theoretically allows all of the channels on the network to be used for data, which could produce broadband speeds as fast as eight to 10 Gbps if a network carried only broadband and had zero television channels. Since there are still a lot of TV channels on a cable network, most cable companies have increased the maximum download speeds to around 1 Gbps using DOCSIS 3.1.

One limitation of a DOCSIS network is that the standard does not allow for symmetrical data speeds, meaning that download speeds are generally much faster than upload speeds. This is an inherent design characteristic of DOCSIS 3.0 and 3.1 where no more than one-eighth of the bandwidth can be used for upload. This is the limitation that stopped the cable companies from upgrading upload bandwidth speeds during the pandemic.

CableLabs has developed the next-generation standard, DOCSIS 4.0, that will allow for symmetrical gigabit data speeds. This will require even more empty channel slots on a cable network, which can only be accomplished by increasing the overall system bandwidth. The gear needed to upgrade to DOCSIS 4.0 won't hit the market for at least three years. Most of the big cable companies have already said they are not interested in upgrading immediately to the new standards since the upgrades are expensive. Cable companies will ultimately face a big decision because if they are going to upgrade to DOCSIS 4.0 they also might instead consider the leap to fiber. Most analysts think that the upgrade to fiber is likely decades away, but most think that cable companies will eventually migrate to fiber.

There is a distance limitation on coaxial cable. Unamplified signals are not generally transmitted more than about 2.5 miles over a coaxial network from a network node. This limitation is based mainly on the number of amplifiers needed on a single coax distribution route. Amplifiers are needed to boost the signal strength for coaxial distribution over a few thousand feet. Cable companies try to limit the number of amplifiers on a coaxial route to five or less since adding amplifiers generally reduces broadband speeds. This limits the longest coaxial cable runs to around 12 miles. That's one of the reasons why HFC is an odd choice for serving rural areas.

DSL

Many telephone companies, particularly the largest ones, still provide a lot of DSL (digital subscriber line) that delivers a broadband path over a copper network. The copper networks are aging and were built between the 1950s and early 1970s. The copper networks were originally expected to have an economic life of perhaps 40 years and have now exceeded the economic life of the assets. The copper networks are deteriorating as a natural process of decay due to sitting in the elements. Maybe even more importantly, the copper networks have deteriorated to some extent due to neglect. The big telcos started to cut back on maintenance of rural copper in the 1980s as the companies were deregulated from some of their historic obligations. At some point, the copper networks will die even though regulators continue to act like they will keep working forever.

DSL works by using a frequency on the copper that sits just above the frequencies used for telephone service. There are different kinds of DSL standards, each of which has a different characteristic in terms of how much bandwidth is delivered and how far the signal will travel. The most efficient forms of DSL can deliver up to 24 Mbps service over a single telephone wire. Some telcos bond two sets of telephone wires together and offer speeds up to 48 Mbps.

The most important characteristic of DSL is that data speed delivered to customers decreases with the distance the signal travels. This means that the DSL speeds differ throughout a community, and even within a neighborhood. The general rule of thumb is that most of the types of DSL can deliver a decent amount of bandwidth for 2 to 3 miles over copper. The speeds delivered to a given customer can be affected by:

- How far that customer lives from a DSL transmitter (called a DSLAM).
- The size of the copper wire serving the customer (sizes typically vary between 16-gauge and 24-gauge copper).
- The age and quality of the copper (copper wire slowly degrades over time, particularly if the copper comes into contact with the elements or with longstanding water).
- The quality of the telephone wiring inside of a home (this varies a lot, particularly for wires that were installed by the homebuilder rather than by the telco).
- The type of DSL electronics used to serve a customer. There are still older DSL technologies in use that have maximum download speeds of only a few Mbps and newer DSL that can deliver speeds as fast as 48 Mbps.
- The backhaul network used to bring bandwidth to the DSL network. DSL is like most broadband technologies and bandwidth is shared between users in a given neighborhood. If the total usage demanded by the neighborhood is greater than the bandwidth supplied to the neighborhood, then everybody gets slower speeds while the network is over-busy.
- Additional bandwidth choke points, which are places in the network that can restrict customer bandwidth if not engineered properly. For example, the neighborhood DSL hubs might contain older technology or not be fully stocked with the circuit cards needed to provide the best service.
- And finally, speeds can be impacted by how a customer gets broadband to devices. For example, an old WiFi router can cut down the speed between what is delivered to the home and what makes it to computers and other devices inside the home.

All of these factors mean that DSL speeds vary widely. Two adjacent homes can have a significantly different DSL experience.

Fixed Wireless Technology

Fixed wireless technology is more properly referred to as point-to-multipoint wireless technology because a transmitter is placed on a tower or other tall structure and connects to multiple customers wirelessly.

There are several characteristics of the technology that will dictate the quality of the bandwidth that can be delivered to customers:

- <u>The frequencies used</u>. There are different bands of radio spectrum that can be used for fixed wireless technology. The FCC has allocated certain bands of frequency specifically for this use. Some frequencies are public, meaning that anybody can use them. Others are licensed to some degree so that only carriers possessing a license can use the spectrum. Some spectrums have geographic limitations on where it can be used. The most commonly used frequencies are discussed below.

  Every frequency has different characteristics. In general, the lower the spectrum band, the further the signal will travel at a fixed power level (something that the FCC mandates). However, the lower the frequency the less amount of bandwidth that can be transmitted with the same size slice of frequency. Frequencies also differ in terms of characteristics like the ability to penetrate foliage, the ability to deal with precipitation, the ability to handle interference, etc. Because of all of these factors, the deployment of fixed wireless around the country varies, meaning the bandwidth that can be delivered differs.

- Distance from tower. Wireless bandwidth weakens with distance from the transmitting tower. A customer located close to the tower can receive the maximum amount of bandwidth available for the spectrum being used. To give an example, if a tower is using a 2.4 GHz (Gigahertz) spectrum, and considering only customers with good line-of-sight, customers within a mile will get the full capacity of the spectrum, customers within 1 to 3 miles will get most of the capability of the spectrum, customers from 3 to 5 miles might get half of the capability of the spectrum, customers after that get some fraction of the capability up to a point at perhaps 10 miles from the tower where the spectrum doesn't work.

- Line-of-sight. Line-of-sight is a term that refers to there being a direct visual line of sight between the transmitter on the tower and the radio at the customer premise. In rural areas, you'll often find receivers placed in odd spots in order to establish the line-of-sight. Perfect line-of-sight means there are no physical impediments in the path such as foliage. Unfortunately, foliage can significantly sap the effectiveness of most of the spectrums used for fixed wireless. Probably the most common problem with line-of-sight is physical barriers like hills that stop some customers from being able to see a transmitter.

- Size of broadband channel. The FCC determines the size of the channels used for each spectrum band. For broadband purposes, the larger the channel size the greater the amount of broadband. Unfortunately, many of the channels of spectrum in the U.S. are relatively small since channel size was determined years ago before the spectrum was designated for broadband.

- Interference. Most bands of spectrum are subject to interference. This can come from another wireless ISP operating in the same geographical area, from malfunctioning radios that are broadcasting signals in the wrong frequency, or from natural sources. As an example of the last item, people of my age remember when blenders and microwave ovens interfered with analog TV channels 2 through 5.

- Fiber to towers. It's important to have adequate bandwidth at each tower to provide maximum bandwidth to customers. The ideal configuration is to bring fiber to every tower. Bandwidth can be brought to a tower wirelessly, but it's still important that enough bandwidth is being delivered. The two reasons why we see a lot of slow fixed wireless are (1) trying to serve customers living too far from the nearest tower, and (2) having inadequate backhaul bandwidth at the tower.

  One of the biggest issues with backhaul for fixed wireless is providing the backhaul by a microwave wireless link instead of using fiber. The issue with wireless backhaul is that wireless ISPs often string multiple hops together. A single microwave shot to serve a tower is likely adequate as long as the distance isn't too far. But if the ISP strings multiple towers together – sending broadband to tower 1, then tower 2, then to tower 3, the bandwidth gets diluted because the total bandwidth on the first hop is shared with all of the other towers in this chained network. We see this often in real life. I know of a wireless ISP that is connected to fiber in South Dakota and makes multiple wireless hops to reach customers in south-central Minnesota. The multiple hops result in low-bandwidth speeds under 10 Mbps.

- Using multiple frequencies. We see the best results coming from towers that use multiple bands of spectrum. That enables giving each customer the most appropriate spectrum and also helps to keep trying to serve too many customers on any one spectrum band. Using multiple frequencies available means an increased opportunity to find a good solution for each customer in the service area.

There are several current frequencies of spectrum that can be used for this purpose and more that will be coming on the market in the next few years:

900 MHz. This is a public band of spectrum available to anybody. This is a band of spectrum from 902 to 928 MHz. The spectrum has been used for years for two-way communication. This spectrum does a good job of penetrating foliage and can also penetrate somewhat into buildings.

The downside of the spectrum is that there are only a few relatively small channels and it can't deliver much bandwidth. ISPs use this to reach customers that otherwise could not be reached but deliver small bandwidth products (think 10 Mbps broadband).

WiFi. WiFi is short for wireless fidelity and is meant to be used generically when referring to any type of 802.11 network. The FCC has currently set aside two swaths of frequency for WiFi: 2.4 GHz and 5.8 GHz. In a point-to-multipoint network, these two frequencies are often used together. The most common way is to use the higher 5.8 GHz to reach the closest customers and save the lower frequency for customers who are farther away.

In practical use, in wide-open conditions, these frequencies can be used to serve customers up to about 6 miles from a transmitter, although speeds can be slow at the far end of 6 miles. We know of networks doing speeds up to 100 Mbps for short distances using these frequencies. Most ISPs using this technology advertise speeds of around 25 Mbps.

The FCC has recently also approved the use of 6 GHz WiFi for outdoor point-to-multipoint networks. This can provide greater bandwidth for customers who are within a few miles of a tower.

- CBRS Spectrum - 3.5 GHz: In 2019 the FCC approved the use of the 3.5 GHz spectrum band known as the Citizens Broadband Radio Service or CBRS. This is a huge swath of spectrum covering 150 MHz of spectrum between 3,550 and 3,700 MHz.

  The FCC has set aside 80 MHz of this spectrum for public use, similar to WiFi, and auctioned the remaining spectrum of 70 MHz in June 2020 to cellular carriers. All of the spectrum must give priority to military uses.

The spectrum also must be shared among users in the public space, something that will be monitored by authorized SAS administrators. The FCC has named five administrators: Amdocs, CommScope, Federated Wireless, Google, and Sony. It's expected that the cellular carriers are going to heavily use the public bandwidth for delivering 5G, so in more populated areas this spectrum will probably be too busy for point-to-multipoint applications. However, in rural markets, the public spectrum might go unused, in which case it would be available to boost the speeds for fixed wireless broadband. Equipment using this spectrum became common in 2020. This spectrum sits in the middle between the two WiFi bands used for fixed wireless today and has great operating characteristics.

- White Space Spectrum: The FCC has been doing trials with white space spectrum that sits in the same range as TV channels 13 through 51, in four bands of frequencies in the VHF and UHF regions of 54–72 MHz, 76–88 MHz, 174–216 MHz, and 470–698 MHz. The FCC order refers to white space radio devices that will work in the spectrum as TV band devices, or TVBDs. The FCC approved greater use of these frequencies for point-to-multipoint radios.

  The FCC auctioned a lot of this frequency in 2018, with the buyers ranging from the big cellular companies to Comcast. This was called an incentive auction because TV stations that gave up their spectrum got a share of the sale proceeds. In 2020 the FCC made some of this spectrum available for rural broadband. The rules are similar to CBRS as far as having to share with neighbors to reduce interference disputes.

  The FCC required that radios using this frequency use what they are calling cognitive sensing. This means that an unlicensed user of the spectrum will be required to vacate any requests for usage from a licensed user. While this would not be a problem where there is only one user of the white space spectrum, where there is a mix of licensed and unlicensed users the unlicensed provider needs to pair radios with other spectrums to be able to serve customers when they have to cede usage to a licensed user.

High-Orbit Satellite Broadband.

There are currently two high-orbit satellite providers available in the U.S.: Viasat, which was formerly marketed as Exede or Wildblue, and HughesNet. For both, the availability depends upon having a clear line of sight from a satellite dish at a customer location to a satellite.

The most limiting aspect of satellite broadband is latency, which means a delay in the signal. These satellites are parked at over 22,000 miles above the earth, and when an internet connection must travel to and from a satellite, there is a noticeable delay; that delay makes it hard or impossible to do real-time transactions on the web. Current satellite latency can be as high as 900 milliseconds. Any latency above 100 milliseconds creates problems with real-time applications like streaming video, voice over IP, gaming, websites that require real-time inputs such as online education, and connections to corporate WANs (for working at home). When the latency gets too high such services won't work at all. Any website or service that requires a constant connection will perform poorly, if at all, with a satellite connection.

Satellite broadband also comes with tiny data caps, meaning customers are highly limited by the amount of data they can send or receive during a month.

Cellular Broadband

Cellular broadband uses the same cellular data that is delivered to cellphones for home or business broadband. This generally requires putting a small external receiver on a building and sending the bandwidth through the walls using a wire.

All three major cellular companies (AT&T, T-Mobile, and Verizon) now offer cellular broadband in some rural areas. All three say they have plans to expand the service. In recent years, the three carriers sold what was labeled as cellular hot spots. These plans typically had small monthly data caps similar to what can be purchased for a cellphone. These plans are highly limiting for home broadband and most of the new plans now include much larger data allowances.

Today's cellular network still uses a technology called 4G LTE, although there are still some rural cell sites using 3G technology. The first columns of numbers below represent the average nationwide speeds for each of the cellular carriers in the U.S. that was measured by reviews.org at the end of 2020. The second set of numbers demonstrates that cellular networks are faster in big cities. These speeds are from tests taken in 26 major cities by *PC Magazine* in the summer of 2020.

	Nationwide Average		26 Major Cities	
	Download	Upload	Download	Upload
AT&T	28.9 Mbps	9.4 Mbps	103.1 Mbps	19.3 Mbps
T-Mobile	32.7 Mbps	12.9 Mbps	74.0 Mbps	25.8 Mbps
Verizon	32.2 Mbps	10.0 Mbps	105.1 Mbps	21.6 Mbps

Cellular data speeds are faster in cities for several reasons. First, there are more cell sites in cities. The speed a customer receives on cellular is largely a function of how far the customer is from a cell site. In cities, most customers are within a mile of the closest cellular tower. Next, the cellular carriers have introduced additional bands of spectrum in urban areas that are not available outside cities. The biggest boost to the AT&T and Verizon speeds comes from the deployment of millimeter-wave cellular hotspots in small areas of the downtowns in big cities – see the discussion below.

Anybody who watches TV knows that the cellular carriers are in full 5G marketing mode. If you believe the TV commercials, you'd now think that the country is blanketed by 5G, since each cellular carrier claims a bigger coverage area than their competitors. However, almost all of their claims are marketing hype. Right now, in early 2021, there are no cellular deployments that can be legitimately called 5G. It's also worth noting that 5G is a cellular technology. The sole purpose of 5G is to make cell sites perform better.

Full 5G will not arrive until the carriers have implemented the bulk of the new features described in the 5G specifications. From what is discussed in the Institute of Electrical and Electronics Engineers forums, most of the 5G features are two to four years away. The same thing happened with 4G and it took most of a decade to see 4G fully implemented. In fact, the first U.S. cell site fully meeting the 4G standards was not activated until late 2018. Over time, we'll see new 5G features implemented as they are released from labs to field. New features will only be available to those that have phones that can use them, so there will be a two-to-three-year lag until there are enough phones in the market capable of using a given new feature. This means every 5G phone will be out of date as soon as a new 5G feature is released.

Today there is no 5G anywhere on the planet because the 5G features that will make cell sites perform better have not yet been incorporated into cell sites or into phones. We can expect to start seeing these features over the next three to four years at cell sites, and a few years longer as future generations of cellphones can use the new features.

The carriers also hint that 5G will have speeds up to a gigabit. Even when 5G is fully implemented, the cellular data speeds are not going to be blazingly fast. The 5G specification calls for 5G cellular speeds of about 100 Mbps – which was also the specification for 4G.

Most of what is being called 5G today is nothing more than the use of new bands of spectrum in 4G. New spectrum does not equal 5G; the 5G experience only comes with 5G features. Existing cellphones cannot receive the new spectrum bands, and so the carriers are selling new phones that can receive the new spectrum and labeling that as 5G.

Full 5G is likely not coming to rural America for a long time. Rural cell sites aren't under the same stress as urban ones due to fewer customers trying to use a given cell site, so there is no urgency to upgrade rural sites to 5G. Even when true 5G features come to rural cell sites it's not going to make much difference since rural cell sites are far apart, and the cool bells and whistles with 5G involve having smaller cell sites close together.

Millimeter-Wave Technologies

Millimeter-wave spectrum use frequencies higher than 10 GHz. These spectrum bands have extremely short wavelengths, meaning they can carry a lot of broadband. There are three technologies using millimeter-wave spectrum that the cellular carriers often co-mingle with discussions of 5G. The only one that is 5G is the cellular product described above.

<u>5G hot spots</u>. There are commercials on TV showing cellphone speeds of over a gigabit. This is not 5G. This is a phone equipped to use millimeter-wave spectrum. The most accurate way to think about this new technology is as a 5G hot spot, similar to a hot spot that might be found in a coffee shop, only mounted outdoors on a pole. The signal only travels a short distance, mostly under 1,000 feet from a transmitter. It needs line-of-sight and can be easily blocked by any impediment in the environment. The signal won't pass from outdoor transmitters into buildings, which makes this an outdoor-only technology when mounted on utility poles. This technology only makes sense where there are a lot of people, such as downtown urban corridors, stadiums, and business hotels.

There is a lot of speculation in the industry that this is a novelty product being deployed to convince the public that 5G will be blazingly fast everywhere. The cellular carriers seem desperate to deploy something they can call 5G—that is, super-fast cellphones—as a way to get headlines. However, it's extremely unlikely that any carrier is going to invest in cell sites closely enough together outside of major downtown business districts. This technology is likely to never reach residential neighborhoods in cities, suburbs, small towns, or rural America. A lot of industry experts are also asking why anybody needs gigabit broadband for cellphones, especially since this technology is deployed to work only outdoors.

Millimeter-wave Point-to-Multipoint (Fiber-to-the-curb)

Another new technology that got a lot of press in 2018 is 5G point-to-multipoint radios using millimeter-wave spectrum. Verizon built this technology in a few neighborhoods in Sacramento, California, and a few other cities in 2018. Verizon took a break after the initial tests and started deploying the technology again in 2020 in a few markets like Detroit. The technology consists of deploying small cell sites on utility poles and beaming broadband to a small receiver attached to the inside of a window. Verizon achieved speeds in the trials of 300 Mbps download, with a hope over time that it can get speeds up to a gigabit.

This technology has historically been referred to as fiber-to-the-curb (FTTC). The technology required building fiber close to every potential customer and then using wireless to bring the broadband into each customer's premise.

The Verizon technology uses high spectrums. The definition of millimeter-wave spectrum includes spectrum with wavelengths between 10 millimeters (30 GHz) and 1 millimeter (300 GHz). Verizon is using some spectrums that are lower, such as 24 GHz spectrum. Interestingly, Verizon is also using C-Band spectrum, which sits between 2.4 GHz and 5 GHz, to goose the bandwidth for the product. This shorter spectrum carries a lot less bandwidth but carriers farther from the fiber on the poles.

The primary operating characteristic of millimeter-wave spectrum is that the signal doesn't travel far. Most engineers set the realistic top distance of this technology at about 1,000 feet from a wireless transmitter, and probably less in field deployment.

The biggest impediment to the business plan is that it requires building fiber along each street served, making this at least as costly as building fiber-to-the-home. The cost of putting fiber on poles can be expensive if there are already a lot of other wires on the poles (from the electric, cable, and telephone companies). In neighborhoods where other utilities are underground, the cost of constructing fiber can be even higher. Another challenge for the technology is that the millimeter-wave spectrum requires a clear path between the transmitter and the receiver in a window in the house.

The technology will only make financial sense in some circumstances. This means neighborhoods without a lot of hills, curvy roads, heavy foliage, or other impediments that would restrict the performance of the wireless network. It also means avoiding neighborhoods where the poles are short or don't have enough room to add a new fiber. It means avoiding neighborhoods where the utilities are already buried. An ideal neighborhood is also going to have significant housing density, with houses relatively close together without a lot of empty lots.

This technology is not suited to downtown areas with high-rises; there are better wireless technologies for delivering a large data connection to a single building, such as the point-to-point radios. This also makes no sense where the housing density is too low, such as suburbs with large lots. This technology is definitely not a solution for rural areas where homes and farms are too far apart.

Verizon recently announced that this product will be the primary way to grow the broadband business and the company says it plans to pass 50 million homes with the technology by the end of 2025.

<u>Point-to-multipoint Millimeter-wave Radio (Gigabit wireless)</u>

One of the big controversies in the recent RDOF auction was that the FCC allowed three of the top ten grant winners to bid using gigabit wireless technology. This was Starry (Connect Everyone), Resound Networks, and Nextlink (AMG Technology). By bidding in the gigabit tier these technologies were given the same technology and weighting as a carrier bidding to build fiber-to-the-premise. There was a huge outcry from fiber providers that claim that these bidders gained an unfair advantage because the wireless technology will be unable to deliver gigabit speeds in rural areas.

Fiber providers say that the wireless technologies violate the intent of the grants. Bidding in the gigabit tier should mean that an ISP can deliver a gigabit product to every customer in the RDOF grant area. Customers don't have to buy a gigabit product, but the capability to provide that speed to every customer must be there. This is something that comes baked-in with fiber technology—a fiber network can deliver gigabit speeds (or 10-gigabit speeds these days) to any one customer, or easily give it to all customers.

There is no denying that there are wireless technologies that can deliver gigabit speeds. For example, there are point-point radios using millimeter-wave spectrum that can deliver a gigabit path for up to 2 miles or a multi-gigabit path for perhaps a mile. But this technology delivers the bandwidth to only a single point. This is the technology that Starry and others use in downtown areas to beam a signal from rooftop to rooftop to serve apartment buildings, with the bandwidth shared with all of the tenants in the building. This technology delivers up to a gigabit to a building, but something less to tenants. We have a good idea of what this means in real life because Starry publishes the average speed of its customers. In March 2021, the Starry website said that the average customer received 232 Mbps download and 289 Mbps upload. That's a really good bandwidth product, but it is not gigabit broadband.

There is a newer technology that is more suited for areas outside of downtown metropolitan areas. Siklu has a wireless product that uses unlicensed spectrum in the V-band at 60 GHz and around 70 GHz. This uses a Qualcomm chip that was developed for the Facebook Terragraph technology. A wireless base station that is fiber-fed can serve up to 64 customers, but the catch is that the millimeter-wave spectrum used in this application travels only about a quarter of a mile. Further, this spectrum requires nearly perfect line-of-sight.

The interesting feature of this technology is that each customer receiver can also retransmit broadband to make an additional connection. Siklu envisions a network where four or five hops are made from each customer to extend broadband around the base transmitter. Siklu advertises this product as being ideal for small-town business districts where a single fiber-fed transmitter can reach the whole downtown area through the use of secondary beams. With a handful of customers on a system, this could be a gigabit wireless product. But as you start adding secondary customers this starts acting a lot like a big urban apartment building, and the shared speeds likely start looking like what Starry delivers in urban areas: fast broadband, but that doesn't meet the definition that every customer can receive a gigabit.

The real catch for this technology comes in the deployment. The broadband strength is pretty decent if every base transmitter is on fiber. But wireless ISPs are likely going to cut costs by feeding additional transmitters with wireless backhaul. The other major issue with this technology is that it's great for the small-town business district, but how will it overlay in rural areas? The RDOF grants cover some of the most sparsely populated areas in the country. The Siklu technology will be quickly neutered by the quarter-mile transmission distance when customers live more than a quarter mile apart. Couple this with line-of-sight issues and it seems extremely challenging to reach a lot of the households in most RDOF areas with this technology.

Low-Orbit Satellite Technology

There are several major companies planning on providing fleets of low-orbit satellites to provide broadband service. There are now satellites in the sky from Starlink (Elon Musk), Project Kuiper (Amazon), and OneWeb. Following is a list of the satellite plans that have been officially notified to regulators:

	Current	Future	Total
Starlink	11,927	30,000	41,927
OneWeb	650	1,260	1,910
Telesat	117	512	629
Samsung		4,600	4,600
Kuiper	3,326		3,326
Boeing	147		147
Kepler	140		140
LeoSat	78	30	108
Iridium Next	66		66
SES 03B	27		27
Facebook	1		1
Total	13,153	39,728	52,881

Low-orbit satellites have one benefit over the current broadband satellites that sit more than 22,000 miles above the earth. The low-orbit satellites will orbit between 200 and 800 miles high. By being significantly closer to the earth, the data transmitted from low-orbit satellites will likely have a latency of between 25 and 35 milliseconds—about the same as experienced in a cable TV broadband network. This is much better than the current latency for high-orbit satellites, which has been reported as high as 900 milliseconds. The low-orbit satellites can easily support real-time applications like VoIP, video streaming, live internet connections like Skype, or distance learning.

One of the most interesting aspects of the technology is that a given satellite passes through the horizon for a given customer in about 90 minutes. A large constellation of satellites is needed to always have one in the sky over a given customer.

Elon Musk and his company Starlink have the early lead. The company launched two test satellites in 2018 and launched 60 satellites in May of 2019. As this paper was being written, the company had just passed having 1,300 satellites in orbit. In 2019 the FCC established a rule where an operator must deploy satellites on a timely basis to keep exclusive rights to the spectrum needed to communicate with the satellites. Under the current FCC rules, a given deployment must be 50% deployed within six years and completely deployed within nine years. Starlink recently revised its launch schedule with the FCC for the first phases of launches with the following schedule.

	Satellites	Altitude (Km)	50% Completion	100% Completion
Phase 1	1,584	550	March 2024	March 2027
	1,600	1,110		
	400	1,130		
	375	1,275		
	450	1,325		
Phase 2	2,493	336	Nov 2024	Nov 2027
	2,478	341		
	2,547	346		
	11,927			

This is an aggressive schedule and will require launching 120 satellites per month just to meet the 50% completion goal. Starlink also recently filed plans with the International Telecommunications Union (ITU) to launch 30,000 additional broadband satellites over the 11,927 now in the planning stages. These filings are clearly laying down the gauntlet for other planned satellite providers. Nobody knows if Starlink is serious about the huge number of planned satellites or if this is a play to gain more favorable regulatory rules.

Another company with satellites already launched is OneWeb, founded by Greg Wyler of Virginia in 2012. The company originally include investors like Virgin, Airbus, SoftBank, and Qualcomm. The company went bankrupt in early 2020 and was purchased by the British government and a large cellular company from India. The company had 192 satellites in orbit at the time of this paper and plans to launch an initial constellation of 550 satellites and an ultimate deployment of 1,910 satellites. The original plan was for a polar orbit that would serve places like Alaska and northern Canada. The coverage plan with the new ownership is not clear, but the British government says the business will move forward.

Another interesting entrant into the market is Jeff Bezos and Amazon. The company filed plans to enter the business and filed with the FCC under the name of Kuiper Systems LLC. Amazon has big plans, and the FCC filing said the company wants to launch a constellation of 3,236 satellites into low-earth orbit. Like Elon Musk, Jeff Bezos also owns a rocket company, Blue Origins, which has developed an orbital-class rocket called the New Glenn. In April 2021, the company announced a contract for nine rocket launches for satellites with the United Launch Alliance out of Cape Canaveral.

We now have beta test data and pricing for Starlink. The download speeds look to be ranging from 30 Mbps to 200 Mbps. The pricing is $99 per month with the customer having to pay $500 for the receiver. Elon Musk still says that speeds will get a lot faster, but numerous critics are suggesting that when the satellites get oversubscribed, speeds will get slower.

Skeptics also doubt that these companies can launch all of the planned satellites. To put their plans into perspective, consider the number of satellites ever shot into space. The United Nations Office for Outer Space Affairs has been tracking space launches for decades. It reports at the end of 2019 that 8,378 objects had been put into space since the first Sputnik in 1957. As of the beginning of 2019 there were 4,987 satellites still in orbit, although only 1,957 were still operational. There was an average of 131 satellites launched per year between 1964 and 2012. The idea of putting many thousands of satellites into space in a short time still seems like a daunting challenge.

While space is a big place, there are some interesting challenges from having this many new objects in orbit. One of the biggest concerns is space debris. Low earth satellites travel at a speed of about 17,500 miles per hour to maintain orbit. When satellites collide at that speed, they create many new pieces of space junk, also traveling at high speed. NASA estimates there are currently over 128 million pieces of orbiting debris smaller than 1 square centimeter and 900,000 objects between 1 and 10 square centimeters.

NASA scientist Donald Kessler described the dangers of space debris in 1978 in what's now described as the Kessler syndrome. Every space collision creates more debris, and eventually there will be a cloud of circling debris that will make it nearly impossible to maintain satellites in space. While scientists think that such a cloud is almost inevitable, some worry that a major collision between two large satellites, or malicious destruction by a bad actor government could accelerate the process and could quickly knock out all of the satellites in a given orbit. It would be ironic if the world solves the rural broadband problem using satellites, only to see those satellites disappear in a cloud of debris.

Comparing the Technologies

The following discussion reviews the primary pros and cons of each broadband technology:

<u>Fiber</u>

- Fiber is the ultimate technology in terms of broadband that can be delivered. Both active ethernet and PON technology today can deliver speeds to customers of as much as 10 Gbps.
- Fiber can easily handle symmetrical gigabit speeds with PON technology.

- It can be argued that fiber is a hundred-year technology (see next section) if the network is well-maintained.
- Fiber is the most expensive technology in most cases. This makes it hard to justify building fiber in rural areas without grants or other subsidies.
- Fiber wires can handle speeds up to a terabit, and the limiting factor is the lasers. It's likely that fiber electronics must be upgraded every 10 to 12 years.
- Fiber electronics is a mature technology and fiber networks typically need only minimal routine maintenance.

Point-to-multipoint wireless (fixed wireless)

- This technology is more an art than a science. Every neighborhood seems to be different.
- The typical maximum speed is around 100 Mbps download. To achieve that speed upload speeds must be set low. Many deployments are at speeds far less, with speeds in some places barely better than dial-up.
- Speeds drop in relationship to how far a customer is from the transmitter. At the outer range of delivery distance (around 6 miles in most deployments), the speeds drop off and disappear.
- Requires line-of-sight between tower and customer, so some customers can't get the service.
- There are a lot of truck rolls with this technology as receivers get dislodged by storms or wind.
- The electronics seem to last no more than seven years due to being outdoors. That's a lot of replacements over time.
- Speeds are best when each tower has fiber, and are less so with wireless backhaul.

Hybrid-fiber coaxial (HFC)

- With deployment of the DOCSIS 3.1 technology, a cable network can usually deploy download speeds of 1 Gbps.
- Upload speeds are much slower and are theoretically limited to one-eighth of the total bandwidth, although most deployments are even slower than that. In the future, these networks will be able to be upgraded to symmetrical speeds with DOCSIS 4.0, but it will be an expensive upgrade.
- Factors that can lower performance include having too many households in a node or having older repeaters or power taps. It's not unusual for parts of a city to have slower speeds due to such local issues.
- The copper wires in most urban networks were built in the 1970s and 1980. Older wires create more interference and degraded performance and eventually the networks will have issues similar to telephone copper networks.
- The maximum distance a customer can be away from fiber is about 12 miles, meaning this is not typically a good rural technology.

High-orbit satellite

- Speeds as fast as 40 Mbps download.
- Extremely high latency makes it hard to do real-time web functions like working from home, VoIP, gaming, connecting to schools, etc.

- Small monthly data caps that either jack up the price or slow down data for the remainder of the month.

Cellular broadband

- This uses the same frequencies and broadband that is sent to cellphones.
- Rural speeds are much slower than urban speeds.
- Speeds get slower with distance from the cell tower.
- Until recently, the plans had tiny data caps similar to cellular data limits. Data caps have recently climbed, and T-Mobile claims unlimited data.

Millimeter-wave hot spots

- This puts millimeter-wave hot spots on poles to send to specially equipped cellphones.
- Speeds can be more than a gigabit.
- This only works outdoors. The signals won't pass through anything and the body of the customer can block the signal.
- Only built today in urban downtowns. Transmitters are only about 1,000 feet apart, so it's a costly network.

Fiber-to-the-curb

- Builds fiber on streets and beams to homes using wireless technology. The only significant ISP to date is Verizon. Verizon says it will pass 50 million homes by the end of 2025.
- Early speeds around 300 Mbps download.
- Customers must be within 1,000 feet of a pole-mounted transmitter.
- Requires line-of-sight. Has limitations and doesn't work as well on wooded, curvy, or densely populated streets.
- Costs approximately the same as fiber-to-the-premise.

Millimeter-wave point-to-multipoint

- Similar to fiber-to-the-curb but sends signals to only a few receivers, which then bounce the signal to other customers.
- Touted as a way to deliver bandwidth to a small-town business district.
- Can deliver gigabit speeds, but with connection to multiple links will probably deliver something slower.

Low-orbit satellite

- Only Starlink currently has beta test customers.
- Starlink download speeds are between 50 Mbps and 150 Mbps. Speeds are expected to get slower when more customers are added to the network.
- Will require a huge number of satellites in the sky. Satellites last only about five years and must be replaced. The challenge of launching enough satellites might be the biggest issue.
- Brings broadband to remote places that may never see another broadband option.
- There is a concern of space debris making the satellite orbits unusable for centuries.

C. Replacement Costs and Economic Lives

No broadband network element lasts forever. Electronics age and stop working or grow obsolete because of innovation. Trucks, computers, and operational assets wear out and have to be replaced. Fiber will eventually wear out and has to be replaced. Even buildings and huts will eventually need to be upgraded or replaced. This section looks at how replacement costs affect the economic lives of broadband assets. This is important because an asset built with a grant today is going to eventually need to be replaced.

Causes of Obsolescence

Assets have to be replaced for two reasons: functional obsolescence or technical obsolescence. It's easy to understand functional obsolescence because assets wear out over time. Trucks get too old to keep running. Computers and cellphones stop working. The electronics in a network can get too old and eventually stop working. There is no choice but to replace assets that wear out.

Technical obsolescence happens in several ways:

- Sometimes technology improves and an ISP no longer wants to deploy technology that customers don't want to buy. As an example, the first generation of PON technology was called BPON. This technology provided 622 Mbps download and 155 Mbps upload bandwidth to share with 32 customers. When cable companies upgraded to 100 Mbps broadband, this technology became undesirable to ISPs because the customer speeds were slower than cable company broadband. Most of the BPON technology in the field has been upgraded to GPON, which is roughly eight times faster.
- The other technology obsolescence is referred to as vendor obsolescence. Vendors will sometimes stop supporting a perfectly functional technology in favor of something new that has been developed. ISPs get nervous when a vendor stops supporting a technology because it becomes harder to buy spares and the vendor will eventually withdraw technical support. The most extreme form of vendor obsolescence is when a vendor goes out of business. I had a number of customers with relatively new long-haul fiber electronics networks that had to be replaced when Nortel unexpectedly folded.

Electronics Overlay

Something relatively new in the fiber electronics industry is the concept of overlays. This means that new versions of a technology can be installed side-by-side with older technology. To provide an example, the most widely deployed type of FTTP electronics is GPON. As ISPs want to start upgrading to faster XGS-PON, the overlay concept allows adding XGS-PON customers into the same network by integrating XGS-PON cards into the GPON chassis.

This kind of overlay allows for upgrades over time or selective upgrades. An ISP can upgrade PONs where there is the most demand. They can upgrade customers that want to buy faster broadband but can keep customers who are happy with existing broadband speeds on the current technology. An overlay extracts the most economic life out of an electronics card because it doesn't have to be taken out of service until it has functional problems.

Overlays were promised with past technologies but never delivered. However, we are seeing overlays today that allow an ISP to mix fiber technologies in the same rack and same network.

Planning for Obsolescence and Replacement

Smart ISPs will plan for asset replacements and upgrades. An ISP might have a five- or 10-year forward-looking plan that predicts when electronics must be replaced. This allows financial planning to handle big upgrade costs. It means being realistic about how long assets will last and having a long-term capital plan that budgets for replacements.

<u>How Long Do Assets Last?</u>

This is a hard question to answer generically because every ISP is different. For example, trucks will wear out sooner for an ISP that drives long distances to reach customers. Here are some general observations based upon what I see with my client base:

- <u>Vehicles</u>. Most ISPs drive vehicles until they aren't roadworthy. Typical maintenance vehicles last five to seven years.
- <u>Buildings</u>. Permanent buildings typically last for longer than anybody working at the ISP will still be alive. But it's not untypical to remodel the inside of a building every 30 to 40 years. Small outdoor huts can show age in 30 to 40 years. Air conditioning systems typically have to be replaced every 12 to 15 years. Battery backup power is good for five to seven years. Electronics racks can be good for as long as the building lasts.
- <u>Computers and cellphones</u>. The IRS provides a five-year depreciation life for these assets, but they rarely last five years.
- <u>Fiber transport electronics</u>. This generally lasts for about a decade. This is one of the categories of electronics that is prone to technical obsolescence – ISPs often upgrade to get larger data capacity.
- <u>Fiber-to-the-home electronics</u>. The core electronics are good for 10 to12 years and are subject to vendor obsolescence. The electronics will likely last longer in an overlay upgrade scenario. The electronics at the customer premise (ONTs) should be good for 10 to 12 years. However, they might be upgraded before then to get faster speeds. The passive elements in the network like the splitters should last as long as the fiber network.
- <u>Wireless electronics</u>. In recent years we've seen relatively short lives for wireless electronics as the technology has been rapidly improving. But the experience of WISPs that have been in the wireless business for a while is that the electronics at the tower and at the customer premise are good for maybe seven to 10 years, at most. Being mounted outside takes a toll on the equipment.

Is Fiber a Hundred-Year Investment?

There are those who argue that fiber is a hundred-year investment. Let's look harder at the factors that affect the life of fiber. We're now seeing fiber built in the 1980s becoming opaque or developing microscopic cracks that impede the flow of light. A fiber route built in 1981 is now 40 years old, and the fact that some fiber routes are now showing signs of aging has people worried. Does this mean that fiber needs to begin to be replaced as soon as 40 years?

Industry experts don't think so. Fiber cable manufacturing techniques are much improved over the past 40 years and fiber purchased today should avoid many of the aging problems experienced by

1980s fiber. Newer glass is much clearer and less likely to grow opaque. Newer glass is also a lot less susceptible to forming microcracks. The sheath surrounding the fiber is vastly improved and helps to keep the light transmissions on path.

We've also learned a lot about fiber construction since 1981. It turns out that a lot of the problems with older fiber are due to the stress imposed on the fiber during the construction process. Fiber used to be tugged and pulled too hard during installation and that created the stress points that are now cracking. Fiber construction methods have improved, and fiber enters service today with far less construction stress.

Unfortunately, the engineers at fiber manufacturers won't cite a life for fiber. I imagine part of that reluctance is not creating an implied guarantee of long life. Manufacturers understand that factors like poor construction methods or constant fiber cuts can reduce the life of a given fiber. But off the record, I've heard lab scientists at these companies conjecture that today's fiber cable, if well handled, ought to be good for 75 years or more.

The issue of fiber cuts is not a minor one. Every time a fiber is cut and spliced, the transmission quality degrades a little. If you cut a fiber route enough times the route will experience problems long before the life expectancy. There always seem to be some fiber routes that get cut a lot more than others, and those fibers are not going to last as long. In some networks the aerial fibers get cut more often due to storm damage. In other networks, the buried fiber gets cut routinely due to poor practices of other contractors.

That still doesn't necessarily get us to 100 years. It's important to understand that the cost of updating fiber is far less than the cost of building the initial fiber. The biggest cost of building fiber is labor. For buried fiber, the biggest cost is getting the conduit into the ground. There is no reason to think that conduit won't last for far more than 100 years. If a stretch of buried fiber goes bad, a network owner can pull a second fiber through the tube as a replacement without having to pay again for the conduit.

For aerial fiber, the biggest cost is often the make-ready effort to prepare a route for initial construction, along with the cost of installing a messenger wire. To replace aerial fiber usually means using the existing messenger wire, with no additional make-ready, so replacing aerial fiber is also far less expensive than building new fiber. The most important aspect of aerial fiber lasting a long time is probably the question of how the poles will age and survive.

Fiber is an unusual asset where the asset is not ripped out and replaced when it finally starts showing end-of-life problems. It's not hard to replace just a part of a troublesome fiber route. And in doing so, new construction avoids the big costs from the initial construction.

Many similar utility assets are not like this. For instance, upgrading a water network generally means digging and laying all new pipes. It may sound a bit like a mathematical trick, but the fact that replacement of fiber doesn't mean a 100% replacement means that the economic life is longer than with other assets. To use a simplified example, if fiber needs replacement every 60 years, and the cost of the replacement requires only half of the original cost, then the economic life of the fiber is 120 years; it takes that long to have to spend as much as the original cost to replace the asset.

III. Challenges of the Rural Market

There are many challenges when operating an ISP, and many of these risks are magnified for a rural ISP. Following is a discussion of the risks faced by new ISPs trying to enter the broadband market and for ISPs trying to stay competitive in an existing market. Section A looks at what I call marketing and competition risks. Section B looks at other issues faced by entities that want to become an ISP for the first time.

Marketing Risks

There are always market and marketing risks facing any new ISP. There are numerous examples of new ISPs that were unable to sell to as many customers as needed to meet business plan objectives. Marketing risks can be deadly. A business that doesn't get enough customers and revenue to cover costs either has to fold or, if it's part of another business, subsidize unexpected losses.

This raises the question of how many customers a rural ISP must win to be successful. In the industry, this is referred to as the break-even customer penetration rate. This is a fairly easy number to calculate for an ISP that has a feasibility financial projection. The business has to get enough customers to cover annual operating expenses, which encompass operating expenses, debt payments, and routine replacement capital. Once the business understands the likely annual cash outlay requirements, it's fairly straightforward to determine the number of customers needed to generate the needed amount of cash.

In recent years we've seen new rural fiber networks gain market penetration rates between 60% to over 90% after the first four to five years of operation. As described immediately below, that range of penetration rates is largely due to the demographics (incomes, ages, and percentage of seasonal residents).

One of the hardest costs to cover in rural networks are debt payments which can be large due to the high cost of building rural networks. It's conventional wisdom in the telecom industry that it's nearly impossible to generate enough revenue solely from customers to be able to cover the full cost of debt for a rural fiber network. This is why the builders of rural fiber networks proceed only after having secured grants of some kind to reduce debt to an affordable level.

Because of the variability of penetration rates and the level of grant funding, it can be a bit of a puzzle to determine a reasonable business plan for rural fiber. We advise clients to tackle this in two steps. First is the market research to determine the percentage of households that will likely buy services. Once you have that number, and a realistic financial forecast, then an ISP can determine the level of grant funding needed to make a project work. Sometimes this order is reversed if a grant opportunity materializes first – but we would still be hesitant to advise any ISP to proceed without the marketing study to make sure it'll get enough customers.

Demographic Issues

New ISPs can fail to understand the demographics of the local market and overestimate the number of potential customers. I've always called this the 'build it and they will come' mentality – but they don't always come. There are many reasons why a new ISP might get a lower market penetration than expected:

- Household income. One of the biggest issues is the failure to understand the level of income of residents of a market area. Numerous studies have shown a strong correlation between household income and broadband adoption. Only about half (53%) of households with annual incomes under $30,000 buy broadband. This contrasts sharply with 93% of homes with incomes over $75,000 that buy broadband.

  There are studies available for those who want to dig deeper into quantitative and qualitative research into broadband affordability for low-income households. The first was published by the Benton Foundation and authored by Dr. Colin Rhinesmith.[2] The second report is issued by the Quello Center and is authored by Bianca Reisdorf.[3] This report looks at a study conducted in three low-income neighborhoods of Detroit. Both reports say that low-income households with a limited budget appreciate the advantage of having broadband at home but can't fit it into their budgets. They find it difficult or impossible to prioritize broadband compared to paying rent or buying food. These studies indicate that a big part of the solution for getting broadband into homes without it is going to have to involve finding a way to pay for the monthly broadband access.
- Aging populations. The gap of broadband adoptions due to age has been narrowing in recent years, but there are still fewer homes with elderly residents who buy broadband.
- Dropping population. An analysis of U.S. Census data shows that 16% of states and 34% of U.S. counties are steadily losing population. There is some glimmer of hope that this trend might have been slowed, or even reversed in some places by the pandemic as people sought out more remote places where they can work from home. But the big outflow of urban population last year likely migrated to places that already have good broadband.
- Seasonal residents. I know ISPs that were surprised to find out that seasonal customers in resort areas did not want broadband at the level assumed by the ISP.

In all of these cases, more market research before building the network could mean a more realistic business plan. There are tools like surveys, canvasses, and sign-up list campaigns that can be conducted before launching a network.

Inability to Sell

Some ISPs are not good at selling. This is not just limited to municipal entities that are unfamiliar with how to sell and often applies also to incumbent telephone companies or cooperatives that have been selling to the same group of customers for many decades.

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[2] Digital Inclusion and Meaningful Broadband Initiatives. https://www.benton.org/publications/digital-inclusion-and-meaningful-broadband-adoption-initiatives

[3] Broadband to the Neighborhood. https://papers.ssrn.com/sol3/papers.cfm?abstract_id=3103457

I took a sales training course many years ago that made an important point: achieving sales goals is not random. There are tried and true sales techniques that apply across markets everywhere that have been shown to work. Selling involves explaining the value of the products being sold to people that are often not ready to make an immediate buying decision.

I've known ISPs that try to sell passively with newspaper ads, mailers, websites, etc. This kind of selling reaches what salespeople call the low-hanging fruit – people that want better broadband and are ready to try something that promises to work.

But ISPs rarely reach business plan market penetration goals through passive selling alone. At some point, an ISP has to talk to all of the rest of the market. This can be done in any number of ways – door-to-door selling, calling, or meeting people at public events like fairs, PTA meetings, or anywhere the public gathers.

Operational Risks

Operational risks are often the hardest for an ISP to fix – because the risks arise from something the ISP is doing poorly.

Poor Market Launch

There is danger in botching the launch of a new network and of tarnishing the reputation of the new ISP business before it gets going. An example of this was the FTTH network in Lafayette, Louisiana, that suffered from huge problems with its video product. This was due to the vendor, Alcatel, not delivering the product that was promised. The TV was so bad that many customers dropped the city ISP, and word-of-mouth stopped a lot more customers from trying the new network. It took over a year to fix the video problems and during that time, the business fell significantly behind the business plan projections. Over time, the city regained a reputation as a quality service provider and eventually reached the target penetration rate, but this problem during the market launch set them back many years.

There is a huge list of issues that could cause a poor market launch. There are several thousand discrete steps that must be taken to build and launch broadband in a new network, and delays in many of these steps mean a delayed deployment of the network. There are a few dozen processes that define the interface with customers and doing any one of these poorly can result in unhappy customers. Some examples of processes done poorly that we've witnessed are poorly coordinated installations where technicians don't show up when promised; sloppy billing practices that render inaccurate first bills; sloppy provisioning where customers don't get the broadband speeds or the other products they were promised; poor call queueing where customers are put on hold for a long time when calling the ISP. An ISP has to perform well on every aspect of the customer interface or face the possibility of word-of-mouth being that the ISP does a poor job – which can quickly damage a launch in a new market.

Loss of Community Support

Occasionally a new ISP can fail if it somehow loses community support. For example, we've seen this a few times when a municipal ISP had fraud or malfeasance by employees. This could happen just as easily to a commercial ISP.

Cost Overruns

I think everybody knows of cases where the funding for infrastructures has gone off the rails, with the final cost of a project being much higher than what was originally predicted. I can remember when I last lived near D.C. and watched the cost of a new bridge over the Potomac River come in at more than twice the original cost estimate. I can remember instances of big cost overruns for infrastructure like schools and roads. Cost overruns can also easily happen on fiber projects.

As mentioned above, cost overruns could be due to problems with the supply chain. A shortage of materials or contractors is likely to increase the cost of building fiber. In times of high demand labor rates typically rise.

The other big gotcha in fiber construction projects is change orders. This means any event that gives a construction contractor a chance to charge more than the original proposed cost of construction. In the example of the bridge that went over budget, most of the extra costs came through change orders.

There are construction firms that bid low for projects with the expectation that they'll make a lot more from change orders. A lot of change order costs can be laid at the feet of the project owner. It's not unusual to see a project go out to bid that is not fully engineered and finalized. Changing your mind on almost any aspect of a project can mean extra costs and cost overruns. Here are a few examples of situations I have seen on projects that added to the costs:

- After the first neighborhood of a project was built, the client decided that they didn't like fiber pedestals and wanted everything put into buried handholes. That meant ripping and replacing what had already been built and completely swapping inventory.
- A contractor ran into a big underground boulder that was incredibly difficult to bore through. This was a city network, and the client would not allow an exception to build shallower only at this boulder and insisted on boring through it – at a huge, unexpected cost.
- I worked on a project where the original specification was to build past every home and business in the community. Once construction was started the city client decided to build fiber to every street, including the ones with no current buildings. That's a valid decision to make, but it added a lot to construction costs.

There is almost an endless list of situations that can add construction costs. The bottom line is that fiber builders need to know what they want before a project starts. There should be at least preliminary engineering that closely estimates the cost of construction before starting. Project owners also need to be flexible if the contractor points out opportunities to save costs. But my observation is that a lot of change orders and cost overruns come from network owners who don't know what they want before construction starts.

Municipal Purchasing Rules

There is a big pile of contracts to negotiate and materials to buy to build a fiber network and we've seen local governments struggle badly with the complex purchasing process for fiber. While purchasing rules have the goal of making sure that a municipality doesn't overpay for goods and services, the rules can add significant time when buying all of the needed components and service vendors involved in a broadband network launch.

We've also seen the municipal purchasing process add cost to purchased goods and materials. Most of the vendors in the telecom world are not used to dealing with the municipal purchasing process, so many of them pad their prices when bidding in RFPs – fully expecting to negotiate the prices lower later, only to sometimes find that their bid price was accepted without negotiation. We also find that there are quality vendors that refuse to participate in the municipal purchasing process.

Supply Chain

One of the biggest issues for a new ISP that wants to launch in the next few years is problems with the supply chain. It looks like 2021 and the next few years are going to see a superheated broadband market. The broadband markets have already been busy. Companies like Verizon have gobbled up construction crews all over the country. Verizon is talking about passing 50 million homes with fiber-to-the-curb by 2025. AT&T announced it wants to pass 3 million new potential customers in the next year. CenturyLink is building fiber again. Smaller telcos like Consolidated, Frontier, Windstream, TDS, etc., all have fiber expansion plans. Even the cable companies are entering the fray, with Charter pledging $3.6 billion for fiber construction over the next few years.

The already hot market will be superheated by the introduction of grant money aimed at fiber construction:

- There was money last year from CARES funding that is being used now for last-mile fiber construction.
- The RDOF grant awarded $9 billion in funding for rural broadband late last year. This construction probably starts hitting the market in 2022.
- There are several giant tranches of funding in the $1.9 trillion American Rescue Plan Act that will start hitting the market this year. This includes $10 billion in funding that is only for broadband. There are also huge dollars going directly to states, counties, and cities to use for infrastructure that can include broadband.
- A number of states have increased funding for state broadband grant programs for 2021, some substantially.
- There continues to be funding for rural broadband from other programs like the ReConnect grants and EDA grants.
- There is a bill in Congress and a recommendation from the White House to spend $100 billion on rural broadband. There is no guarantee this happens, but it would be the straw that breaks the back of much of the supply chain.

The telecom market has never been this superheated before. I think the sudden huge demand for broadband is going to quickly materialize in the following industry shortages:

- Consultants. With broadband funding filtering down to every rural community, rural towns and counties are looking to hire consultants to help them understand the opportunity. This could be looking for full-blown feasibility studies as described earlier in the paper or else strategic or tactical advice. Unfortunately, you can count the number of good broadband consultants on a hand or two. This might mean that communities and ISPs will get advice from inexperienced consultants or even scam artists. This happened a lot in 2009 when the ARRA stimulus grants worth millions hit the market.
- Engineers. There are also a limited number of engineering firms in the country that work in and understand rural markets—perhaps 15 firms. It's likely with the billions of dollars of grants hitting the market that these firms will become fully booked and unable to take on new clients. There is no alternative for this. New ISPs are cautioned to work only with design firms that have professional engineers and that have worked in rural counties.
- Construction companies. The good construction companies that work in rural America are also going to become fully booked. A busy market means higher construction labor rates. It's likely that even projects that find work crews will have a challenge in keeping them as technicians are lured away by higher pay.
- Technicians. In January of this year, 11 major industry trade associations wrote a joint letter to Congress and the White House asking for funding for programs for technician training. The groups estimate that the industry will need 850,000 new man-years of technicians by 2025. That estimate likely doesn't account for any huge federal grant programs.
- Fiber. We're already starting to see a shortage of fiber. Clients who built new fiber routes every year have told me that they are now ordering a year early to be sure to be in the factory supply chain. New ISPs will be at the tail end of the supply chain. It won't be surprising to see projects all set to go that don't have the needed fiber. It takes years for the world fiber market to crank up to meet higher demand. Note that there is huge fiber construction going on in places like China and India that are using much more fiber than is being used by the US.
- Electronics. The fiber electronics market was already in turmoil due to the pandemic. Almost every complex product including automobiles, cellphones, and electronics of all kinds are seeing supply chain problems. This is due in part to problems in the supply chain for raw materials and in other cases due to backlogs in making a few key components like computer chips. Everything I read says that these supply chain problems might take a few years to completely clean up.

There is no way to predict how all of these supply chain issues might impact the market. There are a few things we do know:

- The available construction materials like fiber and electronics are going to the big ISPs first, meaning that new ISPs, like a municipality using federal grant funding, will be at the rear end of the supply chain. Somebody like Verizon might still get fiber on schedule while new entities might have long waits.
- There is no solution for a lack of engineers, consultants, or construction resources. Once all of these resources are committed, some new fiber projects might not find the needed help at all.

- Like with any shortages, the cost of both material and labor are likely to rise. Cost overruns will be a huge problem for grant-funded projects that don't have any source of excess cash to cover extra costs.

Competitive Risks

Competitive risks arise from the way that competitors in the market react to a new market entrant.

Reaction of Incumbents

The incumbent telephone and cable providers generally react in some manner to a new market entrant. The one place this sometimes doesn't happen is when a new market entrant builds fiber in an area served by slow technologies like rural DSL. We see the following common responses from incumbents.

- Low-price specials. The most common response is a stepped-up marketing program by the incumbent that offers low special rates in return for a two- or three-year contract for customers. Such marketing efforts have mixed success, and in some cases the public ignores these efforts. Incumbents have been known to flood the mailboxes of residents with special offers in the early months of construction of a new network.
- Door-to-door sales. In some markets, the incumbents send sales teams door-to-door to try to lock in customers. In larger markets with good competition, the door-to-door selling might be an annual event.
- Matching prices. It's not unusual for an incumbent to match the prices offered by a new market entrant.
- Price war. This is the response that new entrants most fear: that the incumbent will cut prices so much that it's hard for a new market entrant to compete. I can only think of three instances of a price war started by the incumbent, and I haven't seen this in over a decade. The earliest was prompted by a large cable company near Atlanta. The public outcry from this incident was so large that I've never seen this reaction from a big cable company since. The second price war was started by an independent telephone company that wanted to keep a share of the market. The final price war was started by a small family-owned cable company.

Competing Technologies

A new ISP is not guaranteed to have market dominance due strictly to having fiber technology. There can be other ISPs that vie for a part of the market, such as:

- Low-orbit satellite. For now, the only low-orbit satellite is provided by Elon Musk and Starlink. This is in the beta-testing mode and isn't yet a serious competitor. But as Starlink and the two other competitors—Project Kuiper and One Web—get satellites into the sky, this could turn into significant competition. For now, Starlink is charging $99 per month. But there is no reason after the market gets mature that satellite providers couldn't compete on price. Satellite broadband speeds are never going to compete with a fiber network, but there will still be customers that will pick a different ISP, even if it costs more and is not as fast.

- Fixed wireless. Fixed wireless speeds are improving, and for customers that live close to a transmitter the speeds can be as much as 100 Mbps download. From a technological perspective, this won't compete with fiber, but a wireless ISP might compete on price.
- Fixed cellular broadband. This technology will never compete on speed but could deliver speeds of as much as 50 Mbps download for customers near a tower. The cellular companies are likely to compete with low prices and bundling of broadband with normal cellular service: Verizon already discounts broadband by $20 per month for somebody buying Verizon cellular.
- Another fiber builder. It's extremely unlikely that anybody would build a second fiber network in a rural area. But this could happen in towns. We've seen this a few times in the past, mostly where small telcos built fiber in response to a competitor. In urban areas, we saw this response to Google Fiber in Austin, Texas, and the Research Triangle in North Carolina.
- Fast wireless. The paper discusses fast wireless technologies like Verizon's fiber-to-the-curb. Fast wireless technologies are unlikely in rural areas since the technology requires fiber close to each customer. But these technologies might be deployed in county seats and other rural towns to compete with a fiber provider. Anybody building an alternate technology would likely compete on price.

Funding Risks

There are always risks associated with funding. Over the years, I've seen a number of new ISPs falter or fail to launch due to the inability to secure safe funding.

Not Raising All of the Money

It's unfortunately far too common for a new ISP to decide to launch the new business before securing 100% of the financing. I've seen this sink a project when the total funds needed were not secured. Lenders get pickier when lending to a project that is already underway because the lender gets to test all of the ISP's assumptions in real-time. If the ISP is behind in any aspect of the business such as schedule, sales goals, or construction budget, it may have a hard time finding additional funding.

Lenders also are not as ready to lend into an existing project because the lender likely has to somehow mesh with the existing funding source. It's always a challenge to get multiple lenders to collaborate and agree on issues like collateral, and this becomes much harder if a project is already underway, but not yet complete.

Burdensome Grants Requirements

It's easy to think of grants as free money, but nothing is ever really free. I know ISPs that have won grants and then decided to return the grant funding once they fully understood all of the requirements that come along with the grant funds. For example, a grant might expect an ISP to give free service to some types of customers for a fixed time. The grant might demand low prices that won't work in the long-term business plan. The grant might have expensive hoops to jump through such as requiring an expensive environmental study. Grants might restrict the business from selling, merging, or disposing of the grant-funded network for some time. Grants might require more ongoing paperwork than an ISP is willing to tackle.

There is a flip side to this issue. There have been cases of grant funding given to projects that didn't make economic sense – the industry referred to a few examples of this as using grant money to build fiber to nowhere. Such projects can fail even when having much of the cost of construction covered.

A bigger risk comes when a project doesn't get enough grant funding. Grant recipients might be tempted to launch even after getting less grant money than they need, lured by the fact that they received some grant funding.

Compatibility of Funding Sources

One of the biggest problems that new ISPs have is balancing financing from different sources. It's often hard, or even impossible to use different funding mechanisms together. An example is low-cost loans or loan guarantees from the RUS (the Rural Utility Service that is part of the Department of Agriculture). RUS loan rules are rigid and don't mesh well with other forms of borrowing. A RUS loan might require pledging 100% of the collateral of a project to the RUS, or even pledging the ownership of the whole ISP to the RUS. No other lender is going to be willing to provide partial funding for an RUS-funded project.

This is not meant to highlight the RUS, because this can be true for many other kinds of borrowing. For example, it might turn out to be impossible to borrow from two different banks if both banks insist on having the primary position in the case of loan default. This can create a real dilemma for an ISP. It might not be able to find a bank willing to lend the entire cost of a project, but also can't find lenders willing to loan to only parts of a project.

Compatibility almost always boils down to two issues: collateral and surety. Collateral is hard assets that are pledged to a lender if the project is unable to make loan payments. Surety is money that is set aside to pay for a future loan default. For example, a bank might require a borrower to maintain aa minimum amount of cash in the bank during the course of a loan. It's nearly impossible to borrow from multiple sources if each lender doesn't agree on the collateral or surety.

Varying Interest Rates

We just experienced a decade that's had low, stable interest rates. This wasn't always the case, and I can remember back to times when borrowers would watch the interest rate daily to time when it was safe to finance or refinance a business venture. It's always possible to return to that environment of fluctuating interest rates.

The Cost of Success

In the broadband world, there is a phenomenon I call the cost of success. It can cost $1,000 or more to add a new customer to a fiber network and if a new venture does better than expected, then a new ISP can find itself without the capital funds needed to add new customers. If the ISP is unable to borrow extra funding, the ISP has to make customers wait until the business generates enough cash to cover customers in the queue.

Political Risks

I've seen broadband business get into trouble due to what can best be described as political risks. This is where the federal, state, or local government creates problems for the business.

Local Rules and Ordinances

Cities that build fiber are often surprised to find local government barriers to the construction process. There are numerous examples:

- It's routine to have different permitting and rights-of-way rules for private, local, county, state, and federal roads. There are different rules for building through state or federal parks or forests.
- There can be big delays in getting permission to cross or use the rights-of-ways for bridges, railroad tracks, and interstate highway interchanges. I worked with a project that took three years to cross a bridge over the Mississippi River. I worked on a different project that was told that a similar bridge was full and couldn't accommodate additional fibers.
- Permitting can be a big barrier. I've seen cities where a separate permit is required for each pole, a paperwork burden if somebody wants to use the majority of poles in a town.
- It's not unusual to be told that a city doesn't have enough staff to process applications for permits to build fiber everywhere. A city generally needs to be involved in permitting and inspection of completed construction. Cities also might provide the staffing to locate existing utilities before digging can proceed.
- Localities often have unexpected rules. We know a county that wouldn't allow a fiber builder to put fiber in rain ditches along the side of the road, although that had been allowed by the telephone company in the distant past.

Political Meddling

We always advise government entities to work hard at the beginning to shield a broadband business from day-to-day politics. Administrations and politicians change over time and a fiber business must be shielded against future politicians that want to interfere with or even dismantle the fiber business.

There is one anecdote that probably highlights the problem of mixing politics and operating a business. Bristol, Virginia, was one of the first cities to build a municipal fiber business. About a year after the business launch, the Bristol City Council voted to cut rates by 15% in response to an upcoming local election. As it turns out, this put the business underwater, and in the year following the rate decrease, the City Council was forced to raise rates by 20% to bail out the business. After this debacle, the City Council moved the fiber business to a standalone utility and killed the City Council's ability to affect rates.

We've also seen local governments that make it difficult for a new ISP to get rights-of-way, permits, or a franchise agreement.

Change of Law

It's a rare event, but I've seen states change the rules related to municipal ownership and operation of a network even as there was a city trying to launch a new broadband business. This happened to three of the earliest municipal systems in Chattanooga, Tennessee, Bristol, Virginia, and Lafayette, Louisiana. A decade later we saw courts tell Chattanooga, Tennessee, and Wilson, North Carolina, that the municipal broadband businesses couldn't be expanded outside of the city. It's always possible for a change of low to negatively affect any ISP.

IV. Funding Broadband Networks

A. The Typical Capital Stack

For a large percentage of broadband projects, the biggest challenge is finding the funding. This section of the report looks at the various ways that communities have been able to fund broadband networks. If a community wants fiber badly enough, there probably is a way to pay for it.

There are a number of different financing options to consider. Below we look at the following:

- Private financing (loans)
- Public financing
- Grants
  - Federal programs
  - State programs
- Loan guarantees
- Alternate tax revenues
- Customer financed
- Public-private partnerships

Private Financing Options

When commercial ISPs build networks, they must rely on traditional private financing, meaning loans. Following are the key elements that determine the cost of bank financing:

> **Equity**. Most forms of private financing require some equity. Equity means that the borrower brings some sort of cash or cash equivalent to the business as part of the financing package. The amount of equity required will vary according to the perceived risk of the venture by the lender. The higher the risk, the more equity required.
>
> Equity can take a number of different forms:
>
> - Cash. Cash is the preferred kind of equity and lenders like to see cash infused into a new business that can't be taken back out or that doesn't earn interest.
> - Preferred equity. For a stock organization, like an LLC or other type of corporation, the business can issue some form of preferred stock that then acts as equity. Preferred equity usually gets some sort of interest rate return, but the payments are

not usually guaranteed like they are for bank loans. If the business gets into a cash crunch, they must pay bank loans and other forms of debt before they pay preferred equity interest.

- Assets. It's possible to contribute assets as equity. For example, a new fiber venture might be seeded by having one of the partners contribute an existing fiber route or another valuable asset to the business. In such a case the contributed asset often must be assigned a market value by an independent appraiser.
- Non-recourse funds. Non-recourse funds means accepting a contribution to the business that is not guaranteed to be paid back. To give an example, in Sibley and Renville counties in Minnesota, a fiber business was launched by a cooperative. The local government provided an economic development bond to the business as a non-recourse loan. This means that the new fiber business will make its best effort to make the bond payments, but if it is short of cash then the government entities that issued the bonds would have to make the bond payments. The banks involved in that project looked at the contributions from the bonds to be the same as equity.

Bank loans. The banking industry generally doesn't like to finance long-term infrastructure projects. This is one of the primary reasons why the country has such a large infrastructure deficit. Fifty or more years ago, banks would fund things like power plants, electric and water systems, telephone networks, and other long-term revenue-generating assets. But various changes in banking laws have required banks to maintain larger cash reserves, which makes them less willing to make long-term loans. Banks have also increased their expectations over time to want to earn higher interest rates. Many attribute this to the fact that giant publicly traded banks have captured most of the banking market. Banks don't like long-term loans since the interest rates get locked in for many years, possibly depriving the banks of earning more on their own equity.

Most banks prefer not to make loans with a term much longer than 12 to 15 years, and many telecom projects can't generate enough cash in that time period to repay the loans.

Banks are also averse to start-ups and prefer to make loans to existing businesses that already have a proven revenue stream. It's extremely hard for a first-time borrower to be able to borrow the kind of money needed to build a broadband network.

There is one unique banking resource available to companies who want to build fiber projects. This is CoBank, a boutique bank and itself a cooperative. This bank has financed hundreds of telecom projects, mostly for independent telephone companies and electric cooperatives. CoBank is a relatively small bank, has strict requirements for financing a project, and like larger banks, is leery of start-ups. It also expects significant equity to be infused into a new venture. It tends to have somewhat high interest rates and somewhat short loan terms of 10 to 12 years. Cooperatives also have another bank that lends only to cooperatives: the Rural Telephone Financing Cooperative (RTFC).

One interesting source of bank financing is local banks. Historically local banks were the source in many communities for car and home loans. But over the past few decades, those loan portfolios have migrated to other lenders and local banks have been struggling to find worthwhile projects in their regions. We know of many broadband networks that have been financed by local banks.

The biggest challenge of borrowing from a local bank is that it typically has a relatively small lending limit. Most local banks won't make an individual loan for more than a few million dollars. That obviously doesn't go far when building a network. However, local banks have become adept at working in consortiums of multiple banks to make larger loans. This spreads the risk of any loan across many banks. A banking consortium usually begins with a local bank in the area of the project, with the local bank taking the lead role of finding other bank partners and of servicing the loan. This approach requires a lot of extra effort from a local bank, but the approach has been used to finance telecom projects.

Collateral. The biggest issue that banks have in lending to broadband projects is the lack of collateral, which is the assets they inherit if the project should fail. Banks like hard collateral like buildings, vehicles, shares of stock, and things they know they can readily sell for a reasonable price. Banks don't like broadband networks as collateral, because even a little bit of web searching shows them that failed networks are sometimes sold for pennies on the dollar.

It's important to understand the importance of collateral. Communities often want nearby ISP to build fiber in their town. What they generally fail to realize is that the ISP would likely have to pledge their entire business as collateral in order to secure the loan to finance a new market, meaning that if the new venture fails, the ISP can lose the whole business.

Return on bank equity. Banks don't consider only the interest rate when making loans. A bank concentrates on its return on equity and will consider a combination of factors like interest rates, upfront and monthly loan fees, the likelihood that a borrower will pay a loan off early or default on a loan, etc. A bank will look at a dozen financial parameters before making an offer of interest rate and term—all based on its analysis of return on bank equity. There is a misperception among many borrowers that interest rates are negotiable, but the same project offered to multiple banks is likely to get a nearly identical financing package offered by all of the banks.

Federal Loans

Rural Utility Service (RUS). This is a part of the Department of Agriculture and is the only federal agency that makes direct loans to broadband projects. The Rural Broadband Access Loan and Loan Guarantee Program (Broadband Program) furnishes loans and loan guarantees to provide funds for the costs of construction, improvement, or acquisition of facilities and equipment needed to provide broadband in eligible rural areas. These loans can't be used for any town with a population of over 20,000. The RUS acts much like a bank and follows similar lending practices. I like to describe the RUS as a bank from the 1950s because its lending rules were set by Congress to loan money for rural electrification and have never been modernized.

RUS makes broadband loans and loan guarantees to:

- Finance the construction, improvement, and acquisition of facilities required to provide broadband, including facilities required for providing other services over the same facilities.
- Finance the cost of leasing facilities that are required to provide broadband if the lease qualifies as a capital lease under generally accepted accounting principles (GAAP). The financing of such a lease will be limited to the first three years of the loan amortization period.
- Finance the acquisition of facilities, portions of an existing system, and/or another company by an eligible entity, where acquisition is used in the applicant's business plan for furnishing or improving broadband. The acquisition costs cannot exceed 50 percent of the broadband loan amount, and the purchase must provide the applicant with a controlling majority interest in the equity acquired.
- Finance pre-loan expenses, i.e., any expenses associated with the preparation of a loan application, such as obtaining market surveys, accountant/consultant costs for preparing the application, and supporting information. The pre-loan expenses cannot exceed 5% of the broadband loan excluding any amount requested to refinance outstanding telecommunication loans. Pre-loan expenses may be reimbursed only if they are incurred prior to the date on which notification of a complete application is issued.

RUS is allowed to make loans to a wide range of entities. Borrowers can be either nonprofit or for-profit and can be one of the following: corporation; limited liability company (LLC); cooperative or mutual organization; Indian tribe or tribal organization as defined in 25 U.S.C. 450b; or state or local government, including any agency, subdivision, or instrumentality thereof. Individuals or partnerships are not eligible entities.

To be eligible to receive a loan under this program, the entity must:

- Submit a loan application. We note that the loan application requires a lot of effort and includes such things as engineering estimates, surveys, mapping, financial business plan models, environmental impact studies, and anything else the agency might ask to see. These requirements can make it expensive to prepare an application.
- Agree to complete the build-out of the broadband system described in the loan application within three years from the date the borrower is notified that loan funds are available.
- Demonstrate an ability to furnish, improve, or extend broadband in rural areas.
- Demonstrate an equity position equal to at least 10% of the amount of the loan requested in the application; and
- Provide additional security if it is necessary to ensure financial feasibility as determined by the administrator.

The RUS has some leeway, and the following describes how RUS loans have been administered over the past few decades:

- The rules say that a project needs at least 10% equity, but in reality, this is often expanded to be anywhere from 20% to 40% at the discretion of the RUS. In effect, the RUS acts as a bank and it will require enough equity that the project can adequately cover debt payments.
- The loan terms are generally in the range of 12 years, sometimes up to 15 years for fiber projects. This is much shorter than the terms available on bond financing, meaning the annual payment would be higher under a RUS loan than with a bond.

- It is exceedingly hard to get a project funded for a start-up business. The RUS typically wants the whole company of the borrower pledged as collateral. Thus, the bigger and the more successful the applicant, the easier it is to meet the loan requirements.
- RUS collateral requirements are overreaching in ways that makes it nearly impossible for a municipality to comply. For example, if the project is going to share fiber with some existing network, such as one built by a school system, the RUS would want that asset as collateral. The RUS might want the whole city's tax revenues as collateral. These requirements are generally not possible.

These rules create a challenge for municipal entities borrowing from RUS. There are a handful of municipal electric companies that have borrowed from RUS – but they were able to do due to being a standalone political subdivision and not directly part of a city or county government.

The other big drawback of these loans is that they take a long time to process. There have been times in the past when the agency had a 12-to-18-month backlog of loan applications. Very few ISPs are willing to wait that long unless they are certain they will be funded. If a borrower is coordinating RUS loans with other forms of financing this wait is not practical. The loans are granted by using a detailed checklist and rating system. This system gives a big preference to making new loans to existing RUS borrowers.

However, the loan fund is large and currently sits at more than $1 billion. Congress generally has been adding additional funds to the RUS pot each year. The RUS also has some discretion and they have it within their power to make a grant as part of the loan. This is something that can't be counted on, but we know of projects where the borrower only had to pay back 80% of what they borrowed. The interest rates can be lower than the market in some cases, but for the last several years, with low interest rates everywhere, the RUS loan rates were not much cheaper than commercial loans.

These loans also require a significant paperwork process to draw down funds along with significant annual reporting requirements. Lastly, RUS loans discourage borrowers from making dividend disbursements when a loan is open, something that stops many entities from considering the loans.

<u>Federal Loan Guarantees</u>

Another way to help finance broadband projects is through federal loan guarantees. A loan guarantee is just what it sounds like. Some state or federal agencies will provide a loan guarantee, which is very much like getting a co-signer on a personal loan. These programs guarantee to make the payments in the case of a default, and this greatly lowers the risk for a lending bank. In return for the lower risk, the banks are required to offer a significantly lower interest rate.

These guarantees are not free. There is an application process to get a loan guarantee in much the same manner as applying for a bank loan or a grant, meaning lots of paperwork. The agency making the guarantee will generally want a fee that is similar to the points often paid on home mortgages. These points are a payment to the agency for issuing the guarantee and are not refundable.

There are several federal agencies that might be willing to make loan guarantees for broadband projects. The following agencies are worth considering:

USDA Business and Industry Guaranteed Loans (B&I): The Department of Agriculture provides loan guarantees through the B&I program to assist rural communities with projects that spur economic development. Such a project must, among other things, provide employment and improve the economic or environmental climate in a rural area. These loan guarantees are available to start-up businesses. The program can guarantee up to 60% of a loan of $10 million or greater percentages of smaller loans.

HUD 108 Program: The Department of Housing and Urban Development has a loan and loan guarantee program that is allotted for economic development. There is both federal money under this program as well as money from this program given to the state to administer. While these loans and loan guarantees generally are housing-related, the agency has made loan guarantees for other economic development projects that can be shown to benefit low- or moderate-income households. If enough of a fiber project can be said to benefit low-income residents, then these loan guarantees can theoretically be used for a fiber project.

Small Business Administration 504 Loan Program: This program by the SBA provides loans or loan guarantees to small start-up businesses. These loans or loan guarantees must be made in conjunction with a bank, with the bank providing some loan funds directly and with the SBA loaning or guaranteeing up to 50% of the total loan.

Public Financing Options

The two primary mechanisms used for public financing are revenue bonds and general obligation bonds. There are some major benefits of using bond financing. The term of the bond can match the expected life of the assets and it is not unusual to find bonds for fiber projects that stretch out for 25 or 30 years. It’s also possible to finance a project completely with bonds, meaning that no cash or equity is needed. The primary historic source of public money used to finance broadband projects is through the issuance of municipal tax-exempt bonds, meaning the buyers of the bonds don’t have to pay federal and/or state income taxes on the revenue from the bonds.

Revenue bonds: Most of the municipal fiber networks that have been built have been financed through revenue bonds. Revenue bonds are backed by the revenues and the assets of the fiber network and the associated business. With a pure revenue bond, a local government will not have to repay the bonds if the project fails. With that said, having a bond default is a financial black eye that might make it hard for a community to finance future projects. So, to some degree, most governments feel obligated to pay back revenue bonds, since there is a big cost for not doing so.

It has gotten harder to finance broadband projects with pure revenue bonds due to some failures on the part of other municipal networks. Among these are networks in Monticello, Minnesota, Crawfordsville, Indiana, and Alameda, California. These kinds of failures have caused bonding houses to be leery about pure revenue bonds and have made financing with revenue bonds more expensive. A more common kind of financing is a hybrid between revenue bonds and general obligation bonds. This would be a revenue bond with a debt service reserve fund that would be used in the case of a default. The government would have to guarantee that the debt service reserve fund would be replenished if ever used.

The cost of a bond issue cannot be judged only by the interest paid. The other financing costs of bonds can outweigh the interest rate in the effect on the bottom-line cost of repaying a bond issue. Because of market reluctance to buy revenue bonds, they often have higher interest rates than general obligation bonds, but they also can incur the following costs:

> Debt service reserve fund (DSRF). Many revenue bonds require borrowing additional funds to be kept in escrow as a hedge against missing future payments. The DSRF is often set to equal a year's worth of principal and interest payments. This money is put into escrow and is not available to operate the business.
>
> Capitalized interest. Bonds begin accruing interest from the day the money is borrowed. Since fiber businesses take several years to generate enough cash to make bond payments, the bondholders require capitalized interest, which means borrowing the amounts needed to make debt payments for up to the first five years of a project.
>
> Bond insurance. Bond insurance is an upfront fee paid to an insurance company that will then pay one year of bond payments to bond holders in case of a default. We've seen bonds issued that have required both a debt service reserve fund and bond insurance.

In recent years, the interest rates charged to bonds have been lower than the interest rate on commercial loans. But that has not always historically been the case. The difference between bond interest rates and commercial interest rates both change over time; that difference is referred to in the industry as the "spread." Sometimes the spread favors bonds and at other times it favors commercial borrowing. Interest rates are also not the same for all kinds of bonds. For instance, the interest rate for revenue bonds can be considerably higher than general obligation bonds due to the perceived higher risk.

General Obligation Bonds (GO bonds): If revenue bonds aren't an option, then the next typical alternative is general obligation bonds. General obligation bonds are backed by the tax revenues of the entity issuing the bonds. This backing can be in the form of various government revenues such as sales taxes, property taxes, or the general coffers of a government doing the borrowing.

Many states require a referendum to approve general obligation bonds. Most states have a few exceptions for things like economic development bonds that don't require a referendum, but local governments sometimes hold a referendum anyway just to make sure the public supports the initiative being financed.

Comparing Bond and Bank Financing

Benefits of bond financing. There are several major benefits for using bond financing:

- The term of the bond can match the expected life of the assets and it is not unusual to find bonds for fiber projects that stretch out for 25 to 30 years. It's difficult to finance a commercial loan longer than 15 years. The longer the length of the loan, the lower the annual debt payments.
- Bonds can be used to 100% finance a project, meaning there is no need for cash or equity to fund the new business. Lack of cash equity is often a huge impediment to finding bank financing.
- Bonds often, but not always, have lower interest rates than commercial debt. The interest rate is dependent upon several factors including the creditworthiness (bond rating) of the borrower as well as the perceived risk of the project.
- It's generally easier to sell bonds than to raise commercial money from banks. Sometimes bonds require a referendum, but once bonds are approved there is generally a ready market for buying the bonds and raising the needed funds.

Benefits of commercial financing. There are also a few benefits for commercial financing.

- Generally, the amount that must be borrowed from commercial financing is lower, sometimes significantly lower. This is due to several issues associated with bond financing. Bond financing often contains the following extra costs that are not included with commercial loans:
    - Surety. Bonds often require a pledge of surety to protect against the default of the bonds. The two most common kinds of surety are the use of a debt service reserve fund and bond insurance. A debt service reserve fund borrows some amount of money, perhaps the equivalent of one year of bond payments, and puts it into escrow for the term of the bond. The money sits during the life of the bond issue to help make bond payments should the project have troubles. Bond insurance works the same way, and a borrower will pre-pay an insurance policy at the beginning of the bond that will cover some defined amount of payments in case of a default.
    - Capitalized interest. Bonds typically borrow the interest payments to cover bond payments for up to five years.
- Construction loans. Another reason that commercial financing usually results in smaller debt is through the use of construction financing. A commercial loan will forward the cash needed each month as construction is done, and interest is not paid on funds until those funds have been used. However, bonds borrow all of the money on day one and begin accruing interest expense on the full amount borrowed on day one. Construction loans allows borrowers to draw on loans only as needed, while bond financing is often padded with a construction contingency in case the project costs more than expected.
- Deferred payment. Commercial financing often will be structured so that there are no payments due for the first year or two. This contrasts with bonds that borrow the money required to make these payments. Fiber projects, by definition, require several years to generate revenue, and deferring payments significantly reduces the size of the borrowing.

- Retirement of debt: It's generally easy to retire commercial debt, which might be done to pay a project off early or to refinance the debt. This contrasts with bonds that often require that the original borrowing be held for a fixed number of years before it can be retired or refinanced.

Opportunity Zones

Congress created a new tax opportunity as part of the 2017 Tax Cuts and Jobs Act. The act created opportunity zones in which investors can get special capital gains treatment and other tax breaks for investing in qualified infrastructure within an opportunity zone. Each state governor then designated specific opportunity zones.

Qualified investments made inside an opportunity zone can get special tax treatment. The first benefit is that taxes on capital gains from past investments can be deferred if the gains are invested inside of an opportunity zone. For example, if investors had a capital gain from the sale of a property, they could invest those gains and not pay taxes on the gains now but have those gains deferred until as long as 2047. Investors have until 2026 to make such investments.

An investor also gets tax forgiveness on new investments made inside the opportunity zones if that investment is held for at least 10 years. Most of the opportunity zones include sizable areas of low-income residents and a qualified investment must meet a test of benefiting that community in some significant way. A fiber network that will bring broadband to all the homes in an opportunity zone should meet that test; there are lot of demonstrable benefits of fiber.

Opportunity zone funds have been created to invest in qualified investments. This portion of the financing portfolio would likely have a smaller interest rate and might not have to pay back the full cost of the investment.

New Market Tax Credit

The New Markets Tax Credit (NMTC) Program was established in 2000 as part of the Community Tax Relief Act of 2000. The goal of the program is to spur revitalization efforts of low-income and impoverished communities across the United States and territories. Most of rural America qualifies for new market tax credit financing. New market tax credits are normally used to fund only a small portion of a project.

The NMTC Program works by giving big tax credits to investors that are willing to invest in infrastructure projects in qualifying communities. The tax credits are so lucrative that often the other terms for accepting the funding are modest. The tax credit equals 39% of the investment paid out—5% in each of the first three years, then 6% in the final four years, for a total of 39%.

The Community Development Financial Institutions (CDFI) Fund and the Department of the Treasury administer the program. The process of how Treasury allots credits is complicated, but in essence, there are entities around the country each year that are awarded tax credits and these entities work as brokers to provide the credits to specific projects. The credits are often purchased by the large national banks or other firms that invest in infrastructure.

Generally, in practice, these funds act as a mix of loans and credits to the recipient. For instance, a community that received these funds might have to pay some modest amount of interest during the seven years of the tax credit and might have a balloon payment for the principal at the end of the financing period. However, often some, or even all of the principal might be excused, making this look almost like a grant.

Because different entities get the credits each year, the process for applying for this money is somewhat fluid. However, there are consultants who specialize in finding new market tax credits.

Alternate Tax Revenues

Communities are increasingly considering alternate tax revenues to pay for some or all of a fiber network. There are huge benefits to a broadband network launch from pledging a property tax increase or sales tax increase to pay for a broadband network. Funding that is repaid from some other revenue stream lowers the pressure on a fiber project to generate significant cash quickly.

Here are a few examples of this kind of financing:

- Lyndon Township, Michigan. This township of about 1,000 homes voted to raise property taxes to fund the construction of a fiber network. The township then partnered with a local broadband cooperative to provide services. The township was rural with homes on big lots and was too small to support fiber using only the revenues from a broadband business to cover debt. Property taxes increased an average of $25 per month per homeowner. High-speed fiber broadband is available for about $60 per month, when without this financing the town would have been left with no viable broadband.
- Utah Telecommunications Open Infrastructure Agency. UTOPIA is a consortium of many small towns in Utah that banded together to get fiber. Each town (and the citizens of the town through a referendum) pledged property tax revenues to fund part of the cost of building the fiber network.
- Cook County, Minnesota. Cook County funded about half of its fiber network using a federal grant awarded from the ARRA stimulus funding program in 2009. The county held a referendum and used a sales tax increase to pay for the matching funds to the grant. This is the northernmost county in Minnesota that is a tourist area, but the broadband was so poor that hotels and restaurants couldn’t take online reservations or even process credit cards live. The network was ultimately built and is operated by the local electric cooperative.
- North Kansas City, Missouri. This city used tax revenues from several floating casinos anchored in the city to pay for fiber. These revenues paid for 100% of the cost of the network. The city eventually made broadband free for residents.

Customer Financing

When an ISP or municipality is unable to finance a project, we’ve seen citizens or local businesses step up and agree to directly fund some or all of a broadband project.

Contribution to aid in construction. Numerous ISPs, telcos, and cooperatives have a program where the ISP will agree to extend its network to customers if those customers agree to pay the cost of the construction. We are aware of examples where a few customers, or even a whole neighborhood raised the needed money to get connected to a nearby broadband network.

This concept is becoming fairly common for entire subdivisions. Most homeowner's associations are established as non-profit corporations that can borrow the money to use for this purpose if the homeowners vote to increase the annual homeowner association levy.

Mason County Public Utilities District, Washington. This is a countywide municipal electric utility. It has agreed to provide broadband, within reason, for any homeowner or group of homeowners that each agrees to contribute $3,500 toward the cost of construction. The big caveat is that the PUD must have existing fiber reasonably close to customers that want to exercise this option. The PUD will finance the contribution over time for as long as 12 years.

Ammon, Idaho. This is the only municipal attempt we know of that is funding a fiber network in this way. The City of Ammon will connect homes or businesses to the fiber network for a contribution of $3,500 upfront to cover the cost of construction. Ammon applies eligibility to join the network by neighborhood, so a sufficient number of homes in a given neighborhood must agree to pay this price for the whole neighborhood to be eligible to join the network.

Public-Private Partnerships (PPPs)[4]

A public-private partnership is formed when a government entity and commercial entity fund a project together. There is no one model for a PPP and such an arrangement can be structured in many ways. The main benefit of a PPP is that the commercial operator of a project benefits by getting some funding assistance from the municipal partner. This allows the business to blend the benefits of bond and commercial financing and is one of the ways that makes it easier to get through the first few years of a new fiber project.

The general benefits of bond financing are what makes public money attractive to a commercial partner—low interest rates, long repayment terms, and small or no payments for the first few years. But the downside is that there are more overall financing costs and in the long run a bond makes a project cost more in terms of cash. The safety of a bond in the first few years, though, can be attractive.

There are benefits to combining the two kinds of financing:

- Banks will often consider the financing that comes with bonds as the equivalent of equity, meaning that the commercial partner will not require as much, or even no, cash equity.
- In terms of the amount borrowed, the two methods work well together if construction loans are used to cover the construction, and bond financing is used for the longer-term financing costs.
- Combining the two methods works to produce a payment term that is longer than a traditional commercial loan.

[4] Section I.A. of this report discusses the different kinds of PPPs.

- Combining the two methods also usually means lower debt payment during the first few critical years while the network is being built.
- Both municipalities and commercial telcos have a natural borrowing limit—meaning that there is always some upward limit on the amount of money that each partner can borrow. As an aside, the debt ceiling is often the main impediment to funding a project 100% with bonds. Fiber projects are generally large projects, and the required funds can easily exceed the credit limit of a city.

But even with all of these benefits it's often a major challenge to combine funding from disparate sources. The two biggest challenges are collateral and surety.

- Collateral is defined as hard assets that are pledged to secure a loan. Broadband networks are generally lousy collateral because the value is only created after customers are added to a network. Empty networks are typically worth only a fraction of the cost of building the network. To make matters worse, it's almost impossible for the same asset to provide collateral to more than one lender. This is a challenge for every broadband partnership because at least one lender has to agree to accept inferior collateral.
- Surety refers to a guarantee to continue to make loan payments should a broadband business not perform as well as expected. Municipalities can pledge tax revenues as surety. Unless a commercial partner has an extremely solid balance sheet it probably can't make a strong surety pledge. For example, many ISPs, including some relatively large ones, have to pledge the entire company as surety/collateral. Partnership financing deals often break down when banks can't get adequate surety from both partners.

<u>Other Sources of Financing</u>

We've seen communities get creative in finding sources of financing. Take the example of the RS Fiber Cooperative formed in Sibley and Renville counties in Minnesota. The financing structure included two sources of funding we had not seen used before:

- **Loans from individuals**. The cooperative borrowed money directly from people and businesses in the service area. These loans involved contracts and covenants like any other loans. The money borrowed in this manner reduced the amounts that had to be borrowed from external sources, and generally these loans avoid the large fees associated with external financing. One interesting form of customer contributions is for a new ISP to sell 'shares' in the business. Some sell ownership in a way that resembles stock sales and others have used something akin to crowd funding, where investors can buy a portion of a share. This is a relatively new way to fund networks. We know of an ISP in Vermont that has successfully combined selling shares with a bank loan.
- **Loans from other cooperatives**. Since RS Fiber is a cooperative, it found that it was able to borrow from a farm cooperative at low interest rates. Cooperatives are a unique type of business that is required by law to either invest profits back into the business or else return them as dividends to members. Because the level of dividends is limited by law, cooperatives often find themselves with large cash reserves. They are allowed to lend these cash reserves, but only to other cooperatives.

Pros and Cons of the Various Funding Sources

Bank Financing

- The larger nationwide banks rarely lend to infrastructure projects—at least in projects operated by smaller ISPs that aren't big publicly traded corporations.
- Smaller regional and local banks will sometimes lend to broadband projects. But they rarely will provide loan terms over 10 or 12 years, with most such loans set no longer than seven years. That's a hard payback period for a new broadband venture.
- Banks are leery in general about broadband networks as collateral. This means that they often require significant cash equity as part of any project. For smaller ISPs, loans mean making personal guarantees and even putting the owner's house on the line.
- Banks rarely lend to local governments for infrastructure because it's hard for cities to meet the collateral profile.
- Bank financing is cyclical. There are times when it's much easier or harder to obtain a bank loan, meaning that it's hard to count on as a source of funding. The bank might not be lending when an ISP needs the funding.

Federal Loans

For now, federal loans come primarily from the RUS, although it's possible to get SBA loans.

- The loan application process is paperwork heavy.
- The approval process can take a long time. In the best of times, it's four to six months but has slowed down occasionally to over 18 months just during the last decade.
- RUS borrowing terms are not negotiable. A borrower accepts them or doesn't get the loan.
- RUS has severe collateral requirements. For example, even fairly large ISPs must pledge the entire business to get a large loan.
- RUS loans also don't mesh well with other forms of borrowing. It's nearly impossible for an ISP to have an RUS loan and a loan from some other bank.
- Interest rates can be incredibly low for qualified buyers and certain kinds of projects. But some loans are at market rates.
- The loan term can be for as long as 25 years, although 15 to 20 years is more typical.
- There are also restrictions on things like the amounts of dividends that can be paid to owners while there is an outstanding RUS loan.

Loan Guarantees

- Loan guarantees play a dual role of providing lower interest rates and also ensuring against the default of a project. During the last decade, with relatively low interest rates there has been little demand for loan guarantees. These will come back into demand if future interest rates move higher.
- Federal loan guarantees require the same onerous paperwork as federal loan applications.
- The process can easily take four to six months.

Municipal Bonds

- There is a misperception that a government entity can issue bonds whenever it needs to borrow. A government can't sell bonds if the issuance is thought to be risky. This means that government entities have a maximum borrowing capacity just like corporations.

- Bonds can fund 100% of the construction cost of a broadband project. Federal bond law allows only an additional 5% borrowing to cover the start-up and operating costs of a new ISP business.
- To get tax-free bonds, the project can't be to the financial benefit of a commercial entity like an ISP partner.
- Bond interest rates can be low if the government has a good credit rating, but rates can be as high or higher than commercial bank interest rates.
- Bond terms can be as long as the expected life on the assets being constructed. There are bonds for fiber with terms as long as 30 years.
- Many local governments are required to hold a public referendum before selling some kinds of bonds. Bond issues don't always pass on a ballot.
- Issuing bonds means disclosing significant details on a project. Since bond documents are generally public, that means letting the competition know a lot about a project before it's built.
- Bonds are often backed by tax revenues, meaning that a government is forced to raise taxes if it defaults on a bond issue.
- Bondholders generally expect to begin collecting interest payments immediately. This means that bond-funded projects usually borrow the first several years of interest payments, which adds to the size of the borrowing.
- Bonds can be extremely difficult to renegotiate, while banks loans can routinely be refinanced and recapitalized.

State bonds. While not a major source of broadband funding, there are states that float large infrastructure bonds each year and make the funds available to infrastructure projects in communities throughout the state. The main purpose of this is to relieve local governments from floating small bonds for relatively small infrastructure projects. I've seen such bonds used for part of a broadband project before, where the state bonding was used to construct the headend/business office building for a new municipal ISP. There is no reason these bonds can't be used more for broadband in the future.

One of the best uses of state funding is to act as matching funds for federal grants. I've seen state money be used in this manner a number of times.

Opportunity zones/new market tax credits

- Each of these financing tools has complex rules that require bringing in specialty bankers.
- These tools typically can finance only a relatively small part of a project. It's often hard to justify all of the extra work needed to make these effective.
- These tools would not likely be used unless a project has an extremely complicated capital stack.

Alternate tax revenues

This means using a source of government revenues like property taxes, sales taxes, etc.

- Partial funding through an alternate source of revenue takes a lot of the financial pressure from a new municipal ISP.
- Funding most of all of a network this way means the business has an easier path to profitability.

- This often requires a referendum.
- Should make it easier to acquire a second source of funding due to lowered risk.

Customer contributions

- Can be a way to help pockets of customers get added to an existing network.
- Difficult to utilize for all customers since many households can't afford to pay to connect to a network.
- It's an interesting idea if the payments can be spread out over time to be made affordable.

Typical Capital Stacks

There are fiber projects with a half-dozen sources of funding. But most capital stacks are much simpler. Following are the most common capital stacks for different kinds of borrowers. None of these structures mentions grants, but grants can be folded into any capital stack.

Municipal ISP

Municipal ISPs prefer to fund projects 100% with municipal bonds. When available, a city is almost going to prefer revenue bonds over general obligation bonds.

If the size of the borrowing is too large, municipalities will next consider some form of alternate tax revenue, such as covering part of the project with sales tax revenues.

It's rare for a municipal borrower to infuse equity (accumulated cash) into a capital project.

Small Telco

Smaller telcos (under 100,000 customers) will typically finance new fiber projects with a combination of loans from an industry lender (RUS or CoBank) plus some cash equity. It's rare for a telco to be able to borrow 100% of the cost of a project.

These loans require pledging the new network to the lender and often require pledging the entire company as collateral.

Electric Cooperative

Electric cooperatives tend to fund new projects using industry financing plus equity. Some electric cooperatives borrow from the RUS, but more common would be to borrow from a coop-friendly lender like CoBank or RTFC.

Cooperatives sometimes accumulate large amounts of cash and sometimes make sizable equity contributions to new projects.

Independent Fiber Overbuilder

These are small fiber overbuilders that are not associated with a municipality, telco, or cooperative. Like all borrowers, these borrowers prefer to have one major source of borrowing, like a bank. But when such a source isn't available, these are the borrowers that sometimes end up with complicated funding stacks. One such example is RS Fiber, a newly formed cooperative in Minnesota. The funding stack included a non-recourse loan from the municipalities involved (which was borrowed with municipal bonds), sales of 'shares' in the cooperative to a few community organizations and individuals, a low-interest loan with a nearby farming cooperative, a state broadband grant, and a traditional bank loan. Such funding stacks are complex and issues like surety and collateral are hard to work through.

Large Publicly Traded ISP

Large telcos and cable companies typically finance projects through a combination of equity and corporate bonds. Big corporations don't want to deal with banks and all of the issues or surety and collateral. Big corporations can sell corporate bonds (often referred to as junk bonds) directly to bond buyers, meaning there is no intermediate lender. Telcos as small as 100,000 customers might be able to sell into the bond market, but the smaller the corporation, generally the higher the interest rate that must be paid on bond debt. It's typically impossible for an outsider to know how any specific broadband project has been funded by a big corporation.

Public-Private Partnerships

This implies some funding from both the public partner and the private partner. Typically, each partner borrows in the ways just described above. The biggest issue is deciding which entity gets first priority for loans, and it is generally the entity that puts in the most money.

B. Federal Grants and Funding Programs

This is an unusual year to be talking about federal grants because numerous new grant opportunities have arisen as a result of the federal CAREs funding last year and the $1.9 trillion American Rescue Plan Act (ARPA) from this year. There is also talk in Congress and the White House of funding a federal infrastructure plan that likely would include some massive monies for funding rural broadband.

There are two primary sources of ARPA funding for broadband. The first is a $10 billion Coronavirus Capital Projects Fund to be issued through the Department of the Treasury. This funding will be distributed in the form of a state block grant and each state is guaranteed to get at least $100 million. Most states will get more, with many states getting $200 million to $300 million. The biggest question still to be answered is any restrictions that are put onto the funding from Treasury. It's clear in the ARPA enabling language that this money is aimed primarily at last-mile infrastructure; we'll have to wait to see how much flexibility Treasury gives to the states. Treasury could also layer on specific guidelines on how to use the money.

States will be free to use any mechanism they want to distribute this money. We already know of several states that will distribute the money through the existing state broadband grant programs, while other states will distribute this money in some different manner. Most states are in the process now of getting ready for this funding, which should be distributed to the states in two payments over two years starting in May 2020. It's likely that these funds will have a finite time frame in which to be spent (speculation is two to three years), so states are expected to quickly choose state grant candidates so that there is sufficient time to build the networks before the money expires.

The ARPA is also providing $360 billion in funding that is going to go straight to state, county, city, township, and tribal authorities. This money is aimed at programs that the local governments deem to be a high need based upon the impact of the pandemic. Local governments might use this money to replace tax revenues lost during the pandemic, but the money can be used for any project that the local government can justify as being related to the pandemic. Many communities have said that broadband was one of the biggest problems encountered during the pandemic and are planning to use some of this funding for a local broadband project.

It's hard to define all of the possible broadband monies in the ARPA because this program spreads funding to numerous existing and new programs. Consider just the area of ARPA funding for libraries, which be used in some cases to fund network construction, and which also could provide computers, hotspots, and possibly monthly data plans for customers. I can identify the following list of the many ways that the ARPA funds libraries (and there are likely programs I've missed):

- The ARPA allocates $200 million to the Institute of Museum and Library Services. This is an independent federal agency that provides grant funding for libraries and museums. $178 million of the $200 million will be distributed through the states to libraries. Each state is guaranteed to get at least $2 million, with the rest distributed based upon population. This is by far the largest federal grant ever made directly for libraries.
- Libraries are also eligible to apply to the $7.172 Emergency Connectivity Fund that the ARPA is funding through the FCC's E-Rate program. This program can be used to compensate for hot spots, modems, routers, laptops, and other devices that can be lent to students and library patrons to provide broadband.
- The ARPA also includes $360 billion mentioned above that will go 60% to states and 40% directly to local and tribal governments. Among other things, this funding is aimed at offsetting cuts made during the pandemic to public health, safety, education, and library programs.
- There is another $130 billion aimed at offsetting the costs associated with reopening K-12 schools to be used for hiring staff, reducing class sizes, and addressing student needs. The funds can also be invested in technology support for distance learning, including 20% that can be used to address learning loss during the pandemic. This funding will flow through the Department of Education based upon Title I funding that supports schools based upon the level of poverty.
- Another $135 million will be flowed through the National Endowment for the Arts and Humanities to support state and regional arts and humanities agencies. At least 60% of this funding is designated for grants to libraries.
- There is also tangential funding through the ARPA that could support libraries. This includes $39 billion for Child Care and Development Block Grants and Stabilization Fund plus $1 billion for Head Start that might involve partnerships with schools and libraries. There is also $9.1 billion to states and $21.9 billion for local programs for afterschool and

summer programs to help students catch back up from what was a lost school year for many.

There is an even longer list of programs that could be aimed at schools, some of which could be used to contribute toward building fiber to schools. There are monies in the ARPA that can be aimed at other related areas like electric smart grid technology that could be used to build fiber. There is a similarly long list of monies aimed at tribes, and that money could be used for broadband and could be combined with other grants as part of local partnerships.

We think that a community that is clever could put together grants from multiple sources that could be added together to help pay for broadband. The two primary sources of ARPA broadband funding are listed below, but we think those funds could be supplemented with funds aimed at schools, libraries, public safety, electric smart grid, smart city, Tribes, and economic development.

Federal Broadband Grants.

There are several long-standing federal broadband grant programs that can be used to build broadband infrastructure:

e-Connectivity Grant Program. In March of 2017, Congress passed a one-time $600 million grant/loan program to build rural broadband. The project was labeled as the e-Connectivity Pilot. There has been additional money added to this program each year.

ReConnect Grants.[5] In the 2017 farm bill, Congress created a grant program called ReConnect. The program awarded $200 million in grants, $200 million in loans, and $200 million in a combination of grants and loans in 2019. Congress reauthorized an additional $600 million to be awarded in 2020. There is a lot of hope in the industry that Congress will continue to renew these grants. These grants are administered and awarded by the U.S. Department of Agriculture.

Community Connect Grants.[6] This program has been around for decades and specifically targets parts of the country that are the poorest and that have poor broadband. This grant program is administered by the USDA and has historically awarded $30 million to $35 million per year in grants. Grant awards for the program are generally between $100,000 and $3 million and require at least a 15% matching from the grant recipient. It hasn't been announced yet if there will be grants in 2021, but it's expected there will be.

BroadbandUSA Program.[7] This program is part of the Department of Commerce's National Telecommunications and Information Administration (NTIA). The agency provides an annual database of grants that can sometimes be used for broadband and are often used for other purposes. Examples include the Appalachian Regional Commission and the Community Development Block Grant (CDBG) Program.

[5] https://www.usda.gov/reconnect

[6] https://www.rd.usda.gov/programs-services/community-connect-grants

[7] https://www.broadbandusa.ntia.doc.gov/new-fund-search

But there are many more federal programs that can provide broadband funding. The full list of federal broadband grant programs is at this website maintained by the NTIA.[8] There are federal grants that cover issues like broadband adoption, broadband financing, digital skills training, feasibility studies, public computer access, broadband research, and smart city applications. This website allows for each identification of specific kinds of grants.

Emergency Broadband Benefit Program

The Emergency Broadband Benefit (EBB) program is another pandemic-related program that is funding home broadband bills for qualified households. The program was funded with $3.2 billion and is being administered by the FCC.

The EBB will provide a discount of up to $50 per month toward broadband service for eligible households and up to $75 per month for households on qualifying tribal lands. Eligible households can also receive a one-time discount of up to $100 to purchase a laptop, desktop computer, or tablet from participating providers if they contribute more than $10 and less than $50 toward the purchase price. The EBB funding is limited to one monthly service discount and one device discount per household.

The following households are eligible for the EBB discount:

- Has an income that is at or below 135% of the federal poverty guidelines or participates in certain assistance programs, such as SNAP, Medicaid, or the FCC's Lifeline.
- Is approved to receive benefits under the free and reduced-price school lunch program or the school breakfast program, including through the USDA Community Eligibility Provision in the 2019-2020 or 2020-2021 school year.
- Received a federal Pell Grant during the current award year.
- Experienced a substantial loss of income due to job loss or furlough since Feb. 29, 2020, and the household had a total income in 2020 at or below $99,000 for single filers and $198,000 for joint filers.
- Meets the eligibility criteria for a participating provider's existing low-income or COVID-19 program.

This funding is given to ISPs, so a customer must enroll through its ISP, assuming the ISP is participating in the program. The EBB will disburse funds until the money runs out. There is already talk in Congress about adding additional funding to the EBB.

Rural Digital Opportunity Fund (RDOF)

This grant was awarded by the FCC and funded by the Universal Service Fund. The first phase of this auction was conducted in the form of a reverse auction that concluded near the end of 2020. That grant was supposed to award $16 billion in grants but ended up awarding a little over $9 billion. The remaining $7 billion, and another $4 billion will be auctioned at some later date.

[8] https://broadbandusa.ntia.doc.gov/new-fund-search

In a reverse auction, grant applicants were bidding on the grant dollars by census block. In each round, the bidding went lower until there was only one grant recipient remaining. The grant allowed a wide range of technologies from DSL through fiber. There were weightings assigned to provide more bidding priority to the fastest technologies. The grant monies will be paid out over 10 years. A grant winner is expected to complete construction within six years, with completion milestones starting with the third year.

Much of the industry thinks the FCC made some major mistakes with the RDOF grants. Here are a few of the controversies that arose as a result of the grant process:

- The FCC chose the areas to be included in the grant. The grants were supposed to be aimed at places in the U.S. where households can't buy broadband of at least 25/3 Mbps. The areas were defined by the broadband speeds reported by ISPs, which have been highly overexaggerated for many years in the FCC mapping system. It's been estimated that as much as half of all areas that should have been eligible for these grants were excluded due to the way that ISPs report marketing speed for broadband products instead of actual speeds. One example of this is in Georgia, which created its own broadband map in 2020. The state believes that there are twice as many homes without good broadband as shown on the FCC maps—an additional 252,000 homes. I have seen this same phenomenon in almost every rural county I have studied.
- The dollar amounts to be awarded in the grants were also established by the FCC using cost models that are supposed to estimate the cost of broadband for each census block. As might be expected, the cost of building broadband is very much a local issue. The cost of aerial fiber construction might be higher than the FCC models due to the poor condition of local utility poles. The cost of buried construction might be a lot higher than the FCC models due to underground rock. It appears that the cost model was generous to places in the plains of the Midwest and too low in the mountains of Appalachia, the Ozarks, and the Rockies.
- Some grant areas were included in error. For example, there were some major urban airports included in what was supposed to be a grant for rural America.
- The bidding was done too quickly. The rounds of grant bidding started at 100% of the available grant award and dropped a full 10% at a time, to 90%, 80%, 70%, etc. Grant participants said this dropped too drastically. For example, there is a huge difference between bidding for 40% of the funding versus 30%, and participants wanted more tiers of bidding between the big 10% increments.
- Three of the top 10 winners of the grant funding were funded to provide gigabit fixed wireless technology. There was a huge outcry in the industry because nobody believes that there is a wireless technology that can deliver a gigabit of speed in rural America where customers are far apart and where there are a lot of physical impediments to the line-of-sight needed for the technology. The consensus is that the FCC erred by allowing these technologies to bid at this tier because that made the wireless technology functionally equivalent to fiber. Where fiber can deliver a symmetrical gigabit product to every household in a census block, it's likely that fixed wireless might bring that speed to a handful of households, bring something significantly slower to most households, and be unable to bring broadband to some households due to line-of-sight issues.
- There was also a big outcry when Starlink and Elon Musk won $900 million. Many feel that low-orbit satellite is an unproven technology that may never have the capacity to serve

all of the households covered by the grants. This issue covers two different concerns. First, it's becoming clear that satellite broadband is going to have problems serving homes with impaired vision of the sky, such as homes in heavy woods or homes on the side of hills. There is also an overall capacity concern that there will not be enough backhaul to the satellite constellations to connect millions of homes to the internet.
- There were also a few winners that many believed should not have been allowed to win huge amounts of grant funding. The biggest of these is LTD Broadband, a small wireless carrier from Minnesota with around 100 employees. The company won over $1.3 billion in grants and promised to largely build fiber-to-the-premise. Many doubt that a company of this small size is up to such a gigantic construction challenge. Many also think a company of this small size will be unable to raise the needed billions of dollars of matching funds.
- Some of the bids went extremely low. There were a substantial number of grant awards at only 1% or 2% of the proposed FCC funding for a census block. It's impossible to meet the RDOF requirements in such cases without a substantial external cash infusion.
- Finally, the FCC is not opening up the details of the proposed solutions to the public. Each grant winner has filed details of how it will meet its financial, technical, and managerial goals for the grant areas, and those opposed to some of the winners want to see the details before the FCC erroneously awards huge amounts of grant money that is likely to fail.

This grant raises a good question about why a regulatory body like the FCC is conducting large technology grants. Most of the eventual problems with the grant were foreseen and companies warned the FCC, yet the grants concluded with a huge list of controversial problems.

The industry is waiting to see how the FCC handles some of the controversies. There are parties prepared to sue the FCC in some instances whether it awards or rejects the grants. Some of these grants could get mired in court cases and be badly delayed. It will be interesting to see how the FCC conducts the second half of this grant award and if it will fix some of the controversial issues. The FCC has also put a reverse auction on hold that was aimed at funding rural towers needed to bring 4G LTE cellular service to all of rural America.

Improving the Federal Funding Process

There are at least three significantly different processes in place today for awarding federal grant monies. All of these methods are in play in 2021.

- <u>Traditional funding request</u>. The RUS loan process and grants like ReConnect rely on what I'll call traditional funding requests. For these funding sources, the requestor prepares an engineering estimate of the cost of a specific solution to bring broadband to a specific place. The government judges if the request is accurately estimating the costs and can make a value judgment about whether a grant request is worthy of being funded. The granting agency creates some sort of grading method to compare different grant requests.

  The primary benefit of this kind of grant process is that the amount of grant can be exactly right-sized to the opportunity. With cost estimates blessed by a professional engineer, the grant requests are usually pretty accurate. This gets rid of issues like the problems in the

RDOF grant where the FCC arbitrarily assigned the amount of grant for each census block based upon a nationwide cost model that is demonstrably too high or too low in many places.

This also lets the granting agency discuss the worthiness of various types of grants. It may decide to mostly fund fiber but also take a chance on some other technology. Traditional grants let the granting agency pursue any larger administration goals. If there is a desire to give more money to tribes or to poor areas of Appalachia, this can be decided by picking grants that meet the desired goals.

One problem with this method is that it's slow and it requires a large and experienced staffing effort to give away billions in this manner. The grant applications ask for a lot of information that the grant agency has to digest.

- State block grants. There is a lot of hope among states that they'll get to play a bigger role in the future in determining where broadband grants are spent. We recently saw how states react to block grants after states were awarded broadband funding in 2020 under the CARES funding awards. From what I can see, states took the CARES money seriously. States quickly elicited feedback from stakeholders and carefully deliberated on how to use the funding.

  Giving grant monies to states has some big benefits. States know where the biggest needs are for better broadband while the federal government instead relies on the FCC maps, which overstate broadband coverage, particularly in rural areas. The states also know the ISPs operating in the state. They will know the ISPs that have garnered huge numbers of customer complaints (and those who are well-liked).

- The reverse auction. Recent reverse auction grants had huge problems. The numerous issues with reverse auction were discussed earlier in this report.

Major issues with some federal grants. There are some recurring complaints about federal broadband grant programs:

- Federal grants often have little or no oversight to make sure the money is spent as intended. The best example of this is the CAF II grants from the FCC that awarded over $9 billion to improve the DSL broadband from the large telephone companies. It appears that there are many places in the country where the specified upgrades were never performed. The telephone companies offered little than an annual letter stating that upgrades had been performed.
- Federal grant funds often include requirements for expensive environmental and historic preservation studies are done as part of accepting grants. While there are places where these certifications make sense, the majority of grant funds are used to build facilities in existing public rights-of-way that already host existing utilities.

C. State Grants

There are a number of existing state broadband grant programs. A few of the state broadband grant programs have been around for five years or more, but many of these programs are relatively new. Here is a list of all of the state broadband offices as of June 2020.[9] Other states have a less formal arrangement for considering broadband issues and include broadband in economic development agencies or something similar.

Back in February before the federal ARPA funding was announced, many of the state broadband offices or governor's offices had announced increased broadband spending for 2021. But before 2021 was barely started, many plans for state broadband grants went out the window due to the new expected federal funds that will send significant grant monies to states. As this paper is being written the federal grant rules have not yet been published, so states are still on hold. Some states have already said they hope to add the new federal money to the existing state broadband grant funding. Other states are going to distribute the federal money in some different mechanism. Some are likely to put state programs on hold for a year to concentrate on distributing the federal funding.

Some state grant programs also got thrown into turmoil due to the final announced winners of the RDOF auction. Let me explain the situation in my state of North Carolina to explain the turmoil caused by the RDOF grant.

The North Carolina grant program is called the Great Grants. These grants are administered by the N.C. Department of Information Technology. The funding rules for awarding grants were specified by state legislation. Charter won a large percentage of the RDOF funds in North Carolina, with some RDOF funds going to cooperatives and Starlink. The state grants can't be used for any areas that have already been funded by some other grant. Further, the Great Grants can be awarded only for areas where households can't buy broadband that receives at least 25/3 Mbps.

The RDOF awards largely covered all of the areas in North Carolina that have speeds less than 25/3 Mbps (using the FCC maps to define grant eligibility). The RDOF grant awards effectively eliminated the areas in the state where the Great Grants can be awarded, meaning that until legislation is passed that redefines how the Great Grants can be used, there are basically no areas in the state that are eligible for state Great Grants. Unfortunately, there are big parts of the state that have poor broadband but for which the incumbent telcos incorrectly report broadband speeds of 25/3 Mbps or faster. But the state grant program cannot fund such areas. There are a lot of questions whether there will be any state grants awarded this year. There are also a lot of questions about how the state will use the ARPA block grants and everybody assumes the state will figure out a way to do so.

I'm hearing similar stories from all around the country as the RDOF grants and the ARPA funding are drastically affecting the grant landscape in 2021 and probably 2022.

It's hard to write a critique of state broadband grant programs since they vary so widely. In many states, the state grant program changes from year to year. A good example is the Border-to-Border grant program in Minnesota. This is a 'traditional' grant program in that applicants ask for funding

9 https://www.ncsl.org/research/telecommunications-and-information-technology/state-broadband-task-forces-commissions.aspx

for specific projects and must provide engineering estimates for the cost of construction. This grant program has changed priorities almost every year since it's been created in reaction to pressure from the governor's office or from legislators. While the grant process is similar from year to year, there are fresh priorities or other rules imposed each year on who is eligible for grant funding. This year-to-year reassessment of the grant rules is pretty typical for state grant programs since in most states the funding for the grants is approved annually by the legislature, meaning that there is some political influence in the grant rules and process.

State grant programs have also varied widely in effectiveness. An example of a state grant process that went awry was a state grant for $100 million in California a few years ago that was mostly given to AT&T and Frontier, the two biggest incumbent telcos in the state. The program was initially intended to be available to a wide variety of applicants, but politics shifted the use of the money at the last moment.

Even state grant programs that are run well will have informal requirements such as making sure that some of the funding goes to each corner of the state. If I had any suggestion to make state broadband grants better, it would be to take politics out of the process, but that's never going to happen. I don't want this to sound like a complaint about state broadband grants, because most of the programs have done well in helping to fund needed broadband projects. Taken as a whole, the state broadband grants are heads and tails better than the RDOF grants recently awarded by the FCC. One of the biggest factors in favor of state grants is that the people in a state know where funding is most needed.