Feasibility Report for a Community Network

Farmington / Farmington Hills Michigan

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SUMMARY OF FINDINGS

The cities of Farmington and Farmington Hills jointly hired CCG Consulting (CCG) to undertake a feasibility study to analyze the current broadband market in the cities and to make recommendations regarding the viability of building a new broadband network that would address the current broadband gaps and provide capacity for future growth.

Perhaps the most significant feedback we got from residents and businesses was that broadband is inconsistent. There are homes and businesses in the cities that can get great broadband, but other parts of the cities with poor broadband. We more normally see cities where the broadband options are more homogeneous throughout the market. Here, the quality of broadband seems to differ by neighborhood. Frustration with the broadband experience is likely the prime reason why as many as 61% of residents and many businesses would consider moving to a new broadband network.

This Summary of Findings discusses the primary results of our analysis and references the portion of the study that describes each issue in more detail.

Broadband is Not as Good as it Should Be

There are broadband gaps in the community between the broadband that residents and businesses want compared to what is being delivered.

Some Customers Have Robust Broadband. We found that some customers have robust broadband. This is mostly residential customers served by fiber on AT&T or by WOW!, as well as businesses served by fiber from a number of providers.

Charter Download Speeds. Charter is the incumbent cable provider in the cities, having purchased a network that was formerly operated by Bright House Networks. The Charter network is often not delivering the speeds that customers are paying for. As part of the study, we asked the public to take a speed test and the results surprised us. 42% of Charter customers showed download speeds under 50 Mbps (megabits per second), with 10% of customers getting download speeds under 10 Mbps. These speeds are far below the speeds that Charter promises, which is at least 100 Mbps download. The results of the speed tests surprised us because we've studied other Charter markets where the majority of customers are receiving speeds close to subscribed speeds. We also heard from Charter customers that speeds are inconsistent throughout the day and that there are intermittent outages (Page29).

There are a few possible explanations for the slow download speeds. We know that the Charter network has been updated to the newest DOCSIS 3.1 standard since we found some customers able to buy the gigabit product. The most likely reason for the slow speeds is that the Charter network configuration has not been modernized. For example, there might still be large neighborhood nodes where too many homes are sharing broadband. A more likely explanation is a configuration described as cascading. In the ideal network configuration Charter would bring fiber to small nodes of a hundred or so homes. In a network with cascading, fiber is brought one neighborhood node, but then additional neighborhoods are added off this one fiber. The customers in the first node get the best download speeds, with subsequent nodes seeing slower speeds. We can't think of any other reason why so many homes are getting download speeds under 50 Mbps.

There are always some homes in every market that get slow speeds due to issues such as bad wiring or outdated WiFi routers – but we generally don't see this impacting more than 5% of customers in a market, so this can't explain the universally slow speeds in the cities.

AT&T DSL. AT&T is still operating DSL technology over copper wires. Most AT&T customers have download speeds between 10 Mbps and 30 Mbps, with a few even faster. There was breaking news as we completed this study and AT&T announced on October 1 that it will no longer install new DSL customers (Page 27). This effectively will make Charter a monopoly provider in most parts of the cities since it will be the only option for purchasing broadband.

Upload Speed Gap. Much of the study was done after the start of the pandemic. The pandemic uncovered a new broadband gap where residences began caring about upload speeds. Upload speed measures how fast data can be sent from a user's computer to the internet. Good upload speeds are needed for connecting to a school server, for working at home and connecting to a work server, and for connecting to online video meetings like Zoom. Additionally, just before the pandemic, many of the big gaming platforms moved their games online, creating a new demand for low latency uploading. Many residents who thought they had adequate broadband suddenly found that they were unable to conduct multiple simultaneous upload connections at the same time. This phenomenon appeared all over the country as residences began using significant upload activities for the first time.

The upload speeds in cities are sluggish. On AT&T DSL the upload speeds are mostly under 10 Mbps. For Charter, one-third of customers reported upload speeds under 10 Mbps, 54% had speeds between 10 Mbps and 20 Mbps, and 13% had upload speeds between 20 Mbps and 30 Mbps (Page38).

The Broadband Gap is Growing. The fact that many homes are experiencing slow broadband speeds is the most significant gap we identified. To add to the broadband gap problem, the demand for broadband is growing at an extraordinary rate. Perhaps the easiest way to understand this is through the average amount of bandwidth homes use each month. The following statistics are gathered and reported by OpenVault, a company that provides software for the large companies that operate the Internet backbone. In early 2018, the average home used 215 gigabytes per month of broadband (combined download and upload usage). By early 2019 this had grown to 274 gigabytes. By December 2019, the average home used 344 gigabytes. After the onset of the pandemic, by March 2020 the average home was using 403 gigabytes. This slowed a bit by June 2020, but the average home in the country was still using 380 gigabytes – a 74% increase since 2018.

According to Cisco, the amount of bandwidth used by homes has been growing at a steady rate of 21% annually since the early 1980s. That kind of steady growth is a challenge for any network. Even if networks can handle the customer demand for bandwidth today, broadband networks will be severely distressed as broadband demand keeps growing at a torrid pace (Page 49).

Other Broadband Gaps. The study examines other broadband gaps in the cities. The survey identified that 10% of households have no home broadband. Another 6% of homes only get broadband through their cellphones. These percentages are fairly typical of what is seen in most cities of you size (large cities like Detroit have a larger percentage of homes without broadband). The report discusses the various reasons why homes don't have broadband. The most prevalent reason is the cost of broadband, which the industry refers to as the affordability gap. There are other homes that can't afford both broadband and computers, which the industry refers to as the computer gap. There are also those in every city who don't buy broadband because they aren't computer using computers and functioning on the Internet, which the industry refers to as the Broadband Skills gap. The report discusses ways that other cities are tackling each of these issues (Page 45)

There is Market Demand for Better Broadband

As part of the study we looked at market demand. We first conducted a statistically valid random residential survey that asked about the current state of broadband with a target accuracy of 95% plus or minus 5%. This survey was supplemented with an online residential survey. The key findings of the statistically valid survey are as follows (Page19):

- 85% of residents have a wired home broadband connection today, which is a few percentage points under the national average.
- 86% said they are still buying a traditional cable TV package which is higher than the nationwide average of less than 70% at the time of the survey.
- 42% of residents said they are unhappy with their current home broadband speeds. That's much higher than we would expect in a market that is served everywhere by cable companies.
- 39% of respondents say that somebody in their homes uses the Internet to work from home. That is made up of those that work at home fulltime (7%), those that work several days per week (11%), and those that work from home occasionally (21%). Note that these results were obtained before the pandemic and we are sure many more people have been working from home during 2020.
- 48% of respondents said that they would consider moving to a new network to get faster speeds at the same price they pay today. 78% said they would consider moving to a fiber network for lower prices. Only 24% said that better customer service would lure them to a new network. 29% said they would consider moving to a fiber network if they got more reliable service.

<u>Business Questionnaires and Interviews</u>. We heard from businesses using a business questionnaire and through direct interviews.

- Every business we heard from described their current broadband as adequate. However, almost every business also said that faster broadband would improve their business (Page 26)
- Businesses told us that many employees struggled with working from home during the pandemic due to broadband issues.
- Businesses using AT&T described the broadband as somewhat slow, but with solid steady performance. Businesses using Charter told us that in past years that Charter had major prolonged outages, but that the problem seems to have been fixed. However, all business customers using Charter report that they still have numerus short outages ranging from a few minutes to half an hour.

Building a Fiber Network Is Expensive

Our engineers selected a network design that uses a mixture of Passive Optic Network (PON) technology to bring speeds up to a gigabit for homes and businesses along with the capacity to use Active Ethernet (AE) technology to provide larger bandwidth to customers that need it Page 63). The fiber network was designed to reach past every home and business in the cities. Our engineers used Oakland County GIS records to determine the location of potential customers.

The fiber network is designed to go primarily on poles where other utilities are on poles but would be buried underground where other utilities are currently buried. The network design is robust and is designed to provide fiber for every home and business in the study areas today as well as the capacity for future expansion and growth. The extra capacity could be used for numerous reasons such as supporting electric smart-grid, supporting smart-city applications, or for providing for new housing and business growth. Our engineers determined that a new fiber network would require the following fiber construction:

Miles of Fiber	Farmington	Farmington Hills	Total
Aerial	6.5	113.1	119.6
Buried	41.2	375.2	416.4
Total	47.7	488.3	536.0

Following is a summary of the cost of building the network. This cost estimate considers a customer penetration rate of 50% at the end of year 5. The investment would vary with greater or fewer customers (Page 112).

	Farmington Hills	Farmington	Both
Fiber	$70,864,684	$ 7,793,783	$ 78,658,617
Drops	$ 9,344,861	$ 1,626,676	$ 11,011,477
Electronics	$13,053,456	$ 3,073,523	$ 15,813,173
Huts	$ 188,060	$ 116,360	$ 304,420
Operational Assets	$ 1,688,389	$ 528,444	$ 1,773,604
Total	$95,139,450	$13,138,786	$107,561,142
Cost per Passing	$3,007	$ 2,144	$2,848
Cost per Customer	$6,014	$ 4,289	$5,696

It's Financially Feasible to Build a Fiber Network

Operating Models**.** We studied different operating models. We looked at a model where the cities create an ISP. We looked at the feasibility of a partnering with a single commercial ISP to operate the network. We looked at open access, where the cities would build a fiber network and invite multiple ISPs to use the network. We looked at an option where an ISP would lease the network from the cities.

Our Approach to the Financial Analysis. We used the following approach in estimating the revenues and costs for operating a new fiber network for each of the three scenarios:

- A base model was created for each operating model. We arbitrarily chose a 50% market penetration (the percentage of customers using the network) for each scenario. We don’t know how many customers a new fiber business might win and chose these penetration rates as typical of other similar fiber markets and based upon the responses to the residential survey.
- We looked at the feasibility in the base study of bringing fiber to each city individually as well as bringing it to both together.

- All financial models cover a 20-year period.
- All projections include projected financing costs for borrowing the money needed to build and launch the network.
- We believe the engineering cost estimates are conservatively high.
- All studies include an estimate of future asset costs that are needed to connect future customers and to maintain and upgrade the network over time. We've assumed that electronics wear out and need to be replaced periodically during the studied time frame.
- Products were priced at a modest discount from the existing prices in the market today. The expectation is that the internet speeds on fiber will be significantly faster than the speeds available in the cities today.
- The estimates of operating expenses represent our best estimate of the actual cost of operating the fiber business and are not conservative. Most operating expenses are adjusted for inflation at 2.5% per year.

Financing Options Considered. Using feedback from the cities we considered several primary methods of financing a fiber network:

- We considered using 100% general obligation bond funding.
- We considered a scenario where a customer would contribute $3,500 to be added to the fiber network. This could be paid in a lump sum or financed over as long as 10-years.
- We considered an option in between these first two options where customers would pay $500 to join a cooperative.

Key Financial Study Results**.** The assumptions used in creating the various financial plans for each scenario are included in Section III.C of the report. The results of the financial analysis are included in Section III.D of the report (Page 117). A summary of the financial results is included in Exhibit II (page 183). Following are the key financial findings of our analysis.

- It Looks Difficult to Launch a Standalone ISP in Farmington. Farmington looks to be too small to support a standalone ISP that doesn't also include Farmington Hills. The breakeven penetration needed to make an ISP work in Farmington is 72% - an unachievably high goal.
- A City-based ISP Can Work. The analysis shows that the cities could launch an ISP. However, the business is going to require a penetration rate of 46% for the business to avoid subsidizes. While the customer survey hinted that the potential penetration rate could be as much as 60%, the business is fairly risky with such a high breakeven penetration rate.
- Commercial ISPs Are not Likely to Invest in Fiber**.** The analysis shows that it seems unlikely for a commercial ISP to fund and construct a fiber network in the cities. The returns on investment look slim and ISPs have better opportunities elsewhere. This is not to say that ISPs might not build some fiber – but if ISPs build, they will likely cherry-pick and build fiber only to neighborhoods where they can make a good return rather than build everywhere.
- Open Access Doesn't Look Feasible. We could not find any scenario with an open access network where the cities don't lose a lot of money. The revenues generated by open access can cover the operating costs of an ISP business, but the revenues are not enough to support the cost of the debt.
- Hiring an ISP to Operate the Business is Possible. It is feasible to hire an ISP to operate the business. Finding ISPs to take on this role isn't easy, but it's possible. In the analysis we looked at different scenarios such as engaging with a commercial ISP partner, a non-profit partner, and a cooperative owned by customers. The cash margins on a business with a partner are lower than if the cities created an ISP – but it can work with enough customers.

- Leasing the Network Might be Feasible. One of the best options we found was leasing the network to an ISP. This could work because it gives ISP the possibility to make profits without making a big capital investment. The challenges will be in finding an ISP willing to guarantee lease payments to the cities.
- General Obligation Bonds are Better than Revenue Bonds (From a Financial Perspective). There are pros and cons for the two kinds of bonds other than just financial considerations. However, from a purely dollar perspective, the cost of general obligation bonds in the current market are lower than using revenue bonds.
- Funding with Customer Contributions. We looked at a scenario where single-family homeowners contribute $3,500 to join the fiber network and landlords of apartments buildings with more than 4 units contribute $2,250 per living unit. The results from this scenario are intriguing. The hardest aspect of this scenario is estimating the number of households and landlords willing to pay the fees – even if those fees are spread over 10 years ($29 per month). In the following analysis we assumed a 40% customer penetration rate – but we have no basis for that estimate.
    - City as ISP. In this scenario the customer fees would allow the city to reduce customer rates for residents who paid the connection fees by as much as $26 per month – reducing basic broadband to $34 per month and gigabit broadband to $54 per month. This comes fairly close to a breakeven from a customer perspective since the fee equates to $29 per month over ten years.
    - Partner-for-Hire Scenarios. The customer savings would be a little less if the cities hired an ISP to operate the network. The savings in monthly retail rates with a commercial ISP operator is $21 per month and $24 per month with a non-profit operator.
    - Open Access. This scenario still doesn't look feasible. The customer fees only reduce wholesale rates by $5 per month, meaning customers would pay the connect fee and not gain much monetary benefit. Customers would gain the benefit of choosing among multiple ISPs.
- The Business is Sensitive to a Few Key Variables. Our analysis shows a base business case that's unforgiving for downsides – but there are opportunities to perform better than our base analysis. Following is the impact from changing the key variables for the scenario where the cities create an ISP to serve both cities:
    - Penetration Rate: The most important variable is customer penetration rate. We used a penetration rate of 50% as the starting point in the analysis. There would be a huge downside for a business that doesn't meet the target penetration rate. Our analysis shows that changing the penetration rate by only 1% changes cash over 20 years by over $3.2 million. While the impact is a benefit for beating the target penetration rate, there is a significant penalty should an ISP underperform and not meet penetration goals.
    - Broadband Prices: The financial results show a high sensitivity to broadband prices. The studies all assumed starting price of $60 for the basic broadband product. Changing broadband prices by only $1 per month changes cash flow over 20-years by almost $3.1 million.
    - Interest Rate: The impact of interest rate is important but is less than the other key variables. If the project was funded by bonds, changing the interest rate by one-half percent (50 basis points) changes cash flows over 20 years by over $9.5 million.

Other Findings

There are other findings that are important for the community to consider when contemplating if you should try to build a new fiber network:

Other Findings. The report also explores a number of other specific questions asked by the RFP.

- Future Proof. Fiber is a future-proof technology. It's the only technology that can satisfy the broadband needs of today and also the needs decades from now.
- Broadband Prices in the Market. It's impossible to describe current prices as affordable, but they are typical of other markets. We envision that Charter will continue to increase rates (Page 13)
- Future Technologies. The report explores if there are future technologies other than fiber that might present a competitive threat to any entity building a fiber network today, including 5G. We conclude that none of these technologies will be a strong competitor to a fiber network (Page 87)
- Getting Local Buy-In. The report describes how other communities have been able to involve the public and key stakeholders in the decision of whether to build fiber. (Page 165)
- Benefits / Risks. The report looks at the many benefits of building a fiber network as well as the risks associated with launching a fiber business (Page 168).
- Issues with Serving MDUs. The report looks at the challenge involved in bringing broadband to multiple-dwelling units (apartments, condominiums, and townhouses (Page 173).

RECOMMENDED NEXT STEPS

We make the following recommendations as steps you might take after receiving this study in order to move towards better broadband.

1. **Determine if You Want to Continue the Investigation**. The first step the cities need to undertake is to digest this report and start a dialogue about the findings of this study. The big question to answer is if the state of broadband is poor enough for the cities to spend money to improve broadband. In most studies we've done it's been obvious if cities should move forward or not – but here it's not so clear. This report contains a wide range of information that should help you make the decision.

2. **Determine the Best Operating Model.** There is no clear-cut winner among operating models to bring better broadband. It looks feasible for the cities to start an ISP, but that business plan will require getting close to a 50% market penetration rate to be successful. It's possible to instead hire an ISP to operate the business, but the margins for that option are even tighter. One of the most intriguing options is to lease the network to an ISP, and the challenge for this business model is to find an ISP that can guarantee lease payments. Finally, the scenario where customers pay to join the network looks interesting – but this option is hard to make work for apartment residents. The only option that does not look feasible is open access.

3. **Educate and Involve the Public**. The report discusses a number of ways that other communities have educated the public on the broadband issue. The first step is to circulate this report. This report was created for the purpose of explaining the wide range of issues associated with fiber to elected officials and the public. Our goal was to explain highly technical issues in plain English for the benefit of the nontechnical layperson.

   But there are many additional steps needed to bring the general public into the discussion of broadband. For example, many communities follow up a report like this one with neighborhood meetings intended to answer basic questions the public has about broadband. Most communities also begin the process of gathering public support and a method to further communicate with the public through such tools as a broadband website, a broadband newsletter, or some other kind of tool that can be circulated to discuss the progress of the investigation into fiber.

4. **Consider the Public-Private Partnership Option**. Some of the feasible options include finding and working with a partner. The first partnership option we studied is for the cities to build a network and hire an ISP partner to operate the business. We've suggested that this could be done by an existing ISP. We've also suggested more local options such as creating a non-profit or a cooperative to operate the network. The second option is to lease the network to an ISP.

   If the cities decide you want to pursue those options, the next step would be to reach out to potential ISP partners. The report discusses ways that other communities have been able to successfully find partners. It will take a lot more work to flesh out how you might create a community non-profit or cooperative to take on that role.

5. **Consider Looking at Local Broadband Gaps**. Section I.D. of the study looks at broadband gaps other than download speeds. For example, 15% of the homes in the cities don't have a home broadband connection, often due to the high price of broadband access. There is a list of specific recommendations at the end of Section I.D. that looks ways that local government can help to solve and close various broadband gaps.

6. **Staffing / Finding a Local Champion**. It's been CCG's experience that a project of this magnitude is not going to progress unless there is some kind of local champion. A local champion is some person or group that is tasked with tackling the various recommendations made in this report. A local champion clearly has to be pro-broadband, but open to all possibilities of how this might work in the community.

   Communities have staffed the ongoing effort in a number of ways. There are communities for which broadband is such an important issue that they dedicate government or economic development staff to the issue. It would be unusual for this to effort to immediately require full-time staff, but eventually it could become so.

   More typically, government staffing is not going to be sufficient to move the broadband issue forward. That's not hard to understand by looking at these recommendations and seeing a list of issues must be tackled like public education and outreach, funding, governance, finding an ISP partner, etc.

   Most communities that have successfully tackled getting broadband network also bring in volunteers from the community. The cities already have a volunteer broadband committee, but the ongoing volunteer effort is likely to be different than in the past. To be effective, volunteers need to be organized and giving specific tasks to achieve and a schedule to meet. It would be somewhat normal to have several different volunteer committees that tackle different issues. Such volunteer efforts need some level of funding to achieve their goals. It's also important that any volunteer efforts have oversight to make sure they are headed in the right direction.

   The recommendation is to identify and activate both government and volunteer resources and to develop a plan to use these staffing resources to tackle the various issues associated with broadband. The most successful efforts require that staffing be directed to solve specific tasks, given specific timelines to meet, and are properly funded to achieve the goals.

7. **Figure out Funding.** The primary funding mechanisms considered in this report included using municipal bonds and also to partially fund the network using contributions from customers. Both of those ideas will require additional effort.

   The study also suggests some more esoteric types of partial funding such as taking advantage of opportunity zone financing to pay for a portion of the network. We rarely see new community fiber networks funded from only one source. While this study only considered a few options, the cities should consider the wide range of possible funding sources to see what best works.

8. **Push the Incumbents to do Better**. All three incumbents could do better:
   - We recommend that the cities meet with Charter and put pressure on them to upgrade the network to get better performance. We suspect that Charter purchased a network with problems, but the company needs to upgrade the network to deliver adequate broadband everywhere in the cities.
   - WOW! seems to be delivering the speeds that they advertise in Farmington, but the cable network doesn't reach everybody. We recommend that the city encourage WOW! to expand its network.
   - AT&T has built some fiber-to-the-premise in the cities. It's worth prodding them to build more fiber, although since the company makes decisions at the national level this might be a hard sell.

9. **Investigate Regulatory Requirements.** The RFP didn't ask us to investigate regulatory issues. Michigan has a specific set of regulatory rules that apply only to municipalities that want to get into the telecom business. Some of these rules are embedded in Section 484.2252 of Michigan code[1]. Other rules were enacted by the *Metropolitan Extension Telecommunications Rights-of-Way Oversight (METRO) Authority. Act 48 of 2002*[2]. If the cities decide to move forward you should study these rules. The state proscribes specific steps a city must undertake in order build a network. Other cities have successfully navigated these rules and they can best be characterized as annoyances and not barriers that would stop the cities from offering broadband.

10. **Be Persistent**. Even if the cities pursue these recommendations, it won't be easy to find a single solution that will bring better broadband to everybody. We caution from experience that finding broadband solutions is going to take prolonged effort.

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[1] http://www.legislature.mi.gov/(S(izeaqeexvut0zlqzphjwpqhh))/mileg.aspx?page=getobject&objectName=mcl-484-2252

[2] http://www.legislature.mi.gov/documents/mcl/pdf/mcl-Act-48-of-2002.pdf

I. Market Analysis

A. Providers, Products, and Price Research

The two incumbent residential service providers in the cities AT&T and Charter. Farmington is also partially served by WOW!

Incumbent Telephone Company

AT&T. AT&T is the incumbent landline telephone provider in the cities. AT&T still sells traditional telephone service and legacy DSL broadband under the AT&T brand name. Customers with faster DSL or with fiber have been marketed under the AT&T U-verse brand. In March of 2020, the company rebranded everything as AT&T again and is killing the U-verse name.

AT&T has become a huge conglomerate. The company operates the largest cellular company in the country. They still own and operate a huge landline ISP / telephone company and at the end of the first quarter of 2020 had 15.3 million broadband customers. AT&T owns significant programming resources including Warner Entertainment, which produces movies, as well as cable networks like HBO, TNT, TBS, CNN, etc. The company owns DirecTV and at the end of the first quarter of 2020 had almost 18.6 million cable TV customers.

The company has been losing customers. Since the beginning of 2019, the company has lost a net of over 400,000 broadband customers. The company says the losses are from customers served with DSL and that during that same time frame the company has added nearly 1 million customers on fiber. The company has lost nearly three million cable customers since the beginning of 2019. This is due in part to the trend in the industry where all cable companies are losing customers. But most of the lost customer came when AT&T decided to stop offering special promotional prices to retain customers in both DirecTV and U-verse. The company says they are happy to be rid of customers that were not contributing to the bottom line of the business.

The majority of households in the city using AT&T are still served by telephone copper wires. However, in the speed test results we saw that there are some pockets of AT&T fiber in the cities. AT&T has adopted a philosophy of building fiber for a few blocks around places that they own existing fiber. This might be around existing AT&T customers like a school, large business, or a cellular site. AT&T doesn't make a splash about the fiber expansions – there is no local advertising for fiber and sales are done by mail or by knocking on doors.

The biggest news out of AT&T is that as of October 1, 2020 the company will no longer be installing new DSL customers. This means that customers looking for broadband in the cities will no longer have a DSL option and that broadband from the cable company will be the only option. We also assume that this means that anybody that has a break in AT&T service will not be reconnected. Over time the number of AT&T customers will diminish – until eventually AT&T will likely back out of any services using copper wires.

Stand-Alone Internet. AT&T has simplified their standalone Internet pricing. Over the years they have had a wide range of different speed offerings and prices.

DSL. There are still DSL customers with grandfathered rates and speeds from old plans.

DSL	Download Speed	Price	Introductory Price
Basic 5	5 Mbps	$ 50	$ 40
Internet 10	10 Mbps	$ 60	$ 50
Internet 25	25 Mbps	$ 60	$ 50
Internet 50	50 Mbps	$ 60	$ 50
Internet 75	75 Mbps	$ 60	$ 50
Internet 100	100 Mbps	$ 60	$ 50

Modems are leased at $10 per month. Customers cannot provide their own DSL modem and must use AT&T's.

Fiber Broadband. Following are the prices for AT&T broadband on fiber.

Fiber	Download Speed	Price	Introductory Price
Internet 100	100 Mbps	$ 60	$ 50
Internet 300	300 Mbps	$ 80	$ 70
Internet 1,000	1 Gbps	$100	$ 90

Modems are leased at $10 per month. Customers can provide their own modem.

Data Caps. AT&T Broadband products come with a data cap set at 1 terabyte (1,000 gigabytes). Overage charges are $10 for an additional 50 gigabytes of data. For $30 per month a customer can get unlimited data. The Internet 1,000 product has no data cap and provides unlimited data.

Cable TV Prices

For the last decade, AT&T has sold cable TV over DSL using the U-verse brand. Following are the most recent prices for U-verse TV:

	Channels	Price	Introductory Price
Basic	15 channels	$ 19	$ 19
Family	180 channels	$ 81	$ 35
Essential	360 channels	$102	$ 55
Preferred	470 channels	$119	$ 60
Ultimate	550 channels	$147	$110

A customer has to lease at least one settop box for a monthly rate of $10 per box.

The introductory prices are typically good for 12 months for new customers.

The company rebranded in March 2020 from U-verse to AT&T TV. This is a drastically different product. The settop box is gone and a customer instead gets a dongle or small box that connects to a TV, much like Roku or an Amazon Fire stick. There is an installation charge for the service that includes paying for the dongle, but apparently fee this is often waived. The channel line-ups are much smaller than with U-verse and are closer to what is offered on DirecTV.

Following are the charges for AT&T TV.[3]

	Channels	Price	Introductory Price
Entertainment	65 channels	$ 93	$ 50
Choice	90 channels	$110	$ 50
Xtra	120 channels	$124	$ 50
Ultimate	130 channels	$135	$ 50

AT&T also owns HBO and markets HBO NOW online for $14.99 per month. This is often given as a promotion for some number of months for customers that buy other AT&T products.

Incumbent Cable Company

Charter (Spectrum) Communications is the second largest cable TV company in the country with 27.2 million broadband customers and 16.1 million cable TV customers at the end of the first quarter of 2020. Charter had revenues of almost $46 billion in 2019. The company reached its current size after the 2016 acquisition of Time Warner Cable and Bright House Networks. The company has rebranded its triple-play products as "Spectrum." Charter is the incumbent cable provider in the cities, having purchased a network that was formerly operated by Bright House Networks.

Charter was founded in 1993 and got its start as a cable company in 1995 when it acquired Cable South. Paul Allen, one of the founders of Microsoft, bought a controlling interest in the company in 1998. The company continued to grow through acquisition, buying a dozen smaller cable systems over the next decade. The company went through a bankruptcy in 2009 and was able to walk away from $8 billion in debt, with the majority of the equity in the company going to Apollo Management. Charter announced in late 2017 that they were partnering with Comcast in some markets to be able to provide cellular phone products.

Charter says they have upgraded all of their systems nationwide to a new technical standard, DOCSIS 3.1. This technology from CableLabs allows bonding of an unlimited number of spare channel slots for broadband. This will allow the company to increase data speeds and market a gigabit data product. A gigabit data path requires roughly 24 channels on a cable network using the new DOCSIS protocol.

Along with the introduction of gigabit broadband the company announced across-the-board speed increases for upgraded markets. They announced that the speed of their base broadband produce will now be 200 Mbps. This is an increase from 100 Mbps. However, there are many markets where they are not able to deliver the new faster speeds, and in some markets the standard product being marketed is at 100 Mbps.

While Charter is a giant company, their pricing structure is one of the simplest in the country. The company is going through some major turmoil in that they are moving prices in the recently acquired Time

[3] https://www.att.com/channels/att-tv/

Warner markets to Charter prices, which in many cases are higher, especially since Time Warner was generous in handing out continuing specials and promotions.

Broadband Pricing

The company currently has only two broadband products. As mentioned above, the base product ranges in speeds in various markets between 60 Mbps and 200 Mbps. They also now have a gigabit product in some markets.

Broadband

Charter Basic Internet (Standalone)	
Regular Price	$69.99
Activation Fee	$49.99

Charter has raised rates twice within the last year. A year ago, the base broadband product was $64.99 / month.

Charter Internet (In a bundle)	
Regular Price	$59.99

Note that the basic Internet price above includes a $1 per month increase for 2019. The bundled rate was increased by $5 per month at the beginning of 2019—the biggest increase we can recall ever having seen for broadband.

Charter offers a WiFi router (optional) for a one-time activation fee of $9.99 plus $7.99 month.

There are no data caps on broadband monthly download. However, in June 2020 Charter asked the FCC for permission to begin using data caps. The company has been prohibited from using data caps as a condition for being allowed to purchase Time Warner Cable.

The company has set a target price for a gigabit at $124.95. But in the competitive markets where the company competes against fiber, like Oahu, HI and in North Carolina, the company is selling introductory 1 Gbps for $104.99.

Telephone Pricing

Residential telephone service is only available as part of a bundle and not as a standalone product. Depending upon the bundle, the voice product that comes with the most popular features adds $10 to $15 per month to the cost of a bundle. Charter does not advertise their business telephone rates.

Cable TV Pricing

While the company's broadband and landline prices are simple, their cable TV pricing is one of the most complicated in the industry and there are numerous bundling options. The basic cable rates are:

Basic Cable	$23.99
Expanded Basic	$52.99
Spectrum Select	$72.49 -- adds additional digital channels
Spectrum Silver	$92.49 – adds more channels and 1 movie channel
Spectrum Gold	$112.49 – adds the Movie Channel, Starz, and EPIX to the Spectrum Silver.

There are also numerous other ways to add digital tiers, foreign language programming, and premium channels.

There is a fee called a Broadcast TV charge of $16.45 per month – the most expensive in the industry. Earlier in 2020 this fee was $13.50, and a year earlier was $9.95.

For all plans there is a fee of $7.50 per settop box. A DVR-capable box is $11.99 per month, and DVR service ranges from $12.99 - $19.99 per month.

Charter also offer inside wire maintenance for $4.99 per month.

Wide Open West (WOW!). WOW! is a cable provider in parts of Farmington. WOW! was founded in November 1996 in Denver Colorado. The company has grown through acquisition with the two biggest acquisitions being Americast and Knology. WOW! Entered the local market when the purchased the cable assets of Broadstripe in 2011.

In March 2018, WOW! announced that they had deployed DOCSIS 3.1 technology in almost all of their footprint nationwide – making them the first larger cable company to do so.

Broadband Products

Wow! Offers three tiers or broadband service:

200 Mbps Internet	$49.95
500 Mbps Internet	$54.99
1 Gigabit Internet	$79.99
Modem	$10.00
WiFi	$ 9.99

Telephone

WOW! will add telephone service to a package for $9.99 per month. This product includes 100 minutes of free long distance.

Cable TV

Starting in March 2020 the company is offering streaming video instead of traditional cable TV to new customers. Industry analysts believe that the company will back out of the traditional TV business at some point within the next few years. For now, WOW! offers customers a choice of YouTube TV, Philo, Sling TV, or fuboTV.

Other Providers

Dish Network is a large satellite provider and has customers in the cities. The company had around 9.5 million cable customers nationwide at the end of the third quarter of 2019. Dish Network now also offers an Internet-based cable product branded as Sling TV. This service offers an abbreviated channel line-up and costs less than traditional cable products.

Dish Network has the same pricing nationwide. The standalone price with no discounts is as follows:

190 Channels	$ 79.95
190 Channels +	$ 84.99
240 Channels +	$ 94.99
290 Channels +	$104.99

DirecTV is one of the largest cable providers in the US. The company is now owned by AT&T. The company had 16.8 million cable customers at the end of 2019, down almost 2.4 million customers during 2019. AT&T has decided to end all discount packages, resulting in significant rate increases for many customers who were getting various promotional discounts.

DirecTV now offers an online version of its programming that was called DirecTV Now but which was recently renamed as AT&T TV.

Current prices after the end of any promotional discounts are:

155 Channels - Select	$ 85.00
160 Channels - Entertainment	$ 97.00
185 Channels - Choice	$115.00
235 Channels – Xtra	$131.00
250 Channels - Ultimate	$142.00
330 Channels - Premier	$197.00

The above rates include increases effective January 2020 that ranged from $4 to $8 per month.

Cellular Data

There are four primary cellular companies in the country—AT&T, Verizon, T-Mobile, and Sprint. As this paper was being written, the courts approved the final challenge to a merger between T-Mobile and Sprint. Part of the merger conditions was that Sprint would provide spectrum that would allow Dish Networks to become the fourth cellular nationwide carrier.

The residential surveys showed that some households in the cities use their cellphone data plans for household broadband. Following are the nationwide average 4G data speeds for the four carriers, shown for 2017 and 2019. Speeds are improving over time. However, these are nationwide averages and speeds vary by market. Speeds also vary locally and get weaker with the distance a customer lives from a cellular tower.

	2017	2019
AT&T	12.9 Mbps	17.8 Mbps
Sprint	9.8 Mbps	13.9 Mbps
T-Mobile	17.5 Mbps	21.1 Mbps
Verizon	14.9 Mbps	20.9 Mbps

All four carriers now offer “unlimited” data plans. The plans for AT&T, Sprint, and Verizon are not actually unlimited and have monthly data caps in the range of 20 - 25 gigabytes per month of downloaded data. These plans might provide some relief to homes that rely on cellular broadband, although there have been reports of Verizon disconnecting customers who use too much data on these plans. These plans allow have limits on how much data can be used when tethering from a cell phone for use in other devices, so the plans are not much more useful for home broadband than normal cellular plans. T-Mobile claims to offer unlimited data but begins throttling customers after 50 GB of data usage in a month.

There are two different cellular data standards in use: 3G and 4G. 3G data speeds are capped by the technology at 3.1 Mbps download and 0.5 Mbps upload. The amount of usage on 3G networks is still significant. GSMA reported that at the end of 2018 that as many as 17% of all US cellular customers still made 3G connections, which accounted for as much as 19% of all cellular connections. Opensignal measures actual speed performance for millions of cellular connections and reported the following statistics for the average 3G and 4G download speeds as of July 2019:

	4G 2019	3G 2019
AT&T	22.5 Mbps	3.3 Mbps
Sprint	19.2 Mbps	1.3 Mbps
T-Mobile	23.6 Mbps	4.2 Mbps
Verizon	22.9 Mbps	0.9 Mbps

B. Residential Survey

CCG conducted a statistically valid survey that covered both cities. The survey was conducted by telephone. The city wanted this survey to represent households across the socioeconomic and age range, and the easiest way to get that broad mix is to include cell phones in the survey. Some of the largest survey companies that undertake nationwide surveys have reported that households with landlines tend to be older and more conservative than the average household in a community. It’s become obvious that giving surveys only to landline households will skew the results.

CCG Consulting was able to buy a list of telephone numbers that covered both cities. A statistically valid survey must be conducted randomly, meaning that the calling shouldn’t be clustered around any one particular portion of the study universe. For example, the survey would not be considered to be valid if all of the calls were placed only to one portion of a town. Our method of using the list of numbers was to call every tenth phone number on the list after each completed call. We cycled through the calling list until we got the desired number of completed surveys.

We did not try to direct calls to each city and assumed we would get a reasonable split between the two cities by using the total combined telephone list. The RFP said there are 33,559 households in Farmington

Hill (87%) and 4,959 households in Farmington (13%). Our final calling resulted in 84% of the calls made to Farmington Hills and 16% to Farmington. We find that result to be reasonably representative of each community.

Most business and political surveys strive to achieve an accuracy of about 95% with results that are plus or minus 5%. In layman's terms, this means that the results of such a survey are reliably accurate (the 95% number) and you would expect to get the same results (within 5%) if you could ask the same questions to everybody in the cities.

CCG uses an online survey tool to determine the number of surveys needed to achieve the desired accuracy. The tool is provided by Creative Research Systems and is found online at https://www.surveysystem.com/sscalc.htm. We've used this tool for many years and have manually done the mathematical calculations that demonstrate that the tool is accurate. This tool told us that we needed 380 completed surveys for the two cities combined to achieve the desired accuracy of 95%, plus or minus 5%.

In the US we know that many people distrust the results of surveys, mostly due to results obtained for political surveys. This speaks to the issue of bias. When callers are asked about sensitive or private topics like politics, religion, or anything else personal or controversial it's well-known that many respondents don't answer questions honestly to a stranger like a survey taker. The best example of this is when surveyors ask people for their household income. Survey companies say that as many as half of residential homeowners will not give an accurate response to the salary question.

However, experience shows that there is high reliability with surveys that look at non-emotional topics, such as this survey talking about a routine product purchased by most households. We have practical evidence that they broadband surveys are good market predictors because CCG has been administering these surveys for 20 years and we've had many opportunities to see the broadband penetration rates in communities to compare to the predictions made by our surveys. Surveys are never 100% accurate because sometimes an ISP does something to change the public perception. For example, an ISP that has problems during a network launch might underperform the penetration rate predicted by a survey. In general, we've learned to have faith in the predictions made by these broadband surveys.

Survey Results

The survey produced some interesting results. A full copy of the survey questions and the responses are included in Exhibit I of this report. Here are highlights of the survey results:

<u>The Survey Respondents</u>

We ask each respondent if they lived in Farmington or Farmington Hills and ended any calls to people that didn't reside in the cities.

<u>Broadband Customers</u>

85% of survey respondents have some form of landline broadband. 50% of respondents use Charter, 33% use AT&T, and 2% use WOW. The FCC reports that almost 86% of homes nationwide now have a broadband connection. However, the FCC nationwide numbers are skewed because there are roughly 14 million rural homes in the country that have no option to buy broadband. If the FCC nationwide statistics are adjusted for those homes, then the nationwide average broadband penetration everywhere except those rural areas is 90%. This means the overall broadband penetration rate in the cities is lower than the national average for urban areas.

CCG Consulting has been tracking the nationwide telecom markets for years and we know that customers nationwide are abandoning telco DSL in favor of the faster cable modem broadband. In 2019 the largest cable companies collectively gained over 3.1 million new customers for the year while the largest telcos collectively lost over 600,000 customers. We were a bit surprised to see that Charter and WOW! together have a 52% broadband market share – in most cities the cable company has a higher market penetration.

Another 5.5% of the respondents said their only source of broadband is cellular. Nobody claimed to be using satellite broadband. Only 9.5% of the respondents have no broadband access.

Cable TV Penetration

In another interesting result, 86% of survey respondents report the purchase of traditional cable TV. That is significantly higher than the nationwide average, which dipped below 65% by the end of 2019. The market share for cable customers is: 52% use Charter, 28% use AT&T, 2% use WOW, and 4% use satellite.

We also note that the number of households using satellite TV is smaller than what we normally see. In many cities the satellite penetration of cable TV is often as high as 10% of homes. The survey didn't ask customers why they chose their current provider.

We speculate that the high level of cable penetration is due to bundling. In many other US markets, the telephone incumbent doesn't offer cable TV, and so anybody using DSL typically doesn't buy cable TV unless they buy it from satellite providers. But AT&T and Charter both offer cable TV, and both companies push customers to buy bundles of products.

11% of survey respondents claim to be cord-cutters that watch all content online or else use an over-the-air antenna. There are not yet any reliable estimates of the national market share of cord-cutters, but most estimates put it somewhere between 15% and 20% of households. The percentage of cord-cutters is growing rapidly, so it is expected for the homes with traditional cable in the town to drop over time. 3% of homes in the cities claimed to watch no TV.

Telephone Penetration

78% of homes still claim to have a landline telephone. The nationwide landline penetration has dropped below 40%.

This is the one statistic from the survey that we can't fully trust. We have no way of knowing the mix of homes using landline and cellular numbers in the list of numbers we purchased. However, the high percentage is not unprecedented, and CCG has done surveys in a few cities recently that had an even higher penetration of landline subscribers. We've also surveyed communities with low landline penetration rates. This seems to be a regional issue with cities all over the board in terms of keeping landlines.

This also is a good indication of bundling by the incumbents. AT&T in particular pushes buying a landline as part of a U-verse DSL package. They often advertise in a way to make it seem like the voice line is inexpensive. Both companies will sell a standalone broadband line, but there were years in the past where both AT&T and Charter forced a bundle and people had to buy voice and/or cable TV to get good broadband – in the past, it was hard to buy the higher broadband speeds without buying a bundle.

Customer Bills

The survey asked customers what they pay each month for the triple-play services. The most significant part of this response is that 298 households or 78% of those in the survey said they purchased a bundle of services. That is probably part of the reason why the survey shows such a high percentage of landline telephones – landlines are included in many bundles.

We've found that this question of how much people pay must be taken with a grain of salt because what people say they pay is often quite different than what they pay. For example, a household might report a special price deal they were promised without realizing that their actual bill is much higher due to extra fees and charges. It's especially easy these days for customers that pay automatically with credit cards or bank debits and to not know the amount they pay.

54% of those with bundles told us they are paying between $150 and $200 per month. Another 10% of homes pay even more than that with 1% of the market paying more than $300 per month.

We do surveys in a lot of cities and the prices paid and the distribution of prices look pretty typical.

Uses of Broadband

39% of respondents say that somebody in their homes uses the Internet to work from home. That is made up of those that work at home fulltime (7%), those that work several days per week (11%), and those that work from home occasionally (21%). We note that the survey was conducted just as the pandemic was starting and we would expect a higher percentage of people to be working at home today.

32% of respondents report having school-age children at home.

Satisfaction with Existing Broadband

42% of respondents say they are unsatisfied with their Internet speeds at home. That's one of the highest percentages we have seen in an urban market. The reasons that customers cited for being unhappy with Internet speeds are as follows:

- Slower speeds than expected
- Unreliable connections (meaning outages)
- Inconsistent performance (meaning speeds vary over time)

- Poor streaming. That either means slow speeds, high latency, or major network congestion at the ISP. We also got complaints of the Internet freezing, but that typically refers to a video stream that pauses.
- Problems playing games. This is often due to poor upload speeds.
- Problems using multiple devices at the same time. This is usually a symptom of not receiving enough speed to satisfy the household.

Support for a Fiber Network

We asked respondents what factors would lead them to move their service to a new fiber network.

- 48% said that they would consider moving for faster speeds at the same price they pay today. That aligns with an earlier answer on the survey that indicated that 42% of households are unhappy with their current broadband speeds.
- 78% said they would consider moving to a fiber network due to lower prices.
- Only 24% said that better customer service would lure them to a new network.
- 29% said they would consider moving to a fiber network if they got more reliable service.
- Only 6% said they would consider moving to a fiber network if it meant avoiding data caps. That's an interesting response because AT&T has data caps on DSL service, but Charter does not use data caps. With AT&T data caps customers pay $10 for every 10 gigabytes of monthly data usage – with a cap of $100 extra. Customers can instead pay $30 extra for unlimited usage. The data caps on DSL faster than 12 Mbps is 600 gigabytes per month. We postulate that the customers that want to avoid data cap charges are likely paying the extra fees today.

Preferred Business Model

The survey asked respondents about the preferred business model for a new fiber network.

- 46% preferred the cities to own and operate the network.
- 27% wanted the cities to own the network and operate it as open access to allow multiple ISPs to serve the community.
- 6% wanted the city to partner with a commercial ISP.
- 6% wanted a private ISP to own and operate the network.
- 15% had no preference.

This is an interesting response for cities that have not expressed any open desire to be an ISP. For 46% of the community to prefer the cities as the ISP demonstrates a lot of public trust in city government. The second biggest preferred model of open access would also have the cities owning the fiber network.

We typically see a much higher preference for partnerships of for having a new ISP build a network in a city. We've always found that fear of having to pay higher taxes has often pushed down the preference for municipal ownership.

Interpreting the Results of the Survey

It's always a challenge to interpret survey results. Proponents of fiber will see plenty of support in the survey responses, but opponents of fiber can probably say the same thing. We interpret the survey to mean the following:

High Cable TV and Telephone Penetration. The cities combined have an 86% penetration of cable TV. We've recently seen a few other cities that high, so the result is believable – but it's significantly higher than the 65% nationwide penetration of cable TV. The two cities combined have a 78% penetration of landlines. Due to nature of buying a list of phone numbers to conduct the survey we can't be certain that is number is correct.

We think that both of these results are likely due to the high percentage of respondents that say they buy a bundle of services (78%). This has also been the reason we've seen in other cities that have high cable TV and landline market penetration. Both AT&T and Charter push customers to buy bundles of service and also price bundles to entice customers to trade-up. There were times in the past when both companies made it hard or impossible for residents to buy a standalone broadband connection.

Dissatisfaction with Broadband Speeds. The dissatisfaction with broadband speeds at 43% is higher than what we normally see in cities. Since urban customers have the option to buy broadband from a cable company, we more normally see dissatisfaction in the 20% range. We understood this response more once we saw the results of the speed tests, which showed a lot of relatively slow speeds on the Charter network.

Business Model Preference. Residents in both cities showed a strong preference for the cities to own the fiber network. We're rarely seen a preference this high, and in most cities a much larger percentage of residents want an outside ISP to invest in the city. We interpret the preference to mean that citizens trust the cities.

Working from Home. 39% of homes say that somebody works in the home at least part time. This response was higher than what we've historically seen and is no doubt influenced by part of the survey being administered in March 2020 during the pandemic. We would not be surprised if the percentage of working at home is even higher today.

Reasons for Considering a New Network. The two predominant reasons that respondents would consider changing to a new fiber network are faster speeds and lower prices. Since the percentage of homes that favor lower prices was high, at 78%, we interpret this to mean that price is a major factor in the city when choosing a broadband solution. For example, price is probably a factor for the larger than average percentage of homes that are choosing AT&T DSL over cable broadband, since AT&T has lower prices generally than Charter. We've typically been seeing a lower percentage of homes still using DSL for broadband.

Online Residential Survey

At the end of the telephone survey the cities posted the same survey online, and we got an additional 48 responses.

Online surveys about broadband tend to gather responses from people with a high interest in broadband. This is due to a phenomenon called self-selection, where people not interested in the topic covered by an online survey tend to not bother to take the survey. That was the case in this survey and 100% of the respondents have home broadband (as opposed to 85% of the larger random survey). The online survey also differed for cable TV penetration, with 56% of respondents buying cable TV, compared to 86% of those in the random survey. Only 29% of the respondents to the online survey have a landline telephone.

61% of those in the online survey are unsatisfied with their home broadband speeds. This compared to 42% for the larger random survey.

Somebody works from home in 87% of those responding to the online survey, compared to 39% for the larger survey. 53% of the online respondents have school-age children at home compared to 32% for the larger survey.

One of the more interesting comparisons between the online versus random survey respondents asked why they would consider changing to another provider.

Would change providers for:	Online Survey	Random Survey
Faster Speeds	80%	48%
Lower Prices	60%	78%
Better Service	50%	24%
More Reliable Service	65%	29%
No Data Caps	63%	6%

Below is a comparison between the two surveys asking the preferred broadband solution:

Operating Preference :	Online Survey	Random Survey
City is the ISP	17%	46%
ISP Partners with City	13%	6%
Open Access	28%	27%
Private ISP builds network	15%	6%
No preference	27%	15%

While the online group still preferred that the city owns the network, the response this was still far lower than the random survey.

There is always value in obtaining additional responses to a survey. You can’t add together responses from a random and a non-random survey since this would invalidate the statistical reliability of the random survey. However, in this case, the respondents of the online survey look to be best classified as ‘power users’ compared to the average household in the cities. They care a lot more about speeds and reliability than average and care less about price. The online survey respondents are also much more concerned about data caps, meaning many of them probably use a lot of broadband in a month. The online group has cut the cord and dropped landlines to a much larger extent. The results of the online survey give the cities a glimpse of how some of the more active and largest residential data customers feel about broadband in the city.

C. Other Market Research

Interviews and Business Questionnaires

CCG reached out too businesses in two ways. The cities posted a business questionnaire on their web site that asked businesses to tell us about their broadband. The cities also asked us to call and interview key stakeholders in the community to learn about broadband issues in more detail.

Here are a few of the things we learned from the questionnaires and interviews:

- The schools have world-class broadband provided on fiber. The Internet connection is provided jointly through a collaboration between Managed Way and Merit Networks. Each school district receives a 10-gigabit connection that is then subdivided to schools based upon need.
- Like school systems everywhere, the school systems struggled during the pandemic with connecting to students who either had no home computer or that had no home broadband connection.
- The interviews were conducted during the COVID-19 pandemic and we received comments that lack of home broadband was hurting a lot of citizens during the pandemic. The public sources of broadband like the library and Starbucks had shut down and people didn't have a source of broadband outside the home.
- Several employees of the cities told us that speeds are adequate, but that there functions they are unable to perform due to lack of bandwidth, such as send emails with large attachments or videos. Each city employee we interviewed said that their department has a wish lists of functions they could do with faster broadband.
- Interestingly, no business in the city said their broadband was great, but all described it as adequate. Almost every business said that faster broadband would improve their business.
- We heard some anecdotes about the ISPs in the market. Several businesses said they switched to AT&T because they had problems in the past with repeated outages from Bright House Networks (the local cable company before being purchased by Charter in 2015). The general opinion of AT&T (which is delivering broadband over DSL) was that the connections were steady with only a few minor outages in the last few years. However, speeds were universally described as "okay," with a comment from every AT&T customer that they would like faster broadband. Businesses still using Charter did not tell us about any major outages, so those issues have probably been corrected since the Charter takeover. However, Charter customers told us that they have numerous short outages, ranging from a few minutes to half an hour.
- One interviewee told us that AT&T had unilaterally doubled their download speed delivered to the business during the pandemic.

Speed Tests

CCG created an online speed test that was published on the website by each city. The primary purpose of the speed test was to see if residents and businesses were getting the broadband speeds they subscribed to.

The overall purpose of the speed tests is to judge the overall quality of broadband in the market. For example, CCG has conducted similar speed tests in markets where the incumbent cable company delivered faster speeds than advertised and other markets where the speeds are slower. The speed tests were to make a qualitative judgement about the networks of the cable and telephone companies operating in the cities.

Speed tests are not 100% reliable and don't always deliver a true picture of the broadband being delivered to a given address. However, we've found that when multiple speed tests are taken that we can understand the overall quality of broadband in a community. Following are a few of the criticisms that can be made about speed tests:

- A speed test only measures the speed of a ping and a short-term connection of less than a minute between a user and the test site router used by the speed test. That doesn't necessarily indicate the speed of every activity on the web such as downloading files, making a VoIP phone call, or streaming Netflix.
- Every speed test on the market uses a different algorithm to measure speed. In the cities we used the speed test from Ookla, which is one of the most popular speed tests. Ookla's algorithm discards the fastest 10% and the slowest 30% of the results obtained. In doing so, the speed test might be masking exactly what drove someone to take the speed test, such as not being able to hold a connection to a VoIP call. Ookla also multithreads, meaning that they open multiple paths between a user and the test site and then average the results together.
- A speed test can report slow speeds due to network issues within the home such as problems with a home WiFi router or faulty wires inside a home. A slow speed test doesn't always mean that the ISP has a slow connection.
- Internet speeds vary throughout the day, and anybody that takes multiple speed tests in the same day will see this. Taking only one speed test might not tell the real story about a given customer.
- Some ISPs use something called "burst" technology. This provides a fast Internet connection for one or two minutes. ISPs know that a large majority of Internet activities are of a short duration – things like opening a web page, downloading a file, reading an email, or taking a speed test. The burst technology increases the priority of a customer during the burst time window and the Internet connection then slows down when the temporary burst is over. This raises an interesting question – what's the real Internet speed of a customer that gets 100 Mbps during a 2-minute burst and something slower after the burst – there is no consensus in the industry.

121 residents took the online speed test. With the above caveats in mind, following are the results from the speed tests taken for this study:

AT&T

AT&T mostly serves the community with DSL over telephone copper wireless. However, the speed tests also show that AT&T has built at least some fiber in Farmington Hills. There were nine customers who took the speed test that are clearly being served by AT&T Fiber. This is not unusual and almost every city served by AT&T has some pockets of fiber. The company has an interesting business plan and over the last five years has built fiber to pass nearly 15 million homes and businesses. AT&T has done this by expanding fiber around locations where they already have a fiber presence. This could mean places that are near to a cellular tower, a school, a large business customer, or some other place where AT&T has an accessible fiber connection. The company has been building for a few blocks around these fiber nodes, and there might only be a few dozen homes or businesses being offered fiber in these small neighborhood clusters. AT&T doesn't advertise the presence of fiber but instead knocks on doors and markets directly and only to the homes that can get a fiber connection.

We received 38 speed tests from AT&T customers, which included 9 customers served by fiber and the rest served by DSL.

The speeds on DSL were pretty typical for what we see in other markets, as follows:

DSL Download Speed	
0 – 10 Mbps	2
11 – 20 Mbps	10
21 – 30 Mbps	10
31- 40 Mbps	4
41 – 50 Mbps	1

DSL Upload Speed	
0 – 10 Mbps	20
11 – 20 Mbps	7

The speeds on fiber were much faster. There were three customers subscribed to a 100 Mbps connection on fiber who were getting an average of 80 Mbps download. There were two customers subscribed to 200 Mbps on fiber who were getting an average of 144 Mbps download. There were four customers subscribed to gigabit fiber that were getting an average download speed of 594 Mbps. The fastest speed measured was 777 Mbps.

The upload speeds for AT&T fiber are also faster than on DSL. The average upload speed for the 100 Mbps customers was 17 Mbps, for the 200 Mbps customers the average upload speed was 67 Mbps, and for the gigabit customers the average upload speed was 498 Mbps.

The latency for DSL customers was 39 milliseconds. The best DSL connection had a latency of 22 milliseconds and the worst a latency of 94 milliseconds. The average latency for fiber customers was 9 milliseconds. As a reference, the standard definition of latency is that it's a measure of the time it takes for a data packet to travel from its point of origin to the point of destination. Broadband connections with latency under 100 milliseconds are generally considered as adequate for most home applications.

There are a lot of underlying causes for delays that increase latency – the following are primary kinds of delays:

- Transmission Delay. This is the time required to push packets out the door at the originating end of a transmission. This is mostly a function of the kind of router and software used at the originating server. This can also be influenced by packet length, and it generally takes longer to create long packets than it does to create multiple short ones. These delays are caused by the originator of an Internet transmission.
- Processing Delay. This is the time required to process a packet header, check for bit-level errors and to figure out where the packet is to be sent. These delays are caused by the ISP of the originating party. There are additional processing delays along the way every time a transmission has to "hop" between ISPs or networks.
- Propagation Delay. This is the delay due to the distance covered by a given transmission. It takes a lot longer for a signal to travel from Tokyo to Baltimore than it takes to travel from Washington DC to Baltimore. This is why speed tests are usually created to find a nearby router to ping so that

they can eliminate latency due to distance. These delays are mostly a function of physics and the speed at which signals can be carried through cables.

- Queueing Delay. This measures the amount of time that a packet waits at the terminating end to be processed. This is a function of both the terminating ISP and also of the customer's computer and software.

Total latency is the combination of all of these delays. You can see by looking at these causes that poor latency can be introduced at multiple points along an Internet transmission, from beginning to end.

The technology of the last mile is generally the largest factor influencing latency. A few years ago the FCC did a study of the various last mile technologies and measured the following ranges of performance of last-mile latency, measured in milliseconds: fiber (10-20 ms), coaxial cable (15-40 ms), and DSL (30-65 ms). These are measures of latency between a home and the first node in the ISP network. It is these latency differences that cause people to prefer fiber. The experience on a 50 Mbps fiber connection "feels" faster than the same speed on a DSL or cable network connection due to the reduced latency.

Latency is why cellular wireless connections seem slow. Cellular latencies vary widely depending upon the exact generation of equipment at any given cell site. But 4G latency can be as high as 100 ms. In the same FCC test that produced the latencies shown above, satellite broadband was almost off the chart with average latencies of 650 ms.

A lot of complaints about Internet performance are actually due to latency issues. It's something that's hard to diagnose since latency issues can appear and reappear as Internet traffic between two points uses different routing. But the one thing that is clear is that the lower the latency the better.

Charter

There was a wide range of speeds reported on the Charter network – more of a range that we typically see from cable broadband networks. 78 Charter customers took the speed tests, with the results summarized as follows:

Charter Download Speed	
0 – 10 Mbps	7
11 – 20 Mbps	7
21 – 30 Mbps	7
31- 40 Mbps	8
41 – 50 Mbps	4
51 – 75 Mbps	9
76 – 100 Mbps	5
101 – 150 Mbps	9
151 – 200 Mbps	11
201 – 300 Mbps	7
301 – 400 Mbps	3
400 Mbps +	1

We have been doing similar feasibility studies for years and we have never seen this kind of range of speeds from a cable company network.

Charter claims that they have upgraded to DOCSIS 3.1 technology in all of their markets, and they have done so in the cities. The fastest speeds possible on a DCSIS 3.0 network was about 250 Mbps. Also, before Charter made the upgrade, many markets had the bulk of customers subscribed at 60 Mbps.

I live in Asheville, North Carolina that is also served by Charter. I was subscribed to their basic Internet product of 60 Mbps download. About two years ago, Charter unilaterally upgraded everybody here with 60 Mbps service to 135 Mbps. Around the country, other networks were unilaterally increased to speeds between 100 Mbps and 200 Mbps. I’ve always assumed that the difference in speeds between cities is due to the quality and condition of the local coaxial cable. Just as Charter purchased the network in the cities from Bright House Networks, Charter has purchased networks across the country from other cable companies. Some of these networks were built to higher standards than others.

I was surprised when I saw the speed test results for Charter. I’ve not seen customers served by a cable company network experiencing speeds under 50 Mbps for several years, and definitely didn’t expect to see so many customers with speeds under 10 Mbps and 20 Mbps. The speed test results make it easier to understand why there are still a significant number of residences in the market still using AT&T.

There are two possible explanations for the slow speeds on the Charter network. It’s possible that customers were grandfathered with old and slow products sold by Bright House Networks, and which Charter has never forced customers to upgrade. For example, if a customer has a 20 Mbps product from Bright House many years ago, Charter may still be selling them the same product. In our experience this is unlikely, but it is possible.

The other possibility is that there are big problems in the physical network. Some parts of the Charter network seem to be in decent shape. For example, there are several customers subscribed to Charter’s 400 Mbps product that have speed test results just under 400 Mbps. But there are also customers paying for the 400 Mbps product who are getting half the subscribed speed.

It's easy to assume that the Charter network is roughly in the same throughout the city, but that might not be true. There could be neighborhoods with old coaxial cable and others that were built later or upgraded at some time in the past. There could be neighborhoods with high quality coaxial cable and others with problems.

Seeing the wide range of results from the speed tests indicates to us that it’s probably the combination of both factors. There are likely customers in the market that are still subscribed to slower bandwidth products (but which might still be paying prices close to those with faster products). There is also a high likelihood that the quality of the Charter network varies for various reasons. The city could probably figure this out if you were to gather more speed test by address. We’ve worked with other cities that have done this and in doing so they found neighborhoods that had much slower speeds (and also a lot higher discontent with broadband).

Following are the results of the upload speeds from Charter customers:

Charter Upload Speed	
0 – 10 Mbps	26
11 – 20 Mbps	42
20+ Mbps	10

These speeds are fairly typical for cable company networks. Even in markets where download speeds are at 200 Mbps the cable companies have assigned relatively small amounts of bandwidth to the upload path.

The average latency on the Charter network was just under 25 milliseconds. There were only 2 customers with latency higher than 40 milliseconds and 3 between 30 – 40 milliseconds.

WOW!

We only got three speed test results for WOW! A customer who says they subscribe to a 100 Mbps product got 105 Mbps on the speed test. A customer that subscribed to 200 Mbps got 168 Mbps on the speed test. A customer subscribing to 500 Mbps got 414 Mbps on the speed test. The average upload speed was 15 Mbps. The average latency was 20 Mbps.

Customer Bill Analysis

The cities helped us to collect a sample of residential customer bills in the market. Those bills helped us to verify a few things that we in markets across the country:

Hidden Fees. We saw fees on bills that the industry refers to as hidden fees. The fees are called hidden because the companies never mention these fees in their advertising. The big ISPs generally advertise basic prices and customers are routinely surprised by their first bill that is larger than what they thought they would be paying.

Following are the hidden fees seen on the monthly bills of various large ISPs. In addition to the broadcast TV fee and the regional sports fees the report lists the following other fees:

- Broadcast TV Fee. This is a fee that supposedly covers the costs for buying local broadcast rights from networks like ABC, CBS, FOX, and NBC. Up until a decade ago, local networks did not charge cable companies to rebroadcast their signals and were happy with the advertising revenues earned from having many people watch their content. After a few local networks in major markets started charging for “retransmission” of signals, the concept spread throughout the industry and local network affiliates all charge these fees. The fees now range from $3.50 to $4.50 per local station in most markets, with the fees climbing every year. A few years ago, several of the big cable companies moved these fees to a separate Broadcast TV Fee. The companies are not prohibited from doing so, but the companies deceive the public when they don’t fully disclose the fees in advertising.
- Regional Sports Fee. This is similar to the Broadcast TV fee and covers the cost of sports networks that carry regional baseball, hockey, and basketball.

- Settop Box Rental Fee. This is to recover the cost of the settop box hardware. Traditionally in the industry, this fee was around $5 for most cable providers, but this is an area that has also seen big price increases in recent years there are markets where these fees are as high as $12 per month.
- Cable Modem / WiFi Router Fee. This fee recovers the cost of the modem that terminates the broadband connection, and today that usually includes a WiFi router. This fee has the biggest variance in the industry and some ISPs don't charge for this and some charge as much as $10 per month.
- HD Technology Fee. This fee used to be charged by almost every cable company back when they started offering HD channels (fifteen years ago many channels were offered in both an HD and an analog format). Now that the whole industry has largely gone to digital programming, the only big ISP we have found that is still charging this is Comcast.
- Internet Service Fees. This is a relatively new fee that gets billed to anybody buying Internet Access. There is no regulatory or other basis for this fee – it just moves some of the price of a product into a separate fee. We've seen this fee charged by AT&T, RCN, and Frontier.
- Administrative and Other Fees. These are often fees under various names that don't cover any specific costs. However, some fees are specific –business customers using AT&T in California are being charged a $7 fee to recover property taxes.

Charter has some significant hidden fees. The company recently raised the Broadcast TV Fee to $16.45 per month, the highest such rate in the country (Comcast is the second highest at $14.50). Charter raised that fee from $13.50 earlier in 2020 and from $9.95 in 2019. Charter also charges for settop boxes but does not charge a regional sports fee.

It's easy to demonstrate how these fees affect customers. Charter's base TV plan is called TV Select, which Charter advertises on the web for $49.99 per month. A customer buying this plan will get a first bill as follows:

$49.99 - 12-month Promotional Price
$16.45 - Broadcast TV charge
$ 6.99 - Settop box
$73.43 - 12-month promotion total price

After 12 months the base price for Select TV goes from $49.99 to $73.99, a $24 increase – and the full monthly fee jumps to $97.43 after the end of the one-year promotion. The bottom line is that Charter advertises $49.99, charges $73.43 during the first year, and $97.43 after the end of the promotion period.

Consumer Reports collected a number of sample bills in 2019 from customers across the country and reported that the average monthly hidden fees averaged to $22.96 for AT&T U-verse, $31.28 for Charter, $39.59 for Comcast, $40.16 for Cox, and $43.79 for Verizon FiOS. The magazine estimated that these fees could total to at least $28 billion per year nationwide. (this article was before Charter raised the Broadcast TV Fee by $2.95 per month).

To be fair to the cable providers, these fees are not all profits. The companies pay out substantial retransmission fees for local content and pay a lot for sports programming. However, some of the fees like settop box and modem rentals are highly profitable, generating revenues far above the cost of the hardware. Some off the fees like administrative fees are 100% margin for the companies. The primary reason that the big cable companies seem to have the hidden fees is in order to be able to advertise low cable TV rates to lure new subscribers. But when the hidden fees are considered the cable rates are high.

Special Rates. We also saw fees on customer bills from the cities that had rates that are different than list prices. There are several reasons why prices might be different than list prices:

- Advertised Rates. The example above showed Charter's Select TV being advertised at $49.99, with the rate then increasing by $24 after a year.
- Negotiated Rates. Negotiated rates are ones that a customer will negotiate over the telephone. This often happens when a customer calls to drop service, when ISPs offer then lower rates to remain as customers. These rates also always have a time limit are often good for one or two years.
- Grandfathered Rates. Grandfathered rates referred to rates that were in place in the past. Some grandfathered rates come about when ISPs increase speeds and increase rates. There are customers in the market that negotiated years ago to stay with slower and cheaper products, and you might find a few Charter customers still buying speeds like 15 Mbps, 30 Mbps, or 60 Mbps. ISPs. ISPs sometimes allow customers to stay with grandfathered plans for years, because they know these customers are unlikely to leave them.

  Grandfathered rates are even more common when a cable company buys another one. Charter purchased the local cable franchise from Bright House Networks in 2015. We saw a few bills with broadband products and prices that are not typical for Charter and we have to suspect that these are holdover grandfathered rates from Bright House.

It turns out that AT&T and Charter are the two most aggressive ISPs in terms of moving customers off of grandfathered and negotiated rates. AT&T lost nearly 3 million cable customers over the last two years when the stopped honoring grandfathered rates from DirecTV, which AT&T had purchased. The AT&T CEO said they were not unhappy to be losing customers that were not contributing a fair share toward margins.

Over the last year there are reports from around the country of Charter forcing customers they acquired from Time Warner Cable to higher rates. It would not be surprising to see them do the same at some point with grandfathered products from Bight House Networks.

Bundling Discounts. Big ISPs that offer multiple products often offer bundle discounts to customers who buy more than one product. In the residential survey we saw that 78% of the residents were buying a bundled product. This is higher than average, and we see about 70% of homes buying bundles across the country.

Bundled discounts are interesting in that customers get a discount for buying multiple products, but they are never told which product or products got discounted. This is a key feature of bundling because the big ISPs think that bundles make it hard for customers to leave them. For example, if a customer gets a $25 discount for buying a combined cable TV and Internet bundle, they will find that they lose the entire discount of they try to disconnect either product. Many customers change their mind about dropping products or changing providers when they come to understand the impact of bundled prices.

D. Broadband GAP Analysis

A broadband gap is a situation where there some customers with an advantage compared to others in relationship to using the Internet. This report will look at the wide array of different broadband gaps.

The Gap in Broadband Speeds

Duopoly Competition

Any discussion of a broadband gap in any urban area in the country has to begin with a discussion of duopoly competition. Duopoly competition is a market of any kind when two primary competitors compete in a market. In broadband, markets that are divided between a telephone company incumbent and a cable company meets the classic definition of a duopoly.

A duopoly market often shares a lot of the same characteristics of a monopoly market. In a duopoly market the two competitors usually don’t compete on price, with the result being high prices from both competitors and good margins for both companies. Duopoly providers also generally don’t concentrate on customer service since customers only have two choices.

If you look backwards to around 2000, there was true duopoly competition in urban areas. At that time, the capability of telephone company DSL and cable modem service from cable companies was similar in capability, and it was hard at the customer end to distinguish one service from the other. The two competitors mostly advertised about how their broadband was superior to its competitor, but there were no price wars where telcos or cable companies dropped prices to try to win a share of the market. In most places in the US the telephone companies hit the broadband market first, and in the early days the telcos had more broadband customers than cable companies.

However, over time, the cable broadband products improved faster than telephone company DSL Today, the cable companies can offer speed that approach gigabit and their basic broadband product is usually between 100 and 200 Mbps. DSL has improved a lot since 2000, but the fastest DSL today in most markets is a little less than 50 Mbps, while most DSL is even slower. Households generally value the faster speeds offered by the cable companies, and in markets where the two duopoly providers have competed side by side for many years, the cable companies have largely won the broadband battle. This fight is not over, and nationwide statistics show DSL continue to change to cable broadband quarter after quarter.

A lot of economists say that the cable companies have won the duopoly battle, due entirely to having faster broadband speeds. We’ve seen several markets where the cable company has gained 80% or more of the broadband customers. Charter has not done nearly this well and only has a 50% market share in the cities. We speculate that this is because Charter is not blazingly faster than AT&T in the market.

<u>Technology Matters</u>

To a large degree, the broadband speeds available to customers is dependent upon the technology used to deliver the broadband. Our reports will discuss various technologies in more detail when we describe the engineering cost estimates to bring better broadband to the cities.

The general speeds available on various technologies is as follows:

- DSL delivered on one copper pair of wires can deliver speeds as fast as 25 Mbps for up to two miles from the DSL transmitter, assuming the copper is in good condition and other factors are ideal. There are slower versions of DSL deployed in the networks that might have maximum speed capability of 3 Mbps, 6 Mbps, 12 Mbps, or 16 Mbps.
- DSL delivered on two copper pairs can deliver twice the speed. This technology usually only uses the latest types of DSL and has maximum speeds around 50 Mbps. This is generally only deployed in towns where the telco is competing against a cable company.
- The hybrid-fiber coaxial systems from cable companies can bring significantly faster broadband speeds. Networks using the DOCSIS 3.0 standard can deliver speeds up to perhaps 250 Mbps. Networks upgraded to the most recent DOCSIS 3.1 standard can deliver speeds up to a gigabit. Cable networks are limited due to the technology of offering upload speeds that can be not greater than 1/8 of the total broadband delivered.
- High orbit satellite broadband can deliver speeds as fast as 75 Mbps. The problem with this broadband is that the satellites are so far above the earth that there is a lot of delay (latency) in the signal and it’s hard to do real-time web activities like streaming video, connecting to a corporate WAN or a school server, making VoIP calls, or even shopping on some web sites.
- Fixed point-to-multipoint wireless is capable of speeds up to 100 Mbps, although the equipment and configuration of most networks brings speeds significantly less than this, sometimes as slow as only a few Mbps.
- Fiber networks also deliver the fastest broadband. Fiber networks with the older BPON technology are limited to speeds of about 200 Mbps per system. More modern GPON technology can deliver speeds up to a symmetrical gigabit (same speed up and down). There are newer kinds of fiber-to-the-home technology that can deliver speeds up to 10 Gbps.

For some technologies, like DSL, the speed can vary widely in the network – two homes next to each other can have different speeds. The speed of DSL 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 quality of the copper (copper wire slowly degrades over time, particularly if the copper gets directly in contact with the elements or with longstanding water).
- By 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 the field 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 provide bandwidth to a feed 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.
- 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.

The Regulatory Definition of Broadband

The first step in trying to define broadband gaps is to look at the definition of broadband. The following discussion considers the regulatory definition of broadband.

In 2015 the FCC established the definition of broadband as 25/3 Mbps (that's 25 Mbps download and 3 Mbps upload). Prior to 2015 the definition of broadband was 4/1 Mbps, set a decade earlier. The FCC defines broadband in order to meet a legal requirement. Congress established a requirement for the FCC in Section 706 of the FCC governing rules that the agency must annually evaluate broadband availability in the country. Further, the FCC must act if broadband is not being deployed in a timely manner. The FCC report the state of broadband to Congress every year.[4] In these reports the FCC compiles data about broadband speeds and availability and proffers an opinion on the state of broadband in the country. In every report to date the FCC has acknowledged that there are broadband gaps of various kinds, but the FCC has never determined that the problems are so bad that they need to take extraordinary measures to close any broadband gaps. Most recent FCC claim that broadband situation is improving due to actions taken by the FCC.

The FCC didn't use empirical evidence like speed tests in setting the definition of broadband in 2015. They instead conducted what is best described as a thought experiment. They listed the sorts of functions that a 'typical' family of four was likely to engage in, and then determined that a 25/3 Mbps broadband connection was fast enough to satisfy the broadband needs of a typical family of four.

The FCC asked the question again in 2018 if 25/3 Mbps is an adequate definition of broadband. They concluded that 25/3 Mbps is still an adequate definition of broadband. There were numerous filings in that docket that believed that the definition of broadband should be increased.

The FCC is required by law established by the Telecommunications Act of 1996 to report the state of broadband deployment, to Congress. The FCC collects ISP data using a process called the Form 477 process. The FCC collects the following data from every landline broadband ISP in the country (they don't require this data from dial-up providers, from satellite providers or from cellular companies).

- ISPs report broadband customer counts by Census Block. Those are finite geographic areas defined by the US Census bureau that typically cover between 60 and 120 homes. In a city a Census block might be a city block and in a rural area it might cover a large portion of a county.
- For each Census block the ISP reports the fastest speed available to customers.

After the FCC gathers this data from ISPs, they make it available in the form of databases showing the speeds reported by each ISP in every Census Block. The FCC also maps the broadband data in various ways. The most common maps produced by the FCC show areas that don't have broadband that meets the 25/3 definition of broadband, areas that meet the 25/3 speed, areas that achieve speeds of at least 100/10 Mbps, and areas that have gigabit broadband capability. Many other variations of these maps are also possible.

There is one quirk in the FCC reporting process that plays havoc with the databases. If an ISP has one customer in a corner of a Census Block that can buy 100 Mbps broadband, then it is assumed that every

[4] The FCC report to Congress for 2019 can be found at https://docs.fcc.gov/public/attachments/FCC-19-44A1.pdf.

customer in that Census Block can get that same 100 Mbps speed. The database reflects the fastest speed available for each Census block – not the speed being delivered.

To make matters worse, ISPs are supposed to report actual speeds to the FCC, but there is seemingly no penalty for reporting any speed number they want. Many ISPs report marketing speeds instead of actual speeds. As an example, an ISP might advertise DSL as a speed of “up to 15 Mbps” and then report the 15 Mbps speed to the FCC. In actual practice that Census block might have DSL speeds significantly slower than the advertised speed.

Finally, ISPs are free to claim any service area they want and there is no penalty for claiming broadband coverage in a Census block where the ISP has no customers. We know of many cases where ISPs claim coverage of an entire county but might have almost no customers there. Those factors – reporting by Census Block, reporting by advertised speeds, and reporting exaggerated service areas means that the FCC’s reported broadband speeds are often significantly overstated.

The FCC has also allowed big reporting errors into the databases. The 2018 Broadband Deployment Report reached the conclusion that the state of broadband was improving rapidly. It turns out there was a huge error in the data supporting that FCC report. A new ISP in New York, Barrier Free, had erroneously reported that they had deployed fiber to 62 million residents in and around New York. Even after the FCC was forced to correct for the error, they still drew the same conclusions that broadband was getting better, even though the revised report showed million more homes that didn’t have good broadband. This raises a question about what defines “reasonable and timely deployment of broadband” if having fiber to 62 million fewer people doesn’t change the answer.

All of these factors taken together mean that the FCC broadband maps are generally dismal. The broadband speeds in towns might be reported reasonably correctly, although the speeds reported sometimes reflect marketing “up to” speed instead of actual speeds. Speeds for areas just outside of towns and cities are routinely overstated and often show broadband coverage where there is none. Rural areas served by DSL or fixed wireless generally overstate the broadband speeds – and these are the two technologies most widely used in rural America.

In August 2019, the FCC voted to change the method of collecting data to support its broadband maps. The primary new change is that ISPs have to produce “polygons” (or geographic shapes) that cover areas where they have broadband customers today. The ISP maps can also cover areas without current coverage where an ISP could provide a broadband connection within ten business days of a customer request and without an extraordinary commitment of resources or construction costs exceeding an ordinary service activation fee.

The new polygons will fix some big holes in the current FCC maps. The polygons are going to make a noticeable difference when showing coverage for cable company or fiber-to-the-home networks. Those networks have hard boundaries described above as stopping at the “last home.” Today’s mapping by census block doesn’t recognize these hard boundaries and often counts customers outside these networks as having access to faster speeds. Unfortunately, the FCC is still not invoking penalties for ISPs that overstate broadband speeds.

The Upload Speed Crisis

The COVID-19 pandemic has exposed a broadband problem that was never much realized or discussed before. Many homeowners who thought they had good broadband found that they were unable to function if multiple people in the home tried to simultaneously connect to work or school servers.

Perhaps the easiest way to describe the problem is with a real-life anecdote. I have a colleague who was sent home to work along with her husband and two teenagers. The two adults are trying to work from home and the two kids are supposed to be online keeping up with schoolwork.

The family has a broadband connection from a cable company with a download speed over 100 Mbps bus have an upload speed that hovers around 10 Mbps. On top of their normal broadband usage, the family suddenly had to make a lot of new connections. Each of them needs to create a VPN to connect to their office or school servers. They are also each supposed to be connecting to Zoom or other online services for various meetings, webinars, or classes. The family needed to make several telemedicine connections during the pandemic. The home still continues to need bandwidth for normal functions like reading emails or backing files up in the cloud. Each member of the family also had their cellphones connect to WiFi whenever they walked into the home.

The new connections the family needed to make have significantly different bandwidth characteristics than the way they used broadband before the pandemic. Consider the bandwidth needs described by Zoom on its web page.[5] Zoom says that a home should have a 2 Mbps connection, both upload and download to sustain a Zoom session between just two people. The amount of download bandwidth requirement increases with each person connected to the call.

Telemedicine connections tend to be even larger and also require the simultaneous use of both upload and download bandwidth. Connections to work and school servers vary in size depending upon the specific software being used, but the VPNs from these connections are typically as large or larger than the requirements for the Zoom. Straight math shows fairly large requirements if four people are trying to make 2-way simultaneous connections at the same time.

The simplistic way to quantify bandwidth needs is to add up the various uses. For instance, if four people in a home each wanted to have a separate Zoom conversation, the home would need a simultaneous connection of 8 Mbps both up and down. But bandwidth use in a house is not that simple, and a lot of other factors contribute to the quality of bandwidth connections within a home. Consider all of the following:

- WiFi Collisions. WiFi networks can be extremely inefficient when multiple people are trying to use the same WiFi channels at the same time. Today's version of WiFi only has a few channels to choose from, and so the multiple connections on the WiFi network interfere with each other. It's not unusual for the WiFi network to add a 20% to 30% overhead, meaning that collisions of WiFi signals effectively waste usable bandwidth. A lot of this problem is going to be fixed with WiFi 6 and 6 GHz bandwidth, which together will add a lot of new channels inside the home.
- Lack of Quality of Service (QoS). Home broadband networks don't provide quality of service, which means that homes are unable to prioritize data streams. If you were able to prioritize a

[5] https://support.zoom.us/hc/en-us/articles/204003179-System-Requirements-for-Zoom-Rooms

school connection, then any problems inside the network would affect other connections first and would maintain a steady connection to a school server. Without QoS, a degraded bandwidth signal will likely affect everybody using the Internet. This is easily demonstrated if somebody in a home tries to upload a big data file while somebody else is using Zoom – the Zoom connection can suddenly not have enough bandwidth available and will either freeze or drop the connection – as millions of Zoom users experienced.

- Shared Neighborhood Bandwidth. Unfortunately, a home using DSL or cable modem doesn't only have to worry about how other in the home are using the bandwidth, because bandwidth is shared with everybody else using the same ISP in their neighborhood. As the bandwidth demand for the whole neighborhood increases, the quality of the bandwidth available to every home degrades.
- Physical Issues. ISPs don't want to talk about it, but events like drop wires swinging in the wind can affect a DSL or cable modem connection. Cable broadband networks are also susceptible to radio interference – your connection will get a little worse when somebody is operating a blender or microwave oven.
- ISP Limitations. All bandwidth is not the same. For example, the upload bandwidth in a cable company network uses the worse spectrum inside the cable network – the part that is most susceptible to interference. This never mattered in the past when everybody cared about download bandwidth, but an interference-laden 10 Mbps upload stream is not going to deliver a reliable connection for Zoom.

The family in question quickly figured out that their bottleneck was upload speeds. They discovered that they could not all work at the same time – and so they had to take turns using the Internet for school or work. The problem was even more aggravating because they sometimes ran into problems when even only two of them were working at the same time. It appears that that the amount of upload bandwidth available to the home varied during the day, likely as the result of factors outside of the home.

This family thought they had great broadband. They had never had a problem before the pandemic, except for a few times when the teenagers were running multiple games in the cloud at the same time. But suddenly, the broadband connection was not adequate, and the family looked around for alternatives. Unfortunately, they didn't have any and there were no broadband products available for their home that had faster or more reliable broadband.

The nearest analogy to this situation harkens back to traditional landline service. We all remember times, like after 911, when you couldn't make a phone call because all the circuits were busy. That's what's happening with the increased use of VPN connections to school and work servers. Once the upload path from the neighborhood is full of VPNs, nobody else is going to be able to grab a VPN connection until somebody "hangs up."

The Business Broadband Gap

Most businesses have the same issues as residents in terms of limitations of technology. There are some unique issues affecting business broadband:

- In many towns the original cable company might not have built the cable network to reach business districts. Back in the 1970s and 1980s the cable companies didn't expect to sell enough cable TV service to businesses to justify the cost of the network. Even though the cable company is now

usually the fastest broadband solution in a town, there are often still businesses that are not connected to the cable company network.
- In cities, the telephone and cable companies are often willing to build fiber to a sufficiently large enough customer. Such fiber availability, if it even exists, is also often limited by how close a business might be to an existing fiber.
- Businesses have drastically different broadband needs. For example, there might be one business with a 100 Mbps connection from the cable company that is satisfied with the service. Next door could be another business that finds the 100 Mbps connection inadequate and that struggles to operate their business because of the broadband.

Microsoft Speed Data

Microsoft is in an interesting position when it comes to looking at broadband speeds. The vast majority of computers in the country download sizable upgrade files from Microsoft. Even many Apple computers are loaded with Microsoft Office products like Word, Excel, and PowerPoint.

Microsoft decided a few year ago to record download speeds of software upgrades. There is probably no better way to measure a broadband connection than during a big file download. Most speed tests only measure broadband speeds for 30 seconds to a minute. There are a lot of ISPs in the country that deploy a technology generally referred to as “burst.” This technology provides a faster download for a customer for the first couple of minutes of a web event. It’s easy for a customer to know if their ISP utilizes burst, because during a long download, such as one updating Microsoft Office, the user can see the download speeds drop to a slower speed after a minute or two. This technology has great benefits to customers since the large majority of web activities don’t take long. When customers visit a website, open a picture, or even take a speed test, the customer only needs bandwidth for a short time to complete most web tasks. The burst technology gives customers the impression that they have a faster download speed than they actually have (or it could be conversely argued that they have a fast speed just for a minute or two). ISPs make burst work by giving a priority to the first minute or so of a new web activity.

Here is what Microsoft found for measurements of downloads done in September 2018:
- The 2018 FCC data claimed that 24.7 million people in the US didn’t have access to download speeds of at least 25/3 Mbps. In September 2018 Microsoft claimed that 162.8 million people were downloading data at speeds slower than 25/3 Mbps.
- The FCC claimed in 2018 that 99.4% of the people in Oakland County had access to broadband of at least 25/3 Mbps. In September 2018, Microsoft measured only 64% of people in the county using broadband of at least 25/3 Mbps.

It’s important to note that the FCC and Microsoft are not measuring the same thing. The FCC is measuring the percentage of homes that have 25/3 Mbps broadband available as a purchase option. Microsoft is measuring the actual speeds of downloads. There are a few reasons why the speeds might be different:
- Some people opt to buy broadband products slower than 25/3, even when faster broadband is available.
- Some households receive slower speeds due to issues in the home like poor-quality WiFi routers.
- The biggest difference is probably due to the ISPs overstating the speeds they are making available.

The Microsoft numbers are astounding once it's recognized that cable companies provide more than half of all broadband in the country – and they predominantly sell speeds thar are claimed to be faster than 25/3 Mbps.

The Gap in Broadband Availability

The FCC reports that broadband adoption for the country is around 87%. Even after accounting for the rural areas that have no broadband option, there are many millions of customers that can get broadband at their homes, but that do not buy it. Numerous studies and surveys have asked people why they don't buy broadband when it's available.

John B. Horrigan published a paper[6] earlier this year titled Measuring the Gap that makes the point that the reasons that homes don't have broadband are complicated. There have been studies over the years that have tried to pin down the primary reason that homes don't have broadband, but by doing so the studies have glossed over the fact that most homes have multiple reasons for not having broadband.

A good example of this is a Pew Research Center survey in 2019 that explored the issue. In that survey:

- 50% of respondents said that high prices are a reason for not having broadband, but only 21% said price is the primary reason.
- 45% of respondents said they relied on smartphones that could do everything they need, but only 23% said that was the primary reason for not buying broadband.
- 43% said they were able to get access to the Internet from a source outside the home, but only 11% gave that as the primary reason.
- 45% said that the cost of a computer is too expensive, but only 10% gave that as the primary reason.

As Horrigan points out, sometimes there is bias in the questions being asked in a survey. A survey that has pre-conceived ideas about why folks don't have broadband will miss some of the reasons. Consider a 2017 survey from the California Emerging Technology Fund. This survey showed different reasons than Pew for why homes don't have broadband because the survey asked different questions. The survey showed:

- 69% said the cost of monthly access and of affording a computer or smartphone was too high. 34% listed this as the primary reason for not having broadband.
- 44% said it was too difficult to set up a computer and to learn how to use broadband, which 12% gave this as the primary reason.
- 42% said they were concerned about privacy and computer viruses, while 21% gave this as the primary reason for not having broadband.
- 41% said they had a lack of interest in being online, with 22% giving this as the primary reason for not having broadband.

The results of those two surveys are drastically different because the surveys asked different questions. If a survey doesn't provide the option to say that privacy is a reason for not having broadband, then that gets missed. People can only respond to the questions asked in a survey as presented to them. For example, there were 12% of respondents in the second survey above that worried about privacy as their primary reason for not having broadband. There had to be people that felt the same way in the Pew survey, but

[6] https://www.digitalinclusion.org/blog/2020/02/11/measuring-the-gap-by-john-horrigan/

since that question was never asked, respondents were forced to pick from among the choices they were given.

FCC Adoption Rate

In the 2019 annual report to Congress the FCC reported on broadband adoption by various speeds by state. Adoption rate is the percentage of households that have purchased broadband that meets or exceeds various speed thresholds. For some reason that they don't explain well, in the 2019 broadband report to Congress the FCC reported broadband adoption rates for 2017. This means two things. The overall adoption rates are understated because we know that the overall number of homes buying broadband has been increasing every year. However, since the data used in the FCC report comes from the Form 477 data, the percentage that that buying a given speed is likely overexaggerated. That makes for some confusing results, but since the same issues affect every state, the overall rankings of broadband adoption by state is probably reasonable.

In the 2019 report to Congress, the FCC reported the following broadband adoption rates for Michigan (meaning the percentage of customers who are buying the listed speeds at their home):

Homes buying at least 10/1 Mbps	67.5%
Homes buying at least 25/3 Mbps	57.6%
Homes buying at least 50/5 Mbps	51.9%
Homes buying at least 100/10 Mbps	18.0%
Homes buying at least 250/25 Mbps	1.2%

To put the FCC numbers into perspective, the percentage of homes that get at least 10/1 Mbps broadband (67.5%) puts Michigan in the middle of the state rankings, but far below states like Delaware, New Jersey, Massachusetts, and Maryland that are above 80%.

FCC Availability of Broadband

The FCC also looks at the availability of broadband by county, meaning the percentage of homes that could buy broadband at various speeds. Here's what the FCC reported to Congress in 2019:

Oakland County

Urban population:	1.19 million
% that can buy at least 25/3 broadband	97.4%
% with 4G LTE coverage	99.8%
% with both	100.0%

Rural population:	60,858
% that can buy at least 25/3 broadband	98.8%
% with 4G LTE coverage	100.0%
% with both	98.8%

Oakland County is near the top of the list of counties with the best broadband in Michigan.

How Does the US Rank with the Rest of the World?

Cable Company from the United Kingdom has been gathering data each year that compares broadband speeds and prices from around the world.

The most recent report on broadband speeds is from 2019.[7] The rankings are based upon many millions of speed tests, and 2019 average download speed for the US is based upon over 132 million speed tests. The US ranked 15th in the world in 2019 with a national average download speed of 32.89 Mbps. We are behind countries like Taiwan, Singapore, Sweden, Denmark, Japan, Netherlands, Spain, Norway, Belgium, and others. The average speeds in the US have been increasing and was 25.86 Mbps in 2018 and 20.00 Mbps in 2017. During that time, the US climbed from 21st fastest to the current rank of 15th. The speed increases are largely due to upgrades in speeds in urban areas by cable companies, although there are also fiber-to-the-home builds in both urban and rural markets across the country.

The Gap in Broadband Affordability

Statistics on Affordability

In larger cities it's somewhat easy to equate broadband penetration rates to household incomes. This is due to the fact that a Census block in a city might be as small as a block or two, and it's easy to match Census data to broadband data from the FCC.

An analysis of recent FCC 477 data that compared broadband coverage to incomes showed a direct correlation between household income and buying a home broadband connection. 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 buy broadband. There is no clearer evidence that there is an affordability gap for 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.[8] The second report is issued by the Quello Center and is authored by Bianca Reisdorf.[9] 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 must involve finding a way to pay for the monthly broadband access.

Comparing US Broadband Prices to the World

[7] Broadband speeds around the world. https://www.cable.co.uk/broadband/speed/worldwide-speed-league/

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

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

Cable Company of the United Kingdom also tracks broadband prices around the world. The most recent comparison of prices is from 2020.[10] The average price of broadband in the US in 2020 is $50. It's worth noting that these prices were gathered from advertised prices, and most big ISPs in the country advertise temporary special prices that expire after a one or two-year period. The advertised price also doesn't include the cost of a modem or WiFi router. The average price of the US ranks as the 119th most affordable out of 206 countries. However, it's worth noting that most the countries that are more expensive than the US are either third world countries or island nations. The few exceptions of first world countries that are more expensive than the US are New Zealand, Norway, and Switzerland.

In that same report, the US looks better when looking at advertised prices compared to advertised bandwidth. In that comparison the average cost per megabit of speed in the US is $0.26, placing the US 27th in terms of affordability. However, we know that many ISPs advertise speeds that are faster than what they actually deliver – but this may be true in other countries as well.

Broadband Prices in the Cities

The broadband prices in the cities are high and there is not much price competition. The prices for AT&T and Charter are nearly the same for basic broadband. There are markets in the country with even higher prices, with Comcast and Cox having higher broadband prices than Charter. But there are other telcos, like CenturyLink, with DSL prices lower than AT&T.

AT&T DSL is essentially $60 per month, regardless if the speed is 10 Mbps or 100 Mbps download. And since customers must lease a DSL modem, the real price for DSL is $70 per month. The downside to the price in the cities is that it looks like a lot of homes have slow speeds. Where $70 might not feel expensive for a 50 Mbps or a 100 Mbps connection, it feels too high for somebody getting a 10 Mbps connection.

AT&T Fiber is not inexpensive. A standalone 100 Mbps connection on fiber is $60 per month. Customers have an option to use their own modems, but otherwise have to lease a modem for $10 per month. A gigabit connection on AT&T is $100 per month.

Charter's standalone broadband is $70 per month. Customers can save $10 by bundling with another product. Charter also adds a $7.99 fee monthly for the modem.

The best broadband bargain in the market is WOW! with basic 200 Mbps broadband priced at $50 per month, with a $10.00 modem.

ISPs Bridging the Price Gap

Charter. Charter has a low-income program called Internet Assist. Charter charges $17.99 for a connection at 30 Mbps. There are no data caps. To be eligible a home must qualify for the National School Lunch Program, a state lunch program, or Supplemental Security Income for seniors.

[10] Broadband prices around the world. https://www.cable.co.uk/broadband/pricing/worldwide-comparison/

Federal Lifeline Program

Both AT&T and WOW! participate in the Federal Lifeline program that is part of the Universal Service Fund. With the program a customer can receive a discount of $9.25 per month off a telephone bill or broadband bill. The program works by the carrier providing a discount to customers and the FCC reimburses the ISP for the discount. This means it costs the carrier nothing to offer the discount – the discount is funded by the FCC.

Residents can be eligible for the plan if they qualify for SNAP (formerly Food Stamps), SSI, Federal Section 8 housing, Federal Public Housing Assistance (FPHA), VA Veterans pension, or VA survivor's pension. The FCC now maintains a database that is updated monthly that informs the carriers if a customer remains eligible for the discount.

It's worth noting that AT&T has been trying hard to drop out of the Lifeline program and has successfully done so in fourteen states. Michigan and five other states still require AT&T to remain in the program, but there is a good chance that AT&T will be able to eventually withdraw from the program. We don't think AT&T widely advertises the availability of the discount to customers.

The Homework Gap

In 2010 the FCC adopted the National Broadband plan, and one of the key provisions of that plan is that every American community should have gigabit broadband connections to public schools.

Since that time, the State Educational Technology Directors Association has increased that recommendation and recommend that large schools provide at least 1.4 Mbps of broadband per student for large schools and 2.8 Mbps per student in smaller schools in order to provide adequate bandwidth.

At the end of 2019 there was 743 public schools nationwide that still don't have at least a 100 Mbps broadband connection (10% of the national goal). The group Education Superhighway[11] reported recently that all but 20 schools in Michigan have fiber connectivity.

The bigger issue concerning education is what is being labeled nationally as the homework gap. This is the situation where students have broadband at school but don't have adequate broadband and/or computers at home to enable them to do homework. The issue recently became a lot more serious when students were sent home due to COVID-19 and asked to finish the school year remotely. Even homes with broadband found they had problems connecting to both school and work servers at the same time.

How much bandwidth is needed to do schoolwork at home? It varies according the specific set-up at a given school. The typical way for a student to connect to a school system network is through the creation of a virtual private network (VPN) connection. A VPN works by grabbing and reserving a dedicated data path between the home and a server, in this case a school server. While that student is connected to the school, that data path is dedicated to the student and can't be used for other purposes in the home without kicking the student off the VPN connection.

[11] https://www.educationsuperhighway.org/

The VPN generally tries to establish a separate download and an upload data path. The download path is used to download documents like homework assignments, with the biggest download being when the school homework involves viewing videos that are streaming from the school server. On the upload path the VPN is used when students send completed homework or else perform functions online line like taking a test. We've gotten reports from network engineers that a school VPN will use between 2 Mbps and 4 Mbps in both the upload and download direction.

The Quello Study.

Teachers have understood for many years that students without broadband and/or computers at home don't perform as well in class. There was recently a definitive study that quantified the impact of the homework gap. The study was just released in March 2020 and was done by the Quello Center that is part of the Department of Media and Information at Michigan State University.[12]

This a definite study because it used study techniques that isolate the impact of broadband from other factors such as sex, race, and family incomes. The study involved 3,258 students in Michigan in grades 8 – 11 from schools described as being in rural areas. The study was done in such a way to get results of schoolwork concerning students without violating student confidentiality.

The study showed significant performance differences for students with and without home broadband. Students with no Internet access at home tested lower on a range of metrics including digital skills, homework completion and grade point average. Some of the specific findings include

- Students with home Internet access had an overall grade point average of 3.18 while students with no Internet access at home had a GPA of 2.81.
- During the study, 64% of students with no home Internet access sometimes left homework undone compared to only 17% of students with a high-speed connection at home.
- Students without home Internet access spend an average of 30 minutes longer doing homework each evening.
- The study showed that students with no Internet at home often had no alternative access to broadband, such as a library. 35% of students with no broadband also didn't have a computer at home. 34% of students had no access to alternate sources of broadband such as a library, church, community center, or homes of a neighbor or relative.

One of the most important findings was that there is a huge gap in digital skills for students without home broadband. To quote the study, "*The gap in digital skills between students with no home access or cell phone only and those with fast or slow home Internet access is equivalent to the gap in digital skills between 8th and 11th grade students*." Digital skills not only require competence in working with technology, but also means the ability to work efficiently, to communicate effectively with others, and managing and evaluation information. This is a devastating finding that students without home broadband fall three grades behind other students in terms of developing digital skills.

Students with lower digital skills translates directly to performance on standardized tests. A student who is even modestly below average in digital skills (one standard deviation below the mean) tends to rank

[12] http://quello.msu.edu/wp-content/uploads/2020/03/Broadband_Gap_Quello_Report_MSU.pdf

nearly 7 percentiles lower on their total SAT/PSAT score, 5 percentiles lower in math, and 8 percentiles lower in evidence-based reading and writing.

The study also showed lower expectations by students without broadband at home. For example, 65% of students with fast broadband have plans to pursue post-secondary education. Only 47% of students with no Internet access have such plans. Students who are even moderately lower in digital skills also are 19% less likely to consider a STEM-related career (science, technology, engineering, and math).

Another major study by the National Center for Education Statistics (NCES),[13] an agency within the US Department of Education looked at the homework gap. That study compared test scores for 8th grade students both with and without a home computer. The results showed:

- On tests of reading comprehension, students who have a computer at home had an average score of 268 compared to a score of 247 for students without a computer.
- In testing for mathematics, students with a computer at home scored 285, while those without scored 262.
- In testing science, students with a computer scored 156 compared to 136 for students without a computer.
- In testing competency in information and communication technology, students with a home computer scores 152, compared to 128 for students without a home computer.

<u>Other Uses of Broadband for Education</u>.

The US Bureau of Labor Statistics reported earlier this year that the average American baby boomer held 12.3 different jobs between the ages of 18 and 52 - that was 12.5 jobs for men and 12.1 jobs for women. It's much harder to measure a change in careers, meaning a change to doing something drastically different than prior jobs, but researchers have looked at the data and said that most people change careers at least several times during their work life. The above statistics don't tell the whole story because many people are now working well past 65 years of age, including many older workers trying a new career at the end of their working life.

Many new jobs and careers today require online training. New employees are often expected to complete online training courses at the start of a new job. Many out-of-work adults pursue online training to learn a new career. Anecdotal evidence suggests that taking training or educational courses from a distance (across the country) requires more bandwidth since it's harder to hold a VPN session when the bandwidth varies.

The biggest group of online learners (outside of the COVID-19 crisis) are students pursuing a post-secondary education online. The National Center for Education Statistics reports that over 5.4 million students, mostly undergraduates take at least one course online during a school semester. Over 2.6 million students pursue their entire degrees online each year. Graduate students are even more prone to take online courses, with 22% taking classes exclusively online compared to 11% for undergraduate students.

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[13] https://nces.ed.gov/pubs2017/2017098/index.asp

The Computer Gap

One of the things that digital inclusion advocates have learned is that it's not enough to get affordable broadband to a home if they can't afford a computer or other devices to use the broadband. It's now clear that cellphones are good tools for things like shopping online but are inadequate for students trying to do homework. Any plan to close the digital divide has to find solutions for closing the computer gap.

A survey by Pew Research Center in 2019 shows a huge disparity between household income and technology adoption. Consider the following results of that study:

	Less than $30,000	$30,000 to $100,000	Over $100,000
Home Broadband	56%	81%	94%
Smartphone	71%	85%	97%
Desktop	54%	83%	94%
Tablet	36%	55%	70%
All the Above	18%	39%	64%

Other studies have shown that the percentages of homes that have any these technology tools really shrinks for homes making under $25,000 per year.

A big problem for low-income homes is that they can't afford both broadband and the cost of buying and maintaining a computer or similar device. Computers are some of the shortest-lived electronics we buy and typically have to be replaced every 3 or 4 years. The above numbers highlight the problem of getting broadband into low-income homes – a solution is needed for both broadband and for a computer.

The historical solution to lack of computers was to put computers in libraries and public places. However, this solution is inadequate for many reasons. First, it requires students to travel to where the computers are. In communities where a lot of students don't have computers it's difficult to have enough to meet the demand. Libraries also often don't have good enough broadband to support multiple simultaneous users.

However, the best reason to get computers into homes compared to libraries is that numerous studies have shown that computers in the home have a huge positive impact on students compared to any other factor. Computers have the biggest positive impact on students when they are part of daily life and convenient to use when needed.

We can't forget that computers aren't only for students. Adults need computers today just to participate in the modern world. Computers are needed to hunt for a job. Computers are needed to pursue online training and education. Computers are needed to consider jobs that all employees to work from home. Computers are needed today to interface with many government programs.

There are a number of different approaches that communities have tried to solve the computer gap that will be discussed below in the section talking about solutions for the digital divide.

The Digital Literacy Gap

Before the pandemic, the US job market appeared to be robust due to the low unemployment rate, which has been low by historic standards. However, a closer look at the statistics tell a different story. Workers with upper income jobs have been faring extremely well. For example, starting jobs for new computer, engineering, and similar tech graduates are at an all-time high. It’s a good time to be a high-tech worker. However, over half of all job openings in the country are classified as middle-skill jobs (with the three categories being high-skilled jobs, middle-skill jobs, and unskilled jobs). These jobs generally don’t require a college degree. An analysis by the Benton Foundation a few years ago showed that over 80% of middle-skill jobs require some degree of digital literacy. Unfortunately, a lot of people seeking middle-skill jobs lack the digital skills needed to land these jobs.

This lack of sufficient digital literacy to find middle-skill jobs is perhaps the best way to describe the broadband skills gap. Middle-skill jobs don’t require coders but need people who possess basic computer skills like knowing how to use Microsoft Word or Excel. It means being able to type fast enough to do data entry, write-emails, or do other expected tasks in the average workplace.

In the early days of the computer age the federal government operated many training programs that taught the basic computer skills. Today it seems to be assumed that students graduate from high school with these skills. However, a student who has never had a home broadband connection or a computer and who only did homework on a cellphone probably doesn’t have the needed digital skills. It’s now up to local communities to find their solutions to the digital literacy gap.

An example of a community that has tackled this is the Enterprise Center in Chattanooga Tennessee. This is a nonprofit that is trying to solve the digital divide in the city. Chattanooga is a city that has invested in fiber broadband infrastructure and offers gigabit broadband on fiber to every resident of the city. However, like in all cities they found out that low income homes couldn’t afford the broadband, didn’t have computers, and didn’t have the digital skills needed to use a computer. The Enterprise Center began offering basic computer training in 2019 and was shocked when it was overwhelmed by a huge number of people who wanted basic training. The Enterprise Center is now looking for ways to greatly expand the training to meet the demand.

A Pew Research Center survey in 2016 showed that a lot of adults were interested in digital training. 60% of adults were interested in learning how to use online resources to find trustworthy information. In today’s world of misinformation that percentage is probably even higher today. In the Pew study, 54% of adults were interesting in training that make them more confident in using computers and the Internet.

Future Broadband Gaps

The Future of Broadband Speeds and Capacity

The gap analysis so far has discussed existing broadband gaps. It’s important to realize that there will be new broadband gaps coming that we can already predict. One of the issues to consider when looking forward is that broadband speeds are a moving target – that is, the need for residential and business broadband grows every year. This is not a new phenomenon and the need for bandwidth has been growing at nearly the same rate since the early 1980s. Home and business demand for bandwidth speeds and the amount of desired downloading has been doubling every three to four years since then.

As an example, 1 Mbps DSL felt really fast in the late 1990s when it was introduced as an upgrade from dial-up Internet. The first 1 Mbps DSL connection was nearly twenty times faster than dial-up, and many people thought that speed would be adequate for many years. However, over time, households needed more speed and the 1 Mbps connections started to feel too slow - so ISPs introduced faster generations of DSL and cable modems that delivered speeds like 6 Mbps, 10 Mbps, and 15 Mbps. Cable modem speeds continued to grow in capacity and eventually surpassed DSL, and in most cities the cable companies have captured the lion’s share of the market by offering internet speeds starting between 100 Mbps and 200 Mbps.

Bandwidth requirements are continuing to grow. Firms like Cisco and Opensignal track speeds achieved by large numbers of households by examining Internet traffic that passes through the major Internet POPs. Both companies estimate that home internet need for bandwidth downloading as well as the need for broadband speeds are growing currently at about 21% annually. Business use of bandwidth is currently growing at 23% annually.

This report earlier discussed how the FCC set the definition of bandwidth in 2015. If you accept 25/3 Mbps as an adequate definition of bandwidth in 2015, then growing the requirements for speeds would increase every year 21% as follows:

2015	2016	2017	2018	2019	2020
25	30	37	44	54	65

This is somewhat arbitrary because it assumes that the broadband needs in 2015 were exactly 25 Mbps. For example, if the actual broadband need for the average household in 2015 was 22 Mbps, then the predicted speed for 2020 would be 57 Mbps. What is not arbitrary is that the need for bandwidth and speed increase over time.

If we accept the premise that 25 Mbps was the right definition of broadband in 2015, then it’s reasonable to believe that the definition of broadband today ought to be at least 50-60 Mbps. That would infer that there is a broadband gap today for any customer who can’t buy 50-60 Mbps broadband.

Broadband is not only measured by speed and there are firms that track the volume of data that households and businesses use. The firm OpenVault measures total usage by households using software deployed by the biggest ISPs around the country and around the world. They recently announced that the average US household at the end of 2019 used 344 gigabytes of data per month (download and upload combined). That number grew from 274 gigabytes at the end of 2018 and 215 gigabytes at the end of 2017.

As might be expected, home broadband usage has exploded to COVID-19. OpenVault reported that as of the end of March 2020 that the average US home used 402.5 gigabytes of usage, up 17% from the 344 gigabytes reported just 3 months earlier at the end of 2019, and up 47% from the 274 gigabytes measured a year earlier. OpenVault says that most of the growth was realized in the last two weeks of March as employees and students started working from home in earnest.

One of the most startling numbers to come from OpenVault is what they call power users – homes that are using more than 1 terabyte (1,000 gigabytes) of data per month. At the end of March 2020, 10% of all US homes were using a terabyte or more of data, an increase of 138% over the 4.2% of homes that used a terabyte of data just three months earlier at the end of 2019. Even more interesting, 1.2% of homes used 2 terabytes of data at the end up March, up 215% from the end of December. The big ISPs like Comcast are supposedly not billing for data caps during the pandemic – but they must be licking their chops at the flood of new revenues this will created if these homes don't return to pre-COVID usage levels.

We saw the demand for faster broadband products also leap upward. At the end of March 2020, the percentage of homes subscribing to gigabit data products jumped to 3.75% of homes, up from 2.8% at the end of 2019 and up from 1.9% a year earlier. Amazingly, more than 1% of all homes in the US upgraded to a gigabit data plan in just the last three months – that's something that's been predicted for years. Those homes are not likely going to downgrade to slower speeds – so gigabit broadband is now becoming a significant segment of the market. OpenVault says that 12% of US homes now subscribe to speeds of 200 Mbps or faster.

The OpenVault data also validates what's been reported widely by ISPs – that the patten of broadband usage is changing by time of day. For years, the peak period for broadband usage – the busy hour – was always in the evenings. In the first quarter of 2020 the amount of usage in the evenings stayed flat and all of the increased usage came during the daytime as employees and students used broadband and video conferences to function.

OpenVault says that usage peaked in the third week of March. It will be interesting going forward to see the how home usage changes. OpenVault doesn't have any better crystal ball than the rest of us, but they are predicting that broadband usage will never return to the historic patters. They predict that a lot of people will continue to work from home, meaning increased broadband demand during the day. They believe there will be continued pressure on the upload data paths. People who have learned to videoconference during the recent months are likely to continue that practice in the future. Companies and employees that realize they can be productive at home are likely to work more from home, even if only on a part-time basis.

These various statistics are a clear indication that the FCC should be periodically increasing the definition of broadband. The agency looked at broadband speeds in a docket in 2018 and concluded to keep the definition at 25/3 Mbps. However, there was a lot of compelling filings in that docket that argued that the definition of broadband should be 50 Mbps to 100 Mbps.

The point of this section of the report is that we can't get hung-up on the FCC's definition of broadband when looking at the broadband gap. Practically every home that uses broadband would admit to downloading and uploading a lot more data today than they did just a few years ago.

It's also important to look into the future when considering broadband needs. For example, if an ISP builds a new broadband solution today, that solution should be prepared to handle the broadband requirements a decade from now. Consider the following chart that predicts broadband needs moving forward. This applies the same 21% annual growth rate for bandwidth demand that we're currently seeing. Forward predictions are always criticized for being too aggressive, but the need for broadband has been growing at roughly the same rate since 1980 and it's not a big stretch to predict continued broadband growth into the future.

2020	2021	2022	2023	2024	2025	2026	2027
65	79	95	115	139	169	204	247

It's not hard to put this prediction into perspective. Cable companies that serve over 60% of all broadband customers in the country already provide minimum speeds today of between 100 Mbps and 200 Mbps. That speed varies a bit by market due to the condition of local coaxial networks.

The above chart suggests that by 2027 (or some year close to then) that a 200 Mbps product will start to feel sluggish to some households. Cable companies have unilaterally increased speeds over the years, and it would not be surprising to see speed increased again before 2027.

It's also not hard to imagine that seven years from now that the national definition of broadband ought to be around 250 Mbps. That doesn't mean that the FCC will continue change the 25/3 Mbps definition. There is a political downside if the FCC increases the definition of broadband – the change would reclassify millions of homes as not having broadband.

One of the conclusions that can be reached by this analysis is that any new network built today ought to be cable of meeting the expected broadband speeds of the next decade. The only technologies capable of that are fiber-to-the-premise, cable company hybrid-fiber networks, and some wireless technologies using millimeter wave spectrum that are just now being trialed in a few markets.

The Consequences of the Poor Broadband

There was a time when academics theorized about the impacts of poor broadband. We don't need to theorize today because residents with poor broadband or communities with poor broadband are fully aware of the ways that slow broadband impacts them.

The cities have an interesting broadband landscape. There are least a few customers that can buy gigabit broadband on AT&T fiber. Customers can subscribe to speeds on Charter up to 400 Mbps - although it appears that Charter can't deliver that speed everywhere. Customer that subscribe to WOW! can get speeds up to 500 Mbps. But there are homes in Farmington that can't subscribe to WOW! and only have AT&T DSL for an option. It also appears that parts of the Charter network have broadband speeds far slower than expected and where homes might not have good broadband options.

Following are some of the consequences to the cities of poor broadband:

<u>Impact of Poor Broadband for Citizens</u>

- <u>Lower Property Values / Working from Home</u>: We now know that housing prices are higher in communities with great broadband options. There are parts of Farmington with robust broadband. If the cities come to be perceived as having inadequate broadband, then housing prices will be affected. There is a sizable number of homes in Detroit that now have fiber broadband, and Verizon has launched the FWA wireless product there with near gigabit speeds.

Realtors have been reporting across the country that broadband is at or near the top of the wish list for most homebuyers today. During the pandemic there has been a lot of value placed on the ability to work from home – and much of that ability comes from fast broadband upload speeds.

Studies have shown that home-based employees are often more productive than those working in the office. Those working at home enjoy big savings, both in dollars and time, from not commuting to an office. There are widespread reports of companies that have experienced good productivity from people working at home that say they intend to continue the practice after the end of the pandemic.

Economists are predicting that the US economy is going to have a greatly increased number of people working from home after the end of the pandemic, and those employees will have more freedom to live where they want. Communities benefit hugely from people who can work from home. Such workers tend to have higher than average incomes, and an influx of such workers would have a significant impact on the cities.

According to Bloomberg, before the pandemic about 4% of the full-time workforce, not counting self-employed people, were working from home. Adding in self-employed people means that work-from-home is becoming a sizable segment of the local economy. Your survey showed 18% of residents in the town working from home before the pandemic (7% full time and 11% part time). It's likely that that number skyrocketed during the pandemic, and it also seems likely that the number won't drop back to the 18% level but will be something higher in the future.

There are a few communities that recognize the economic benefit of having good-paying employees that work from home. For example, there have been several programs to attract people to work from home. One such program was in 2018 where Vermont offered a cash incentive of between $5,000 and $10,000 for families with a home-worker to relocated to the state. The state has an aging population and wanted to attract families with good incomes to help energize the local economy. The state recognized that the long-term local benefits to the state from attracting high-paying jobs is worth a lot more than the cash incentive they are offering.

Since then other communities have tried the same thing. I recently read about a similar effort in Tulsa, Oklahoma, which has been watching its population drop since 2016. In Tulsa in 2019 a foundation is fronting $10,000 payments used to attract home workers to the community. There is a similar program in Topeka, Kansas and in northwest Alabama.

- Education: The concern for the schools is that they are unable to send computer-based work home with students since they know that some of them don't have good home Internet. It's incredibly hard to raise kids today in a home without adequate broadband. The issue is not just data speeds, but also the total amount of downloaded data that even elementary school students need to do homework. This is one of the major problems with satellite broadband, which has speeds up to 75 Mbps, but with tiny data caps and high latency the satellite broadband is inadequate for doing homework. The same is true with cellular data; we have heard horror stories of people with kids ending up with astronomical broadband bills for using broadband from cellphone hotspots for homework.

What we learned during the pandemic is that upload speeds might matter more than download speeds. A student working from home needs to establish a solid and reliable upload link to connect all day to a school server. Most of the broadband connections in the cities can likely support one student or one adult working from home but might not support homes where more than one person wants to make these connections at the same time.

Schools want students to be able to use broadband outside the school. An increasingly common practice in places with adequate broadband is to have students watch video content at home as homework and then discuss it later in the classroom. That frees valuable classroom time from watching video in class. The whole education process is increasingly moving to the web and kids without access to the web are lacking the tools that their peers take for granted.

- Upload Speeds. Upload speeds became a major issue during the pandemic as employees and students were sent by droves to function at home. Households with more than one person trying to use the Internet simultaneously often found that they were unable to fully function. While this was due in some cases to slow download speeds, the more likely problem is slow upload speeds. Except for customer connected to AT&T fiber, the upload speeds in the cities for all other forms of broadband are slow, at 25 Mbps or slower, in many cases much slower. As described earlier in the report, the pandemic has laid bare the fact that upload speeds are inadequate in much of the country. Poor upload speeds are perhaps the biggest broadband gap in the cities.

- Medical / Telemedicine: Telemedicine is the process of using broadband to connect patients to doctors over the Internet. Patients can talk to doctors using a video connection if the home has adequate broadband. Before the pandemic one of the most common uses for telemedicine was allowing patients able to talk to specialists in distant locations. Another common use has been for holding regular non-intrusive visits for things like counseling so that patients can make a scheduled appointment without major disruption to a work schedule.

  A growing area of telemedicine is the use of medical telemetry devices, which can monitor patients after they've had medical procedures. For example, Saint Vincent Health System in Erie, Pennsylvania has been using these technologies and has lowered readmission rates of patients after surgery by 44%. CoBank recently sponsored a trial in Georgia for rural diabetes patients and showed a significant improvement for patients who could be monitored daily and who could communicate easily with doctors.

  It's going to be interesting to see if telemedicine stays after the end of the pandemic. In the past months, telemedicine visits have skyrocketed. During March and April of 2020, the billings for telemedicine were almost $4 billion, compared to only $60 million for the same two months a year earlier. As soon as Medicare and other insurance plans agreed to cover telemedicine, a lot of doctors insisted on remote visits during the first few months of the pandemic. In those early months we didn't know a lot about the virus and doctor offices were exercising extreme caution about seeing patients. But now, only four months later a lot of doctor's offices are back to somewhat normal patient volumes, all done using screening patients at the door for temperature and symptoms.

There was a recent article about the topic in Forbes that postulates that the future of telemedicine will be determined by a combination of the acceptance by doctors and insurance companies. Many doctors have now had a taste of the technology. It seems likely that the telemedicine platforms in place now will get a lot of feedback from doctors and will improve in the next generation of software upgrades.

The recent experience with telemedicine is going to make a lot of doctor's look harder at their broadband provider. Like most of us, a doctor's office likely relied a lot more in the past on download speed rather than upload speed. It's likely that doctor offices making simultaneous telemedicine visits are unhappy with cable modem service or DSL broadband. Doctor's will join the chorus of those advocating for faster broadband speeds – particularly upload speeds.

My prediction is that telemedicine visits will not stay at the current high level but will be here to stay. I think when somebody books a visit to a doctor that they'll be given a telemedicine option when the reason for the visit doesn't require an examination. The big issue that will continue to arise is the number of homes without adequate bandwidth to hold a telemedicine session. We know there are millions of people in rural America who couldn't make and maintain a secure connection for this purpose, but there are probably even more people in cities that either don't have a home computer or a home broadband connection.

Impact of Poor Broadband for Businesses

There are numerous consequences of poor broadband for businesses. While some businesses have unique and specific requirements, there are a number of problems caused by poor broadband that affect most businesses.

Impact on Day-to-day Operations. Just like with households, most businesses are seeing their broadband needs growing rapidly year-over-year. Each one of the following routine business functions requires bandwidth. Businesses without adequate bandwidth must forgo or compromise on how they communicate with the world and function day-to-day.

- To Communicate with Customers. Businesses routinely have portals that make it easy for customers to place and track orders and to communicate the with business. Inadequate broadband means lower sales. The old days of transacting business through purchasing agents is slowly fading away and most commerce between companies is becoming automated – which improves accuracy and speeds up the ordering process. Businesses that operate busy ecommerce ordering sites need big amounts of bandwidth to make sure that all customers have a successful purchasing experience.
- To Communicate with Vendors. Businesses also routinely use the portals of their own vendors to buy whatever they need to operate.
- To Communicate with Other Branches of the Company. Many businesses are now part of larger corporations and maintain open data connections to communicate with other parts of the company and with headquarters.
- Working in the Cloud. It's now common for companies to work in the cloud using data that's stored somewhere offsite. This can be in one of the big public clouds like the ones offered by Amazon, Google, or Microsoft or it can be a private cloud available only to employees of the business. This is the change in the ways that companies operate that has probably created the most recent growth in bandwidth.

- Security Systems. Businesses often have their security monitored by offsite firms. Security today also means the use of numerous video cameras (and the ensuing video streams) used to monitor the inside and outside of a business.
- Sending and Receiving Large Data Files. Most businesses report that the size of data files they routinely transmit and receive have grown significantly larger over the last few years.
- VoIP. Many businesses now provide the voice communications between their various branches using Voice over IP. A reliable VoIP system needs to have dedicated bandwidth that is guaranteed and that won't vary according to other demands for bandwidth within the business.
- Communicating via Video. We've finally reached the time when employees routinely communicate via video both inside and outside the business.
- Email and Advanced Communications. While many businesses still rely on email, many have gone to more advanced communications systems that let parties connect in a wide variety of ways. Businesses are using collaborative tools that let multiple employees from various locations work on documents or other materials in real time.
- Supporting Remote Employees. Many businesses now save money by allowing employees to work from home full or part time. They need reliable broadband links to provide home-based employees the same access to systems that are on site.
- Data Back-up. Companies are wary of hacking and ransomware and routinely maintain several remote copies of all critical data to allow them to restore data after a problem.
- Internet of Things Sensors. Companies with automated manufacturing processes capture and store data on the performance of machinery. Companies routinely use sensors as part of alarm systems to warn them of any problems in hardware and software systems.

Entrepreneurship. The fastest growing parts of many local economies is the growth of small business, many which start in the home. Small businesses often start with one or a few employees and grow over time as they succeed. Start-up businesses generally are highly reliant upon good broadband.

Smart Factories. While the number of manufacturing jobs continues to drop, there is a movement in the country to create new smart factories that can work with a much smaller number of employees. Factories are being built, or older factories are being retrofitted to be more efficient. Smart factories need a lot of bandwidth for functions like the following:

- Programmable Robots. Automated factories are using robots that can perform a range of different tasks that can be directed by software to perform the need task at the right time.
- Collaborative Robots (Cobots). Collaborative robots work with human operators to take over time-consuming or high-precision work to enable the human operator to concentrate on the tasks that require judgement and experience.
- Precision Manufacturing. Robots can be used to perform high-precision tasks that were difficult and time-consuming with human operators.
- Making and Handling Customer Materials. Factories are manufacturing modern materials like carbon nanotubes on site as part of the manufacturing process.
- Performing Complex Chemical Processes. Automated machines are being used to handle the creation of complex chemicals that are either dangerous to handle or that require highly precise processes to create.
- Remote Instructions. Robots can be directed by remote engineers or technicians from a different location when that's needed for custom tasks.

- Equipment Monitoring. Sensors are used to monitor machinery and robots to predict machine failures and to dispatch repairs or order replacement parts before they are needed.

Economic Development and Jobs: Reliable and affordable broadband is still one of the key elements in traditional economic development to lure new companies to a community or to keep existing companies from leaving. As vital as broadband is to residents it’s even more vital to businesses.

Businesses want more than just fast broadband. They often require multiple feeds of broadband from different ISPs, on diverse routes to guarantee that they don’t lose connectivity.

Many businesses now want their employees to have broadband at home so that they can work from home as needed while gaining access to data in company servers. A new business will consider the whole broadband profile of an area before deciding to locate there. There are numerous municipal fiber ventures that claim significant economic benefits from fiber networks they’ve built. Many of them have been able to lure new businesses or have seen existing businesses expand.

Possible Solutions for the Broadband Gaps

This section of the report looks at some of the solutions that communities are finding in closing some of these different broadband gaps. It would probably require a 1,000-page paper to cover all of the ideas being tried in different communities, so these are a sample of some of the more interesting and effective ideas being tried.

Bridging the Availability Gap

Lending Mobile Hot Spots. There are many communities that are lending mobile hot spots to citizens through the libraries much the same way they lend books. A person can check out a hot spot for some period like a week or 10 days, which will provide broadband that can be used with computers or tablets.

This program requires two things. First, the cities would need to buy mobile hot spots and be prepared to continue to fund them into the future. You’d also need to partner with one of the big cellular companies to provide free or inexpensive cellular data to power the hot spots. Other communities have been successful in creating such partnerships. It’s worth noting that these hot spots will only work where there is cellular broadband available – so you should try to put together a map of where cellular works and doesn’t work – much like mapping landline broadband as described above.

Create More Public Hot Spots. The cities also can fund more public hotspots. Outdoor hot spots are particularly effective since students can sit in cars and use them any time of the day or night. The easiest way to start this process is by extending the WiFi at city buildings to the outside areas surrounding the buildings. To the extent that city buildings already have decent broadband, the concept is to share it with the public. It’s particularly easy to make bandwidth available to the public in the evenings when the government offices are closed, and the bandwidth isn’t being used – sharing this bandwidth adds no cost to what you pay for broadband.

Reward Businesses for Creating Hot Spots. We've seen communities that reward businesses for creating good public hot spots. The reward can be anything from public recognition and awards to some sort of break on local taxes and fees.

Bridging the Affordability Gap

This is probably the hardest gap to solve. Broadband is priced too expensively for many homes, and affordability efforts look for ways to bring less expensive broadband to the homes that most need it.

Inform the Public About Available Programs from Incumbents.

All three incumbent providers – AT&T, Charter, and WOW! - have programs that can reduce the price of broadband for customers that qualify. Regardless of their public relations announcements, these companies don't widely advertise the availability of the lower-price plans and many homes that qualify for these plans don't know about them.

The cities could undertake an education campaign to notify citizens about these plans. This would mean first fully understanding the details of each plan – who qualifies and what documentation does a home need to enroll. Armed with that knowledge the cities could mount an education campaign to get more subsidized broadband into homes that need it.

Find Broadband Solutions for Public Housing.

Many communities have found ways to bring affordable or free broadband to public housing. A common model is to buy one high-speed connection to a public housing complex and then use WiFi to distribute broadband to individual living units. Such connections often include low-cost or even free connections from local ISPs as a public service.

There is one national nonprofit that concentrates on this effort. ConnectHomeUSA[14] has helped communities find broadband solutions for public housing across the country. This organization works with another nonprofit, EveryoneOn to implement the solutions.

Support Local Affordability Efforts.

There are nonprofit organizations around the country that are tackling the affordability issue. One of the more ambitious such efforts is being done by Mobile Beacon.[15] This is a nonprofit that works nationwide to bring low cost mobile broadband to nonprofits organization around the country, and through those local nonprofits brings low cost broadband to low-income people.

There are numerous solutions being used by the nonprofits working with Mobile Beacon. One common effort that was discussed above is to provide portable WiFi hotspots that are distributed from libraries.

[14] https://connecthomeusa.org/

[15] https://www.mobilebeacon.org/

Mobile Beacon has also negotiated a deal with Sprint to provide low-cost cellular broadband to students and others that is priced as low as $10 per month for an uncapped cellular broadband connection.
An interesting study[16] was done looking at the impact of bringing broadband to low-income homes for the first time in the Twin Cities in Minnesota through the Mobile Beacon effort.

- 94% of Mobile Beacon subscribers use the internet daily and 82% say they use the internet several hours a day.
- The average home with Mobile Beacon used 41 GB of data per month. Students used an additional 25 GB per month. People looking for jobs used 14 GB more per month.
- The Mobile Beacon broadband had an immediate impact on students. Parents report that students spend an average of more than 4 hours per week doing homework on the Internet.
- The new Internet connection allows adults in low-income homes to get training. 32% of adults in the Mobile Beacon program were taking online courses,

Bridging the Computer Gap

Many communities have solved at least some of the computer gap.

Take-Home Computers for all School Kids. The most common solution are schools that send computers home with students. In some school systems these computers can only be used to connect to the school system network, making them homework-only computers. But other school systems have recognized that these might be the only computer in a home and let students and their family use the computer for other purposes. The biggest problem with school-provided computers are students that don't have a broadband connection at home.

Foster Programs to Get Computers into Homes. One such program is the nonprofit E2D[17] (End the Digital Divide) in Charlotte, North Carolina. The organization refurbishes laptops contributed by businesses in the Charlotte area and gives them to students. The organization has taken a several-prong approach to making this happen:

- They solicit used laptops from businesses in the Charlotte area. Most big businesses replace laptops every few years and most of them have been ending up in the landfill. Now a number of businesses send all of their used laptops to E2D.
- Used laptops need to be refurbished and E2D started several computer labs in area high schools where they hire students at a decent wage to refurbish the computers and install new software. The purpose of these labs is not only to get the laptops ready to distribute, but they are providing technical training for kids that is helping them move on towards college or a technical career.
- Households that get a new computer also get a live tutorial and technical support to best take advantage of the new laptops.
- Finally, the Charlotte area has a lot of homeless families and there are thousands of homeless kids in the area. E2D has partnered with Sprint to provide mobile hot spots and data plans that are providing broadband access to homeless students and others with no broadband.

[16] Bridging the Gap. https://www.mobilebeacon.org/wp-content/uploads/2017/05/MB_ResearchPaper_FINAL_WEB.pdf

[17] https://www.e-2-d.org/

The whole concept got started in 2012 when 12-year Franny Millen asked her father how kids without computers can keep up with schoolwork. She wanted to know what could be done about the problem and resolved to fix it. Her father, Pat Millen, founded E2D as a result of her challenge.

Another organization that works nationwide to fund computers is Minneapolis-based nonprofit PCs for People.[18] They provide PCs to households that need them and work with other entities including Mobile Beacon and E2D. The county, or some local nonprofit, could connect with PCs for People to find ways to get computers into the hands of the neediest households in the county. A local nonprofit could also mirror what's been done elsewhere.

Bridging the Broadband Skills Gap

There are many cities and nonprofits that have created programs to help citizens get basic computer literacy training. Some of the ideas that have worked elsewhere include:

Create a Computer Training Location. One of the most effective approaches we've seen is for communities to create a space for computer training. This might be a room that includes a number of computers – something many communities call a computer lab. Once such a training located is created, communities have found that it's not difficult to find volunteer trainers to teach computer skills courses. As mentioned above, when Chattanooga started their training program this way they got twice as many requests for training than what they expected.

Allow the Schools to be Used After hours for Training Adults. A number of communities use computer training centers that already exist in schools to hold after-hours training for adults.

Develop Training Course in the Libraries. A number of communities have developed computer training programs through their libraries.

[18] https://www.pcsforpeople.org/

II. Engineering Design and Cost

A. The Technologies

Fiber Technology

Per the Cities' preference, we only studied fiber technologies. The fiber design considered two technologies. Active Ethernet technology has been in widespread use for more than 30 years; GPON has been used for over 15 years. These are both mature technologies that are widely used and well understood industry wide.

Gigabit Passive Optical Network (GPON**)**

This technology was chosen as the primary way to deliver broadband. GPON makes use of optical splitters so that as many as 32 customers can share the same fiber (i.e., light source). If fewer customers are served from the same light source there is more potential bandwidth for each customer.

A GPON network can be designed in numerous configurations, but all designs include the same key elements. All networks start at a network core where the connection is made to the Internet. At this core, the ISP generally inserts the signals for the various products being delivered to customers.

From the core there are direct fibers to Optical Line Terminal (OLT), which are the devices that provide the light source for customers. These OLTs can be located in the same location as the fiber core or else can be spread around the city in neighborhood nodes, generally in huts or large cabinets.

There is one fiber leaving the OLT for each "PON," which is the local network consisting of up to 32 customers. These fibers go to splitter cabinets where each fiber is then "split" into the 32 separate fibers that go to customers. The splitter cabinets can be located at the same location as the OLT electronics, or they can be moved deeper into the network to be closer to customers. The name "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 and split into 32 individual paths. The paths from the splitter are "home runs" meaning that there is a dedicated fiber between a splitter site and each customer.

One of the biggest benefits of the GPON network is a savings in fibers in the network. Only one fiber is needed to serve an OLT and one fiber goes from the OLT to each splitter. The fiber is only divided into individual customer fibers at the splitters, which can be deep into the network. The GPON technology chosen provides 2.4 Gbps down and 1.2 Gbps upstream from each group of 32 customers.

Another advantage of PON is the number of electronic interfaces is reduced by the split, since one laser at the OLT can communicate with up to 32 customers. Increased bandwidth can be gained by reducing the number of customers on a PON – reducing a PON to 16 customers would double the bandwidth available per customer. Most fiber builders today choose GPON for residential service because it provides acceptable bandwidth and is less expensive than competing technologies.

One consideration when designing PON networks is the optical distance from an OLT port to the customer ONT; the design of the 2.5 GPON network includes allowance for 1.32 split and a distance limitation of

20 km (12.4 miles) design limit. This design was selected based on current vendor optical transmission availability. Due to the limited size and distances within the electric service territory, the number of remote cabinets resulting from detailed engineering will be mostly constrained by cabinet capacity rather than distance.

Future expansion of the network could utilize several technologies such as course wave division multiplexing (CWDM) or dense wave division multiplexing (DWDM) to increase bandwidth without having to remove, rearrange, and/or replace equipment in the network.

The current vendors for PON equipment include Alcatel-Lucent, Adtran, Zhone, Nokia, and Calix. Today passive optical networks use the gigabit passive optical network (GPON) technology primarily, even though more advanced versions do exist and are discussed below.

<u>Advantages</u>.

- Lower Cost (typically 10-20% less than Active E for the core fiber electronics).
- Can support both RF Broadcast TV and digital IPTV.
- More efficient use of bandwidth at the customer premise. A GPON network delivers 2.4 Gbps of data to a small cluster of houses and an individual customer will normally have access to much of this bandwidth for data transmission, thus giving the customer a faster bandwidth experience at the home.
- For the most part the technology can utilize existing home wiring. The PON network is designed to tie into existing telephone and cable wiring as long as they are conveniently located and in good working order.
- Requires no field electronic devices. The key word about a PON network is that it is passive. This means that no power is needed except in those locations, generally at central offices and major hubs or huts, where the provider places electronics.
- Can easily provide traditional T1s for larger business customers using business ONTs.

<u>Disadvantages</u>.

- Customer must be within 12 miles of a hub when using 1x32 splitter. This means with large installations that multiple hubs are required.
- More customers potentially are affected by a fiber failure in the field.

<u>Active Ethernet (Active E</u>**)**

Each network node in the design is capable of offering metro Ethernet services using active Ethernet technology. This technology provides a direct data connection to a single customer.

An Active E network is essentially a fiber “home run” from the Central Office or other node, meaning that one fiber goes from the electronics core directly to the customer. This technology has several advantages and is well-suited for serving large businesses where the customer requires more stringent network uptime and higher bandwidth. An Active E network also can provide symmetrical data capabilities (upstream and downstream data rates are the same) at high data speeds. The downside to Active E 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. Active E also has higher data capabilities and can inexpensively provide for data rates up to 10 gigabits per second. Faster speeds are possible, but with significantly higher electronics costs. One of the biggest advantages of Active E is that it's easy to change the connection to a single customer as customer requirements change – the laser serving that customer can be changed without affecting any other part of the network.

The primary vendors in the Active E equipment market are Cisco, Calix, Adtran, and Nokia-Alcatel-Lucent. Since PON equipment has won a much greater market share than Active E equipment, this part of the industry has been in a bit of a decline for a few years. Active E is easier to engineer and expand and is useful for customizing solutions for small volume specialized applications.

Advantages.

- Can serve customers up to 36 miles from last active field device.
- Requires less pre-planning and engineering.
- A single point of failure will often affect fewer customers
- Offers true non-blocking 1 Gbps and faster speeds.
- Easily upgradeable to 10 Gbps by switching optics.

Disadvantages.

- Shares data and CATV bandwidth in the same data stream. Today an Active E system can cost-effectively deliver up to 10 gigabits of data to each home, but more typically these networks are designed to deliver 1 gigabit. This is not a shared pipe with neighbors and each customer can get a dedicated gigabit pipe. However, this one data stream must support CATV, data, and voice together. Thus, if a customer is watching multiple HDTV sets, the amount of bandwidth left for data will be something less than a gigabit.
- Usually requires additional home wiring. Since Active E provides only one bandwidth (the data stream), the video service (IPTV) always requires a high bandwidth data wire, such as category 5 or 6 wire to each TV location. The increased use of WiFi and advances in WiFi speeds have mitigated some of this.
- More physical space is required for electronics because there are more fiber terminations onto the electronics. If the electronics are located in the field, the cabinets housing the electronics and fiber terminations can become relatively large. This means most cabinets need to be on private land and not on public rights-of-way.
- Fewer customers served per electronic chassis. Since only one customer can be served per laser then there are fewer customers that can be served from a single card.
- Larger fiber cables are typically used due to the requirement of a single fiber per customer from the ONT to the electronic chassis. The use of larger fiber cable in an aerial application may significantly increases make-ready costs.

B. Network Design

The study looks at building fiber to pass every home and business in the cities.

GIS System

Oakland County has an extensive GIS system in place. This system contains a wealth of information such as streets, address points, structure information (i.e. residential, commercial, government), etc. We utilized this data extensively to determine potential fiber routes, crossing locations for major roads and railroads, equipment locations and other data points needed for the network design.

Passings

The telecom industry uses the term passing to mean any home or business that is near enough to a network to be considered as a potential customer. Our engineers relied on the Oakland County Land Base information to determine the number of passings for this report. Our engineers settled on the following as the count of potential passings in the city:

Residential	Farmington Hills	Farmington	Total
Single Family Home	18,711	2,747	21,458
Small MDUs	1,798	217	2,015
Mixed Use Residential	0	436	436
Total	20,509	3,400	23,909

Business	1,441	186	1,627
Mixed Use Businesses		224	224
Public / Institutional	443	59	502
Industrial	1,139	31	1,170
Total	3,023	500	3,523

Multi-Dwelling Buildings	Farmington Hills	Farmington	Total
5 - 10 Unit MDUs	358	37	395
11 - 19 Unit MDUs	228	109	337
20 - 49 Unit MDUs	79	12	91
50+ Unit MDUs	2	2	4
Total	667	160	827

Multi-Dwelling Units	Farmington Hills	Farmington	Total
5 - 10 Unit MDUs	2,549	262	2,811
11 - 19 Unit MDUs	3,201	1,451	4,652
20 - 49 Unit MDUs	2,241	253	2,494
50+ Unit MDUs	118	261	379
Total	8,109	2,227	10,336

Total Passings	Farmington Hills	Farmington	Total
Residential	20,509	3,400	23,909
Large Multi-Dwelling	8,109	2,227	10,336
Business	3,023	500	3,523
Total	31,641	6,127	37,768

The basis for each of these groups of passings is as follows:

- Residential: This includes single family houses as identified by the city GIS system. For purposes of calculating costs and customers, we also counted apartment units in buildings with 4 or fewer apartment units the same as a single-family home.
- Multi-Dwelling Units: This includes structures that contain more than one dwelling unit. For example, an apartment complex might be made of 10 buildings with 10 apartments or condos each for a total of 100 passings.
- Commercial/Office: It's always difficult counting businesses in a city. Our goal for conducting this study is to count businesses that would be able to independently subscribe to broadband. While there are likely many home businesses throughout the city, it would be difficult to determine the exact number. We've also found that most ISPs don't try to sell business service to business located in homes. We also elected to not rely on US Census data due to the age of the data. US Census data also generally overcounts businesses since there are many businesses that have more than one corporation at a single business address. For example, it's fairly common for a standalone business to put the building in one corporation and the operating business in a separate corporation.

  We also rarely rely on city business directories. These listings tend to be too low and don't count every business that might be a potential customer.

  We elected to derive business counts from the Oakland County GIS data, and tried to clean up the database as much as possible. We think this approach will have properly ignored businesses that operate from home or require a business license without a physical address (like realtors). We did our best to identify buildings that include multiple businesses, since each business is a potential broadband customer. We know the number of businesses is greater than the number of parcels with a business designation. We compared our final count with other cities we have studied and the count of businesses to business parcels looks reasonable to us.

  For study purposes we further separated the businesses into categories that would require more expensive electronics and those that do not. Some of these may require more expensive electronics and higher speeds, more security, or may even want to lease a specific fiber route.

  - Mixed Use: Includes a mix of business and residential establishments within the same structure. For the engineering portion of the study, most business/commercial operations in a mixed-use building will be served by the same equipment used for most residential applications.
  - Medical, Educational: Includes various government, medical; and educational structures across the city as identified by the GIS system. Some of these may require more expensive electronics and higher speeds, more security, or may even want to lease a specific fiber route.

- Other: Includes Recreational, Religious, Transportation, and other Community Institutions as identified by the GIS system. From a broadband perspective these are typically mostly treated as a small business in terms of broadband products.

Miles of Fiber Construction

The network design incorporated some fiber already owned by the city. Finley Engineering determined that the following new fiber is needed for the project.

Miles of Fiber	Farmington	Farmington Hills	Total
Aerial	6.5	113.1	119.6
Buried	41.2	375.2	416.4
Total	47.7	488.3	536.0
Cost per Mile	$162,588	$149,600	$152,244
Cost per Passing	$1,419	$2,011	$1,952

Design Considerations

A FTTP network brings fiber to homes and businesses. There are several key factors to consider in the design of a fiber network:

- Whether to use buried fiber, aerial fiber, or some mix of the two.
- The specific electronics design philosophy.
- Redundancy.
- Connectivity to outside world.

Fiber Design Considerations

Aerial versus Buried Fiber. The first decision that has to be made for building fiber is whether to put the fiber on existing poles or to bury it underground. There are a few key issues that usually drive this decision:

- Cost. If there is a big cost differential between the two construction methods, most fiber overbuilders will choose the lowest cost option, assuming it's a valid option. A general rule of thumb when designing a fiber network is to try to bury fiber where other utilities are buried and to try to construct on poles when other utilities are on poles.
- Maintenance. Aerial fiber is subject to damage from weather. In Michigan this means ice storms and bad thunderstorms. The owner of an aerial fiber network must be prepared to make repairs after storms and also face the occasional major outages that follow a bad storm. However, buried fiber is not without issues. The primary cause of outages for buried fiber is fiber cuts due to somebody excavating in the rights-of-way. It's fairly common for somebody building a driveway or for another utility to cut a buried fiber. This is more prevalent in rural areas where contractors don't realize fiber is present. In towns there usually is a more formal process to locate existing utilities before digging anywhere in or near to streets.
- Access. There are circumstances where it's impossible to use one of the construction methods. For example, both municipalities and electric cooperatives are not required, by federal law, to allow fiber builders to use their poles. CCG Consulting is aware of one case in West Virginia where an electric cooperative would not allow a competitive fiber builder to use their poles. Private

landowners are not required to grant rights-of-way for fiber. This means owners of private roads can block aerial or buried fiber. Since most places want fiber, we don't see fiber kept out of many neighborhoods – but we have seen private subdivisions prohibit fiber if it means digging up their private streets.

- Impediments. There are special circumstances that can make it more expensive and time-consuming to build fiber. For example, it's often expensive and time-consuming to gain the needed rights-of-way to build fiber across bridges, under railroad tracks, or under free overpasses. There are often complicated rules that must be followed to build fiber through state and national parks and forests. We know of states where the Department of Transportation adds burdensome rules to build along state highways.
- Rights-of-Way. Most public roads include public rights-of-way along the sides of the road. Such areas are usually designated by state laws or local ordinances that specifically define the right-of-way. Utilities are allowed to construct in existing rights-of-way, but only to the extent that they do so without harming existing utility facilities. Rights-of-way become an issue when building on private lands or roads.

Considerations for Burying Fiber. Bury fiber is constructed using several different methods:

- Trenching. With trenching, a trench is excavated alongside the road and hardened fiber is either laid into the trench or else conduit is placed in the trench and then conduit is pulled through.
- Direct Buried / Plowing. In places where the soil is soft and there are few rocks it's possible to use a heavy vehicle to "plow" fiber or conduit directly into the ground.
- Boring. With boring, a machine bores a horizontal hole through the earth at the suitable depth and a conduit is then pulled through the hole. Fiber is then pulled through the empty conduit.

Considerations for Aerial Fiber. There are a few issues that affect using aerial fiber, and it's not always the cheapest or easiest alternative.

- Pole Attachment Fees – Anyone that attaches to poles must rent space in the form of attachment fees paid to the pole owner.
- Access – Although regulations guarantee access to a pole, timely access may be a large issue. There are regulations regarding time requirements for pole owners to respond to requests and a builder can even build without permission if enough time passes. The main problem is making sure that the pole is in a condition to be attached to which is discussed below.
- Placement on Poles – There are regulations on where fiber can be placed on poles and how it can be attached. These issues involve ground clearance, separation from other services, separation from power, and other attachments on the pole. Field observations noted that numerous issues in the aerial infrastructure currently in place that does not currently comply with existing regulations.
- Fiber in the Power Space – One way to work around some of the issues with other providers and their attachments is to locate fiber in the power space. Fiber cable is non-conductive and can safely be located near power lines with some additional installation requirements. The downside of this is that any technician who works on the fiber must be certified for high-voltage work. Technicians with this certification are typically paid far more than other similarly trained technicians. The fiber networks around the country located in the power space are typically owned and operated by electric utilities, so they already have technicians and equipment qualified to work in this space.

- Regulations – Current National Electric Safety Code and most pole owners require that every pole be analyzed to verify that the new attachment will not create a code violation and that the pole is strong enough to support the additional load.

Make-Ready. The most important aspect is something that the industry calls make-ready. There are national electric codes that define the spacing between the wires of different utilities. The national electric codes include two important requirements that can affect the cost of getting onto poles. There must be sufficient space between the different providers on a pole. For example, a new fiber must be at least 18 inches above the cable below it (be that a telephone cable or wires from a cable TV company). There are also minimum clearance rules for the lowest that any cable can be above ground for the safety of those beneath the pole. These rules are in place to provide safety for technicians that work on cables during and after storm damage.

When there is not sufficient room for a new wire, then an industry practice called make-ready is invoked. Make-ready is the process of moving the existing wires on poles, as needed, to make room for a new wire. The make-ready can be somewhat simple, such as moving an existing wire by a few inches, or it can be major, such as having to move all of the wires on a pole or possibly even replacing the pole with a taller one.

Make-ready is expensive for two reasons. First, the new attacher has to pay to make all of the needed changes, even if the old wires were out of specification. Second, there can be big time delays while other providers using a pole come and make their changes to make room. Make-ready can be some expensive that in some cases it's cheaper to bury a fiber rather than to deal with the cost and delays doing the make-ready to be able to add a new fiber.

One Touch Make-Ready. The FCC passed new rules that went into effect in May of 2019 that should make it easier to get onto poles. The new rules apply only in the thirty states that follow FCC pole attachment rules. Michigan does not follow the FCC rules. However, in March of 2020 the legislature adopted Michigan-specific rules that are essentially identical to the FCC rules.

The most significant change in the rules is a new classification of poles as either simple or complex make-ready. The order defines how to make this classification. In real life practice, the new attacher will suggest this determination, although it could get overturned by the pole owner.

There are streamlined new rules and timelines for completing the make-ready on simple poles. If the pole owner is unwilling to commit to fixing simple poles in the needed time frame, then the new attacher is allowed to make the changes after properly notifying the pole owner. The new attacher is free to rearrange any existing wires as needed, again after having properly notified all of the parties. These new rules eliminate situations where a pole owner refuses to cooperate with a new attacher, as happened in a few cities where AT&T fought Google Fiber. Something to consider is that the rules require using a make-ready contractor that has been pre-approved by the pole owner – but there are ways around this in some circumstances.

These new rules can mean a big improvement in construction schedule where the needed changes are for simple poles. That would be poles where wires need to be moved to make room for the new attacher. However, the new rules are not necessarily faster for complex poles. Those are poles where the make-ready could cause damage to existing wires or where the old pole must be replaced. The make-ready process for complex poles has always been slow. The new rules tighten up time frames a little, but the time required to get onto a complex pole can still take a long time.

For complex poles the process will still allow the existing wire owners to work sequentially – meaning that they can invite each existing company on the poles to do their own work, one company at a time. This coordination has to be scheduled by the pole owner. The process could still take six months even if done perfectly. The new rules don't seem to provide a solution for when the pole owner or the existing attachers drag their feet on complex poles. Other than some slightly improved timelines, the work on complex poles looks to still be as dreadful and slow as the old make-ready rules.

Fiber Costs

Our analysis was done in stages that allowed us to understand the issues with building broadband in the cities. The review started with identifying where fiber was to be placed on existing poles or buried. We also looked to see if it was possible to build fiber in alleys and backstreets instead of in front of homes.

Once all of the relevant facts were assembled, Finley Engineering undertook a detailed design of selected parts of the city. Our process began by dividing Farmington Hills into 67 small serving sectors and Farmington into nine serving areas.

Finley then undertook a detailed engineering analysis of six sectors in Farmington Hills and three in Farmington. The sectors were chosen to represent different parameters that would affect construction costs. For example, we choose sectors that were mostly aerial, mostly buried, or some mix of each. We chose sectors that had different mixes of businesses and residences. We chose sectors that had different levels of apartment units along with single-family homes. For each of these selected sectors we undertook a detailed engineering analysis. We looked at issues like topography and home density. We then designed a fiber solution for each of the 9 selected sectors. This meant looking at the details of the fiber design. We looked at potential routes for a backbone fiber. We designed a distribution network to reach every home and businesses including determining the sizes of fibers, the placement of electronics, and customer access points, etc. We considered factors like the distance between neighbors, the average drop length to get from the street to buildings, etc.

Finley then determined a specific opinion of probable cost for each one of these nine sectors, where we layered on the cost of materials and labor required to build fiber. We captured these costs in such a way as to determine key metrics, such as the cost per mile of fiber construction in different types of neighborhoods.

Finally, we looked at the remaining sectors and determined how each sector compared in characteristics to the nine sectors. If a sector was nearly identical in nature to one of the sectors we had studied in detail, then we priced out the sector in the same manner as the detailed sector. However, most sectors were not that straightforward – for instance, they might resemble some of the characteristics in two of the test sectors. In that case, we extrapolated the cost of the sector depending upon the degree of similarity. This extrapolation was based upon several factors:

- The varying types of subscribers in each sector.

- The density of subscribers.
- The mix between aerial and buried fiber.

At the end of this process we had developed a cost for each of the smaller sectors. Once we added these sectors together, we added some additional costs to the network. The primary network cost was based upon the assumption that a 48-fiber would be used to connect each sector back to the network core. These larger fibers would not necessarily be constructed with separate cables, and when possible, we incorporated these fibers into other fibers that were designed within the neighborhoods.

Permitting

Our engineering design includes estimates of permitting costs. These costs are largely based on permitting fees required by the individual agencies that would require them (i.e., Railroad, State and County Highways, etc.). These permits are generally on a size and scope basis or a per crossing amount. We have estimated these crossings based on prior projects. These costs may change depending on the amount and locations of the crossings. Additionally, the exact location may need to be altered due to information gathered during the permitting process. These costs are for the permit fees only, any cost to prepare permits or associated documentation are covered under the engineering section.

Engineering

The design also estimates engineering fees. These can vary substantially based on the project requirements, scope of work, and desired level of construction management. For a build as large as the cities of Farmington Hills and Farmington, we made the following assumptions in order to estimate what these costs may look like.

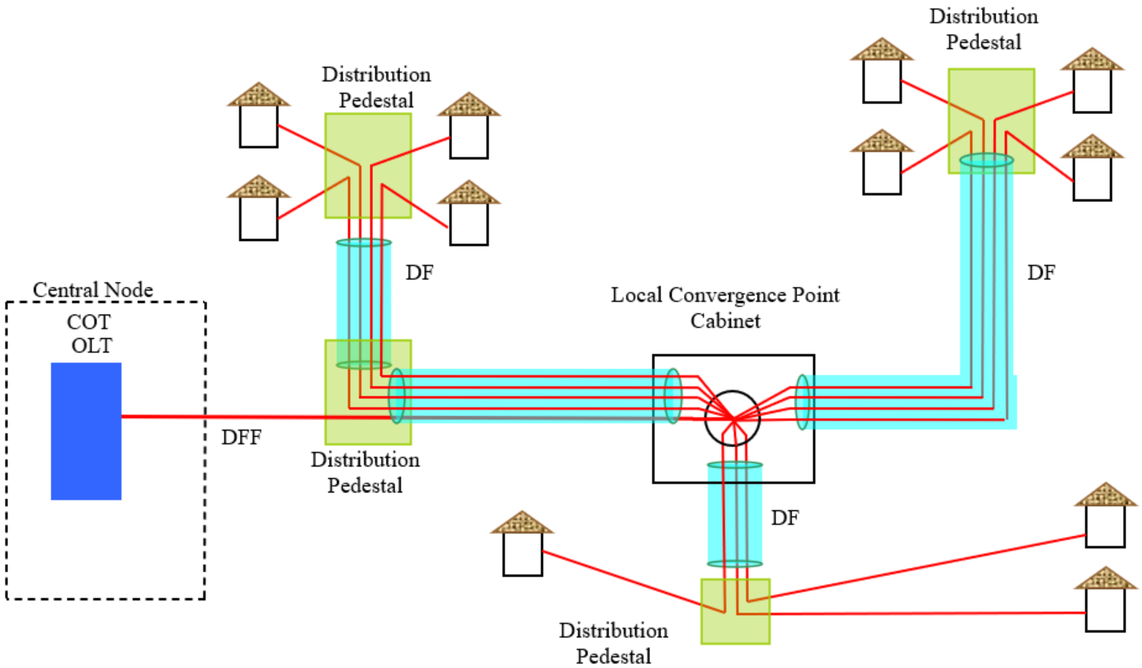
1. A period of 6-8 months in advance would be required to complete the engineering and permitting of an area of the city in order for the construction work to begin. The engineering will then run in parallel with the construction effort as we move forward with the project for another 24-36 months. This would include finishing the high-level design for the entire city, field work such as conduit surveys and staking, site acquisition for electronics location, contract preparation, etc.
2. We assumed a 3-year construction period with a crew of 5 inspectors, 1 supervisor, and 1 office/support person. These personnel would oversee and inspect construction, conduct invoicing, track costs and completion, and assist both the owner and contractor in ensuring the project is completed per the plans and specs.
3. Office support and an on-site Administrative Assistant are also included. These will likely be required during the engineering period, during construction, and afterwards for closeout items.
4. Electronics turn-up and integration are also included for the FTTH equipment as well as the switches and routers.
5. The estimate includes time to prepare and submit permits, coordinate traffic control, and prepare traffic control plans, prepare as-built drawings, contract preparation and execution, environmental filings, etc.

Electronics Considerations

The two most utilized designs for FTTH are Passive Optical Networks (PON) or Active Optical Networks (AON). While advocates of either technology can be quite passionate about their stance, we believe that the overlying electronics is in a constant state of change. Evidence of this can be found in the extremely quick evolution from proprietary systems of the past to standards-based interoperability between venders today. Looking to the near future, virtualization and software defined networks will add their own impact on how services are delivered. The one constant through all of this, the Optical Distribution Network (ODN) is still your largest investment with a projected lifespan of 20 to 40 years or more. We are constantly looking forward at the underlying technology and where money is being spent on research with the intent of designing for the future, not where the electronics are at today. This research allows us to provide advice that will allow you to make informed decisions as you plan your network. Since the ODN is also the most expensive portion of the network, we cannot look to the lowest cost fiber network, but must look to a network that will be usable through its projected life. Therefore, the design for this network was based on ITU GPON standards. ITU's commitment to ensuring new electronics technologies are backwards compatible to the current ODN standards provides the best possible path forward available today,

Farmington/Farmington Hills is a very compact serving area by communications standards. Therefore, with the exception of electronics at the central node and at homes and businesses, we were able to design an entirely passive optical distribution network, eliminating the need for multiple electronic sites with their associated buildings/hut, power, security, and ongoing maintenance requirements. In summary, the network will consist of a Central Node (Node), Distribution Feeder Fiber (DFF), Local Convergence Point (LCP), Distribution Fiber (DF), and the Optical Network Terminal (ONT) at each establishment.

These network elements are shown in the following simplified diagram:



- Central Node: A building or structure housing the common electronics necessary to interface between the Internet on the upstream side and the consumer on the downstream side.
- Distribution and Feeder Fiber (DFF). This is the fiber used to provide signal between the Node and the LCP. In this design, each distribution feeder fiber can support up to 32 passings. The network design also incorporates providing enough fibers so that some larger customers can have a desiccated fiber. Finally, there will be enough DFF in the design to account for future growth.
- Local Convergency Point (LCP). This is a neighborhood cabinet (approximately 36'x24"x60") that serves a discrete local group of passings. The cabinet does not require external power or other utilities and is the place in the network where the fiber is 'split' to reach individual groups of 32 passings. In this design, we divided the network into serving areas containing approximately 500 to 600 passings. The individual serving areas are small enough and border two to three additional serving areas, making it easy to provide redundant routing for high value customers through the adjacent serving areas.
- Distribution Fiber (DF) is fiber placed the LCP and each customer. Again, additional fiber is designed into the distribution fiber network to account for future growth. The distribution fiber is designed in a homerun configuration, meaning that there is a straight shot of fiber from the LCP to any given subscriber.
- ONT (Optical Network Terminal) is the device placed at each customer to convert the optical signal into usable data/voice/video signal.

Nodes and Electronics Sites

It was assumed that all nodes and electronic sites would be located on city property, so we have assumed no land costs.

The central node was designed based on the following parameters:

1. Nodes were sized to house fiber frame equipment large enough to support the LCPs and the immediate serving where the node is located in.
2. Each node includes DC power and batteries to protect against power outages as well as either a connection point for a portable generator or a permanent generator.
3. Nodes are large enough to allow for collocation with multiple ISPs if you pursue the open access operating model.

Electronics Costs

Finley priced the FTTH (Fiber to the Home) electronics in this study based upon recent prices obtained from several different manufacturers. These are established vendors that we have confidence in, and their equipment is similarly priced. Finley Engineering is vendor neutral and is not suggesting that you use any one vendor. Rather, our experience is that the cost of the FTTP electronics is similar between vendors and thus using a recent quote from any of the vendors is sufficient for predicting the cost of the network electronics.

The network electronics will be placed in the central node. Equipment accounted for include:

- AC and DC power Equipment. This is for the DC power plant that will power the network electronics. There are monitoring systems included in these rectifier systems as well as overcurrent protection devices.

- Battery Backups. These are banks of batteries that will connect to the rectifiers to allow the system to sustain short term power losses. These are typically designed for 8 hours.
- Generator Connections or Generators. Generators are for long term outages. Some facilities have existing generators in place; however, a study would be required to determine existing loads and if there is adequate capacity on the generator to support the network equipment. The cost to include a new generator at the Farmington Hills and Farmington node sites are $65,000 and $45,000, respectively. This is based on a single outdoor stand-alone diesel generator.
- Aggregation, Routing, Firewall, and Transport Equipment. Each Central Node will require IP equipment for aggregation of the traffic FTTH traffic for hand-off to an ISP/ISPs located within the Central Node or transport the signal to remote ISPs. Layer 2/3 routers, firewalls, and switches with optical connections will be required to manage the potential amounts of traffic.
- FTTH Platform. This equipment will contain the individual lasers and receivers that will transport data services over fiber to the subscriber equipment.
- Fiber Frames and Terminations. This is where the ring and distributions fibers will be terminated in racks and frames. Jumpers will be installed between these fiber frames and equipment to make the connections from subscribers to the rest of the network.

These systems are largely modular, meaning that more subscribers can be connected by adding more chassis, cards, optics, and even software upgrades. This means that the real costs for initial installation may be higher or lower based on take rates and other factors detailed in the financial report. We have built these models to factor in subscriber counts and take rates for each electronics site and node. Our models calculate equipment and parts needed such as cards, optics jumpers, splicing, and more.

Customer Electronics

The customer electronics used to serve customers is referred to in the industry as an ONT (Optical Network Terminal). This is an electronic device that contains a transceiver which can send and receive light from the network and convert to traditional Ethernet on the customer side of the network.

Traditionally the ONTs have been placed on the outside of buildings in a small enclosure and have been powered by tapping into the electricity after the power meter. But today there is also an ONT that can be placed indoors; and is powered by plugging it into an outlet, much like the cable modems used by cable companies. The cost of the two kinds of units is nearly identical and so the study doesn’t choose between the two types of units.

Some companies still put the ONT on the outside of the home to give their technicians 24/7 access to the units. But other providers are electing internal units since they are protected from the weather. The industry is split on this choice, but it appears that internal units are becoming the most predominant choice for new construction. One of the major contributing factors is the advancement of WiFi technology and the increasing number of wireless devices in the home.

ONTs are also available in multiple sizes that can be categorized into units designed to serve homes and small business and units designed to serve large businesses. The study assumes that the smaller unit was used for the vast majority of customers. These units provide one to four Ethernet streams, which is sufficient for the large majority of customers.

- Residential costs: The model assumes that the hardware electronics for an ONT costs $105. This is a simple ONT with only a single Ethernet and POTS line. The alternative is a slightly more expensive device that allows up to 4 Ethernet ports. Our study includes an additional cost for an optional WiFi router. The study assumes this is optional since not all customers will want an IS-provided router. Routers can be built into the ONT or provided separately. We recommend a separate WiFi unit which allows for updating just the ONT or the WiFi unit without having to replace both.
- Business costs: Many small businesses can use the same ONT as residences, but larger businesses sometime require the use of more advanced ONT equipment. Today the only real use for the larger business ONTs are to serve businesses that still have a large number of traditional analog telephone lines. These larger units' cost on average $1,380.
- Battery Backup: Historically many FTTP networks have been designed with battery back-up for the ONT. However, many small fiber providers have stopped providing batteries. The batteries were historically installed to power telephones in the case of a power outage at the home. However, there are fewer and fewer phones in existence that are powered from the phone line and most phones must be plugged into an outlet. When such a phone loses power, it can't be powered by the battery for the ONT.

In 2015 an FCC ruling declared that every voice provider must offer a battery back-up solution for customers that buy telephone service that is not delivered on copper. Here is what the FCC ordered:

- The ruling only covers residential fixed voice services that do not provide line power (which is done by telephone copper). This does not apply to business customers.
- The back-up power must include power for all provider-furnished equipment and anything else at the customer location that must be powered to provide 911 service.
- From the effective date, companies must describe to each new customer, plus to every existing customer annually the following:
    - The solutions offered by the company to provide 8 hours of backup for phone service, including the cost and availability.
    - Description of how the customer's service would be affected by loss of power.
    - Description of how to maintain the provided backup solution and the warranties provided by the company.
    - How the customer can test the backup system.
- Within three years of the effective date of the order a provider must provide a back-up solution that is good for 24 hours and follow the above rules.

What this means is that any ISP offering voice must also offer an optional battery backup plan for customers, but they will be able to charge enough to recover the cost of the battery backup unit. We have not included this cost in the study since the assumption is that the business would be able to charge the full cost of buying any such optional battery backup systems to the customer.

Other Assets

There are other assets needed to operate a triple-play fiber business. This would include the electronics at the head-end as well as at the customer locations needed to provide the triple-play services. There are also ancillary assets needed to operate the business such as vehicles, computers, etc. These assets will be described in more detail in the financial report.

Multi-Dwelling Units (MDUs)

There are a number of issues that affect the ability to bring fiber to multi-dwelling units (MDUs), which are apartment and condominium complexes. This is discussed in more detail in Section IV.C. Generally, the drop and electronics costs are lower for an MDU since these components can be shared among multiple tenants, however, the wiring costs to reach these tenants can easily offset or even exceed these savings.

Farmington Hills and Farmington have a high number of MDUs in many configurations, so we modeled 5 different scenarios.

1. Under four units per structure.
2. A structure with 10 units.
3. A structure with 35 units.
4. A structure with 100 units.
5. Units where copper wiring can be reused.

In the study we have assumed that the cost of serving an MDU customer with less than 4 units is roughly the same as serving an equal number of single-family homes (a duplex would cost the same as 2 homes for example). The most cost-efficient way to serve these units is to bring fiber directly from the street to the individual units.

Structures larger than four units must be constructed and served differently. For example, instead of building multiple drops to reach each unit there would more typically be single larger fiber drop (12 fibers) that could be terminated inside or outside the building. Conduit and fiber would then be routed from this splice point to each individual unit. Looking at satellite imagery it appears that many of the apartments in the cities have independent exterior access and do not have common hallways or spaces. The most economical way to serve these would be to attach fiber in conduit to the outside of the building.

We then examined the cost of serving apartment buildings of different sizes. For example, following is a typical cost we would expect for bringing fiber to a 10-building apartment unit:

10 Unit Building Description	Unit Cost	Qty	Ext. Cost
MDU ONT's			
Fiber Wiring Cost per Unit	$594.00	10	$5,940.00
Indoor ONT 1GE, 1POTS	$138.60	10	$1,386.00
SFU Power Cord and Fiber Jumper	$42.24	10	$422.40
			$7,748.40
		GRAND TOTAL	**$7,748.40**

The cost components differ by the size of MDUs. For example, for larger apartment building it’s possible to use extra electronics as a way to reduce the size and costs of the needed fibers. In real life an assessment would be made about the most efficient way to serve each apartment building that is to be added to the network. The following example shows the sample cost of serving a larger apartment with 35-units.

35 Unit Building			
Description	**Unit Cost**	**Qty**	**Ext. Cost**
Electronics Closet			
1x32 Splitter	$1,000.00	1	$1,000.00
FTTH Chassis Package & Fiber Mgmt.	$1,129.92	1	$1,129.92
48" Wall Mounted Fiber Frame W/Cassette Shelf	$835.56	1	$835.56
Patch and Splice Cassettes	$203.28	12	$2,439.36
2m Fiber Jumpers	$11.55	50	$577.50
Fiber Management	$330.00	1	$330.00
Installation Turn-up and Testing	$3,300.00	1	$3,300.00
			$9,612.34
MDU ONT's			
Fiber Wiring Cost per Unit	$990.00	35	$34,650.00
Indoor ONT 1GE, 1POTS	$138.60	35	$4,851.00
SFU Power Cord and Fiber Jumper	$42.24	35	$1,478.40
			$40,979.40
		GRAND TOTAL	**$50,591.74**

Larger apartments are even more complex. Structural components of larger buildings such as concrete floors and beams create barriers that are difficult to penetrate and can drive up rewiring costs. Below is an example of the costs of serving a 100-unit apartment building, including the cost of rewiring.

100 Unit Building			
Description	**Unit Cost**	**Qty**	**Ext. Cost**
Electronics Closet			
1x32 Splitter	$1,000.00	3	$3,000.00
48" Wall Mounted Fiber Frame W/ Cassette Shelf	$835.56	1	$835.56
Patch and Splice Cassettes	$203.28	12	$2,439.36
2m Fiber Jumpers	$11.55	120	$1,386.00
Fiber Management	$330.00	1	$330.00
Installation Turn-up and Testing	$5,280.00	1	$5,280.00
			$13,270.92
MDU ONT's			
Fiber Wiring Cost per Unit	$1,108.80	100	$110,880.00
Indoor ONT 1GE, 1POTS	$138.60	100	$13,860.00
SFU Power Cord and Fiber Jumper	$42.24	100	$4,224.00
			$128,964.00
		GRAND TOTAL	**$142,234.92**

There is one other option to consider in bringing broadband to apartment buildings. In the past few years, G.Fast technology has emerged as a powerful tool to serve these larger facilities. G.Fast brings fiber to the building and then used existing telephone wires to bring broadband to apartment units. G.Fast speeds vary depending upon several factors, but it's been widely reported that G.Fast can deliver speeds in many apartments between 300 Mbps and 400 Mbps. There are more recent developments in the labs at vendors that means speeds might get even faster. Below is an example of what a 35-unit MDU might cost to rewire with G.Fast.

35 Unit MDU with G.Fast Description	Unit Cost	Qty	Ext. Cost
10G Electronics			
10 G Active Ethernet Transport Card W/ X Ports	$3,895.00	1	$3,895.00
10GE SFP	$425.00	2	$850.00
G.Fast 16 Port Indoor Unit	$2,900.00	2	$5,800.00
Installation	$1,500.00	2	$3,000.00
			$4,745.00
MDU ONTs			
Copper Wiring Rehab	$250.00	35	$8,750.00
G.Fast Modem 1GE, 1POTS	$110.00	35	$3,850.00
Power Cord	$17.00	35	$595.00
			$26,740.00
		GRAND TOTAL	**$31,485.00**

The study incorporated a mix of these different costs. We assumed that some apartments would be wired with new fiber while others would utilize existing telephone wiring and use G.Fast. Our goal was to show a representative cross section of costs that together would be a reasonable estimate for the cost of serving apartments in the market.

What we've seen in the market is that this method of pricing is fairly representative because ISPs typically decide to not serve apartment where the cost of wiring is too expensive.

Our Opinion of Probable Cost

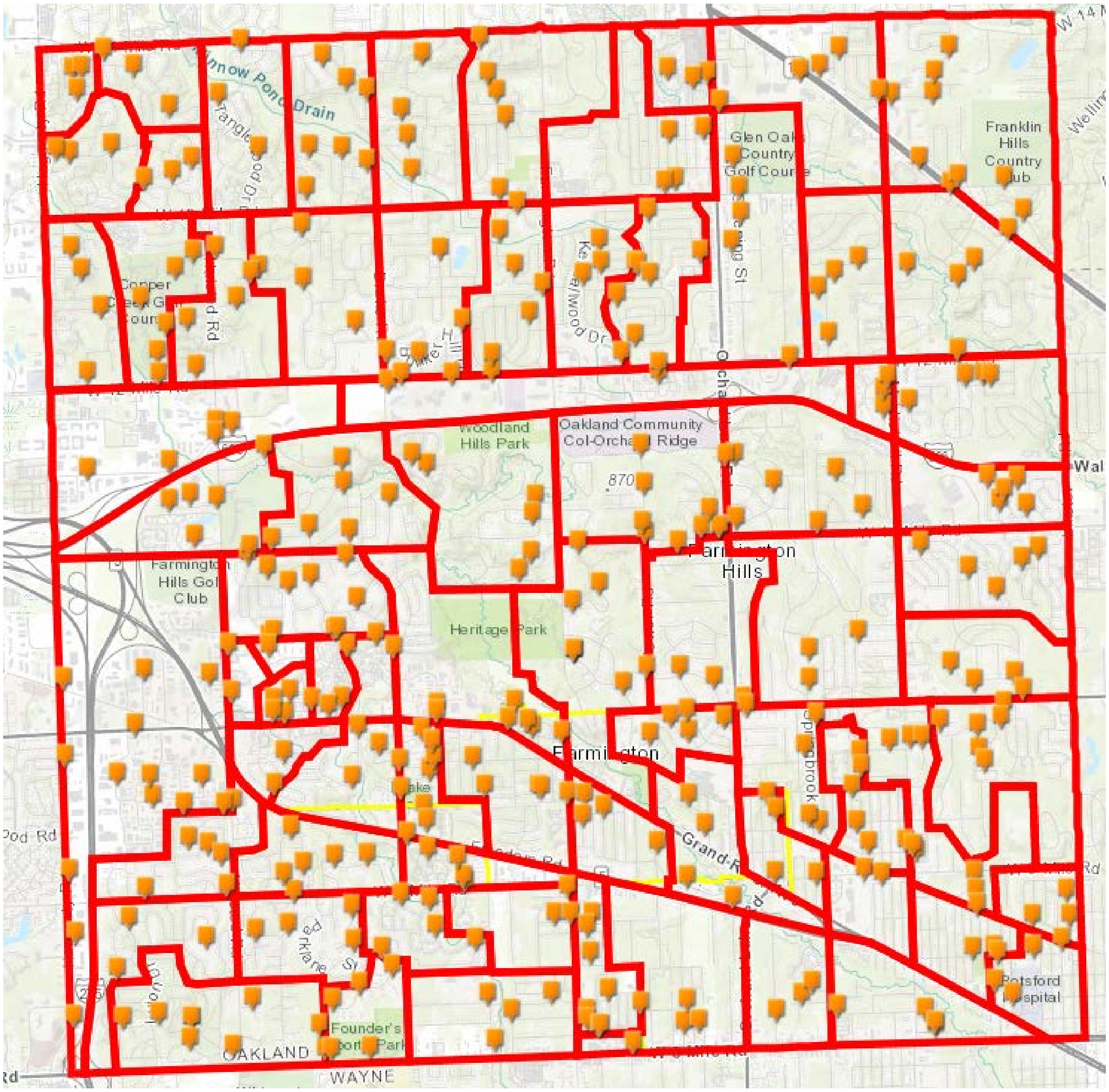
Creation of the Opinion of Probable Cost (OPC) to build fiber within the communities started with an onsite field survey of both communities by Finley. The review looked at the condition of the existing pole lines, potential buried fiber routes (back lot or front lot), the best method of construction (aerial or buried) for each portion of a serving area, the distance between subscriber points, average drop length, etc. Information gathered during the field survey was logged using a GPS enabled data collector and plotted in the preliminary design maps for both communities. The diagram titled "**Farmington and Farmington Hills – Field Survey Map**" on the following page shows the serving area boundaries and the datapoints recorded for each area. As stated earlier, Farmington Hills was divided into 67 smaller serving areas while Farmington was divided into nine serving areas

Six representative serving areas in Farmington Hills and three serving areas in Farmington (see the green areas in the diagram titled "**GPON Serving Areas – Review of areas designed and measured**") were selected to implement a preliminary design for each serving area. The design consisted of mapping out proposed mainline routes in each serving area using the field data to select the appropriate method of construction and path the new fiber would follow to serve every subscriber in the area. A sample of the design is shown in the diagram titled "**GPON 8E Theoretical Design**". Once the mainline routes were created, the subscribers were connected to the mainline routes and the cables were then sized to accommodate the subscribers, plus projected growth, in the serving area. Knowing the method of construction, the fiber size (# of fibers in a cable), cable lengths by size, and fiber splice points, Finley was able to create a preliminary list of the major construction units required to build those areas. Using our experience with similar projects, either in the construction phase or just completed, we averaged the lowest three bids from all of the projects for each unit to derive a base price for each unit.

We then applied an inflation factor based on our understanding of local conditions and the projected supply and demand for labor and materials for the next several years to derive each unit's cost used in the OPC. Applying the unit costs to the proposed major construction units allowed us to create a total cost to build each of the 9 study areas. Dividing the total build cost of each area by the number of mainline route miles in each area allowed us to derive a baseline cost per aerial and buried mainline route mile for each of the 9 designed study areas.

The projected route miles in fifteen of the remaining serving areas were measured to determine the average route miles for each serving area based on the size of the serving area. At that point, route miles for each of the remaining serving areas was estimated and each serving areas that were not designed were compared to the designed study areas to find the best match based on potential route path types, subscriber density, and difficulty of construction to extrapolate the OPC to build each community.

Farmington and Farmington Hills – Field Survey Map



Legend:

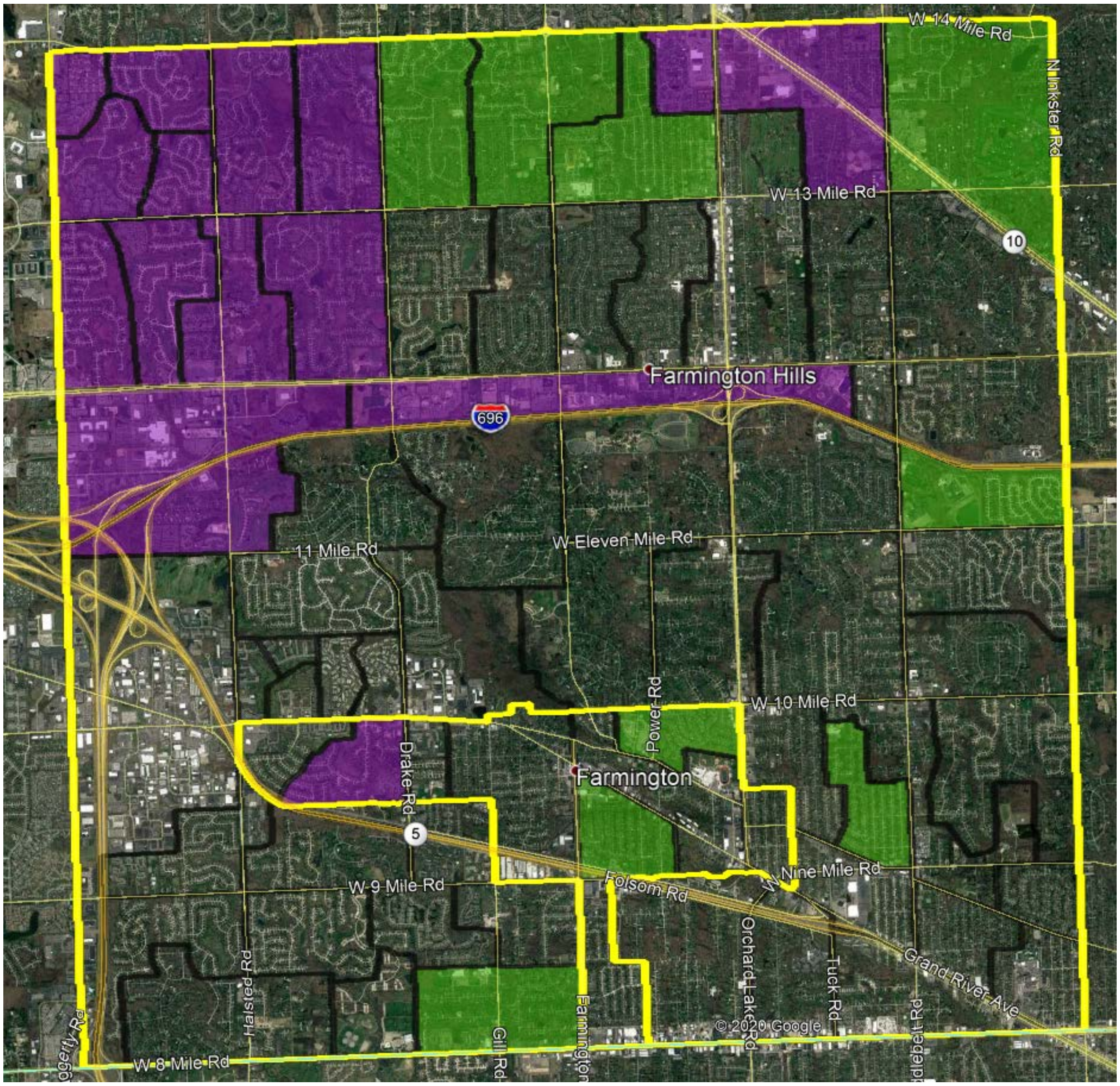
Farmington and Farmington Hills Boundaries

GPON Serving Areas

Route Survey Points: Locations in the field where actual buried/underground construction conditions were observed to help create the statistical model for the study. The survey looked at the following conditions:

- back lot line/front lot line
- aerial/buried
- general space availability on existing poles to determine how a FTTH network could be built.

GPON Serving Areas – Review of areas designed and measured



Legend:

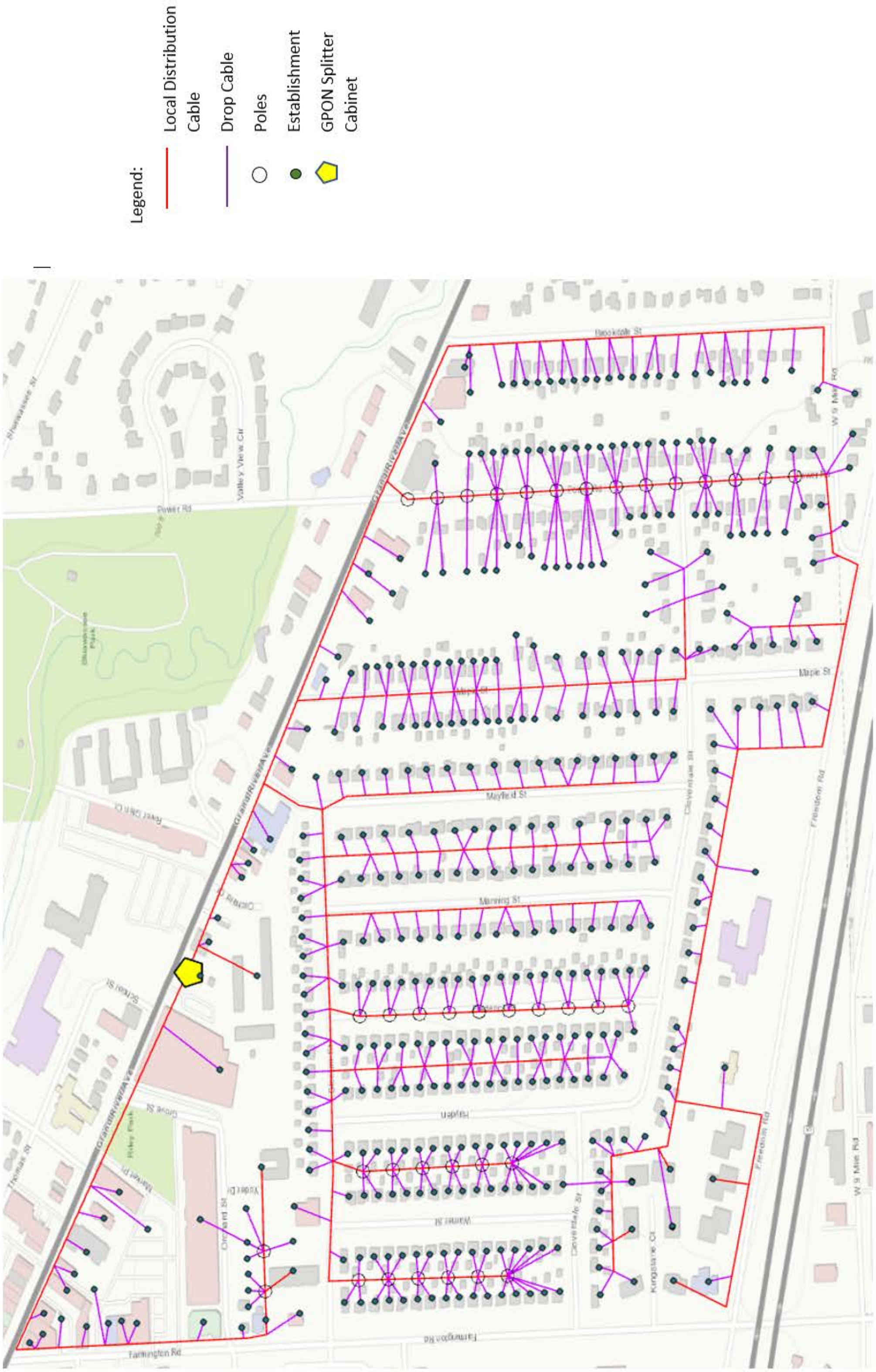
Farmington and Farmington Hills Boundaries

GPON Serving Areas

GPON Serving Areas where a theoretical design was completed. The design evaluated routes, construction type, and subscriber locations. The design provided theoretical fiber sizing with estimated cable footages, splicing, and drop placement information.

GPON Serving Areas where both aerial and buried routes were laid out

GPON 8E Theoretical Design



We used the following design parameters for various parts of the fiber network:

- 48 fiber were allocated to connect each serving area back to their node.
- Common fiber sizes of 12, 24, 48, 96, 144, 216, 288, 432, and 864 fibers
- Cable Fill Factor was 1.5 fibers for each existing establishment.
- Customer drops use 4-12 fibers, depending on the type of customer.
- The assumption that all buried fiber would be placed in duct.
- LCP Nodes sizes were 288, 360, 432, 576, 864, and 1152 ports
    - The LCP was sized based on the fibers terminated at the LCP

Farmington Hills FTTH Opinion of Probable Cost Summary: 67 Local Serving Areas

Build Rt Miles	Est. Passed	Est. Served	Mainline Cable Costs	Drop Cable Costs	Local Convergence Cabinets Costs	Total OSP
488.26	**36362**	**36362**	**$ 60,869,764**	**$ 26,582,264**	**$ 3,160,935**	**$ 90,612,963**
				Cost Per Passing		$2,491.97

Farmington FTTH Opinion of Probable Cost Summary: 9 Local Serving Areas

Build Rt Miles	Est. Passed	Est. Served	Mainline Cable Costs	Drop Cable Costs	Local Convergence Cabinets Costs	Total OSP
47.77	**5503**	**5503**	**$ 6,472,363**	**$ 3,862,273**	**$ 532,434**	**$ 10,867,070**
				Cost Per Passing		$1,974.75

Drops are the fibers that are connected between the distribution fibers and the home/business. Finley has estimated that the average length of a residential drop in the city is around 60 feet. Our estimate for business drops in the city is an average of 140 to 180 feet depending on the area though some individual drops can be much longer. Our estimate of drop distances was derived by sampling homes and businesses using the Orlando GIS databases. Once the average length was determined we added costs for handholes, grounding materials, conduit, NID shell to terminate the fiber on the house and other categories to come up with an average cost as shown below. There are different costs for different categories of structures due to how the fiber is brought to the structure, termination location requirements and locations, etc. Below is a table showing these categories and costs on a per drop basis.

C. Competing Technologies

Existing Technologies

There are several technologies used in the town today to deliver broadband. Each of these technologies will be explained below.

- AT&T serves the cities with copper telephone wires using DSL technology.
- The speed tests show that AT&T serves some customers using fiber.
- Charter and WOW! use hybrid fiber/coaxial (HFC) technology to provide the triple play services.
- Some large businesses, cell towers, and other large bandwidth users are served with metro Ethernet.
- Some homes get broadband using the data on their cellphone plans.

DSL over Copper Wires

AT&T uses DSL (Digital Subscriber Line) to provide a broadband path over a copper network. The copper networks were built between the 1950s and early 1970s. The copper networks were originally expected to have an economic life of perhaps forty 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. AT&T and the other big telcos started to cut back on maintenance of 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 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 they deliver 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. AT&T is able to bond two telephone wires together and offer speeds up to 48 Mbps. From what we can see in the speed test, there seems to be DSL delivered by a single pair and also DSL delivered with bonded pairs.

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 the town, 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. AT&T transmits DSL from their historic central offices. They also might transmit DSL from deeper in the copper network from field cabinets placed in various neighborhoods around the town.

DSL signal strength is also affected by the quality of the copper. The newer the copper and the larger the gauge of the copper wire, the better the signal and the greater the bandwidth. Many of the copper wires in the town are old and have gotten water damage over the years and won’t carry the full amount of bandwidth.

Hybrid Fiber Coaxial Network

Charter is the incumbent cable company. WOW! provides cable service in parts of Farmington. The technology used in these networks is referred to as Hybrid Fiber Coaxial (HFC). 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 is a broadband optical receiver that accepts the fiber signal from the headend and converts it into a signal that is sent over coaxial cable to reach homes and businesses.

Some of the slow speeds we saw in the speed tests indicate that some of the coaxial copper wires in the Charter network are aging, similar to the telephone copper wires. The coaxial network in the cities were likely built in the 1970s. Coaxial cable networks exhibit signs of aging sooner than telephone copper networks because the wires act like a huge antenna, and older networks attract more interference and noise and it becomes harder to transmit the signals through the wires.

An HFC system handles delivery of customer services differently than an all-fiber network. For example, in an HFC network, all 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. This means a significant portion of the bandwidth in the Charter and WOW! network is used for delivering TV signals.

In an HFC network all of the customers in a given node share the broadband in that node. This means that the numbers 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 data pipe for a given neighborhood. The architecture of using neighborhood nodes is what has given cable companies the reputation that data speeds slow down during peak usage times, like evenings. However, if nodes are made small enough, then this slowdown doesn’t have to occur.

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 data services. Historically a cable network was used only for television service, but in order 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 for the purpose of freeing 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 data to be delivered over an HFC system follows a standard called DOCSIS (Data Over Cable Interface Specification) that was created by CableLabs. Likely around a decade ago Charter upgraded to the DOCSIS 3.0 standard that allows them to bond together enough channels to create broadband speeds as fast as about 250 Mbps download. A few years ago Charter upgraded to a new standard, DOCSIS 3.1, that theoretically allows all of the channels on the network to be used for data and which can produce broadband speeds as fast as 8–10 Gbps if a network carried only broadband and had zero television channels. It looks like the fastest speed currently available in Farmington Hills is 400 Mbps.

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 the upload speeds. This is an inherent design in DOCSIS 3.0 and 3.1 where no more than 1/8 of the bandwidth can be used for upload. CableLabs has developed an upgrade being called DOCSIS 4.0 that will allow for symmetrical gigabit data speeds. This will require even more empty channel slots on a cable network and the new standard assumes that cable company will increase total system bandwidth of the network to at least 1.2 GHz of bandwidth. So far, the big cable companies have been silent on the topic and there is speculation that few of them will be interested in this expensive upgrade.

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. Modern cable companies try to limit the number of amplifiers on a coaxial route to five or less since adding amplifiers generally reduces broadband speeds.

Metro Ethernet

Metro Ethernet is the primary technology used to deliver large bandwidth to a single customer over fiber. For example, this is the technology that is likely being used to bring bandwidth to the schools. It's likely that all three incumbents in the market sell to at least a few customers using this technology. This technology is often also referred to as active Ethernet.

Metro Ethernet technology generally uses lasers that are capable of delivering 1 gigabit or 10 gigabit speeds, although lasers as fast as 400 Gbps are available. ISPs can choke speeds to slower levels based upon what a customer is willing to pay for.

Many ISPs dedicate a fiber for each metro Ethernet customer, but that's not mandatory. For example, an ISP could light a fiber to deliver 10 Mbps and string that fiber to multiple customers each buying 1 Mbps service.

Cellular Broadband.

The survey showed that about 5.5% of residences use only their cellphone for home broadband. There are obvious limitations on using cellphone for home broadband. The amount of broadband capacity is small compared to wireline broadband. Most standard cellular plans provide 10 gigabytes of broadband usage per month or less. Even the unlimited plans offer only 20 – 25 gigabytes per month of broadband. One of the limitations on unlimited data plans is that they can only be used to tether to computers or other devices for a limited amount of capacity per month – most of the data in the plan must be consumed by the cellphone.

Customers can buy more broadband if they exceed the subscribed capacity, but this is some of the most expensive broadband in the world, typically priced at $10 per extra gigabyte. While it would unusual for somebody in the cities to spend a lot for cellular data plans, CCG has talked to rural customers across the US who have monthly cellular data bills in excess of $500 per month if they use cellular data to support students doing homework.

AT&T and T-Mobile have started to offer what they call fixed cellular data plans. With these plans the carriers place a small dish on a customer home and use cellular frequencies to deliver fixed wireless broadband. The fixed broadband is for normal home consumption – it uses cellular frequency but is not delivered to cellphones. These plans have much larger data caps than on regular cellular plans. For example, the AT&T fixed cellular plan has a monthly data cap of 215 gigabytes. T-Mobile has said they will offer this product nationwide if they are allowed to merge with Sprint – that merger was approved by the courts in February 2020, so perhaps this will become available in the next few years.

<u>Fiber-to-the-Home (FTTH)</u>.

AT&T is using FTTH technology to provide broadband to some pockets of customers in the cities. This technology is the same technology being considered in this feasibility study and was discussed at length in Section II.B above.

<u>Fiber-to-the-Curb</u>

One of the most intriguing technologies that the cities should be aware of is fiber-to-the-curb. Currently, the company pioneering this technology is Verizon. Verizon refers to the technology as fixed wireless access (FWA). The technology consists of building fiber along streets and then beaming wireless using millimeter wave spectrum to customers. Historically, this kind of technology has been referred to as fiber-to-the-curb.

Verizon introduced the technology in 2018 and deployed trials in parts of Houston, Indianapolis, Los Angeles, and Sacramento. In June of this year Verizon introduced the second generation of the technology, with the first new market being Detroit.

The first-generation technology required mounting an antenna on the outside of a home to receive the signal. The new technology hangs a receiver on the inside of a window that faces the transmitter on the pole. Verizon claims the new technology can be self-installed by customers. One of the key requirements for using the technology is that there must be a good line-of-sight between the transmitter on the pole and customers. That means no intervening trees or other impediments.

Verizon claimed that the first-generation equipment technology could deliver speeds up to 300 Mbps for up to 2,000 feet from a pole. Many engineers in the industry guessed that the more realistic distance is 1,000 feet or less. Verizon claims the new technology can deliver speeds up to a gigabit, and Verizon is no longer making any distance claims.

Verizon claims that the technology will meet all 5G specifications. However, currently there are no 5G features yet being used in the field, and this is basically a millimeter wave Ethernet path to a home. When 5G is finally introduced in the field this technology might benefit some if it can use the 5G features that tailor bandwidth paths to customer demand. But since most 5G features are intended to benefit cellular traffic, this specific technology is not likely to be improved much when layering on 5G features.

From a deployment perspective, this is an expensive technology to deploy. It means building fiber deep into residential neighborhoods. The industry analysts at MoffetNathanson looked at the first-generation equipment and said they didn't see how the technology could be any cheaper than building fiber-to-the-home. The expensive part of a FTTH network is the fiber along a street, and that is still needed for this technology as well.

Verizon claims to have plans to pass 30 million residents with the technology. The pricing on the product is simple, at $50 for Verizon Wireless customers and $70 for anybody else. This technology will compete well against cable since the cable companies currently sell gigabit broadband at prices of $100 or higher. Any neighborhood that gets this technology ought to see some price competition – and if not price competition, at least expanded customer choice.

This technology doesn't make sense everywhere. It's a technology aimed at streets with single family homes or rows of small businesses. It's not going to handle apartment buildings where there are units that don't face the street with the fiber. The technology doesn't work well in the neighborhoods where utilities are buried. The technology won't work well on streets with heavy vegetation or streets that are highly curved. This technology will be hard to justify in places with neighborhoods with large lots and lower housing density.

This is a new technology and the only company currently offering it is Verizon. It's too early to have any customer or industry review to talk about how it really works. However, if it operates anything like how Verizon claims, it could be a serious competitor to cable company broadband.

Future Technologies

This section looks at new technologies that are likely coming within the next few years to the US.

Next Generation Fiber Technologies. There are two next-generation and competing fiber-to-the-home technologies that will allow connections to customers to be upgraded to 10 Gbps broadband and even faster - NG-PON2 or XGS-PON. The current widely deployed GPON technology will eventually hit a technology wall. The technology delivers 2.4 Gbps downstream and 1 Gbps upstream for up to 32 customers, although many networks are configured to serve 16 customers at most. This is still an adequate amount of bandwidth today for residential customers and can easily provide a gigabit product to every customer if desired.

GPON technology is over a decade old, which generally is a signal to the industry to look for the next generation replacement. This pressure usually starts with vendors who want to make money pushing the latest and greatest new technology - and this time it's no different. After taking all the vendor hype out of the equation it's always been the case that any new technology is only going to be accepted once that new technology achieves an industry-wide economy of scale. That means being accepted by at least one large ISP.

The most talked about technology is NG-PON2 (next generation passive optical network). This technology works by having tunable lasers that can function at several different light frequencies. This would allow more than one PON to be transmitted simultaneously over the same fiber, but at different wavelengths. That makes this a complex technology with multiple lasers and the key question is if this can ever be manufactured at price points that can match other alternatives.

The only major proponent of NG-PON2 today is Verizon, which recently did a field trial to test the interoperability of several different vendors including Adtran, Calix, Broadcom, Cortina Access, and Ericsson. Verizon made an investment in Ilhavo in August 2020, a Portuguese company that is developing NG-PON2 lasers. Verizon seems enamored with the idea of using the technology to provide bandwidth for the small cell sites needed for a 5G network. However, the company is not building much new residential fiber. They announced they would be building a broadband network in Boston, which would be their first new construction in years, but there is speculation that a lot of that deployment will use wireless 60 GHz radios instead of fiber for the last mile.

The market question is if Verizon can create enough economy of scale to get prices down for NG-PON2. The whole industry agrees that NG-PON2 is the best technical solution because it can deliver 40 Gbps to a PON while also allowing for great flexibility in assigning different customers to different wavelengths. Still, the best technological solution is not always the winning solution and cost is the greatest concern for most of the industry. Today the early NG-PON2 electronics are being priced at 3 - 4 times the cost of GPON, due in part to the complexity of the technology, but also due to the lack of economy of scale without any major purchaser of the technology.

Some of the other big fiber ISPs like AT&T and Vodafone have been evaluating XGS-PON. This technology can deliver 10 Gbps downstream and 2.5 Gbps upstream—a big step up in bandwidth over GPON. The major advantage of the technology is that it uses a fixed laser that is far less complex and costly. In addition, these two companies are building a lot more FTTH networks than Verizon.

While all of this technology is being discussed, ISPs today are can deliver 10 Gbps data pipes to customers using Active Ethernet technology. For example, US Internet in Minneapolis has been offering 10 Gbps residential service for several years. The Active Ethernet technology uses lower cost electronics than most PON technologies, but still can have higher costs than GPON due to the fact that there is a dedicated pair of lasers, and a dedicated fiber for each customer. A PON network instead uses one core laser to serve multiple customers.

It may be a number of years until this is resolved because most ISPs building FTTH networks are still happily buying and installing GPON. One ISP client told us recently that they are not worried about GPON becoming obsolete because they could double the capacity of their network at any time by simply cutting the number of customers on a neighborhood PON in half. That would mean installing more cards in the core without having to upgrade customer electronics.

The bottom line of this discussion is that we decided to not consider NG-PON2 for the primary technology to deliver FTTH services. The technology is still too expensive and since it has not yet been accepted widely in the industry it might never get long-term support by vendors.

However, our network design allows for an eventual migration to XGS-PON or NG-PON2 through what is called an overlay. That means introducing the new technology while maintaining the current network. This would allow for an orderly transition over time while bringing faster 10-gigabit connection to customers that need it immediately. The fiber network design can accommodate these future technologies and faster speeds.

5G Cellular Technology. Today's cellular network uses a technology called 4G LTE, although there are still many rural cell sites using 3G technology. Nationwide, the cellular carriers in the US average data speeds for 4G LTE is around 25 Mbps download, with the fastest cell sites usually located in major metropolitan areas. Like with all radio technologies, cellular data speeds drop in relation to the distance a customer is from a cell site and good cellular data speeds only are available for around 2 miles from a cellular tower. A customer that is more than 3 miles from a tower will get slow cellular data speeds.

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, as each cellular carrier claims a bigger coverage area than their competitors. However, almost all of their claims are marketing hype.

In 2020 there will be no cellular deployments that can be legitimately called 5G. Full 5G will not arrive until the carriers have implemented the bulk of the new features described in the 5G specifications. For now, none of the important features of 5G have been developed and introduced into the market. 5G deployment will come in stages as each of the 5G features reaches markets – the same thing that happened to 4G. For now, all of the major 5G improvements are still under development in the labs.

From what is discussed in the IEEE forums, most of the 5G features are 2 - 5 years away. The same thing happened with 4G and it took most of a decade to see 4G fully implemented – in fact, the first US 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 2 to 3-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.

Most of what is being called 5G today refers to the introduction of new bands of spectrum. 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.

Even when 5G is fully implemented, the cellular data speeds are not going to be blazingly fast. The 5G specification calls for a goal for 5G cellular speeds of about 100 Mbps – which was also the specification for 4G, but never realized. There will be reports of fast speeds using new spectrum, but that will die down quickly. At first, anybody lucky enough to grab new spectrum will likely have a great experience. This will mostly be because almost nobody else is using the spectrum at a given cell site. As more phones can use the new spectrum, the performance will drop back to normal 4G speeds – and maybe even a little slower. Much of the first wave of spectrum being released is in lower frequency bands such as 600 MHz for T-Mobile and 850 MHz for AT&T. These lower frequency bands don't carry as much data as higher frequencies.

5G Hot Spots. There are commercials on TV showing cellphone speeds of over a gigabit. This is not 5G. This is a phone equipped to use a new frequency band called millimeter wave spectrum. This is an ultra-high frequency that carries 10-30 times more data than traditional cellular frequencies.

It's easiest to think of this technology as a 5G hot spot, similar to a hot spot that might be found in a coffee shop, only mounted outdoor 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. 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 world that 5G will be blazingly fast everywhere. The cellular carriers seem desperate to deploy something they can call 5G, and super-fast cellphones are a good way to get headlines. However, it's extremely unlikely that any carrier is going to invest in cell sites that close together outside of major downtown business districts. This technology is likely to never reach to residential neighborhoods in cities, suburbs, small towns, or rural America. A lot of industry experts are asking why anybody needs gigabit broadband for cellphone, and only outside since there are no high bandwidth applications for cellphones.

<u>The Need for Small Cell Sites.</u> Communities of all sizes are seeing requests for adding small cell sites. These are small cellular sites that are placed on poles rather than on the big cellular towers. It's likely that when a cellular company, or one of their subcontractors makes such a request they will tell you this is for 5G.

The fact, is, for now these cell sites are being added to bolster the 4G networks. It's not hard to understand why the 4G cellular networks are stressed. The cellular companies have embraced the 'unlimited' data plans, which while not truly unlimited, have encouraged folks to use their cellular data plans. According to Cisco the amount of data on cellular networks is now doubling every two years – a scorching growth rate that would mean a 60-fold increase in data on the cellular networks in a decade. No network can sustain that kind of traffic growth for more than a few years without becoming congested and eventually collapsing under the load.

The cellular companies have a 3-prong approach to fix the performance problems of 4G. First, they are deploying small cell sites to relieve the pressure from the big cellular towers. A small cell site in a busy neighborhood eliminates a lot of stress from the big cellular tower in the neighborhood.

The cellular companies also have been screaming to the FCC asking for new mid-range spectrum, because adding spectrum to cell sites and cellphones expands the data capability at each cell site. Unfortunately, it's a slow path between the FCC approving new spectrum until the time when new spectrum is installed in cell sites and enabled in smartphones. The FCC has awarded several bands of mid-range spectrum in the last year and are looking at more.

Finally, the cellular carriers are counting on 5G. There are a few aspects of 5G that will improve cellular service. The most important benefit comes from frequency slicing that will right-size the data path to each customer and will get rid of today's network that provides a full channel to a customer who is doing some minor broadband task. 5G will also allow for a customer to be connected to a different cell site if their closest site is full. Finally, the 5G specifications call for a major expansion of the number of customers that can be served simultaneously from a cell site. Unfortunately for the cellular carriers, most of the major 5G improvements are still five years or more into the future.

There is a fourth issue that is a likely component of the degrading cellular networks. It's likely with expanding broadband needs that the backhaul links to cell sites are overloaded at times and under stress. It doesn't matter if all the above changes have been made if the backhaul is inadequate – because poor backhaul degrades all broadband services. The big cellular carriers have been working furiously to build fiber to cell sites to eliminate leased backhaul. But much of the backhaul to cell sites is still leased and the lease costs are one of the major expenses for cellular companies. The cellular companies are reluctant to pay a lot more for transport and bandwidth, and so it's likely that at the busiest times of the day that many backhaul routes are now overloaded.

Low Orbit Satellite Technology

We almost didn't include this technology in the report since it is extremely unlikely that the companies selling broadband out of satellites will be selling services in urban areas. The technology is best suited to provide broadband in remote and rural locations. However, there has been so much hype about the satellites that it's worth discussing to dispel ideas that these companies could become a serious competitor in the cities. There are several major companies planning on providing fleets of low-orbit satellites to provide broadband service. This includes efforts by Starlink (Elon Musk), Project Kuiper (Amazon), and OneWeb that have announced plans to launch swarms of satellites to provide broadband.

In March, OneWeb filed for Chapter 11 restructuring when it was clear that the company could not raise enough cash to continue the research and development of the satellite product. In July, a bankruptcy court in New York approved a $1 billion offer to take over the company filed jointly by the British Government and Bharti Airtel. Airtel is India's largest cellular company. The restructured company will be owned with 45% stakes by Britain and Bharti Airtel, with the remaining 10% held by Softbank of Japan, the biggest original shareholder of OneWeb. Other earlier investors like the founders, Intelsat, Totalplay Telecommunications of Mexico, and Coca-Cola have been closed out of ownership by the transaction.

There is speculation that the British government purchased the company to create tech jobs in the country and that all R&D and manufacturing for OneWeb would immediately shift to England from Florida. There is also speculation that the mission of the company will change. Greg Wyler, the original CEO of the company had a vision of using the satellites to bring broadband to parts of the world that have no broadband. He chose a polar orbit for the satellites and was going to launch the business by serving Alaska and the northern territories of Canada like Nunavut. I've seen speculation that the revised company is likely to concentrate instead on wholesale connections to telcos and ISPs, such as providing backhaul for rural cell sites.

Elon Musk's satellite venture StarLink was recently in the news when the company said it was going to raise 'up to $1 billion' to continue the development of the business. The company still has a long and expensive road to success. The company has raised over $3.5 billion to date before this latest raise, but a recent Bloomberg article estimates that the company will need to raise an additional $50 billion between now and 2033, which is when the company is projected to be cash-positive.

StarLink now has over 540 satellites in orbit, but the business plan calls for over 4,000 satellites in the first constellation. Keeping the first constellation in place will be an ongoing challenge since each satellite has an estimated life of 5 to 6 years. Starlink will forever have to be launching new satellites to replace downed satellites. Starlink has even more ambitious plans and has told the FCC that it might eventually launch over 30,000 satellites – but they need to fund and launch the original batch first.

The US government and the FCC seem to be in Starlink’s corner. It’s still not clear if the FCC will allow StarLink to participate in the upcoming RDOF grants auction in October. It would be incredibly unusual to award giant federal grants for a product that is still on the drawing board and for an ISP that hasn’t raised 10% of their needed funding.

StarLink recently made a very-public announced that it was looking for beta customers – likely as a way to spur fundraising. Early Starlink customers will likely see blazingly fast speeds, which would happen for any broadband technology that could devote the bandwidth from one server to connect to one or two customers. The bandwidth delivered on a fully-subscribed satellite network will be far less – but that won’t stop the company from using a beta test to set unrealistic expectations of future satellite broadband speeds.

The last LEO player that is still active is Jeff Bezos venture that is still using the preliminary name of Project Kuiper. The FCC recently approved the concept of Project Kuiper to move forward and FCC Chairman Ajit Pai recently said he supported the company’s plans to start the process of FCC licensing of the technology. Project Kuiper has one advantage over other competitors in that Jeff Bezos could self-fund much or all of the venture. It was reported that just for the month of July 2020 that Bezos’s net worth climbed by $9 billion. Funding is going to be a constant hurdle for the other two major competitors, but Project Kuiper might be the fastest to deploy if funding is not an issue.

Skeptics are doubting if the 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 (NOOSA) has been tracking space launches for decades. They report at the end of 2019 that there have been 8,378 objects 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. Since 2012 we’ve seen 1,731 new satellites, with 2017 (453) and 2018 (382) seeing the most satellites put into space.

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 a large number of 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.

III. Financial Projections

This section of the report looks at the detailed assumptions that were made in creating the financial business plans. The business plans created are detailed and contemplate all aspects of operating a broadband business. The business plan assumptions represent our best estimate of the operating characteristics for such a business. As a firm, CCG consults to hundreds of communications entities that provide retail broadband. This has given us a lot of insight into how ISPs operate. We believe that the financial results shown in these models are characteristic of similar operations elsewhere and we believe our assumptions are realistic.

The primary goal of the business models is to look at the various scenarios from the perspective of an ISP that would operate the business. The purpose of these models is to provide a way for ISPs to understand the broadband opportunities in the cities. We've learned with experience that almost every ISP is theoretically interested in expanding. However, no ISP is really interested until they understand the numbers. Only then can they decide if the opportunity is something they can get financed and that meets their requirements as an investment opportunity. These studies help the ISPs understand the opportunity of expanding broadband into the cities.

A. Operating Models

There are several operating models that the cities can consider. Following are the operating models most prevalent in the US market today.

Retail Model – Single Provider as the ISP

This scenario considers the network being built and operated by a single entity. The results would be similar if the operator were the municipality or a single ISP.

From a business perspective this is the simplest operating model. CCG has learned from experience that if a market can't be profitable with one provider, then other options like partnerships and open access also can't be successful. By definition, partnerships divvy up profits among multiple entities. If there's not enough profit for one provider then there's not enough profit to support multiple parties.

Open Access

In this scenario the municipality builds a fiber network and makes it available to multiple ISPs. These ISPs would sell broadband and other products to customers.

This model operates financially by the fiber owner selling access to the ISPs in an arrangement that is often referred to as selling loops. These loop charges are the only source of revenue for the network owner.

Public-Private Partnership (PPP)

There are a wide variety of public private partnerships that can be created between a government entity and an ISP. Some of the more common types of PPPs are as follows:

- The government builds the network and hires an ISP to operate the network.
- The government builds the fiber network and fiber drops and the ISP partner provides customer electronics and everything inside the home.
- The government builds only the fiber and the ISP supplies everything from the street to connect to the customer.
- The government owns none of the network. Instead the government takes steps to help an ISP succeed. That might mean being an anchor tenant and giving all of your business to the ISP on a long-term contract. It might mean contributing land, building space or other hard assets. It might mean relaxing construction requirements such as permitting, locating, and inspections to lower the cost of building the network.

There are also a wide variety of ways that revenues, profits, and risks can be shared between partners.

The following discussion examines the pros and cons of each of the operating models described above.

Retail ISP

A retail ISP is a single entity (could be the government or a single ISP) that operates a retail broadband network. A retail ISP normally owns the network, hires the staff, operates the business, and benefits from any profits. It's not hard to cite examples of single-operator networks since almost all of the ISP networks in the country are this type.

<u>Advantages</u>

<u>Profits</u>. A single owner/operator can make all of the profit from a fiber business.

<u>Flexibility</u>. A single owner/operator can make instant decisions to change products or prices or to respond to competition.

<u>Disadvantages</u>

<u>Risk</u>. The flip side of the ability to make all of the profits is that a single owner/operator also takes all of the risk. If the business doesn't succeed the ISP can lose their investment.

<u>Financing</u>. The primary impediment to building and operating a fiber ISP is the cost of building the fiber network. Cities often wonder why commercial ISPs don't build fiber network if the business plan to do so looks profitable. The fact is that there are not many entities capable of borrowing the money needed to finance sizable fiber networks. Most small ISPs are limited by the amount of equity they can bring to a new market and by the collateral they can pledge to a borrower.

Open-Access Model

Open access refers to the business model where a municipal entity builds a network and then sells access to multiple ISPs. The government's only revenues come from selling access to the various ISPs. 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 US 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, Verizon, 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 that pursue a specific small customer niche. 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 the largest telcos or cable companies agreeing to operate as a competitor on somebody else's network to serve residential customers. The large ISPs in the US will lease fiber outside of their footprint to serve large business customers, but they 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 with 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 in Chelan County, Washington that was reduced at one point to having only one primary local ISP that was selling to residential customers. The network originally had almost a dozen ISPs, but over the years the ISPs either folded or were purchased by the remaining ISP. The network now has two ISPs, but even with that it's hard to call the Chelan County network open access.

A similar thing happened in Provo, Utah before the city sold the network to Google Fiber. The network had originally attracted eight ISPs, but over time they ended up with only two. 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.

<u>Examples of Open-Access Networks</u>. Following is a list of some of the other 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 legislation passed a number of years ago. There are numerous different open-access models being tried at various PUDs, with the largest networks in Chelan County PUD, Grant County PUD, Douglas County PUD, and Pend-Oreille 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 serves a number of small towns. The Provo network was losing a lot of money and the city decided to sell the network to Google Fiber for $1. Utopia is still operating a wholesale business but had significant financial problems since inception.
- A similar law was passed in Virginia after Bristol Virginia Utilities (BVU) built a retail fiber network. The legislation grandfathered BVU as a retail provider but only allows other cities to operate open-access networks. So far, the wholesale model has been adopted by a few cities, the largest being Roanoke, which offers open access on a limited basis to only parts of the city.
- Tacoma, Washington chose an open access model where the city is the retail provider of cable TV, but connections to the network for telephone and broadband are sold wholesale to ISPs.
- 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.
- There are a number of municipal networks that have built fiber rings, and which are promoting “open access” to carriers. For the most part these networks only serve business customers.
- 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 they were unable to find ISP partners, they decided to offer full retail services directly to residents.

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.

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 $120 per customer per month. The average revenues on an open access network are far smaller, at perhaps $30 - $40 per customer per month.

There are some cost savings for the network owner in an open access environment. The network owner doesn’t have to provide the triple play products. They don’t have to see, bill customers, or provide customer service. But it’s still extremely difficult for the network owner to be profitable with open access. The network owner still has to cover the full cost of debt. The network owner still has to 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.

Not Many Quality ISPs. Every open-access network that has been tried in the US has had trouble finding and retaining ISPs on the network. Some examples are discussed above. The ISPs willing to operating in this environment are generally small and undercapitalized. Open access then forces these ISPs to compete against other small competitors, which holds down end-user rates, but which then also puts pressure on ISP earnings. Two of the largest open-access networks in Chelan County, WA and Provo, UT essentially lost most of the ISPs on their network over a decade of operations.

Leads to Cherry Picking. The open-access model, by definition, leads to cherry picking. If ISPs are charged to use the network, then these fees will generally lead them to not want to sell to priced and low-margin customers. All of the open access networks listed above report this as an issue. 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. CCG has never seen an open access network that has a customer penetration rate as high as would be expected if the same community had a municipal retail provider. Cherry picking means fewer customers on the network.

No Control over Sales Performance. The network owner in an open-access network has no control over the customer sales process. That means they only do as well as the ISPs on the network. In CCG's experience, having talked to many of the ISPs that operate on open access network, the ISPs tend to not have the resources for major marketing efforts or else they only want to serve a niche market and don't try to mass market. A retail ISP that owned the same network would try to sell to everybody – but that never happens on an open access network.

Stranded Investments. One interesting phenomenon that especially affects open-access networks is stranded investments at customer premises. When a customer moves or stops service with a network operated by one entity there is usually a big push to reestablish service at that location. However, in an open-access network many ISPs don't make this same effort. Therefore, over time there grows to be an inventory of homes and businesses with a fiber drop and ONT that are no longer used and are not contribution to the cost of the business. CCG knows of one of the larger open-access networks with 25,000 active customers that has 5,000 locations where the fiber has been abandoned with no current service.

Public-Private Partnership (PPPs)

PPPs initially arose internationally as a way to finance infrastructure needs that local, regional, or national governments could no longer pay for up front or could only insufficiently finance from taxes, bonds, or other methods of raising government monies. Taken as a whole, governments in the US are today unable to fund all of the needed infrastructure and so more and more PPPs are being formed to finance infrastructure. There have been estimates that collectively there are several trillion dollars more of needed infrastructure projects in the country than could be financed by the combined borrowing power of all of the state and local governments added together.

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 only a few examples of this in the US. This scenario means that a government takes all of the financial risk of building a network and then hands the operations to somebody else. This is 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 and Charlottesville, VA and Westminster, MD. CenturyLink has reached a similar arrangement with Springfield, MO.

PPP Funded Mostly by the Commercial Provider. There are many examples where a commercial provider built a fiber network and doesn't consider the venture to be a PPP. Generally, any ISP that uses the normal avenue of obtaining rights-of-way and then adheres to the franchise and permitting processes in a city are free to build fiber.

It's also not a PPP if a government gives concessions to attract an ISP. The first few markets for Google Fiber are reported to have this arrangement. It's widely believed that Kansas City granted major concessions to Google Fiber to get them to build fiber there. This may have been things like free rights-of-way, expedited permitting, use of city land for placing facilities, etc.

For this kind of arrangement to be a traditional PPP, a municipal entity 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 value. It might be free or reduced telecom prices provided to government buildings or fibers connecting government locations together. 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 would 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 PPP. There are a number of examples of telecom PPPs working in the country today. Such partnerships are structured in many different ways and following are a few examples.

- Zayo partnered with Anoka County, MN. This is a suburban county just north of the twin cities. 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 their own cost.
- Nashville, TN 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.
- There are dozens of small cities where the city built an initial fiber network to connect to schools, water systems, etc. and now allows 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, MN, 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.
- Several of the Public Utility Districts (PUDs) in Washington have built fiber into business and residential neighborhoods but then allow ISPs to build fiber loops and electronics and connect to the core network.
- Google Fiber recently announced that they would be partnering with West Des Moines, Iowa in a network that can best be described as open access conduit. The city is going to build empty conduit along every street in the city and also extend the conduit to each home and business in the city. The network will be available to any ISP, but Google Fiber is the first announced ISP. Google would pay to bring their conduit through the fiber, and the company has said it plans to complete in the whole city. This plan puts the most expensive part of the network onto the city, although the ISP still has to pull fiber and pay to connect inside of customer homes.
- 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 for their contribution. For example, this is a common practice with school system fiber networks.

There are several kinds of contributions that a government can make to somebody else's fiber network. This could include cash, real estate, excused fees, or sweat equity. Governments can allow a commercial provider to use parcels of lands or give them 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 period of 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 free 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. Most commercial companies won't invest in a business that doesn't return at least a 20% to 30% return on their investment.

<u>Advantages</u>

<u>Smaller Government Investments</u>. The extent to which the private partner funds the network reduces the needed investment from the public partner. A private equity partner can bring cash to the business that might be hard to raise elsewhere.

<u>Disadvantages</u>

<u>Matching Goals and Expectations</u>. 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 built past every home, which ISPs prefer to build to only selected neighborhoods. It's often difficult to put together a structure that can satisfy all the different goals.

Expensive Money. Since commercial partners generally want to make at least a 20% return on equity investments this can be expensive 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 benefits a commercial entity.

Process Driven by Commercial Partner. Communities seeking equity partners for a public-private partnership fiber optics project will have fewer choices for the structure of the business since the external partner will probably demand a for-profit business structure as a likely pre-condition for investment.

Length of Partnership. Many commercial investors only make investments with a mind 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.

Governance Issues. It's a challenge to develop a governance structure 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 timeline for a commercial partner. A commercial partner might make a decision in days, when the government process can't be any faster than weeks.

B. Services Considered

Following is a discussion of the products and services considered in the study.

Telephone Services (VoIP)

Voice over IP (VoIP) is a digital telephone service that transmits a telephone call to customers using their broadband connection rather than establishing a more traditional analog telephone connection. VoIP has been around the industry for a few decades. The first major seller of VoIP was Vonage, which still delivers VoIP over the open Internet. Most VoIP arrangements now use secure private broadband connections rather than the open Internet.

The study assumes that the retail provider of telephone service will purchase wholesale VoIP. This product is available from numerous vendors. These vendors own a digital telephone switch and they deliver calls to and from customers from that switch to the ISP. Our clients tell us that offering voice is still mandatory when selling to businesses since many businesses insist on having a vendor that delivers all of their communications needs.

The alternative to using VoIP is to buy a telephone voice switch and then establish connection between that switch and the public switched telephone network. These connections are referred to in the industry as “interconnection.” We’ve found through several studies that it’s hard to justify buying a switch and paying for interconnection costs unless a service provider expects to serve at least 5,000 telephone lines.

High-Speed Bandwidth (in excess of symmetrical 100 megabits)

The network design for the studies deliver a symmetrical gigabit bandwidth product to every customer in the service areas. Additionally, the network can provide speeds up to 100 gigabits for the largest businesses, although there are probably none that want more than 10 gigabits. It’s anticipated that there would be residential and small business broadband products at speeds less than a gigabit. The study assumes the basic product is 100 Mbps, but that could easily be changed some other speed.

Internet Services (ISP, email, web hosting, etc.)/Security and Authentication Requirements for Business

It was traditional in the industry for an ISP to provide all services related to the Internet as part of their ISP service. This included such things as email, DNS routing, virus checking, spam filtering, etc. Most ISPs also offered services like helping customers create web sites and then hosting them at the ISP headend. A decade ago, there was also a booming ISP business line of providing off-site storage for customer data.

The majority of small ISPs now outsource these functions and product lines. None of these functions are profitable when considering the cost of labor to perform them. In addition, all of the basic ISP functions are now available as a cloud service or from a large, centralized help desk company. Most small ISPs have decided that their primary function ought to be maintain a network designed to provide minimal downtime and leave these various ancillary services to somebody else.

A good example of this is virus checking and security. Virus checking today means not only trying to keep viruses away from customers, but today it means protecting against larger threats to the ISP such as denial of service attacks or the many other kinds of hacking. Most ISPs have found that they can buy better protection from a company that does this function for a hundred small ISPs rather than trying to do this themselves. They’ve found that there is no particular glory from doing these functions well, but there is a huge liability if they perform these functions poorly.

The feasibility studies assume these functions are outsourced. There is nothing to stop an ISP from tackling some or all of these tasks, but that would be contrary to where the rest of the industry is headed.

Managed WiFi

Many small ISPs now offer managed WiFi, which means that the ISP installs and controls the WiFi network at the customer premise. It’s become obvious over the past several years that a large percentage of the problems experienced by customers have been due to poor WiFi networks rather than to the broadband connection. ISPs began selling a product where they would install a high-quality WiFi modem. If a house is large, the ISP installs a meshed network with several networked WiFi routers. Since these routers are part of the ISP network, they can monitor the performance to make sure they are operating properly. Many ISPs also offer related services like helping customers connect new devices to the WiFi system – something that can be done easily from the ISP end.

The market is split, and some ISPs charge extra for this service and others include WiFi in the basic price. In these studies, we've included WiFi in the cost of broadband.

Other Future Products

Today many ISPs are expanding their product lines to add additional product lines that rely upon broadband. Perhaps the best example of this is Comcast. They now offer a wide range of new products. For example, they have sold home security monitoring to many millions of customers. They are now probably the largest single nationwide provider of smart home products and they have a line of products such as smart lighting, smart watering systems, smart door locks, smart thermostats, etc. Comcast has also been selling a cellular product to compete with the big wireless carriers. Comcast even recently tested bundling solar panels with their other products in a few markets.

CCG finds it likely that any ISP operating a fiber network will eventually offer some of these same kinds of products along with products that have yet to be developed. This could include things like medical monitoring to help the elderly live in their homes longer. It might involve intensive gaming connections, including virtual reality and holograms.

It's impossible to build a business case for products that have yet to be developed, but it's reasonable to believe that any sizable ISP will offer new products over the time frame of this study. Our business plans incorporate a generic small future revenue for "new products," which is undefined. The assumptions used will be described under the revenue assumptions below.

Wholesale Bandwidth Products

Wholesale bandwidth products are those sold to other carriers or to large business customers. Such products can be a major source of revenue for ISPs in larger cities. For example, CenturyLink is one of the biggest sellers of wholesale bandwidth products in the country after their merger with Level 3.

Following are the kinds of customers that buy wholesale connections:

- Cellular towers in most markets buy fiber connectivity and bandwidth to connect to the regional cellular hubs. However, there has been a big effort by both Verizon and AT&T to build fiber to cellular towers in many markets.
- Nationwide businesses like hotel chains, banks, manufacturers, etc. usually have an arrangement with a single ISP to serve all of their locations nationwide. These ISPs will consider buying from a new fiber network, but they probably already have reasonably priced connections from AT&T or Charter.
- Complex businesses like hospitals and universities usually have complex needs and look for ISPs that can provide a lot more than just bandwidth.
- Businesses with multiple locations in the same city need customer connections. This might include grocery stores, local banks or other businesses that might operate multiple locations inside the city.
- Giant bandwidth users. This could be things like data centers or large stock trading houses that want large bandwidth with low latency.

Products

Following are the typical wholesale products that are sold to the above kinds of businesses:

- Dark Fiber. This involves selling a fiber that is not connected to electronics. The ISP buying the dark fiber is responsible for providing and operating the electronics necessary use the fiber. Dark fiber might be sold by the mile of fiber, or else by a set fee per dark fiber connection.
- Transport. Some wholesale providers only sell connections between points A and B. This might mean the retail ISP might need to buy several transport paths to serve a customer – for example, there might be one transport connection between and end-user connection and the wholesale hub and a second transport connection between the wholesale hub and the ISP hub.
- Dedicated Bandwidth. Dedicated bandwidth means that the customer doesn't share it with anybody else. The typical products on an FTTP network share bandwidth at some point in the network, but some businesses are willing to pay to buy raw, unshared bandwidth. The network is capable of delivering speeds up to 100 Gbps.

There is only a tiny amount of wholesale revenues included in the studies. We've always been conservative and cautious about including this in a feasibility study unless there is certainty that the ISP will get the revenue.

Offering Voice and Video

One of the questions we're often asked by new ISPs is how they can offer voice and video service. A new ISP can be intimidated by the complexities of these products.

Offering Voice. Until a decade ago, anybody that wanted to offer telephone service had to go through the process of becoming certified as a voice provider and buying and activating a telephone switch that would provide these services to customers. This option is still available to any ISP today and CCG still helps a few ISPs enter the voice business each year.

However, the more common approach today is to buy wholesale voice products, where some outside entity does all of the technical and backoffice work necessary to offer the voice product and the ISP then delivers the wholesale voice product to customers. There are a few different ways this can be done:

Wholesale Voice over IP (VoIP). There are a number of entities in the country that offer wholesale VoIP. The best vendors make this as easy as possible for the ISP, and the wholesale product usually includes all of the following:

- The VoIP provider will be a regulated CLEC (competitive local exchange carrier) and will take care of all needed regulations. In this case the ISP will not need to be certified by the state regulatory body (even though a few states would still encourage the ISP to do so).
- The VoIP provider supplies the voice switch. This is the device that makes and receives calls. For most VoIP providers today the voice switch is located in the cloud and the ISP communicates to and from the voice provider using a dedicated VPN through the normal connection to the Internet. It's also possible to a VoIP provider to place a small switch box at the ISP that would allow local customers to talk each other inside the ISP network if the connection to the IP backbone is severed.

- The VoIP provider provides all interconnections to the world. This means that the VoIP provider will make the needed connections to 911. The VoIP provider will provide for ancillary services like operator services or calls to information. The VoIP provider will bundle in a long-distance service to place and complete long-distance calls. The VoIP provider will also make the needed connections to complete local calls within the ISP's market.
- VoIP products are generally simplified compared to traditional telephone service. For instance, a VoIP might only offer two residential products – one with no long-distance and one bundled with unlimited long distance. The VoIP provider will likely offer the most common types of telephone service used by businesses such as vanilla business lines, or trunk lines to support a key system or PBX. But VoIP providers do not usually support complex business phone systems such as the phone systems that might be used by a university or a big hospital.
- The VoIP provider will take care of functions like number portability that allow a customer to keep an existing phone number when changing to the ISP. The VoIP provider will tie into the national databases so that caller ID will identify the name of calling parties. They will also connect to databases that enable calls to 800 numbers and other similar industry routing databases.
- The VoIP provider will make sure that customers are listed in the white pages and are listed in what are called ID databases.
- VoIP providers typically make it easy to integrate their product into the ISP. For example, they will provide software that can be tied into the ISPs billing system so that an order taken by a customer service rep is automatically schedule for the VoIP provider.

Resold Traditional Voice. ISPs sometimes buy voice service from a nearby telephone company that is willing to sell their voice products wholesale. This might be a small regulated telco or another CLEC. These arrangements can be all-inclusive like the description above for VoIP service – but they usually are not. Each item on the above list would be negotiated and the ISP might take on some of the functions. It would be common in this case the ISP to become a regulated CLEC.

The drawbacks to the kind of arrangements is that the process is not likely automated and integrated since the seller of the voice probably doesn't sell enough of the service to justify spending the money to automate. This means that it will require more work from the ISP to install, change, or deactivate a telephone customer.

But there are upsides for connection to a more traditional voice switch. A traditional switch contains dozens of types of telephone lines and thousands of types of features that can be offered to business customers. VoIP providers often won't support things like Fax lines. A traditional voice switch product if often the preferred choice for ISPs that sell primarily to businesses since they can usually match any product that customers already have and want to keep.

Offering Video. There is no mature wholesale market for buying wholesale video. That makes it much more of a challenge for a new ISP to offer video. But there are still new ISPs that offer video, particular those who sell predominantly residential service to a customer base that expects video from their ISP.

Traditionally, cable TV is delivered to customers though a set of electronics the industry calls a cable TV headend. The headend performs several functions. First, it has satellite dishes that pull national programming from satellites. The headend also needs to find a way to connect to local network stations to be able to air the local channels. The headend then changes the format as needed of the signals to deliver to customers. Signals from satellites are generally compressed the signals must be decompressed and then formatted into whatever format the ISP's technology requires. The headend communicates with customers to deliver only the channels that a customer has subscribed to and wants to watch at a given time. The headend makes special connections with customers that want to buy one-time programming like wrestling matches. The headend generally communicates with a billing system to deliver the records needed to bill each customer.

We haven't heard of a new ISP that has purchased a new video headend in the last decade. The minimum cost of a headend is at least $2 million and can be a lot more depending upon the technology used to communicate with customers.

There are also other requirements that an ISP must meet to be considered as a cable company. The must register with the FCC and comply with some annual reporting requirements. They must obtain a franchise agreement in order to provide cable TV service in most towns. The process of buying programming is extremely complicated and most small ISPs join the National Cable Television Cooperative (NCTC), which buys programming for hundreds of small ISPs. It's not cheap to join the cooperative, and even if somebody joins the cooperative, they will sign a stack of programming contracts several feet tall that layers on numerous obligations due to programmers. It can take well over a year for a new ISP to negotiate contracts directly with programmers, and in doing so they generally pay the highest prices and get the most unfavorable terms. Finally, an ISP that wants to deliver video must sign a contract with each local network station that is within airwave reach of the market. This process is called the retransmission consent process.

If the ISP offers some form of traditional cable TV, the ISP will have to provide settop boxes to customers. Most ISPs charge at least $5 per month for each settop box, and since the boxes generally cost about $130, there is a decent margin if customers keep the boxes for a long enough time.

The worst thing is that after jumping through all of these hoops, there is little or no margin in the cable TV product, and many small operators are losing money on video. This is convinced a number of small ISPs to drop the cable product.

But there are still a few ways for a new ISP to get into the video business:

> Buy Programming from a Nearby Headend. This is similar to ISPs that buy voice from a nearby telco. It's fairly common for ISPs to pay an existing headend to receive the signals from satellites for them. In the industry that function is referred to as transport.
>
> Under this arrangement, the ISP must go through all of the steps described above. They must join the cooperative or otherwise arrange to buy content. They must execute a franchise agreement in the local market and must negotiate a retransmission agreement with every local station in the region.

There is also a cost to this arrangement. An ISP must have at least a 10-gigabit data connection to the headend in order to transmit all of the programming. The ISP also might have to buy gear to remodulate the signal if they use a different customer technology than whatever is used by the headend provider.

In this arrangement and ISP is generally stuck with the same channel lineup that is carried by the headend owner. However, channel lineups don't vary a lot for small cable programmers because the programmers dictate a lot of the lineup, including channel placement.

<u>Buy Wholesale Programming</u>. There is a fledgling wholesale programming market developing and there are a few wholesale providers of programming. The vendors providing this service are trying to make it easier for ISPs, much like is done by the VoIP wholesalers. The cable wholesaler might obtain the need regulatory status and negotiate the cable franchise and the retransmission agreements. The obtains all of the programming and the ISP would not need to sign programming contracts or join the cooperative.

Under this arrangement the ISP will have the exact line-up offered by the wholesaler, since that vendor is the regulated cable provider. Generally, the ISP would be required to mention the wholesaler on customer bills, with something like, "Cable TV powered by X."

<u>Offer OTT Service</u>. This means offering an Over-the-Top video service like Sling TV or YouTube TV. There was a recent announcement that Windstream, a fairly large telco is now offering Sling TV, fuboTV, or YouTube TV to new customers instead of traditional TV. Customers must have a Roku stick or box to receive the service. This basically takes the ISP out of the cable business. There are no regulations to comply with. There are no programming contracts. There are no settop boxes.

The downside to this is that there is likely also little or no margins in the product. However, it does allow an ISP to offer a video product to those that want to buy everything from an ISP rather than subscribe individually.

For now, these products are not yet available to smaller ISPs and Windstream is the smallest company we've heard that offers this. However, we expect that to change and within the next year we're hopeful this could be an option for small ISPs that want to act more like large ISPs.

C. Financial Model Assumptions

<u>Incremental Analysis</u>

It's important to note that all the projections were done on an incremental basis. This means that the studies only consider new revenues, new expenses, and new expected capital costs. This is the most common way that businesses of all sorts look at potential new ventures since the incremental analysis answers the question of whether any new business line will be able to generate enough revenue to cover the costs.

It's important to understand what an incremental analysis shows and does not show. An incremental analysis is basically a cash flow analysis. It looks at the money spent to launch and operate a new venture and compares those costs to the revenues that might be generated from the venture.

An incremental analysis is not the same as a prediction of what the accounting books of a new venture might look like. For example, if one of the existing ISPs in the area was to undertake one of these business plans, they would allocate some of their existing overhead costs to the new venture. The classic textbook example of this is that some of the existing cost of the general manager of the ISP would be allocated to the venture in the accounting books. However, the cost of the salary of the existing general manager is not considered in an incremental analysis since that salary is already being paid by the existing business. If these studies were to show an allocation of the general manager, then they would not be properly showing the net impact of entering the new market.

Timing

Timing is critical to any business plan. The faster that a business can start generating revenues the sooner it can cover costs. These studies are somewhat conservative in the predictions of the speed of the roll-out of the business venture. That means that if an ISP could get customers faster than predicted by the projections that they can have better results than we've shown.

All scenarios anticipate that the first customers will be added to any new networks in the tenth month of the first year after starting the project.

Following are the major milestones as predicted by these forecasts:

- Financing: All of the forecasts assume that the financing is available in January 2021. This is illustrative only and could be changed to any other future date.
- Construction: Fiber construction is done during the summer and fall of the first year. Core construction of the network is done in the summer during the spring and summer after financing. In the fiber everywhere scenario construction carries through the second year.

Pricing Strategy

We assumed that the products would be as simple as possible. As an example, the telephone companies offer a wide range of different telephone products. We assumed that a new business would offer only a few options. For example, for residential service we have assumed only two products - a basic telephone line and a telephone line with unlimited long distance.

There are a number of different pricing strategies used around the country by various ISPs for broadband. Following is a discussion of some of the more common models and a discussion of the pros and cons of the various approaches to pricing.

- Competition. When building broadband into a market that already has existing competition it's important to consider the prices of the competition as well as predicting how they might react to competition.
- Demographics. This asks the important question of what people are willing to pay for broadband. As somebody who works for a lot of ISPs, I observe that a lot of ISPs are not good at this. I

regularly see ISPs that set prices too low based upon the assumption that nobody will buy – but I see other markets with higher prices and similar penetration rates.

- General Pricing Philosophy. ISPs often come to the market with predetermined notions of how prices ought to work. A pricing philosophy is often based upon the overall goals for the business and the way that an ISP thinks about business. For example, some ISPs have a goal of maximizing cash flow or of maximizing profits (not the same thing). Other ISPs are more community based and want to bring fast broadband to as many households as possible. These basic philosophies are often the driving force behind a pricing strategy.

  For examples, some ISPs believe in simplicity and only offer a few products. Other ISPs stress bundles and price accordingly. Some ISPs think that the way to sell a lot of services is by having low prices. Other ISPs think it's better to have higher prices and fewer customers. Some ISPs think it's important to the community to have a low-priced product for low-income households. Some ISPs charge the same prices to residents and businesses – others charge businesses a lot more.

Those various philosophies result in a couple of different pricing schemes that we see in the marketplace. A few key examples include:

- One Broadband Product. A few ISPs like Google Fiber, Ting and a handful of smaller ISPs have one broadband product. They sell a gigabit of speed for a set price. Google Fiber had gone to a 2-product offering, but recently announced they are returning to the flat-rate $70 gigabit. Any ISP with this philosophy is likely not trying to capture a huge share of the market but is content to sell a high-margin product to a smaller number of homes.

- Low Basic Price. Some ISPs set the price for the basic product low. This is done more often by municipal ISPs, but there are small commercial ISPs with the same philosophy. As an example, in these markets somebody might set the price of the basic product on the fiber network as something like 50 Mbps for $40.

  CCG Consulting has access to the prices and the resulting customer counts from nearly 200 ISPs and what we have learned is that most customers will buy the basic broadband product as long as the speed is okay. A basic product set at 5 Mbps likely wouldn't sell, but in today's market a product with a decent speed like 50 Mbps will be perceived as acceptable to most households. Depending upon what we call the 'steps' in pricing, a low-priced introductory product is likely to get 70% - 80% of all customers.

  The consequences to an ISP of low prices is that they likely get a higher penetration rate than an ISP with market rates, but they are also leaving a lot of money on the table.

- Price Steps or Tiers. One of the key aspects of pricing other than the price of the lowest tier is the price steps between products. Consider a $60 starting broadband product and the following tiered price structures:

	Rate 1	Penetration	Rate 2	Penetration	Rate 3	Penetration
50 Mbps	$ 60.00	95%	$60.00	80%	$60.00	60%
200 Mbps	$ 90.00	4%	$75.00	15%	$70.00	30%
Gigabit	$120.00	1%	$90.00	5%	$80.00	10%

For 1,000 Customers:			
Revenue	$61,800	$64,000	$65,000
Increase		4%	5%

The difference in the steps or tiers is that "Rate 1" prices are set $30 between products, "Rate 2" is at $15, and "Rate 3" is at $10. The impact of smaller tiers is that it's easier to upsell customer to faster products. I derived the relative rate structure for the various tiers based upon what I've seen at various ISPs. Customers might voluntarily choose a fast product when the step between tiers is small, and they are more likely in the future to upgrade anytime they feel their speed is bogging down or inadequate. Conversely, when the steps are too large, customer buy and then stick with the lowest-priced tier rather than jump their bill too much.

It's an interesting phenomenon and to some degree is psychological. Consider in the examples above that more customers are likely to buy the gigabit product in Rate 3 for $70 than will buy the 200 Mbps product in Rate 1 for $80. Since both speeds are faster than what households likely need you might think there would be a small difference between the public reaction to the prices – but our experience is that penetration rates act much like the above tables. As a last note, the $60 base price in the above tables is still below market rate.

We have seen that multiple price tiers confuse customers. The above examples have tiers with three prices. We know of ISPs with seven to ten price tiers and in looking at their penetration rates we see that this confuses customers. We have seen the most effective rate structures having no more than four tiers, which can be explained to customers on a fiber network as fast, faster, and fastest.

- Setting Business Rates. Philosophies vary widely on business rates. The incumbent telephone companies and cable companies generally charge a lot more to business than to residential customers. At one time the philosophy behind this is that businesses consume more resources and cost more to serve than residential customers. That's still true for medium and large businesses, but most ISPs will tell you that the average home today uses considerably more bandwidth than the average small retail store. The exception might be a coffee shop supporting a public hotspot, or a business that deals in large files like photographers or engineers.

  We know a few ISPs that charge the same rates to businesses and residences, although that is rare. Most ISPs follow the incumbent pricing practices but offer a decent discount from the incumbent prices.

  One thing that a first-time ISP learns quickly is that incumbents don't have standard rates for businesses, but rather they negotiate them. It's not unusual to find two similar small businesses in the same neighborhood paying rates for the same products that are 50% apart. This creates a challenge for ISPs. Some ISPs set standard business rates that apply to all businesses and others set rates on a custom basis compared to what a business is currently paying.

  The other thing that a new ISP learns quickly is that the large majority of businesses care more about reliability than price. They want their broadband and telephones to always work during business hours. They don't want to pay more than they can afford, but they are not afraid to pay for a quality connection. While a new fiber provider might see good appreciation for a fiber-based ISP saving them money, the chances are that they decided to change ISPs due to outages they have had in the past with their current provider – if they perceive fiber to be a more stable technology. One of CCG's clients recently did a survey of businesses in a new market and over half of them had experience a half-day or longer broadband outage during the last year. For most of them, this was the deciding factor they cited when they talked about the willingness to talk to a new network provider.

- <u>Rate Bundles</u>. The large cable companies are well-known for having bundles of products where they provide a discount to customers buying more than one product. Generally, customers have no idea which products the discount applies to. I would estimate that no more than 15% of the small ISPs that CCG works with provides a similar bundling discount. Most smaller ISPs set prices at rates they perceive to be competitive and don't discount them further. We know a few ISPs that built a business plan and forecasts upon straight rates and then found themselves in financial stress when a marketing person at the company decided they could sell more by offering discounts that weren't in the plan.

  Interestingly, Verizon recently announced that they are doing away with bundled rates for new customers. It will take a few years for customers with older plans to migrate to unbundled rates. Verizon describes the new rates structure as more open and honest and say that it is what customers want. We'll have to wait to see if other big ISPs follow this market trend.

- <u>Introductory Rates</u>. The big telcos and cable companies are also well-known for advertising low introductory rates that increase dramatically after a term contract of one to three years. Most of the rates you'll see from these companies on the web or in advertising are the introductory rates, and the real rates of these companies are generally buried in the small print, if shown anywhere.

  Customers dislike the introductory rate process because they invariably get socked with an unexpected rate increase when rates jump back to list prices. The time of big introductory discounts might be starting to come to an end. AT&T decided last year to stop renegotiating customers to the low rates and when introductory offers end the company is sticking with the list rates. This has cost AT&T a few million customers on DirecTV, but the company says they'd rather have fewer customers that are profitable rather than maintain customers that don't contribute to the bottom line of the company. A few medium-sized cable companies have made this same change.

  I don't know many small ISPs who have used this pricing philosophy. It requires having customers signing contracts and then ties up staff when those contracts end, and customers want to negotiate low rates again.

- <u>Low-Income Pricing</u>. This is covered in more detail in Section I.D of this report. Some ISPs, both giant ones and small ones, offer products to low-income households. Most try to set rates to make it affordable, and most have some criteria for how customers qualify for the low rates, such as having students using the free lunch program. Most ISPs try to set the rates at a level that at least covers costs and perhaps returns a tiny margin.

Rates used in this Study

Telephone Rates

The studies used the following very simplified pricing for residential phone service:

Basic Local Line	$20.00
Line with Unlimited Long Distance	$30.00

We've assumed that both kinds of lines include a full package of features like voice mail, caller ID, etc. The above prices also include any extra fees that the incumbent telcos show separately on the bill, but which are part of the rate. These rates would not include true taxes on the service, such as the tax that supports 911.

Cable TV Products

Offering competitive cable TV in a new market is a challenge. We decided to not include cable TV in the feasibility study. None of the fiber builders in your region offer cable TV today. Even should you find an operator willing to offer cable TV, there is little margin on the product, so adding cable TV would make little difference to the financial bottom line in the analysis. Finally, it's nearly impossible for a small ISP to compete on price with the satellite TV providers and small ISPs that offer TV generally have significantly higher prices. That makes it hard to attract customers to the product even if it's delivered on fiber.

Broadband Products

The studies do not specify data speeds, but we assume that broadband over fiber will be far faster than any broadband available today in the area. We have shown data speeds by 3 tiers. A typical mix of products in three tiers on fiber might be something like 100 Mbps, 250 Mbps, and 1 Gbps.

	Price	**Percentage**
Residential Fiber Broadband		
Tier 1	$ 60.00	70%
Tier 2	$ 75.00	25%
Tier 3	$ 90.00	5%
Business Fiber Broadband		
Tier 1	$ 75.00	65%
Tier 2	$ 85.00	25%
Tier 3	$ 95.00	10%

Most ISPs charge more to businesses for broadband, and the studies assume a $15 additive to business rates.

These would all be shared data products, meaning that the overall bandwidth to provide them is shared among multiple customers. This is not to say that the data path to a given customer is not secure, because the transmission to any specific customer is encrypted for privacy purposes. Still, there might be some business customers that will want a dedicated data product that is not shared with anyone else. The fiber network can accommodate this by providing such customers with an active ethernet connection. Prices for these services would cost a lot more than shared data services.

The financial models assume that the data products don't have data caps and provide unlimited broadband usage to customers.

We've also assumed that these prices include a WiFi model for customers. Many ISPs break this out as a separate charge.

Large Broadband Products

There are potential customers in the cities that might buy larger bandwidth products. The studies are conservative and only predict a small amount of this revenue. It's likely over time that a fiber operator would do better than is shown in the models.

D. Network Capital Costs

The telecom industry uses the term capital costs to describe is the industry term for the cost of assets required to operate the business. The capital expenditures predicted in these models reflect the results of the engineering studies referenced in Section II of the report.

Below is a summary of the specific capital assets needed for each base scenario. The amount of capital investment required varies by the technology used as well as by the number of customers covered by a given scenario.

Capital for broadband networks include several broad categories of equipment including fiber cable, electronics for FTTP, huts and wireless towers, wireless electronics, and customer devices like cable settop boxes and WiFi modems. In addition to capital needed for the network, there are operational capital costs predicted in the projections for assets like furniture, buildings, computers, vehicles, tools, inventory, and capitalized software.

We have tried to be realistic, but a little conservative in our estimates, so that hopefully the actual cost of construction will be something lower than our projections. One way we were conservative was by adding an 5% construction contingency to the cost of the fiber.

However, it is important to remember that the engineering used to make these estimates is high level. The detailed engineering needed to be more precise is expensive and would involve having an engineer examine all places in the potential network to look at local construction conditions. That kind of engineering is generally not done until a project is ready for construction.

The studies all assume that the provider of service will not build a new cable TV headend or buy a new voice switch for the provision of cable TV or telephone service. If the new provider is an ISP that already offers those products elsewhere, the assumption is that they would transport in the products over the fiber backbone. These services are widely available today on a wholesale basis.

Following is the capital required for the base case for each of the three primary scenarios. These represent the capital expended during the first 5 years, which for most projects are covered by borrowing before the business becomes cash positive. The scenarios assumed different customer penetration rates. All scenarios assume a 50% customer penetration rate. The capital costs would be higher or lower if there were greater or fewer customers than the penetration rates used to calculate these figures.

	Farmington Hills	Farmington	Both
Fiber	$70,864,684	$ 7,793,783	$ 78,658,617
Drops	$ 9,344,861	$ 1,626,676	$ 11,011,477
Electronics	$13,053,456	$ 3,073,523	$ 15,813,173
Huts	$ 188,060	$ 116,360	$ 304,420
Operational Assets	$ 1,688,389	$ 528,444	$ 1,773,604
Total	$95,139,450	$13,138,786	$107,561,142
Cost per Passing	$3,007	$ 2,144	$2,848
Cost per Customer	$6,014	$ 4,289	$5,696

Note that the figures for operational assets for both markets combined are not the same as adding the two markets together. The asset costs in each market were considered as if these are standalone markets and include software and other assets that included in each standalone scenario. Also note that these scenarios assume the cities are the ISP – the cost of a few assets like software would be different for an existing ISP.

Customer Costs

Residential Fiber Electronics Costs: The model assumes that the fully installed cost of a customer installation is $401. This includes an ONT and associated hardware, the cost of any needed new wiring, and the cost of installation labor. This cost does not include a WiFi router, which we've assumed is optional for customers. We've assumed these routers cost $115.

Fiber Drops: Fiber drops are the fiber that connects from the street to the customer premises. In this study the cost of fiber drops is significant. The assumption has been made that with the volume of drops needed plus the anticipated speed of network deployment the drops during the first four years of the project would be installed by external contractors.

Drop costs vary according to the length of the drop. For the most part, drops in the cities are relatively short and most homes are reasonably close to the street. The biggest difference in cost for drops is if they use aerial or buried construction. We've assumed that drops would follow the fiber on the street – if the fiber is buried then drops would be buried, otherwise the drops would be aerial from poles. The cost for an aerial fiber is estimated to be $401 while underground drops are $821.

The prices included in the study represent recent pricing being paid in the prices assume you'd pay an external contractor to install drops. We have clients that are able to install drops for a lower cost by constructing with their own crews.

Customer Penetration Rates

One of the most important variables in the study is the customer penetration rate, or the percentage of the homes and businesses in the community that will buy broadband service.

The analysis looks at customer penetration rates in several different ways. The base scenario begins with what we call expected rates. We used an expected penetration rate of 50% as the starting point of our analysis. We think the results of the residential survey justify this level of expected demand. It's possible that a new fiber ISP could do even better in the market, but we try to stay conservative in our analysis.

We also calculated what we call the breakeven penetration rate. This calculates the number of customers that are needed for a project to reach cash breakeven – where the business would always be able to pay for operating expenses, debt, and the ongoing capital needed. The breakeven penetration for Farmington was calculated at 72%. The breakeven for Farmington Hills is 45%. The breakeven for the combined towns is 46%. We'll discuss more below about these numbers.

The only real way to understand the potential broadband penetration rate would be to do a residential survey or a canvass based upon proposed broadband prices. The survey we did for this study showed that nearly 80% of residents expressed a wish for lower-priced broadband – a much higher response than we normally see to that question. As part of launching an ISP business it would be important to look at the willingness of customers to subscribe at specific prices for broadband. This could also be done with a canvass, where you ask the question to everybody in the community. The goal from these efforts would be to get specific feedback about the specific way that ISP would be launched and the specific planned pricing.

Expense Assumptions

The studies look at several scenarios that have different expense structures. For instance, we looked at scenarios where the cities become the ISP or with bringing a commercial ISP to the market – the expenses are different depending upon the operator of the business. Unless noted, the following assumptions assume a business owned and operated by a commercial ISP.

Expense Assumptions

Expenses are the recurring costs of operating the business once it's built. We strive when building financial projections to be conservatively high with expense estimates. It's often less costly for an existing service provider to add a new market than what is shown in these projections.

As mentioned earlier, expenses are estimated on an incremental basis, meaning that the models only consider new expenses that would be needed to open the new market for an existing ISP. In an incremental analysis it's assumed, for example, that the existing ISP is already paying for positions like a general manager, an accountant, etc. and that the ISP only needs to hire employees needed to open a new market and add additional customers.

The primary expense assumptions are as follows:

Employees: Labor is generally one of the largest expenses of operating a broadband network. The models assume that an ISP will need to hire additional staff to take care of the new customers. We have assumed salaries at market rates with an annual 2.5% inflation increase for all positions. We've assumed that the benefit loading is 35% of the basic annual salary. That would cover payroll taxes and other taxes like workers' compensation, as well as employee benefits. It's worth noting that the salary / benefit structure is different for municipalities and commercial ISPs. There are very few ISPs that offer retirement benefits, except a few that are unionized. Our models assume that loaded labor (salary plus benefits) cost more if there is a municipal ISP.

There is also a significant difference in the number of employees required for a start-up ISP created for the market versus an existing ISP adding the cities to an existing business. For example, an existing ISP could conceivably enter your market and only have to hire new customer service representatives, new technicians in trucks, and perhaps a new salesperson. However, if the cities, or some new commercial ISP launched a new business in the cities they would have to hire additional staff like a general manager, marketing staff, inside technicians, billing staff, accounting staff, etc. Our studies are incremental and only look at the new staffing hired for a given scenario, and we recognize the difference in cost between an existing ISP and a new ISP.

This difference is often referred to as the economy of scale. For example, an existing might be able to use existing backoffice staff like a general manager or accountants without hiring anybody new. This makes it less expensive for an existing ISP to open a new market than what it cost them to enter their first market. Said simple, the larger an ISP grows, the more efficient the labor costs.

At a minimum, an ISP entering the market would require the following two additional types of employees:

<u>Customer Service Representative.</u> Takes new orders, answers customer questions about billing, services, etc.

<u>Install/Repair Technician.</u> These technicians provide network maintenance and repair calls. The technicians would maintain both network electronics and facilities as well as customers. In many ISPs these technicians also install new customers.

<u>Help Desk</u>. The studies all assume that the help desk function would be outsourced. This is the function of taking calls from customers asking about technology and equipment questions. Most smaller ISPs outsource this function today and there are high-quality help desk vendors available.

It's likely that even and existing ISP might require additional staff for entering a market of this size. Some of the other positions that might be hired for an existing ISP include:

Salesperson. Almost all ISPs acknowledge that door-to-door sales is the only effective way to sell to business customers. A salesperson would make new sales and also do follow-up to retain business customers.

Inside Technician. The size the cities might drive an ISP to hire an additional inside technician who takes care of core electronics, network reliability, and network security.

Marketing Analyst. Some ISPs would put a marketing analyst in a market of this size to help coordinate and drive local residential sales.

Start-Up Costs: To be conservative, there are some start-up costs included in each scenario. There are expenses associated with launching a new business or new market and rather than list them all specifically we have included them as start-up costs. There are start-up costs even for an existing ISP when entering a new market.

Sales and Marketing Expenses: Every scenario requires a significantly high customer penetration rate to be successful. We used the assumption that there would be a marketing effort to sign customers (instead of the word-of-mouth that often happens in smaller markets). It would be too risky to spend the money to build a network without knowing for sure that there are enough interested customers to allow the business to pay for itself. Marketing expenses shown in the models are likely going to be for that effort. It's possible that such money would be spent earlier than shown in the model.

Cost-of-Good Sold. The projections assume that any telephone or cable products would be purchased externally on a wholesale basis. The study assumes any ISP will have to buy bandwidth and transport to connect the market to the Internet.

Maintenance Expenses: There are a number of routine maintenance expenses that the new business would incur on an incremental basis. These include:

- Vehicle expenses to maintain the vehicles required for the field technicians.
- Computer expenses to support the computers used by employees.
- Tools and equipment expenses.
- Power expenses to provide power to the network.
- Maintenance agreements. Most ISPs buy maintenance agreements to support complex electronics such as the FTTP core, routers, and switches.
- General maintenance and repair of the outside plant network and the electronics to repair damaged or nonfunctional electronics.

Software Maintenance: ISPs maintain a complex software system called BSS/OSS (billing and operational support systems). This software provides a wide range of functions: order taking, provisioning new customers, tracking of customer equipment, tracking of inventory, creation of customer bills, tracking of customer payments (or nonpayment). Since most such software is billed to providers as a starting lump-sum purchase plus a fee for each customer added to the network.

Billing: Billing costs are shown as the incremental cost used to bill customers. We assumed that there would be some mix of mailing paper bills, of charging bills to credit cards, and of charging bills directly as debits to bank accounts.

Taxes: The model assumes that a commercial ISP operating the business would pay state and federal income taxes. These taxes would not apply if the ISP is a municipality or a nonprofit.

We have assumed no property taxes on assets, but it's possible that some amount of this might apply. There are a few places in the country that charge property taxes on fiber networks, but most of the country doesn't. The issue of charging or not charging is usually county specific.

The forecasts do not include any taxes that are assessed to customers. For example, this business would be expected to charge and collect various telephone taxes. These kinds of fees are normally added to the customer bill, and thus customers directly pay these taxes. The models don't show these taxes and the assumption is that the taxes would be collected and sent to the tax authorities on the customers' behalf. They are not shown as revenue or expense to the forecasts, but rather are just a pass-through on the ISP books.

Overhead Expenses: The forecasts include various overhead expenses. Since this is an incremental model it does not include allocated expenses such as an allocation of the general manager's salary. But there are incremental costs attributable directly to the new business. This would include things like legal expenses, accounting audit expenses, consulting expenses, business insurance, and other similar expenses that are related to entering a new market.

Depreciation and Amortization Expense: The forecasts include both depreciation and amortization expense. These are the expenses recognized by writing off assets over their expected accounting lives. For example, the depreciation rate for a vehicle is 20% per year (is written off over 5 years). The cost of a new vehicle is then depreciated monthly to write off the asset over the 5 years, or 60 months. All hard assets are depreciated except land. Depreciation rates are set according to the expected life of the assets—something that is usually determined to comply with IRS rules and also accounting standard practices. Soft assets like software are instead amortized, using the same process as depreciation.

E. Financial Model Results

It is never easy to summarize the results of complicated business plans to make them understandable to the nonfinancial layperson. In the following summary are some key results of each study scenario that we think best allows a comparison of the numbers between scenarios. These summaries look at the amount of cash generated over the life of the plan.

The way to measure profitability in a new business differs according to the structure of the business. A municipal business, for example, generally measures success by the ability of the business to generate enough cash to operate without any external subsidy. While for-profit business would generally expect to generate excess cash and would measure success using something like net income to measure profits.

It is important that a business always has cash in the bank to meet its obligations. In this particular business plan, the ideal situation would be to always have at least $300,000 in the bank to have a cushion against nonlinear monthly expenditures. Not all expenditures are spent evenly throughout the year and a business must maintain a cash cushion to allow for those times of the year when the expenses are higher than normal or when the revenues are lower than normal.

Following are the results of the various scenarios. There is a table of these results in Exhibit II, which makes it easier to compare different scenarios.

Why the Projections Are Conservative

We always try to make our business plans conservative. By conservative, we mean that an actual business plan ought to perform a little better than we are projecting. Following are some of the conservative assumptions used in the business plan:

- The models contain no "home run" revenues. These would be sales of larger broadband products such as selling bandwidth to the local schools or cellular providers. We know that every fiber business gets some of this kind of revenue, but we took the conservative approach of not showing it because we can't guess how much and when such opportunities might occur. We try to avoid predicting such revenues since it's possible this will never materialize.
- The engineering estimates include a 5% construction contingency. We think the estimates of construction costs are solid and this contingency might not be needed.
- In the model, we show an increase in the cost of wholesale bandwidth over time. However, industry costs for raw data might be less than we are projecting and might even drop over time.
- Our model assumes a regular replacement of electronics. However, it is possible that upgrades will be needed less often than we have shown. Further, our assumption is that the cost of electronics at the time of each upgrade would cost as much as the equipment that is being retired. The experience of the electronics industry is that electronics get cheaper and more efficient over time, so the cost of upgrades is probably going to be less than is shown in the model. The vendors in the industry have also gotten better at having phased upgrades that allow for keeping older equipment in place and not having to replace everything at once, making upgrades less expensive than we have projected.
- There are steps that the new business could take to improve upon these projections.
    - Preselling: We've seen ISPs that can get earlier revenues when they presell to customers. This gives them the opportunity to begin connecting homes to the network while the network is being built. This would allow customers to be turned on in "nodes" or neighborhood-by-neighborhood as construction is completed.
    - More Concentrated Build Schedule: It's always possible to build faster than shown in these forecasts if the ISP is able to execute on a faster construction schedule. The amount of network that can be built in a given time period increases by adding more construction crews.
    - Get Temporary Help: There are often other bottlenecks at small companies that can slow down customer installations. This could mean the need for more sales and marketing staff, additional customer service reps, or technicians needed to provision new customers. Service providers should strongly consider using temporary employees during the roll-out of a major new market.

Farmington

This scenario looks at bringing broadband to just Farmington. As a reminder from above, here are the basic assumptions included in the following scenarios:

- Fiber is built to pass every home and business.
- The customer penetration rate is assumed to be 50% at maturity, achieved between 4 and 5 years after the start of the project.
- Bond funding is assumed over 25-years with a 3.0% interest rate. We looked at both general obligation and revenue bonds. All bond scenarios include capitalized interest, meaning that the money needed to pay interest for the first three years is borrowed as part of the bond issue.
- Commercial debt is assumed at 4.5% over 20 years. Commercial debt also assumes 15% equity is required.

Method of Financing

	General Obligation Bonds	Revenue Bonds	Existing ISP
Asset Costs	$13.12 M	$13.12 M	$12.97 M
Equity	$ 0.00 M	$ 0.00 M	$ 2.10 M
Debt	$15.10 M	$16.60 M	$13.80 M
Total Financing	$15.10 M	$16.60 M	$15.90 M
Cash after 10 Years	($ 3.13 M)	($ 3.95 M)	($ 2.18 M)
Cash after 20 Years	($ 5.44 M)	($ 6.49 M)	($ 4.97 M)

There are a number of things to point out about the above results:

- The Farmington market looks to be too small to support a standalone broadband business. Under all forms of financing, the revenues are not sufficient to cover the cost of debt.
- General obligation bonds are less costly than revenue bonds. In the current market the interest rate is lower on general obligation bonds. Revenue bonds also require additional borrowing for surety – a safety net against defaults on the bond.
- A commercial ISP would also be unable to make a profit serving only Farmington.

Sensitivity Analysis with General Obligation Financing

The study then considered what we call a sensitivity analysis. We looked at the impact of changing the key variables and assumptions that have the biggest impact on the bottom line of a fiber project. The following describes the impact of changing key variables for the scenario of financing with general obligation bonds (the first column in the table above). We could create a similar description of the impact of changing the variables for each of the options in the table above – but the impact of most of these changes is similar regardless of the specific business model. For example, the impact of changing prices is the same regardless of the way a project is funded.

Changing Customer Penetration Rate

The base analysis considered a penetration rate of 50%. We also looked at increasing the penetration to 55%. The impact of changing penetration rates high or lower by 5% was a change in cash over 20 years of more than $2.2 million. This means that the impact to the business of a 1% change in penetration rate (from 50% to 51%) is around $450,000. This means the business is extremely sensitive to the customer penetration rate. It will be vital to understand customer demand before launching the business. This also means that it would be prudent to pre-sell to as many customers as possible before launching the business.

The breakeven penetration rate needed for Farmington to be at cash breakeven as a standalone ISP is 72%. This is not an achievable penetration rate.

Changing Broadband Prices

We looked at a scenario that changed broadband prices. Increasing or decreasing broadband prices by $5 per month changed cash flow over 20 years by almost $2.6 million. This means that a $1 change in broadband prices changes 20-year cash flow by approximately $510,000. This is also a high sensitivity. The cautionary tale about this finding is that an ISP must be careful after launch to stick to target prices. If a future decision is made to cut rates to be more competitive, the impact on the bottom line could be drastic.

Changing Financing Terms

We looked at the impact of changing the various financing parameters.

Interest Rate. We looked at a scenario that changed the interest rate by 50 basis points, or 0.5 % (such as changing the interest rate from 3.0% to 3.5%). This changed cash flow by just over $1 million over 20 years.

Loan Term. We looked at the impact of increasing the loan term from 25 years to 30 years. This had a dramatic impact and increased cash over 20 years by more than $2 million. This provides a great incentive to consider the longest loan maturity that can be achieved. Longer loans mean lower annual debt payments (just like with a home mortgage). Bonds can always be repaid earlier if that becomes a goal, but the longer the loan term, the smaller the annual required debt payments.

We looked at the feasibility of shortening the loan to 20 years and we couldn’t find a way to make this work. The payments on a 20-year revenue bond are higher than can be supported by the cash flow of the business.

Adding 5% to the Construction Contingency

We examined the impact of changing the cost of the network. In this case, we chose to change the cost of fiber by 5%, or $300,000. This changed cash over 20 years by $370,000. To put that into perspective, changing the cost of the network by $1 million changes cash flow over 20 years by $1.2 million.

The Additive Nature of the Variables

The impacts citied for the various variables are somewhat additive. For example, the above discussion describes an improvement to cash generated by the business from finding a lower interest rate on debt than shown in the models and for spending less on the network. These improvements are roughly additive, meaning that you can add the results above together and will come close to the impact of making both changes to the models.

Farmington Hills

This scenario looks at bringing broadband to just Farmington Hills. As a reminder from above, here are the basic assumptions included in the following scenarios:

- Fiber is built to pass every home and business.
- The customer penetration rate is assumed to be 50% at maturity, achieved between 4 and 5 years after the start of the project.
- Bond funding is assumed over 25-years with a 3.0% interest rate. We looked at both general obligation and revenue bonds. All bond scenarios include capitalized interest, meaning that the money needed to pay interest for the first three years is borrowed as part of the bond issue.
- Commercial debt is assumed at 4.5% over 20 years. Commercial debt also assumes 15% equity is required.

Method of Financing

	General Obligation Bonds	Revenue Bonds	Existing ISP
Asset Costs	$95.20 M	$95.20 M	$95.05 M
Equity	$ 0.0 M	$ 0.0 M	$ 13.2 M
Debt	$107.7 M	$118.8 M	$ 88.2 M
Total Financing	$107.7 M	$118.8 M	$101.5 M
Cash after 10 Years	$ 1.91 M	($ 3.82 M)	$ 1.14 M
Cash after 20 Years	$18.19 M	$ 9.92 M	$15.14 M

There are a number of things to point out about the above results:

- The Farmington Hills market can support a standalone ISP. However, with bond or commercial financing the business plan is tight for the first ten years of operations.
- Farmington Hills would not be cash self-supporting if financed with revenue bonds. There is not enough cash in the first ten years to cover the extra borrowing needed with revenue bonds.
- General obligation bonds are less costly than revenue bonds. In the current market the interest rate is lower on general obligation bonds. Revenue bonds also require additional borrowing for surety – a safety net against defaults on the bond.
- A commercial ISP could be successful in Farmington Hills, but an ISP would have to bring a lot of equity, and the cash would be tight for the ten years of the new business. It’s unlikely a commercial ISP is going to see investing in fiber in the market as a good investment.

Sensitivity Analysis with General Obligation Financing

The study then considered what we call a sensitivity analysis. We looked at the impact of changing the key variables and assumptions that have the biggest impact on the bottom line of a fiber project. The following describes the impact of changing key variables for the scenario of financing with general obligation bonds (the first column in the table above). We could create a similar description of the impact of changing the variables for each of the options in the table above – but the impact of most of these changes is similar regardless of the specific business model. For example, the impact of changing prices is the same regardless of the way a project is funded.

Changing Customer Penetration Rate

The base analysis considered a penetration rate of 50%. We looked at increasing the penetration to 55%. The impact of changing penetration rates higher was a change in cash over 20 years of more than $15.3 million. This means that the impact to the business of a 1% change in penetration rate (from 50% to 51%) is around $3 million. This means the business is extremely sensitive to the customer penetration rate. It will be vital to understand customer demand before launching the business. This also means that it would be prudent to pre-sell to as many customers as possible before launching the business.

The breakeven penetration rate for financing with general obligation bonds is 48%. That doesn't leave much room for error for somebody pursuing a standalone ISP in the city.

Changing Broadband Prices

We looked at a scenario that changed broadband prices. Increasing or decreasing broadband prices by $5 per month changed cash flow over 20 years by more than $14 million. This means that a $1 change in broadband prices changes 20-year cash flow by approximately $2.8 million. This is also a high sensitivity. The cautionary tale about this finding is that an ISP must be careful after launch to stick to target prices. If a future decision is made to cut rates to be more competitive, the impact on the bottom line could be drastic.

Changing Financing Terms

We looked at the impact of changing the various financing parameters.

Interest Rate. We looked at a scenario that changed the interest rate by 50 basis points, or 0.5 % (such as changing the interest rate from 3.0% to 3.5%). This changed cash flow by just over $8 million over 20 years. This means that changing interest rates by only 10 basis points (changing from 3.0% to 3.1% will change cash flow over 20 years by $1.6 million. This means that the city would need to keep a close eye on interest rates and be ready to not proceed with financing if interest rates move too high. We've been lucky for the last decade that interest rates have held steady for years at a time, but over history it's more normal for interest rates to fluctuate.

Loan Term. We looked at the impact of increasing the loan term from 25 years to 30 years. This had a dramatic impact and increased cash over 20 years by more than $15.6 million. This provides a great incentive to consider the longest loan maturity that can be achieved. Longer loans mean lower annual debt payments (just like with a home mortgage). Bonds can always be repaid earlier if that becomes a goal, but a longer the loan term makes it easier for the business to succeed.

We looked at the feasibility of shortening the loan to 20 years and we couldn't find a way to make this work.

Adding 5% to the Construction Contingency

We examined the impact of changing the cost of the network. In this case, we chose to change the cost of fiber by 5%, or more than $2.8 million. This changed cash over 20 years by $3.6 million. To put that into perspective, changing the cost of the network by $1 million changes cash flow over 20 years by $1.3 million.

The Additive Nature of the Variables

The impacts citied for the various variables are somewhat additive. For example, the above discussion describes an improvement to cash generated by the business from finding a lower interest rate on debt than shown in the models and for spending less on the network. These improvements are roughly additive, meaning that you can add the results above together and will come close to the impact of making both changes to the models.

Both Cities

This scenario looks at bringing broadband to both cities. As a reminder from above, here are the basic assumptions included in the following scenarios:

- Fiber is built to pass every home and business.
- The customer penetration rate is assumed to be 50% at maturity, achieved between 4 and 5 years after the start of the project.
- Bond funding is assumed over 25-years with a 3.0% interest rate. We looked at both general obligation and revenue bonds. All bond scenarios include capitalized interest, meaning that the money needed to pay interest for the first three years is borrowed as part of the bond issue.
- Commercial debt is assumed at 4.5% over 20 years. Commercial debt also assumes 15% equity is required.

Method of Financing

	General Obligation Bonds	Revenue Bonds	Existing ISP
Asset Costs	$107.6 M	$107.6 M	$107.4 M
Equity	$ 0.0 M	$ 0.0 M	$ 14.7 M
Debt	$121.4 M	$123.6 M	$ 97.8 M
Total Financing	$121.4 M	$123.6 M	$112.5 M
Cash after 10 Years	$ 5.78 M	($ 1.12 M)	$ 3.34 M

Cash after 20 Years	$22.38 M	$12.57 M	$18.49 M

There are a number of things to point out about the above results:

- The two cities combined can support a standalone ISP.
- A two-city project would not be cash self-supporting if financed with revenue bonds. There is not enough cash in the first ten years to cover the extra borrowing needed with revenue bonds.
- General obligation bonds are less costly than revenue bonds. In the current market the interest rate is lower on general obligation bonds. Revenue bonds also require additional borrowing for surety – a safety net against defaults on the bond.
- A commercial ISP could be successful in bringing fiber to the two cities. But an ISP would have to bring a lot of equity, and it’s unlikely a commercial ISP is going to see investing in fiber in the market as a good investment. Even after 20 years an ISP has not earned back much more than the original equity invested in the cities.

Sensitivity Analysis with General Obligation Financing

The study then considered what we call a sensitivity analysis. We looked at the impact of changing the key variables and assumptions that have the biggest impact on the bottom line of a fiber project. The following describes the impact of changing key variables for the scenario of financing with general obligation bonds (the first column in the table above). We could create a similar description of the impact of changing the variables for each of the options in the table above – but the impact of most of these changes is similar regardless of the specific business model. For example, the impact of changing prices is the same regardless of the way a project is funded.

Changing Customer Penetration Rate

The base analysis considered a penetration rate of 50%. We looked at increasing the penetration to 55%. The impact of changing penetration rates higher was a change in cash over 20 years of more than $16.1 million. This means that the impact to the business of a 1% change in penetration rate (from 50% to 51%) is around $3.2 million. This means the business is extremely sensitive to the customer penetration rate. It will be vital to understand customer demand before launching the business. This also means that it would be prudent to pre-sell to as many customers as possible before launching the business.

The breakeven penetration rate for financing with general obligation bonds is 46%. That doesn’t leave much room for error for somebody pursuing a standalone ISP in the city. This is lower than the breakeven for serving only Farmington Hills. This is a good demonstration that broadband is an economy of scale business and that serving both cities together produces better financial results than serving either city alone.

Changing Broadband Prices

We looked at a scenario that changed broadband prices. Increasing or decreasing broadband prices by $5 per month changed cash flow over 20 years by more than $15 million. This means that a $1 change in broadband prices changes 20-year cash flow by approximately $3.1 million. This is also a high sensitivity. The cautionary tale about this finding is that an ISP must be careful after launch to stick to target prices. If a future decision is made to cut rates to be more competitive, the impact on the bottom line could be drastic.

Changing Financing Terms

We looked at the impact of changing the various financing parameters.

Interest Rate. We looked at a scenario that changed the interest rate by 50 basis points, or 0.5 % (such as changing the interest rate from 3.0% to 3.5%). This changed cash flow by just over $9.5 million over 20 years. This means that changing interest rates by only 10 basis points (changing from 3.0% to 3.1% will change cash flow over 20 years by $1.9 million. This means that the city would need to keep a close eye on interest rates and be ready to not proceed with financing if interest rates move too high. We've been lucky for the last decade that interest rates have held steady for years at a time, but over history it's more normal for interest rates to fluctuate.

Loan Term. We looked at the impact of increasing the loan term from 25 years to 30 years. This had a dramatic impact and increased cash over 20 years by more than $17.3 million. This provides a great incentive to consider the longest loan maturity that can be achieved. Longer loans mean lower annual debt payments (just like with a home mortgage). Bonds can always be repaid earlier if that becomes a goal, but a longer the loan term makes it easier for the business to succeed.

We looked at the feasibility of shortening the loan to 20 years and we couldn't find a way to make this work.

Adding 5% to the Construction Contingency

We examined the impact of changing the cost of the network. In this case, we chose to change the cost of fiber by 5%, or more than $3.1 million. This changed cash over 20 years by $3.7 million. To put that into perspective, changing the cost of the network by $1 million changes cash flow over 20 years by $1.2 million.

The Additive Nature of the Variables

The impacts citied for the various variables are somewhat additive. For example, the above discussion describes an improvement to cash generated by the business from finding a lower interest rate on debt than shown in the models and for spending less on the network. These improvements are roughly additive, meaning that you can add the results above together and will come close to the impact of making both changes to the models.

Public-Private Partnerships (PPP) – Both Cities

There are numerous ways to structure a public-private partnership where the cities and a commercial ISP work together to fund and bring broadband to the market.

We examined two different kinds of partnerships:

- We looked at a scenario where the cities find an operator-for-hire. In this scenario the cities fully fund the business and hire an ISP to operate the business. ISPs would be paid a management fee for operating the business. An operator might also earn a profit-sharing bonus. The challenge for this kind of arrangement is finding an ISP willing to tackle operating the business for a long period of time. We've heard of a few such relationships, but most ISPs are not going to find this to be of interest because it's a huge amount of work to operate an ISP the size of the cities and the cost to the ISPs is tying up their intellectual capital that could be used to make more money elsewhere.
- We also looked at a scenario where an ISP leases the network. The city builds the fiber network, including the cost of adding customers and the ISPs lease the entire network. This flips the business plan, and all profits would go to the ISP, even though they hadn't made any substantial investment. We know ISPs that are interested in this kind of operating model, because they can earn good money for performing well without risking any capital.

ISP Operator-for-Hire

We looked at three different scenarios. In the first scenario the cities hire an exiting for-profit commercial ISP to operate the business. In the second scenario the cities hire a non-profit ISP to operate the business. The final scenario is intriguing because the cities help to create a cooperative to operate the business.

In this business plan:

- The cities finance and pay for the full cost of building the network and operating the business.
- Revenues all go to the cities.
- The operator-for-hire operates the business. Employees work for the operator-for-hire and not for the cities.
- The cities reimburse the operator for all operating expenses plus pay the operator a management fee. Operators could also earn a bonus or profit-sharing for good performance, but those extra payments are not reflected in the results below.

	For-Profit ISP	Non-Profit ISP	Cooperative
Asset Costs	$107.6 M	$107.6 M	$107.6 M
Equity	$ 0.0 M	$ 0.0 M	$ 7.1 M
Debt	$121.4 M	$121.4 M	$116.0 M
Total Financing	$121.4 M	$121.4 M	$123.1 M
Cash after 10 Years	$ 2.50 M	$ 2.51 M	$ 0.45 M
Cash after 20 Years	$14.39 M	$15.30 M	$ 6.82 M

Commercial Operator-for-Hire. In this scenario This scenario is still profitable for the cities. The commercial ISPs have one big operational advantage over the cities in that commercial companies pay lower benefits, so the labor cost is less than if employees worked for the cities.

In the above scenario we've assumed a management fee of $50,000 per month, or $600,000 per year, that is increased with inflation. That's an amount that would have to be negotiated between the two parties.

Non-Profit Operator-for-Hire. There probably are no such non-profit ISPs – although we do know of a few instances where a municipal ISP operates another market in the manner shown here. It's likely that a non-profit ISP would have to be created locally. That carries additional risk compared to the commercial ISP for hire in that the new noon-profit ISP won't have operated any other markets as an ISP.

This is slightly more profitable for the cities than using a commercial partner and we've assumed the non-profit would agree to a management fee of $20,000 per month, or $240,000 per year. There is an additional upside to this concept in that the 'profits' from operating the business would be invested back into the cities over time by the non-profit.

Cooperative Operator-for-Hire. This is an interesting concept. We considered an option where a cooperative is created that will operate the business. We assumed the cooperative would be paid $20,000 per month for an operating fee, over and above the cost of operating the business.

The cooperative charges households and business $500 to join the cooperative and would provide these fees to the cities to lower the cost of bond borrowing. The cooperative would pass some of the savings from this in the firm of lower rates. In the particular example I studied, the cooperative would lower broadband rates by $6 per month. Over time the cooperative would also likely pay 'dividends' to customers and return some portion of the annual operating fees to customers.

This kind of structure might be interesting to the community in that a cooperative board elected from the community would be in charge of cooperative policies. This would likely result in the lower rates I'm suggested in this example. This scenario is still profitable for the cities since the cooperative would be on the hook to generate enough revenues to cover expenses and operating management fees.

There are numerous variations on the cooperative scenario that can be considered if the idea gains traction in the community.

ISP Leases the Network

In this scenario an ISP leases the network from the city. This flips the above scenario. Here are the specific assumptions behind the above partnership:

- The cities finance the cost of building the initial fiber network and pay for the network assets needed for the first five years.
- The ISP pays for operational assets like vehicles. More importantly, the ISP pays for all assets after year five. This means the ISP is responsible for future customer installation costs and also for the costs needed to maintain and modernize the network. This is the first scenario we've looked at where the ISP has a significant obligation to pay for assets.
- The ISP partner operates the business including maintaining the fiber network. All employees work for the ISP and the city has no fiber employees.
- All revenues go to the ISP.
- The ISP covers all operating expenses.
- The ISP needs a loan to cover the cost of assets.
- The ISP pays a sizable lease to the city. In this example the lease covers the cost of bond financing. The lease would have to be renegotiated once debt is fully retired. Assuming that the lease cost

would drop drastically, the ISP would become far more profitable once the initial leas was completed, and the cities would benefit by any amounts paid for the renewal lease.

These numbers below represent the cumulate cost for each line item over 20 years. The scenario below assumes a commercial ISP. This could also be a non-profit ISP, although it's hard to envision that scenario because a new non-profit would not have the ability to guarantee the lease payments to the cities.

	ISP Partner	Cities
Revenues	261,315,740	1,336,000
Cost of Goods Sold	(8,678,043)	0
Operating Expenses	(80,295,503)	0
Interest Expense	(1,416,648)	(61,212,992)
Income Taxes	(5,569,556)	0
Margin	165,355,989	(59,876,992)
Equity	93,777	0
Assets	(17,458,112)	(105,787,538)
Loans	3,195,741	118,453,000
Loan Repayment	(3,195,741)	(85,100,924)
Net Change in A/R & A/P	(230,687)	0
Cash Generated	147,760,967	(132,312,453)
Lease of the Network	(133,745,416)	133,745,416
Cash Return	14,015,552	1,432,962

There are a few issues to consider this kind of partnership.

- Negotiating the lease between the two parties is the hardest part of the arrangement. No city wants to get lease payments lower than their annual debt payments. No ISP wants to have an arrangement that would make them pay a lease payment that is higher than the cash generated by the business. One of the two parties would have to compromise to make a partnership work.
- Timing is also a critical issue. It's challenging for an ISP to guarantee high lease payments in the early years of a project before the business is fully cash flowing. Most fiber businesses don't hit full stride until somewhere between years 5 to 7. The two parties need to figure out how to get through that period, because the ISP is not going to want to have to make lease payments when there is no cash from the business.
- Smaller ISPs will probably be unable to guarantee lease payments. This means that if the business underperforms that the city could end up subsidizing the bond payments.
- As is shown by the example above if an ISP can pay enough to cover debt payments the cities would not have to subsidize the business.

Open Access

The open access operating model is discussed in Section III.A. of the report. In this model, the cities would build, own, and operate a fiber network and would sell wholesale connections to multiple ISPs which would sell retail services to customers.

There are a lot of difference in the open access model versus the partnership model above. Following are the primary assumptions for the open access network:

- The town would finance, build, own, and operate the fiber network and the fiber drops and would finance the project with general obligation bonds. This means the town would need to have several technicians to take care of the fiber network.
- The cities would pay for all of the electronics. In the partnership scenario shown below, the ISPs would pay only for the customer electronics, although in some open access networks that is also the responsibility of the network owner.
- The various ISPs compete against each other for sales to customers. The ISPs each cover their own cost of sales and operations.
- All retail revenues go to the ISPs.
- The ISP buys ‘fiber loops’. In the example below this rate is set at $30 per month, meaning an ISP would pay that rate for each customer they connect to the fiber network. This differs significantly from a lease in that ISPs only pay for customers that are connected to the network. This means revenues to the cities are low for the first few years until a customer base is built up.
- Open access networks almost never get as many customers as a single ISP would get which owned and operated the network. In the example below, we assumed the overall penetration rate for all of the ISPs is 45%. Penetration rates are lower for several reasons.
    - The ISPs are not liable for the debt on the network and are not driven to push for enough customers to make the business work. ISPs really aren’t bothered in the town that owns the network loses money.
    - The small ISPs that get onto open access network generally are not well funded and tend to not be able to afford a robust marketing program.
    - To some degree, every customer on an open access network returns a positive margin to the ISPs, and so a given ISP might be happy with some lower number of customers.
    - ISPs on an open access network always ‘cherry-pick’. They rarely will sell to customers that buy only the lowest-price fiber product and nothing else. That alone might eliminate 5% to 10% of the market as potential customers.

Following is an example of an open access network. For convenience, all of the ISPs are lumped together.

	ISPs	Cities
Customer Revenues	239,840,432	
Cost of Goods Sold	(7,886,616)	
Operating Expenses	(60,679,590)	(8,332,915)
Interest Expense	(469,440)	(56,034,764)
Income Taxes	(19,949,920)	0
Margin	150,854,866	(64,367,679)
Equity	266,250	0
Assets	(10,051,826)	(112,790,113)
Loans	1,775,000	118,700,000

Loan Repayment	(1,775,000)	(85,016,444)
Net Change in A/R & A/P	(451,599)	(258,581)
Cash Generated	140,617,692	(143,732,817)
ISP Loop Fees	(83,838,660)	83,838,660
Cash Return	56,779,032	(59,894,157)

This scenario shows the ISPs collectively making money and the cities / network owner losing money. This example is pretty typical for the open access in place around the country today. Many of these businesses generate enough cash to cover operating expenses, as does the example above. But the open access model still loses money every year, and a city that builds this network must somehow subsidize the debt payments each year. We don't know of any open access network that covers the full cost of the business including covering debt. A number of the open access networks in the country have been built by municipalities that also operate municipal electric companies. Some of these cities knew the business would need to be subsidized but decided that broadband was needed badly enough to build the network anyway.

We couldn't find a way to turn the above analysis positive. If the town raises the ISP loop fee, the ISP pass this on in the form of higher rates to customers – and that generally results in fewer customers on the network. If the town lowers the loop rate to get more customers, there is not enough revenues generated due to the lower loop rate. This is a market model that doesn't seem solvable.

Collecting Fees from Customers

The cities asked us to look at a scenario where customers contribute to the cost of constructing the network. Specifically, I studied the scenario where customers pay a fee of $3,500 to join the network. This has some interesting ramifications, as follows:

- The concept is that the cities would make this as easy on households as possible. For example, while customers could contribute the $3,500 up front, customers would be able to finance the installation fee for as long as ten years. In paying overtime, a customer would eventually pay the $3,500 plus cover the cost of financing the fee over time – needed because the cities would borrow this money upfront to pay for the network.
- An important consideration is that customers have to somehow pledge to pay this fee even if it's financed over time. A bunch of communities in Utah created a municipal ISP based upon this concept and in the early years of the company too customer pledges as a way to raise funds. This required homeowners to accept a lien against their homes if they didn't pay the fee in full upfront. That lien means that if the homeowner every sells the house that the city collects the remaining amounts due out of the sale proceeds. It can also be troublesome if a homeowner stops paying the fee if it's been financed over time.
- The general concept is that having customers pay to join the network would significantly reduce the cost to the cities to bond for construction – the savings would be passed back to the customers in the form of lower broadband rates.
- One of the most interesting challenges for this concept is how to deal with residents in apartments. There are a number of issues to consider:

  - Landlords must give permission to allow an ISP into a rental unit. As discussed elsewhere in this report, many landlords are going to have financial arrangements with the incumbents or with another competitor and won't allow city fiber into the rental buildings.
  - It's highly unlikely that renters will be able or willing to make the commitment to pay the connect fee. This means that the fee is likely going to have to be paid by the landlord. As long as the cities are willing to finance this payment over time, this is something the landlord could build into rent – something they can probably do to provide fast broadband over fiber.
  - For purposes of the study we determined that the cost to add the average apartment unit to the network is less than adding a single-family home. In the study the fee for landlords was set at $2,250 per rental unit. A landlord would need to pay for entire buildings and not just selected units.
- To be conservative we assumed the market penetration for this scenario would drop to 40% (the assumption was 50% in the straight ISP scenario. There are going to be homes unwilling to make the financial commitment to guarantee the connection fee, even if it's financed over time. There will be homeowners that rent out single-family homes that won't want to pay the fee, because the benefit of cheaper broadband goes to the renter and not to the landlord.

Customer Financing for a City-owned ISP

With all of those caveats, the results of this scenario are interesting.

	General Obligation Bonds	Customer Payments
Asset Costs	$107.6 M	$104.4 M
From Customers	$ 0.0 M	$ 49.5 M
Debt	$121.4 M	$ 70.0 M
Total Financing	$121.4 M	$119.5 M
Cash after 10 Years	$ 5.78 M	$ 0.43 M
Cash after 20 Years	$22.38 M	$ 4.13 M

The most impressive aspect of the above summary is that the business is able to lower broadband rates by $26. That means a basic product like 100 Mbps would cost $34 and a symmetrical gigabit would cost $54 per month. This would be among the lowest priced broadband in the country.

Over ten years the $3,500 fee equates to $29 per month (if it's not financed). Unfortunately, this is still a little larger than the decrease in rates at $26.

Customer Financing for the ISP-For-Hire Partnership

Assuming the same buy-in of $3,500 per single-family home and $2,250 per apartment unit, this scenario would allow for lower rates under this scenario:

- In hiring a commercial ISP to operate the business the broadband rates could be dropped by $21 per month across the board.
- In hiring a non-profit ISP to operate the business the broadband rates could be dropped by $24 per month across the board.
- This scenario doesn't make sense in the cooperative model since customers would be paying the city to join the network and also paying to join the cooperative.

Customer Financing for Open Access

Recall that the analysis above showed huge operating losses for the cities. Collecting a fee from customers provides enough cash to significantly reduce the amount of debt and can make the scenario profitable for the cities. However, the impact would not be large for customers. The customer financing would allow the cities to cut the open access rates to ISPs by $5.

This scenario still doesn't seem feasible because customers will see little benefit from making the $3,500 investment in fiber.

Summary

Bottom line from these scenarios is that the concept is intriguing. There are a lot of unknowns that make it hard to quantify the impact of this scenario, but which could be investigated further:

- It's possible that there is some combination of assumptions that would make this attractive to single-family homes. The example I studied costs a homeowner $29 per month over 10-years to pay the connect fee while rates are reduced an average of $26 per month. There might be scenarios that create a net positive savings.
- This scenario is likely to be more attractive over time as Charter most likely will continue to increase broadband rates every year. Under this scenario the cities would only have to increase rates by small amounts to keep up with inflation, so customers that buy into this concept could be saving a lot more money each month a decade from now.
- It seems likely that the customer penetration rate would be lower if customers had to pay a substantial fee to join the network. Before the cities considered an option like this there would have to be a lot of public discussion. During that process, the cities should be able to undertake a way to quantify customer interest, either through surveys or perhaps a drive to get customers to commit to the concept if it gets funded.
- It's even harder to estimate the impact this would have on landlords. As much as landlords might want fiber, it's hard to judge how many of them would pay for the privilege. While it's unlikely that AT&T and Charter are not going to build fiber to single-family homes, they are likely willing to build to apartment complexes for free – which would badly undermine this method of financing.
- There are conceptual challenges with this concept. It favors single-family homes over apartment tenants. It favors homes that can pledge the connection fee over those that can't. But this also gets fiber built in the city. Selling this idea to the public would be interesting.

What Conclusions Can We Draw from the Financial Results?

The following are the conclusion we can draw from the results of the business plan analysis:

It Looks Difficult to Launch a Standalone ISP in Farmington. There doesn't seem to be enough revenues in Farmington alone to cover the cost of debt for creating an ISP. The breakeven penetration needed to make an ISP work in Farmington is 72% - an unachievably high goal. This is mostly due to what we refer to as economy-of-scale. It turns out that there is a positive impact of adding Farmington in with Farmington Hills – there just doesn't look like a reasonable scenario for creating an ISP for only Farmington.

A City-based ISP Can Work. The analysis shows that the cities could launch an ISP. However, the business is going to require a penetration rate of 46% to reach a cash breakeven for the business to never be subsidized. While the customer survey hinted that the potential penetration rate could be as much as 60%, the business is fairly risky with such a high breakeven penetration rate.

Commercial ISPs Are not Likely to Invest in Fiber. The analysis shows that it seems unlikely for a commercial ISP to construct a fiber network and be an ISP in the cities. The returns on investment are slim and there are too many opportunities for downsides to the business. We would guess that commercial ISPs will find the market to be too risky. This is not to say that ISPs might not build some fiber – but if ISPs build, they will likely cherry-pick and build fiber only to neighborhoods where they can make a good return rather than build everywhere.

Open Access Doesn't Look Feasible. We could not find any scenario with an open access network where the cities did not lose a lot of money. The revenues generated by open access can cover the operating costs of an ISP business, but the revenue cover almost none of the cost of the debt.

Hiring an ISP to Operate the Business is Possible. If the cities decide to move forward, the analysis shows that it could be possible to hire an ISP to operate the business. Finding ISPs to take on this role isn't easy, but it's possible. In the analysis we looked at different scenarios such as engaging with a commercial ISP partner, a non-profit partner, and a cooperative owned by customers. Again, since the margins of operating an ISP are slim, hiring a partner is not without risk and the cash margins on a business with a partner are lower than if the cities created an ISP – but it can work with enough customers.

Leasing the Network Might be Feasible. We looked at a scenario where the cities build the network and lease it to an ISP. This might be feasible because ISP have the possibility to make profits without making a big capital investment. The challenges will be in finding an ISP willing to guarantee lease payments.

General Obligation Bonds are Better than Revenue Bonds (From a Financial Perspective). There are pros and cons to the two kinds of bonds other than just financial considerations. However, from a pure dollar perspective, the cost of general obligation bonds in the current market are lower than using revenue bonds. This is not always the case and there have been times in the past when revenue bonds had a lower cost.

The Business is Sensitive to a Few Key Variables. If the cities decide to move forward and investigate the opportunity, it's vital that to get comfortable with the impacts of changing they key variables. Our analysis shows a base business plan that's fairly unforgiving for downsides – but there are opportunities to perform better than the base analysis. Following is the impact from changing the key variables for the scenario where the cities create an ISP to serve both cities:

- Penetration Rate: The most important variable is customer penetration rate. We used a penetration rate of 50% as the starting point in the analysis. There would be a huge downside for a business that doesn't meet the target penetration rate. Our analysis shows that if building an ISP business for both cities that a change of only 1% in customer penetration rate would cash over 20 years by over $3.2 million. While this same impact would be an upside should the business get more than 50% of the market, this is a significant penalty should an ISP underperform and not meet penetration goals.
- Broadband Prices: The financial results show a high sensitivity to broadband prices. The studies all used an assumed starting price of $60 for the basic broadband product. Changing broadband prices by only $1 per month changes cash flow over 20-years by almost $3.1 million. This adds downside risk to the business - if the business felt pressure to lower rates due to competition, there would be a huge negative impact on the bottom line.
- Interest Rate: The impact of interest rate is important but is less than the other key variables. If the project was funded by bonds, changing the interest rate by one-half percent (50 basis points) changes cash flows over 20 years by over $9.5 million.

It is essential before deciding to get into the business to pin down these key variables. This means that you can't take the financial results listed above or in Exhibit II as the straight answers, because changing any of these variables will change the result of any financial projection.

We demonstrated that the effects of the variables are additive. For example, the improvements that might be achieved through raising the rates or lowering the interest rate on debt can be added together if both variables change in a real business plan.

Funding with Customer Contributions. We looked at a scenario where single-family customers contribute $3,500 to join the fiber network and landlords contribute $2,250 per living unit. The results from this scenario are intriguing. The hardest aspect of quantifying the possibility for this scenario is estimating the number of households and landlords willing to pay the fees – even if those fees are spread over 10 years ($29 per month). In the following analysis we assumed a 40% customer penetration rate – but we have no basis for that estimate.

City as ISP. In this scenario the customer fees would allow the city to reduce customer rates for residents who paid the connection fees by as much as $26 per month – reducing basic broadband to $34 per month and gigabit broadband to $54 per month. This comes fairly close toa breakeven from a customer perspective since the fee equates to $29 per month over ten years.

Partner-for-Hire Scenarios. The customer savings would be a little less if the cities hired an ISP to operate the network. The savings in monthly retail rates with a commercial ISP operator is $21 per month and $24 per month with a non-profit operator.

Open Access. This scenario still doesn't look feasible. The customer fees only reduce wholesale rates by $5 per month, meaning customers would pay the connect fee and not gain much monetary benefit. Customers would gain the benefit of possibly choosing among multiple ISPs.

IV. OTHER ISSUES

A. Funding for Broadband Networks

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 other 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 option to consider. Below we look at the following:

- Private Financing (loans)
- Private Funders of Fiber Networks
- Federal Loans
- Public Financing
- Grants
  - Federal Programs
  - State Programs
- Loan Guarantees
- Opportunity Zones and New Market Tax Credits
- Customer Financed
- Public Private Partnerships
- Other Sources of Financing

Private Financing Options

When commercial ISPS build networks, they have to 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 other valuable asset to the business. In such a case the contributed asset often has to be assigned a market value by an independent appraiser.

- Non-recourse Cash: Non-recourse cash means accepting a contribution to the business that is not guaranteed to be paid back. To give an example, in Sibley and Renville counties, a fiber business was launched in the form of 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 their best effort to make the bond payments, but if they are 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 as a whole does not like to finance long-term infrastructure projects. This is the primary reason why the country has such an 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 from earning more on their own equity.

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

There are exceptions. A few of the large banks like Key Bank and Bank of America have divisions that will make bank loans to municipal ventures that look a lot like bonds. These loans will have long payment terms of 20 years or more and reasonable interest rates. However, most of these loans go for things like power generation plants and other projects that have a strong guaranteed revenue stream. These banks have done a tiny handful of telecom projects, but they view most broadband projects to be too risky.

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 telecom project.

There is one unique banking resource available to companies who want to build fiber projects. This is CoBank, a boutique bank and a cooperative. This bank has financed hundreds of telecom projects, mostly for independent telephone companies and for electric cooperatives. CoBank is a relatively small bank and has strict requirements for financing a project. They are leery of start-ups and we can't think of a start-up they have financed recently. They also expect significant equity to be infused into a new venture. They tend to have somewhat high interest rates and somewhat short loan terms of 10–12 years.

Cooperatives also have another bank that lends only to cooperatives. This is RTFC (Rural Telephone Financing Cooperative) that is owned by cooperatives.

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 last few decades those loan portfolios have migrated to other lenders and local banks have been struggling for a decade to find worthwhile projects in their regions. We know of many commercial projects for small telcos that have been financed by local banks.

The biggest challenge of borrowing from a local bank is that they typically have 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 in a fiber project. However, local banks have become adept at working in consortiums of multiple banks to make larger loans. This spreads the risk of any one 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 role of finding other banking 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 good telecom projects.

Collateral. The biggest issue that banks have in lending to broadband projects is the lack of collateral, which is comprised of the assets they inherit if the project should fail. Banks like hard collateral like buildings, vehicles, shared 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 networks are sometimes sold for pennies on the dollar.

It's important understand the importance of collateral. Communities often ask an ISP operating nearby to come build fiber in their town. What they generally fail to realize is that the ISP likely had 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 they can lose the whole business.

Return on Bank Equity. Banks don't only consider the interest rate when making loans. A bank concentrates on its return on equity and will consider a combination of factors like interest rates, up front 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 up their analysis of return on bank equity. There is a misperception 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.

Private Funders of Fiber Networks

There are a few fiber projects around the country that have been funded by private equity. This is still a relatively new phenomenon. Here are a few examples:

SiFi Networks.[19] This venture is headquartered in Morristown, NJ. SiFi has financed and built a fiber optic network in Fullerton, CA. This is a city with 54,000 passings. This is an open access network, meaning there will be multiple ISPs. For now, the two ISPs are Ting (and ISP headquartered in Canada) and GigabitNow (an ISP from Seattle). SiFi networks is currently working on funding projects in Salem MA, East Harford CT, and Saratoga Springs NY.

[19] https://sifinetworks.com/corporate/fibercity/

Netly.[20] Netly is located in Solano Beach, CA and has built a fiber network in that city. The company is now considering additional cities. They want to fund, build, and operate open access networks, allowing multiple ISPs to use the network.

Federal Loans

The only federal loan program for broadband is operated by the Rural Utility Service (RUS), which is part of the Department of Agriculture. Unfortunately, this agency only makes loans, grants, or loan guarantees for communities smaller than 20,000 people. Even was that limitation change, there are numerous restrictions on RUS loans and we've never seen a loan given to a municipality.

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. First, 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 telecom 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 Monticello, MN; Crawfordsville, IN; and Alameda, CA. These kinds of failures have made investors leery about buying bonds that are only backed by the business. This reluctance has made financing with revenue bonds more expensive.

The cost of a bond issue cannot be judged only by the interest paid. In fact, 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 principle and interest payments. This money is put into escrow and is not available to operate the business.

[20] https://www.netlyfiber.com/

Capitalized Interest: Bonds begin accruing interest from the day the money is borrowed. Since fiber businesses take a number of years to generate enough cash to make bond payments, the bondholders require capitalized interest that is used to make the interest payments for up to the first five years of the project. Basically, the project must borrow the amounts needed to make debt payments, which can add a significant amount to the size of the bond issue.

Bond Insurance: Bond insurance is an up-front 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.

For a number of years now 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. In our financial analysis we assumed that the interest rates are lower on bonds. 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.

What these pledges mean is that if the broadband project fails and can't make the bond payments, then the backing, the pledge revenue source, such as property or sales tax, would have to be used to make the bond payments.

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 government sometimes hold a referendum anyway just to make sure the public supports the initiative being financed.

There are other financing mechanisms that have been used by other municipalities to fund revenue-generating projects. These include:

Variable Rate Demand Obligations (VRDOs): VRDOs are a bond where the principal is paid in a lump sum at maturity. However, the borrower has the right to repay the bonds in whole or in part at any time (upon an agreed-upon notice). VRDOs are effective in circumstances when the borrower wants to match the repayment of the bonds to a revenue stream that varies year to year or a revenue stream that can vary from initial estimates and changes over time. In the case of the new telecommunications system, this type of financing provides the flexibility to make bond payments that match the actual revenues received. If revenues are slower than anticipated, principal payments do not need to be made. If revenues come in faster than anticipated, repayment of the bonds can be accelerated without penalty. We can recall having only ever seen this used once for a municipal telecom system by the city of Alameda, California. This kind of financing is used fairly routinely for other kinds of municipal needs.

VRDOs are most commonly structured as 7-day floating rate bonds. Interest rates are reset each week, and this adds a lot of risk to this type of financing. Unlike fixed-rate bonds, the borrower doesn't know what the interest rate will be on the VRDOs over the life of the issue. Interest rates on VRDOs are on the short end of the yield curve and have therefore historically been lower than interest rates on fixed-rate bonds even with the additional ongoing costs for a liquidity provider and a remarketing agent. There is typically a maximum rate stated that the VRDOs cannot exceed. But in a market where there is a significant increase in overall interest rates this kind of financing could end up being significantly more expensive.

Capital Appreciation (Zero Coupon) Bonds (CABs): CABs are bonds that are issued at a deep discount and which do not bear any stated interest rate. Like a Series E savings bond, CABs are bought at a price that implies a stated return calculated on a basis of the bond being payable at par at maturity. With no stated interest rate there is no interest paid until maturity, at which time all of the compounded accreted interest is paid. With no interest payments required in the beginning years of the bonds, this would enhance the cash flow in the beginning years of the business.

CABs do, however, have several drawbacks over other types of available financing. First, the interest rates on CABs are typically higher than both the fixed-rate and VRDOs. Second, investors prefer not to have a prepayment option on CABs, which limits the flexibility of the government to call the bonds early if revenue collections are better than anticipated or if a restructuring of the debt is needed. This structure is used frequently for various government borrowings, but we've not ever heard of this being used for telecom—although there is no reason why it could not be used.

Grants

Unfortunately, there are no major federal grant programs currently that would provide funding for urban areas. This could change, and in the past, we saw grants used in cities. For example, the City of Chattanooga, Tennessee got a significant grant a decade ago to help build the citywide fiber network.

Federal Broadband Grants: The current federal broadband grant initiatives all fund fiber in places with little or no broadband connectivity. Unfortunately, we don't see any of the current round of grants applying to the cities (or to any other cities that are already served by a large cable company). The current grants include:

Rural Digital Opportunity Fund Grant (RDOF). The FCC has created a massive $20 billion grant program that will be awarded in 2020 and 2021 for rural locations with little or no existing broadband.

ReConnect Grants.[21] 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

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

combination of grants and loans in 2019. Congress reauthorized an additional $600 million to be awarded in 2020. These grants are administered and awarded by the US Department of Agriculture.

Community Connect Grants.[22] This program specifically targets the poorest parts of the country and ones with little or no existing broadband. This program awarded $34 million in 2018 and $30 million in 2019. Grant awards for the program are generally between $100,000 and $3 million and require at least a 15% matching from the grant recipient.

BroadbandUSA Program.[23] 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. We've seen communities be creative in using such grants to fund at least some small portion of a broadband initiative. Every mile of fiber funded through one of these alternative initiatives is one less mile of fiber needed for a whole-city build. For example, we've seen grants provided for things like:

- Building fiber to schools and libraries to replaced expensive leased fiber.
- We've seen a fiber component in smart energy initiatives like smart-grid and smart lighting.
- We've seen public safety grants used to fund fiber to critical public safety locations like sheriff stations, 911 centers, public safety radio towers, firehouses, and other first responders, etc.
- We've seen grants awarded for extending broadband to public housing.
- We're starting to see the placement of conduit for fiber included in state and federal grant funding for federal and state highways.

State Grant Programs

The state of Michigan does not have an office dedicated to broadband. However, Connected Michigan,[24] a subsidiary of Connected Nation has partnered with the Michigan Public Service Commission (MPSC) to oversee broadband-related activities in the state.

Connected Michigan worked with the MPSC to create a "comprehensive broadband planning and technology initiative as part of the national effort to map and expand broadband." The program gathers provider data to create better statewide broadband maps, performs statewide business and residential technology assessments and works with localities on community plans through the Michigan Collaborative Broadband Committee. The program validates broadband coverage for the state and provides guidance and technical assistance to communities, policy makers and others.

[22] https://www.rd.usda.gov/programs-services/community-connect-grants
[23] https://www.broadbandusa.ntia.doc.gov/new-fund-search
[24] https://connectednation.org/michigan/

State Broadband Plan. In January 2018, the Michigan Consortium of Advanced Networks[25] was formed in the Governor's office to create a broadband roadmap for the state. This resulted in the Michigan Broadband Roadmap,[26] which was published in August 2018.

State Broadband Grants. The Connecting Michigan Communities (SMIC) Grant Program[27] is housed in the Michigan Department of Technology, Management, and Budget (DTMB). This grant program provides grant funds to projects that "demonstrate collaboration to achieve community investment and economic development goals of the area impacted" and extend broadband to unserved areas. Unfortunately for the cities, these grants can only be used to assist rural areas that the grant program has identified as unserved.

Loan Guarantees.

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 agency 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 thus greatly lower 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. And then the agency making the guarantee will generally want a fee equal to several interest "points" up front. To some extent, this process works like insurance and the agency keeps these fees to cover some of the cost of defaults. If they issue enough loan guarantees, then the up-front fees can cover eventual losses if the default rates are low. 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 telecom projects. The following agencies are worth considering:

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 loans can theoretically be used for some portion of 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

[25] https://www.michigan.gov/whitmer/0,9309,7-387-90501_90626-463053--,00.html

[26] https://connectednation.org/wp-content/uploads/sites/13/2019/01/Final-Roadmap-8-8-18.pdf

[27] https://www.michigan.gov/dtmb/0,5552,7-358-82547_56345_91154---,00.html

loaning or guaranteeing up to 50% of the total loan. This program would only be possibly available if a small business (an ISP) ended up funding the network.

There are other federal loan guarantees that benefit only rural areas or only a specific region of the country like Appalachia.

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 that area can get special tax treatment. The first benefit is that taxes can be deferred from past investments if the gains are invested inside of an opportunity zone. For example, if an investor 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 benefitting that community in some significant way. A fiber optic network that will bring broadband to all of the homes in an opportunity zone should meet that test – there are lot of demonstrable benefits of fiber.

Most opportunity zone investments are being made from special funds created for that purpose, although a high-wealth individual could also make an investment.

Opportunity zone financing is most attractive when combined across multiple projects. For example, somebody might be interested in making an opportunity zone investment in a fiber network is that was coupled with some other opportunity investment in the same neighborhoods. This might be low-income housing, green energy production, or some other project that has a clear benefit to the local community.

Unfortunately, there are no qualified opportunity zones in the cities. There one just east of the city and north of Walter P. Reuther Freeway, and another just past the southeast corner of the city.

New Market Tax Credits

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. New market tax credits are normally used to fund only a small portion of a project.

Eligibility of the cities to use these funds would depend upon meeting an earnings test, and it’s likely that the cities would not be eligible for these investments. However, this would be worth checking with a specialist working with NMTC since these definitions change from year to year.

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 3 years, then 6% in the final 4 years, for a total of 39%.

The Community Development Financial Institutions (SDFI) Fund and the Department of the Treasury administer the program. The process of how the Treasury allots credits is a complicated one and we won't cover it, but in essence, there are entities around the country each year that are awarded tax credits and these entities work as brokers to allot the credits to specific project. The credits are often purchased by the large national banks or other firms that invest in infrastructure.

Generally, in practice, these funds act like 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 7 years of the tax credit, and at the end would have a balloon payment for the principal. However, in some cases even some or all of the principal will be excused, making this look almost like a grant.

Because the entities that get the tax credits change each year, and because applications are made to the entities that hold the credits, the process for applying for this money is somewhat fluid and changes from year to year. However, there are entities and consultants who help find New Market Tax Credits and who can help you through the maze of requirements.

Customer Financing

When no ISP or municipality can finance a project, we've seen citizens to step up and agree to directly fund some or all of a broadband project. There are several examples of places where this has been done in the country:

> **Property (or Other Kind of Tax) Revenues**. It is possible to obtain some or all of the cost of a broadband network through a pledge of future tax revenues. That pledge can then support a bond. This is different than most bonds for a broadband network where the network would be secured by revenues of the broadband venture. But a pledge of some other kind of tax revenue is one of the easiest ways to get a bond. There are some real examples of this kind of financing:

- Lyndon Township, Michigan: This is a township of about 1,000 homes that voted to raise property taxes to fund to build a fiber network. The township then partnered with a local broadband cooperative to provide services. The project is a win/win for citizens. Property taxes increased about $25 per month per household. The township provides free access to the network to the cooperative, which is charging about $25 for broadband – making the total cost of getting broadband about $50 per month. This is an area that had no broadband before the project.
- UTOPIA, Utah: UTOPIA is a consortium of a number of small towns in Utah that banded together to get fiber. Each town has pledged property tax revenues to fund part of the cost of the network.
- Cook County, Minnesota: Cook County funded about half of their fiber network using a federal grant awarded from the Stimulus funding program in 2008. The county held a

referendum and used a sales tax increase to pay for the matching funds needed to build the project.

Direct Customer Contributions: It's also possible to pay for some of a broadband project through direct contribution of possible customers. This has never been done on a large scale because it would be exceedingly difficult to get a lot of residents to agree to write a check to fund a network. But there are some examples to consider:

- Contribution to Aid in Construction: Most utilities have a program where they will agree to extend their network to customers if those customers agree to pay the cost of the connection.
- Ammon, Idaho: This is the only municipal attempt at funding a network in this way. The City of Ammon will connect customers to a fiber network if they will contribute $3,500 up-front to cover the cost of construction.

Public Private Partnerships

A public private partnership (PPP) 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 different ways. The main benefit of a PPP is that the commercial operator of a project benefits by getting some bond financing 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 the project.

The general benefits of bond financing are what makes public money attractive to a commercial partner—low interest rates, long repayment term, 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.

Combining Public and Private Financing. 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.
- Combining the two methods also usually means lower debt payment during the first few critical years while the network is being built.
- One banking issue must be resolved when combining public and private financing. When there are multiple lenders to a project, one of the lenders must be given the 'first lien position', meaning that payments to them take priority over other loans. It would not be unusual for a bank loan and a bond issue to both want the first lien position. In our experience this dilemma is most often solved by having the municipal bonds take a second lien position, meaning that the municipal bond payments must be secured by something other than the revenues of the project.
- There is also likely to be wrangling between the parties for collateral. As mentioned elsewhere, a physical fiber network makes for poor collateral, but each lender is still going to want to latch on

to whatever collateral they can grab. The most covered collateral is customer revenues, which almost always would go to the lender with the first lien position.

Following are two examples of this type of PPP, both from Minnesota:

- RS Fiber: RS Fiber is a new broadband cooperative that was formed in Renville and Sibley counties. The project was funded from various sources including a loan for 25% of the project supplied by a bond backed by the cities and counties involved in the project. The Cooperative raised the other money with a combination of bank loans and grants.
- Swift County: The county government there contributed a significant percentage of the cost needed to construct a broadband network in the county. The bond proceeds were loaned to Federated Telephone Cooperative and are expected to be paid back over time. However, the county loans took second lien position behind commercial loans.

Other Sources of Financing

Vendor Financing. Vendor financing for electronics was huge during the telecom boom in the late 1990s. Several vendors would finance the purchase and installation costs for electronics for fiber networks. The primary benefit of vendor financing is no payments for a few years while the network is being constructed and customers are being added. Such financing worked best when combined with other kinds of commercial financing. We've heard of several cases of vendor financing in the past year, mostly from some of the lesser-known vendors in the industry.

Loans from Individuals: We've seen broadband projects where 5% - 10% of a project has been funded through loans from individuals in the community. This is a well-known method when constructing fiber networks in a farming community where farmers kick-in a part of the cost of building the network. Such loans usually take last place in payment priority behind any commercial lenders. Banks love such loans because they are direct evidence of community buy-in of the network. Such loans would generally have a simplified loan contract with simple loan covenants. Money borrowed in this manner generally avoids the fees associated with commercial or municipal financing.

Loans / Grants from Nonprofits. We know of several communities that have gotten substantial loans and grants from major nonprofits or trusts. These have typically been nonprofits located in the communities that see the public benefits of broadband.

Comparing Financing Options

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 and most loans are shorter. The longer the length of the loan, the lower the annual bond 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 generally the requirement that creates a challenge for traditional commercial financing.

- Bonds often, but not always, have lower interest rates than commercial debt. The interest rate is dependent upon several factors including the credit worthiness (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 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 (DSRF) 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. They money just sits there to be used to help make bond payments should the project have trouble making the payments. Bond insurance works the same way, and a borrower will pre-pay and 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 some period of time, up to five years.
- Construction Loans: Another reason that commercial financing 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 also means that a borrower will only draw loans they need while bond financing is often padded with a construction contingency in case the project costs more than expected.
- Deferred Payment: Commercial financing Can be structured so that there are no debt payments due for the first year or two. This contrasts with bonds that generally expect interest payments to be paid immediately after borrowing. Since fiber projects can take several years to reach a cash breakeven, it's typical for a bond to pre-borrow the interest payments for the first few years (known as capitalized interest).
- Retirement of Debt: It's generally easy to retire commercial debt, which might be done in order to pay a project off early or to refinance the debt. This contrasts to bonds that often require that the original borrowing be held for a fixed number of years before it can be retired or refinanced.

Funding Strategy for This Project

The RFP asks us to discuss a funding strategy based upon the following questions:

- Stakeholder or potential third-party contributors.
- Grant funding options.
- Millage funding options (municipal bonds).

- Establishing a public-private partnership if viable.
- Capital, revenue bond and municipal self-funding options.
- Provide suggestions on funding sources for the infrastructure buildout.
- Based on estimated user fees, describe a sustainable debt repayment method.

The cities have three possible options for funding a broadband solution:

- Attracting an ISP to Invest in the Cities.
- Public-private partnerships
- City financed network.

Attracting an ISP. This study quantified the cost of building a fiber network everywhere in the cities. There are not many ISPs in the country that are able to make an investment of the size needed to fund and build these networks. Most of the ISPs in the region do not have the financial wherewithal to make an investment of that size.

This is not to say that it is impossible to attract and ISP to the cities – there are other cities that have attracted ISPs to make the needed investments. The topic of attracting a partner is discussed at length in Section B below.

Public-Private Partnerships (PPP). A public-private partnership is going to require a significant financial commitment from the cities since you'll still have to pay for most of the cost of building a network. The three most common forms of PPP are:

- The cities build everything, and you find a partner to operate the ISP business.
- The cities build the fiber network to the point of reaching customers and an ISP partner covers costs inside the home. The ISP partner in this situation would typically operate the business.
- The cities build the fiber network, and an ISP partner builds the drops and provides the electronics needed to provide service.

Each of these options still require a significant investment from the cities since building the fiber network is the biggest cost for bringing fiber to the communities. The options for funding a fiber network are the same as described in the next option below.

City Builds and Operates the Network. In this option the city has to cover all of the costs of the business. That includes the cost of building the network, the operating costs for launching and running the ISP, and the debt costs incurred to finance the network.

Cities that have built fiber networks have mostly funded the networks with municipal bonds – and there are good reasons for doing so:

- Municipal bonds are the only form of financing that allows for borrowing 100% of the costs of building a network, including borrowing to make the interest payments at the beginning of a project.
- While cities are allowed to borrow from banks, most cities are not willing or able to meet the terms required by banks. Banks also have little experience in lending to cities since most such lending is done through municipal bonds.

- Banks are somewhat put off by the public nature of everything to do with financing a municipal project. Banks require non-disclosures from most borrowers and are not comfortable with public disclosure laws.
- Perhaps the biggest reason is that banks rarely make loans for the long payment terms needed to support a broadband business. Most banks loans are under ten years in duration.

This is not to say that bank loans are impossible, but it would be a highly challenging process to tackle for the size of the borrowing needed to this project. This makes the most likely path for financing a fiber project to be municipal bonds.

The biggest decision to make when using bond is the surety. This means the revenue stream that is used to guarantee the bonds. There are a number of ways that other communities have guaranteed bond payments:

- General Tax Revenues. The most common kind of surety for bonds is general tax revenues. Should a bond ever get into trouble the cities would be obligated to raise taxes to cover the shortfall. This would normally be negotiated up-front with the sale of the bonds and the pledge revenues could be property taxes, sales taxes, or any other kind of tax revenue that is under the city’s control and that could be increased to cover bond payments.
- Revenue Bonds. A revenue bond would pledge the revenues from the fiber project to cover bond payments. Should the business underperform, the bondholders have to accept the lower payments. Many such bonds would let the bondholders seize the property in the case of a default, which would mean they would take over the fiber network and business. However, since most bonds are sold to “coupon-pinchers,” meaning small private investors, it’s exceedingly hard for a group of bondholders to agree on that sort of takeover. Every city hopes to get revenue bonds when building a fiber network, but there we don’t think that a pure revenue bond is an option for cities any longer, due to several defaults by cities on revenue bonds for broadband networks. Some of the failures include Alameda, California, Crawfordsville, Indiana, and Monticello, Minnesota.
- Quasi-Revenue Bonds. Most municipal fiber networks have been funding with bonds that straddle both revenue and general obligation bonds. Such projects first pledge all of the revenues from the fiber business to the bondholders. But bondholders don’t feel safe with just the fiber busines revenue pledge and ask for more surety. This primary form of extra surety used is the creation of a debt service reserve fund (DSRF). This generally means that the city borrows (or puts into escrow from general funds) a deposit equal to one-year of debt payments. Should the project ever get into trouble, the bondholders can take bond payments from the DSRF. The city borrower is then required to replenish the DSRF.

  Cities like this process a lot more than a pure revenue bond. For example, if a revenue bond pledges property tax revenues, then the city is obligated to raise property taxes, with zero recourse. However, a city generally has total flexibility in deciding how to replenish the DSRF. They could do so from city cash reserves, or they could find the needed revenue from any other source including raising taxes. Just as a footnote to keep in mind, it would be an extraordinary circumstance if the fiber business can’t cover at least some of the debt payments in a year, so normally a call on a DSRF fund would be some amount smaller than the whole balance of the DSRF.

There are other ways that cities have raised the funds needed to build fiber:

- Homeowner Pledge of Property Taxes. There have been some small communities where homeowners agreed to an increase in property taxes to pay for a fiber network. One example is Lyndon Township in Michigan where homeowners voted to raise property taxes for twenty years to finance the network. The benefit to citizens is that the city was then able to drastically lower the cost of broadband, which is sold for $25 per month. The city still had to issue a municipal bond, but those payments are made from the increased property taxes and none of the revenues from the fiber business are used to pay for debt. This is a net wash for residents who end up paying about $50 per month for the combination of a gigabit broadband connection and the increased property tax bill. There have been a number of communities nearby to Lyndon Township that have tried to duplicate this concept but that have failed to pass a referendum approving the increased property taxes.
- City Pledge of Sales Tax. Cook County, Minnesota paid for about one-fourth of their fiber network through an increase in sales taxes. The sales taxes were increased by a penny, and that revenue goes directly towards covering a portion of the bond payments.
- Homeowner House Equity. Utopia is a network in Utah that covers more than a dozen smaller communities. The business got started by asking homeowners in a community to allow for a lien against each home in the community. These liens provided the surety for the municipal bonds. The fiber business revenues were still expected to cover debt payments. But if the project were ever unable to cover debt payments then the bondholders could have called the homeowner liens and gotten payments from each homeowner in the community. This was a cumbersome process and took a long time to organize. In more recent years as the business has grown, Utopia has refinanced to a more normal debt structure.
- Homeowner Contributions. The City of Ammon, Idaho requires any homeowner that wants to be connected to the network to pay $3,500. The City is willing to spread the payments over a few years. These payments significantly reduce the amount of network that needs to be financed in some more traditional manner.

  There are some drawbacks to the financing method. Neighborhoods only get fiber when enough homeowners have made the contribution. Some neighborhoods will never meet the needed funding threshold and won't get fiber. Probably more importantly, many homes can't afford the payment are locked out from buying fiber. Renters are locked out from fiber if the landlord is unwilling to pay the fee. It seems incongruous for a municipality to support a financing mechanism that discriminates against the poorest people in the community – most cities have the opposite goal, which is to make sure fiber gets to everybody.

  There is a big difference that must be noted between Ammon and the cities. In Ammon, the $3,500 largely covers the cost of building the network to a neighborhood and connecting customers. This works in Ammon due to local factors that hold down the cost of fiber construction. The city sits on an ancient bed of river silt and the cost of burying fiber is as low as will be seen in any city in the US. The poles are also in good shape and have a lower-than-average cost of make-ready. It's unlikely that the Ammon model would work there if the city had to take on a lot of debt to finance the fiber network. The cost of servicing debt is a major cost to the cities, even if you also collect $3,500 from customers.
- Municipal Self-funding. The only municipal network we can think of that was totally self-funded is North Kansas City, Kansas. This small town, surrounded by Kansas City, was able to fund a

fiber network by using revenues from two riverboat casinos moored in the city. Those revenues, by law, could only be used by the city for making infrastructure investments.

However, many cities that build fiber networks contribute some cash towards the project. This is particularly common for cities that operate an electric utility that might be sitting on cash reserves. Cities generally 'lend' the cash internally to the fiber project and expect the money to eventually be paid back to the city coffers. Such loans can be set at a low interest rate to match whatever the funds might have been earnings from investments. Any cash that can reduce bond payments is generally a major benefit to a fiber project since it lowers annual debt payments and reduces the risk of failure.

B. Choosing an Operating Model

How can the cities take this report ad decide what operating model to choose? This involves a decision-making process that commercial ISPs are used to but that might be alien to a government entity. Choosing an operating model means undergoing a three-step process:

- The first is to look internally. Specify your goals. Know your existing strengths and weaknesses in terms of what you might bring as an ISP or as a partner. Understand your willingness to accept risk and the willingness for the community to accept the risk of losses.
- The second step is to then take your attributes and compare them to the pros and cons of the various operating models.
- The final step would be looking externally to see if the option you chose is reasonably feasible. If a city wants to become the ISP, can it borrow the needed funds to build the network? If a city wants to create a partnership, are there partners available?

Step 1 - Internal Assessment

Choosing an operating model means undertaking an honest assessment of the local government's ability to participate in one of more of the operating models. Sometimes this assessment is easy. For instance, if the government is not willing to borrow money, then any options that require the government to help fund the network are off the table. But for a government that is open to the range of possibilities, the internal assessment is a needed part of the process of choosing an operating model.

<u>Goals</u>. This process should always start off with a set of goals of what you want to achieve with better broadband. The goals are important, because the goals alone sometimes dictate the operating models that you must consider. For example, if a goal is to make sure that broadband is affordable for even the lowest-income homes, then inviting in a commercial ISP might be off the table – most commercial ISPs are unwilling to serve everybody in a community or to subsidize service for low-income homes. If the goal is to promote competition over everything else, then the only good choice might be to pursue open access.

<u>Strengths and Weaknesses</u>. One of the hardest things any organization to do is to make a fair assessment of your own strengths and weaknesses. Government entities, almost by definition, don't share the same attributes as a competitive corporation. Before a city contemplates being an ISP, we always recommend that a government entity rate themselves in terms of the attributes that would be desired by a competitive ISP. These include things like:

- Competitive nature

- Quick decision-making
- Comfortable in selling to the public
- Technology savvy and willingness to remain cutting edge
- Willingness to accept the risk of losses and poor performance
- Willingness to hire and fire staff based upon performance
- Willingness to empower employees at all levels to make needed decisions

There are a number of ways to assess strengths and weaknesses. Perhaps the most common is to undertake a SWOT analysis that provides a framework for assessing the strengths, weaknesses, opportunities, and threats posed by a new challenge. If you've never done this there are consultants that can help you through this process. What's most important in this analysis is the willingness to be brutally honest in the assessment.

Even should you decide to move forward, this process is a worthwhile undertaking because it helps to identify organizational weaknesses that must be addressed.

Is a Municipal Electric Utility Necessary to Succeed with Fiber? There is an extra step of consideration for any government entity that is not already operating an electric utility. The majority of government entities that have tackled broadband were already electric utilities, and it's a fair question to ask of necessary that is for success in operating a broadband business.

There are some significant advantages to already being an electric utility:

- The biggest advantage that an existing electric utility has is a billing relationship with every customer in the community. Assuming that the public likes the municipal utility (not always the case) then the utility has instant name recognition and public trust when they open an ISP. This gives them a leg up on a new ISP entering the same market.
- The municipality likely owns most or all of the utility poles, making it a lot easier to build fiber. A pole-owner has a lot more options on how to string fiber on poles. For example, they can place some or all of the fiber in the power space (near to the electric lines), which is something that is rarely available to fiber overbuilders.
- An electric utility already engages in many of the activities needed to operate a fiber network. The company will have technical staff who can easily learn fiber technology. The utility will already have cherry-pickers and technicians used to working on aerial wires.
- An electric utility will already have management staff that doesn't necessarily need to be duplicated. For instance, the general manager of the utility can also be the general manager of the broadband business, which reduces the need to hire a whole new staff to operate as an ISP. This sharing or resources can happen across a lot of middle management.
- An electric utility will already have the needed backoffice functions like accounting, human resources, billing systems, cash collection processes, a public business office, etc. that all must be established for a new ISP.
- An electric utility will already have a customer service group that interfaces with customers. Depending on the size of the community, a lot of residents will be on a first-name basis with long-term customer care employees.
- An electric utility should already have plans in place to allow it to quickly respond to electric outages. This is one of the hardest things for a new ISP to develop. Electric utilities also often have

emergency plans in place that will bring technicians from out of market in the case of major storm damage.

- A municipality with an electric utility often has an easier time raising bond funding. If the electric utility is successful enough, bonds can be issued that are backed by electric rates rather than backed by tax revenues. We've seen cases where this meant that bonds could be issued without needing a referendum.
- One of the less obvious benefits of adding a broadband utility to an existing electric utility is that the electric utility can pick up a significant piece of the cost of building the network. This can be done by having the electric utility pay for a portion of the fiber build for fibers to connect to substations, or this can be done by having the electric utility lease this capacity over time, making them a large customer of the fiber utility. Cities that tackle smart grid have even more opportunities to generate revenues for a fiber utility.
- Another hidden benefit for an electric utility that opens a fiber business is that the operating costs for the electric utility drop. When opening a new line of business, some of the costs that already exist inside the utility, like a portion of the general manager can be allocated partially to the new entity and relieving the electric utility from covering such costs. This can take pressure off of electric rates, or even reduce rates over the long-haul.

There are municipalities without electric utilities that have launched successful ISPs. However, cities with existing electric utilities have a long list of advantages over cities without utilities.

Step 2 – Considering the Operating Models

The next step is to compare the government's attributes – the strengths and weaknesses – against the requirements for the various operating models.

This means making a fair assessment of the government's ability to meet the requirement of each operating model. This first means assessing the ability to meet the big picture items. For example, when assessing the willingness to fund broadband, a government might look at the following types of questions:

- Is there a limit on the amount of funding that can be raised?
- Are there limitations on raising money that might make it difficult? For example, many government entities need a vote of the people before issuing bonds.
- Are there issues about joining a partnership that might make it impossible to use tax-free bonds?

You'd want to ask these questions about all the attributes of the different options.

It also might be useful to go a layer deeper and discuss if the government is willing to tackle the kinds of tasks involved with each operating model. As example of what this means, following is a list of some of the major tasks involved with a city funding and launching an ISP on its own:

Starting from scratch to build an ISP is extremely challenging. It means having to simultaneously master the following types of tasks. This is an abbreviated list, and in a new market launch we've created Gantt charts that list several thousand steps needed to open a new ISP.

- <u>The Technology</u>. This includes the technology of building, maintaining, repairing, and installing fiber. It involves choosing a last mile electronics technology. It means choosing for a variety of different network designs for the network topology including issues like using huts versus centralizing electronics. It involves mastering the process of installing fiber at a wide variety of different homes and businesses. It means deciding how to tackle apartments and other more complex deployment situations. It means deciding how to deploy alarms to notify of network problems, how to monitor the network, how to respond to network problems. It means deciding the ancillary issues such as how to best map the network to most useful in the future or the best way to establish a spares inventory.

- The Construction Process. This involves selecting an engineering firm to design the network. It means Selecting a construction company to build the network. It means finding a vendor and buying the electronics. It means directly buying many of the components of the network. Even if the construction company or engineer purchases the major components of the network there will be long list of things that have to bought directly – and this often overtaxes the government purchasing process. Somebody has to then monitor the construction process to make sure they stay on specification. A municipality often gets involved in the process by issuing construction permits, locating existing underground utilities, inspecting construction work sites, etc.
- Creating the ISP Organization. An organization chart has to be created including detailed job descriptions that often must be integrated into the civil service job structure. Employees must be interviewed and hired. With a new company there has to be a plan for training and integrating employees into a team. This also means defining how the new ISP fits in with the rest of the existing organization. It means defining who in the organization gets to make specific types of decisions.
- Creating the Products. Products and prices need to be selected, down to the smallest detail. For each product, the ISP must decide how it will function – done internally or outsourced, and then the appropriate purchasing processes must be used to acquire and activate all the components of the products. Processes must be established to implementing products for customers. As a small example, if telephone service will be offered, customers will want to keep existing phone numbers and will expect the ISP to "port" the number from the old ISP to the new one.
- Developing Backoffice Practices. This starts with implementing the accounting process and deciding how to account for the cost of the network and the operating expenses of the business. That means developing a chart of accounts. It might mean creating work orders in order to capitalize labor, interest expense and other overheads into the cost of the network. It means defining how cash will work from the business from financing the network through the final process of collecting cash from customers. Bond financing generally layers on a lot of specific processes. The biggest decision to make for the backoffice is the software to use to operate the ISP. This is called BSS/OSS software in the industry, which means a billing and operating software system. It can take 6 – 9 months to implement a new BSS/OSS, so the process of selecting software should start early.
- Develop Provisioning Process. Provisioning in the industry means all of the processes that must be put into place from the time that a salesperson closes a sale until the customer has received their first bill for service. For an ISP to work smoothly processes must be well-defined so that paperwork (hopefully all computerized with BSS/OSS software). It means deciding the steps that must be taken during the process and defining exactly who does each step. Creating an efficient provisioning processes is often one of the most challenging steps for a new ISP. There are a few dozen steps at minimum in the provisioning process such as taking and verifying orders, making sure each customers gets the right products at the time of installation, qualifying customers and doing credit checks or taking deposits as needed, getting each customer properly entered into the

billing system so that all products are billed, coordinating with customers during the process up through scheduling the installation visit, etc.

- Develop Operational Processes. This means defining daily workflow. For example, what exactly does an installer do from the beginning to the end of the day. What software systems do they need to do their job right. What records do they need to keep during the day in terms of a time sheet, a vehicle log, a list of materials used, etc. How does the business decide which field technicians go to which field task? This means keeping track of a time calendar and trying to meet pre-scheduled meetings with customers (something the competition does poorly). How does the business cope with holidays, vacation days, sick days, training days?
- Developing a Sales and Marketing Plan. This starts with developing a brand for the business which includes a logo, web page, social media presence, etc. It means deciding how to communicate with the public during the construction process and then deciding when it's time to take orders. The sales process must be specifically designed. If you're going to advertise it means developing advertising content and figuring out how to get it in front of the public. If you're going to deploy a sales staff it means defining sales quotas, sales compensation. This also means being ready to modify the sales and marketing process quickly as you find out what works and doesn't work in the market.
- Implementing Business Process. This might mean setting up a business office for customers to visit and pay bills. It might mean establishing the processes of getting bills out the door. It means establishing the process of notifying and disconnecting customers that don't pay. It means buying trucks, furniture, computers, etc. for employees. It means getting the needed training for new employees. It means deciding how to take trouble calls and how to react to them. It means developing an escalation process where issues go up the chain as needed to be resolved.
- Deciding on Policies. An ISP will have dozens of policies. Are deposits or credit checks required? What are the options for paying for service (credit cards, bank debits, cash, checks)? It means deciding when customers get notified about non-payment and when they get disconnected and then reconnected. It means determining how and if you're willing to give discounts to customers. It means deciding which employees have the authority to make decisions that directly affect customers.
- Develop Customer Installation Processes. These are the processes at the home or business. Will you use contractors or employees for various tasks? What paperwork does a customer need to sign (contract, terms of service, rights-of-way to cross a yard)? What exactly is included in an installation for free and what incurs extra charges. What are the policies for where you're willing to bring a wire inside a home or business? Can and should an installer upsell customers during the sale process, and how does the rest of the business change an order quickly?
- Meeting Legal / Regulatory Obligations. What federal, state, and local regulations affect the business and how do you make sure you are following regulations? What taxes must be collected from customers and how do you remit taxes to taxing authorities. What contract must be in place with the many vendors for construction and buying the products? Is there insurance you want to buy, or will the municipality self-insure?

Finally, we would recommend that a city contemplate the risks of being an ISP or of each of the other operating models. We've found that the willingness to accept risk of financial downsides is one of the big differences between commercial ISPs and government entities. There is a discussion of risks in Section IV.D of the report.

Step 3 – Looking Externally

Before finally deciding on an operating model we recommend that a potential ISP look externally to validate that what they have in mind is possible.

If everything above was considered in the first two steps, then there are usually only a few external issues to consider. Every situation is different, but the biggest external issues are things like the following:

Finding Qualified Staff. This isn't generally an issue in urban areas, but it can be a major issue in smaller markets. We've seen small-market ISPs struggle and sometimes fail to find needed experienced staff. For example, CCG helped a client find a CFO for a sizable rural ISP and it took nearly two years to finally attract a qualified person. Any new ISP needs at least a few seasoned veterans and finding them and attracting them can be a challenge. There is also often a significant wage differential between public and private jobs that has to be considered.

Verify the Availability of Funding. If you're going to use municipal bonds this would be the point in the process to have a detailed discussion with your bond advisors. Interest rates have been somewhat steady for many years in the U.S., but there is a chance due to the unsettle nature of the economy that this could change. Any government that raised bond money back in times when interest rate fluctuated recalls delaying bond issue to try to find that "perfect" day to sell the bonds in order to get an acceptable interest rate.

If a project is going to require commercial funding, this is the time to get bankers talking to bond advisors to identify any issues that might become impediments.

Finding a Partner. We find that most municipalities tend towards liking partnerships. This means they can bring in somebody that already knows how to operate an ISP. It also might mean mitigating the risk by bringing in commercial funding to help offset some municipal funding. Finding a partner is such an integral step for many municipalities that we're going to discuss the partnership process in detail and answer the question of how to identify a good partner.

The Best Characteristics for an ISP Partner

Experience. We know of several investor-driven ISPs looking to invest and operate broadband networks, but that have never built or operated a network. This isn't to say that such a group can't be a good partner, but it's a higher risk to work with an ISP that doesn't already have customers and that hasn't worked in a partnership before.

There are a few horror stories in the industry of public/private partnerships that went awry because of lack of experience by the ISP partner. In the following two examples the ISP management team was made up of folks with industry experience but who had never worked together as a team before.

- The first example is Utopia in Utah. This is a collaboration of small towns that are working together through the Utopia organization to create economy of scale for the business. State law in Utah doesn't allow municipalities to be an ISP, so Utopia works as an open access network where the cities build the network and various ISPs compete for customers.

Utopia started by hiring an external management team that had not worked in the open access environment before. A number of things went wrong – the networks were late in getting constructed and came in over budget. The ISPs did not sell as aggressively as the business plan had supposed. Utopia ran out of cash before construction was complete and almost folded, but the business was eventually saved through several rounds of refinancing and is now large enough to be financially stable. It took almost a decade of the business being in financial duress to get to that point.

- Another example is Lake County, Minnesota. The county decided to borrow money to build a county-wide fiber network. This is one of the northernmost counties in the state and quite remote. There are 11,000 residents in 2,100 square miles. They hired an outside firm to construct the network and run the ISP. The project went way over budget and the project ran out of money with a backlog of almost 1,000 customers they couldn't connect to the network.

  The project was funded through a combination of a $10 million federal grant and a low interest government loan for $56 million. The county also bonded over $7 million locally for the project plus floated loans to keep the project afloat. The project went completely underwater financially and didn't make enough money to cover debt payments. In 2019 the county sold the network to an ISP for $8.4 million. The federal government had to write off about $40 million in debt and the county still must cover the original bonds plus the internal loans made to the project.

<u>Experience Working with Municipalities</u>. It's somewhat important to work with an ISP that has worked with local governments before. CCG has witnessed a number of public private partnerships with the recurring theme that the two parties get frustrated with each other over time. This is due to two factors – frustration with the decision-making process and a difference in goals and expectations.

Commercial ISPs become quickly frustrated with the municipal decision-making process. Most local governments have a specified legal process that must be followed to make certain kinds of decisions. This might mean listing the topic for a public meeting, waiting for a period of time, and allowing public comment on the issue. Commercial ISPs are used to making decisions quickly and they don't like the drawn-out processes that government requires. Government entities get frustrated as well since their commercial partners push them to make decisions quickly when they can't.

A more fundamental issue in public private partnerships is a fundamental difference in goals. The issue commonly arises when the two parties didn't thoroughly discuss their long-term goals for broadband before a partnership began. Commercial ISPs are often most worried about cash flow and profit margins. If they've invested equity in a broadband network, they become unhappy if the business doesn't meet their earnings goals. Governments often have a different set of goals – serving every household, offering low-priced broadband to low-income houses, providing subsidized broadband to nonprofits and anchor institutions. In many cases, these kinds of fundamental differences can't be overcome and eventually ends up in a dissolution of the partnership.

The differences between the two kinds of entities often surfaces when there is a discussion of rates. Cities often push back against rate increases – particularly in election years. Cities push partners for low rates in general, and often want an ISP to give low rates for low-income households and even free rates to groups like nonprofits.

These kinds of issues are less likely to be a huge problem if the ISP has worked successfully with other municipalities before. A government entity that is working with an ISP that has not partnered in this manner before should have an in-depth discussion up front about expectations. It's a lot easier if the two parties decide up front that they aren't compatible instead of getting a divorce after the partnership has been launched.

Financial Strength. Municipal entities often have a hard time judging the financial strength of partners. Unfortunately, most public/private partnerships are not with big well-financed ISPs. The more typical partnerships are with telephone companies, electric cooperatives, or fiber overbuilders. It's typical for commercial ISPs of this type to overstate their financial security – and they may even believe what they say in doing so. But there are a few fundamental things about ISPs that a city should understand:

- Every ISP has a natural borrowing limit. There is only so much debt that bankers and other lenders will allow them to carry. By definition, when an ISP nears that lending limit it means that bankers think the company is pushing its financial limitations. Any ISP that has borrowed to its limit can't afford to make financial mistakes, and that means the partnership and all of their other ventures need to perform as expected. It's not unusual to see budding partnership be dependent upon obtaining financing, and it's not uncommon for the ISP to not get the hoped-for funding.
- The biggest issue with ISPs and borrowing is collateral. Banks don't look at fiber networks as good collateral for loans because there is little value from repossessing a fiber network. This means the only good collateral that most ISPs have is the value of their existing company. Even surprisingly large ISPs might have to pledge their entire company in order to borrow a sizable amount of money to build an expensive network. It's often necessary for owners of ISPs to make personal guarantees on loans, meaning that both their business and their personal assets are on the line with a new fiber project. ISPs are highly unlikely to disclose to a government partner the details of how they raise money – among other reasons they are scared of public disclosure laws and don't want their personal financial position discoverable as a public record.

Capacity to Grow. One of the hardest things to judge is the ability of an ISP to grow quickly. A traditional ISP like a telephone company may have a lot of customers – but they acquired them slowly over decades. ISPs (and all other types of businesses) often get stressed to the breaking point when they try to grow too fast. It's not unusual for an ISP to somehow assume that existing middle and upper management can handle a growth scenario while still somehow handling the existing responsibilities they've always had.

Just because a company is a great ISP doesn't mean that the company can grow quickly. Unfortunately, there is no way to judge this unless the ISP has already been growing prior to the creation of the partnership.

Fair Recognition of Value. One of the important attributes of a good partnership is the full and fair recognition of the value that each party brings to the partnership. Municipalities should be wary of a partner that overvalues what they bring to and undervalues what you bring. A government can create value for a public/private partnership in a number of ways:

- Funding. Any amounts paid towards funding a broadband network are valuable. Governments often don't know how to set a value for cash contributions – something that commercial partners routinely figure out. It's been my experience that ISPs don't value government funding as much as they do other funding sources. I think this is because government funding doesn't come with the same stringent strings and responsibilities. A local government is not likely (or even able) to require things that a bank might require such as collateral or a lien on a partner's assets. If an ISP gets into financial trouble, the first entity they will try not to pay is a government partner. This can be dealt with in creating a partnership agreement, but to some degree that requires a government to think like a bank.
- Anchor Tenant. Government entities often make good anchor tenants – which is pledging to be an early customer of a network and guaranteeing to buy services with a long-term contract. It's not untypical for a government to be one of the largest broadband customers on a network.
- Other Assets. Governments often have other assets that can benefit a partnership. This could be land for placing equipment; It could be a building to create a central office or a storefront. It might mean towers, empty conduit, or spare existing fiber that can be used to defray the cost of constructing a broadband solution. The value of such assets should be set according to what the partnership would pay to get the same thing from a third party.
- Easier Construction Processes. Local governments often take a significant role during the construction process. They might have to approve permits for rights-of-way. They might be the entity that locates existing utilities. They might require inspection of construction work sites, during and after construction. They might require things life traffic management during construction. Before tackling a major fiber construction project with a partner, a government might review these various requirements to see if they can be streamlined to make it easier to build fiber. Note in doing so that this likely means making any relaxed rules available to any other entity that wants to build fiber.
- Contributed Labor. A government can contribute labor. Using the last example above, a government could agree to conduct permits, locating, or some other service for free as a way to contribute to launching a partnership project.
- Tax Abatements. Tax abatements have always been a tool for economic development. Governments often have it within their power to excuse certain taxes to entities that bring something of economic value to the community. For example, it's common to not charge a large new business any property taxes for some period as a way to lure them to locate in the community. There are numerous taxes and fees that might impact a new broadband network such as property taxes, sales taxes, right-of-way fees, etc. that a government might be willing to waive to help a new network get established.

The bottom line to this discussion is that a government can bring significant value to a partnership, and that contribution should be fairly valued. Even when a government brings tangible value, such as contributing funding, it's not unusual for an ISP to undervalue that contribution. It's even more prevalent for an ISP to not assign a realistic value to the more intangible contributions.

How do You Find Potential Partners?

We've seen almost every partnership we know of come through three different processes:

- Request for Information (RFI). It's fairly typical for communities that want broadband to issue an RFI aimed specifically at soliciting potential ISP partners. These RFIs typically describe the situation in the community, typically describe whatever work has already been accomplished (such as this feasibility study) and describe the role the municipality wants to take in a partnership.

  The RFI then asks ISPs to describe themselves and their capabilities. The RFI generally doesn't go so far as to request a specific solution, but rather asks the ISPs to discuss how they might tackle broadband issues in the community.

  An RFI is generally a first step to determine which ISPs might be interested in partnering. After the RFI the process typically moves to one of the two processes described below.
- Request for Proposal (RFP). And RFP is typically a lot more in depth. In addition to asking ISPs to introduce themselves, an RFP might ask for specific proposed solutions. It might go further in detail asking about the financial strength of the ISP business and details of how they operate in other market.
- Direct Negotiation. It's fairly routine for governments to interact directly with potential ISP partners rather than go through an RFI or RFP. This might involve a local government reaching out to ISPs in the area, or it might be in response to an ISP making an unsolicited proposal to a local government to bring broadband.

Comparing the Three Options.

It's first worth considering the issue from the perspective of an ISP. ISPs are leery of public records laws. They are often highly reluctant to provide financial information, customer lists, or other information that they feel is confidential. They don't trust that local governments will fight to keep such information confidential. ISPs are even more leery of spelling out specific details of their business plan and how they approach a broadband market – they don't want that information to be available to their competitors.

Many ISPs are not willing or able to respond to an RFI or an RFP that asks for lengthy written responses to a long list of questions. Businesses that sell equipment and services are used to the idea of making proposals and usually have a pile of pre-prepared canned responses to the typical questions they are asked by a prospective customer. However, an ISP may never have been asked to make a proposal in writing in the specific and detailed way that might be needed to respond to an RFI or an RFP. There are ISPs that refuse to participate in an RFI or RFP for this and related issues. We know there are ISPs that eliminate cities from consideration if they insist on going through the formal RFP process. They know there are other communities that will talk to them directly without the formal process.

ISPs prefer direct discussions where nothing is put into writing during the negotiation stage. That's the same process that ISPs typically use when they partner with other ISPs – they sit and talk out the pros and cons and mutually decide if there is a potential for a partnership. As often as not, such discussions end up with the realization that a partnership is not a good idea, and the parties amicably go their separate ways and nothing they discussed is in writing.

Here is the process that I like best, having been through a lot of discussions between governments and ISPs:

> For most local governments, the best first step is to invite known ISPs for a high-level discussion about whether any kind of partnership makes sense. This process might involve several meetings where an ISP might come back with ideas, and then another meeting where the local government reacts.
>
> I like the RFI process when it makes sense. For example, I was working with a geographically isolated community where there was no local ISP candidate within fifty miles. An RFI made sense since the community didn't have a wish list of local ISPs to consider. An RFI also might make sense for larger communities. In this case I define larger to mean that the cost of the project is large – perhaps more than $25 million. I've known communities that found an ISP partner through an RFI that they would never have otherwise found.
>
> If a community issues an RFI it should ask for basic information only. That might include asking an ISP to provide their history, telling about the products they normally sell, and talking about the management team. While cities might have a hundred questions for a prospective partner, the ISP is going to be a lot happier if the details of their business are not put into writing at the early stage of meeting and negotiating.
>
> I think RFPs only make sense for larger cities – probably those with network costs over $100 million. It's not likely that a small ISP will respond to such an RFP. Even in an RFP, I recommend not asking for sensitive financial information about the ISP – that can always be provided if the likelihood of a partnership develops.

Establishing Compatible Goals

At some point during the early stages of the process it's vital for both sides to thoroughly discuss their goals for the project. Misalignment of goals is the number one issue that plagues any partnership eventually. Both parties need to fully hear, understand, and be fully comfortable with the goals of the other partner.

Goals generally can be stated simply and don't have to be complicated. Goals for a municipality might be things like serving the entire community, not needing to subsidize the project, keeping rates low, etc. Goals for an ISP might be to generate s specific target of cash flows / profits. It wouldn't be unusual for an ISP partner to eventually want the option to buy the business. An ISP also might want just the opposite and might want to capitalize on the success of the business by selling out after some period of time.

It's important to not only see each other's goals, but it's vital for a municipality to understand the ISP's goals. This is one situation where a municipality might want to discuss these goals with a consultant or somebody with broad industry experience. It's not unusual for two partners to be talking a different language when discussing financial issues and it's vital to fully comprehend what a partner is telling you about their goals.

Alignment of goals is a make-or-break point in a potential partnership. Many of the differences that a municipality and an ISP might have can be negotiated, but you can't negotiate a difference in philosophy. If an ISP has a goal that a municipality can't live with, such as selling out in ten years – then our advice is to not pursue the partnership. When an ISP tells you a goal of that nature, they mean it.

How to Rank Potential Partners?

There are hundreds of questions that a local government might ask an ISP that might range from big important questions like, "Can you bring funding to this project?" to questions that are important but have lesser impact on creating a partnership such as, "What's your process of disconnecting customers who don't pay?"

I advise prospective partners (government or otherwise) to place their questions into three categories, 1) make or break questions, 2) questions that might disqualify a potential partner, and 3) all other questions.

Every community will have its own list of make or break questions based upon their own priorities for what a partner should bring to the table. Make or break questions might be things like 1) "How much funding can you bring to the project?", or 2) "Are you willing to serve everybody in the community?"

Questions that might disqualify a potential partner might be similar questions, again based on the specific priority and goals of a given community. Keep in mind that some of the items in this category might be subject to negotiation – something that should be asked.

The first two categories of questions are the important ones that should be used to qualify and rank potential partners. Other less critical questions are important, but probably don't get considered unless it's close between two candidates. You choose a partner based upon the most important aspects of the relationship.

There are several techniques that are used to compile rankings. Most rankings of this sort are done by compiling the rankings by a team of reviewers. The most important questions might get weighted somehow to have the biggest impact on the composite answer. At the end of this process is a numerical answer that reflects the composite opinion of those doing the ranking. It's likely that such rankings are not even the final answer and often the ranking process will send a government back to ask more questions. Since this is not a purchase of service, but a partnership, it's also highly unlikely that it would be mandatory to take the ISP that ranked the best.

Defining the Roles of Each Partner

It's vital to define the specific roles and responsibilities of each partner. Ideally, this should be done before formalizing the partnership arrangement.

CCG has often used a technique that seems to work ideally in defining a partnership. It starts with a list of all of the tasks needed for launching and operating the upcoming broadband business. The level of detail usually become readily apparent. For example, it it's clear that the ISP is going to have 100% of the interactions with customers, then having a task called "Interface with customers" would be sufficient rather than listing all of the various ways that somebody might interface with customers.

The items on the list would include financial and other contributions as discussed earlier, issues having to do with construction the new network, issues having to do with governance, issues having to do with operating the business.

A responsibility must be assigned for each task on the list. The choices for each task are1) the task is the responsibility of the government, 2) the task is the responsibility of the ISP, 3) the task is a joint responsibility of both parties (in which case that needs to be fully described), or 4) the task is the responsibility of some third party (like an outsourced arrangement). This kind of process quickly shows if the two parties are aligned and agree on all of the responsibilities and if there are tasks where the two sides have a different view. The example used earlier involved setting of rates – this is a good way to get it in writing from both parties about the roles in setting rates.

Making this list serves two purposes. It's a great tool for getting both parties to acknowledge the specific roles of each partner. It also then serves as a great template for developing a contract between the partners.

Maintaining Local Control

One of the hardest things to approach is having a partnership yet retaining local control. The following issues all have bearing on the level of control a municipality might have for an ongoing broadband business.

Before answering the question, I would challenge a municipality to make a list of items they would like to have some control over. It's likely that a list will include major aspects of operating the business such as rates, installation intervals, business hours, priorities of repairing customers after an outage, etc. I then ask the municipality to change hats and look at these same issues from their perspective of the ISP, who is trying to run a profitable business. This exercise often highlights requests for control that are unreasonable.

One of the stories I tell about politics and the broadband business concerns Bristol Virginia Utilities, which was one of the first cities to enter the broadband business. The business was operated by the electric utility, which was a branch of the local government, but which had a full standalone operating authority. The bonds were fully backed by the electric utility, but since the city had to approve any bond issue, the city reserved the right to set and approve rates. A few years after launching the business, and during an election year, the city council voted to slash all of the rates by 15%. The utility warned them this would put the business underwater, and sure enough they were unable to meet a bond payment due six months later. The city got the message and ended up raising the rates to a higher level than the original rates to correct the shortfall, and the city also changed their ordinances so that no future city council could change rates.

There are numerous other examples of negative ways that local governments have meddled in a broadband business. Politicians might make promises to constituents on behalf of the ISP. Politicians often press to give special rates to friends or to forgive bad debts for a constituent. It’s not unusual for politicians to go further and interfere in things like personnel decisions. It’s incredibly important to have clearly defined boundaries and lines so that an ISP can say no to meddling.

ISPs are highly wary of ceding any control to a government entity. ISPs fully comprehend that a partnership with a municipality is always tentative and can change drastically after an election. There are plenty of examples of a council or board that changed from pro-broadband utility to anti after an election. Political changes can put a huge strain on the business relationship even if there are no control issues. ISPs know that the municipality they partner with today may not be the same in the future.

This is not to say that a municipality shouldn’t have any control over the business. One of the more obvious aspects to maintaining control depends upon who funds the network. A municipality is going to get little or no say in how to operate a network that includes significant funding from a commercial ISP. If an ISP brings money to a project, they generally will not take the risk of letting a municipality tell them how to operate the business – since the ISPs primary goal will be in getting a good return on their investment.

But even funding doesn’t always determine control. Many ISPs will only partner if they get to make all of the business decisions – even if the government funded the network. This is why potential partners need to ask all of these questions before they create the partnership.

The only sure-fire way for a municipality to have control is to fund and operate the network. It’s going to be difficult to find an ISP partner that will want a city to influence business decisions once the business is operating. This is a case where a little authority is a bad thing. If a municipality has any authority to control the business, then eventually somebody at municipality will go too far, either today or in the future as the government changes.

The conclusion of this long discussion is that some parts of everything discussed in here should be on the table for a government that doesn’t know the operating model they want to use. If there is interest in either going it alone as a standalone ISP or else partnering with an ISP, then most of the things discussed above should be considered. The decision to get into the broadband business is a consequential one for a government entity. You don’t want to rush the decision and you want to kick the tires on all aspects of the different operating models.

C. Getting Local Buy-In

This section of the report will discuss a community engagement strategy – how to bring the public into the decision-making and implementation of broadband. Government entities have always known how difficult it is to activate the public to get engaged on any issue. It takes an enormous amount of effort to do this right. This section will describe techniques used successfully by other communities.

A community engagement strategy generally has two phases:

- The first phase is exploratory and has the goal of understanding the level of community interest in broadband.
- A second phase would be activated at the point that the community decides to move forward with a broadband solution. The goal of a second phase is to identify residents and businesses who will support a broadband network when built.

Staffing for Community Engagement

Both phases of community engagement require some level of staffing to be successful. Both phases require a focused and persistent effort, so it's important to identify staffing needed to be successful. We've seen many efforts to get community buy-in fizzle when nobody was dedicated to the community engagement tasks. We've seen the following ways that communities have staffed the effort.

- <u>Dedicated Government Staff</u>. The most expensive option, but one of the most effective is to dedicate government staff to concentrate on community engagement. That requires a commitment by elected officials to fund the effort. This would typically not be a permanent position, but rather somebody dedicated to the effort for some fixed period of time. This is also not a 9 to 5 job since interfacing with residents often means evening meetings.

  A county in Minnesota found a broadband solution because the mayor of one of the smallest towns in the county told his economic development director that getting broadband was his top priority. This economic development leader spearheaded the first phase of the process – educating the public on the issue of broadband. This particular area had towns with okay broadband from a cable company and rural areas with little or no broadband. The economic development director met with everybody imaginable in the area including other city governments, county governments, state representatives, and every civic and social group imaginable. After two years of tireless by this one staff person the communities in parts of two counties agreed on a broadband solution. This would never have happened without this one dedicated staff position.

- <u>Volunteers</u>. Volunteers are also an important part of this effort. Every community seems to have some people who really hate the state of the existing broadband and who are willing to volunteer time to hunting for a solution. In the example given above, the economic development director assembled a group of active volunteers to help with the effort to engage with and educate the public. These folks created email lists, went canvassing door-to-door talking about the need for broadband, and showed up at every government meeting to stress that they wanted a broadband solution. It's important that any volunteer effort have some structure and working with a staff person can make sure such a group stays focused. If a community decides to engage volunteers, there should still be a commitment to providing some funding. In the case of the Minnesota effort, local governments funded the effort required to engage in a canvass of the communities to understand the interest in broadband. This included several rounds of mailing postcards asking homeowners to pledge support for broadband.

- Broadband Task Force. Another approach is to create a formal committee of citizens who are willing to work together to explore the issues around community broadband. Such a Broadband Task Force generally is composed of citizen volunteers and perhaps a few elected officials. The group would meet regularly and work towards exploring the need for a broadband solution. It's normal that such a group would report back regularly to the government about their progress. Such a group can collectively take on some of the needed community engagement tasks, and we've seen effective committees do this well. It's not unusual for a Broadband Task Force to solicit help from additional volunteers.

  Such groups are usually given a budget, but also restrained by needing to have expenditure pre-approved. We could write pages on the dos and don'ts of operating a successful citizen's advisory group. It's likely the town has done this before for other issues. The main key for success is to make sure that the group has a specific agenda, a specified budget, and the specified authority to meet their goals. Citizen groups can accomplish great things if they are properly directed to do so – but can stray if not given good direction.

Consumer Education

One important aspect during both phases of community engagement is to provide useful information to help the public better understand broadband issues. We've seen communities tackle public education in some of the following ways.

- Publish This Feasibility Report. While not a lot of people will wade the whole way through a report of this size, it's been written for the layperson.
- Hold Public Meetings. Public meetings can be held to explain the results of this study, or meetings could be more generic and be aimed at explaining the broadband issues. It's worthwhile to have elected officials at public meeting so they can directly hear the kinds of issues that households and businesses have with existing broadband. It's vital to advertise heavily to drive attendance at meetings. CCG and Finley Engineering have been to a community meeting where only one resident showed up, and to others that were standing room only in a large room.
- Broadband Web Site / Social Media. Many communities create a broadband web page or accomplish the same thing using social media. Such a page can be used to educate as well as inform. For example, a common educational feature is to have a lengthy section with responses to "Frequently Asked Questions." Such a website can also inform the public about upcoming events or other things the government wants to advertise.
- Gather List of Broadband Proponents. One important resource is to create a database of local broadband proponents – citizens who say they support broadband. Having list of emails, home addresses, and phone numbers will be useful when it's time to gather support for public actions.
- Broadband Newsletter. Communities often create a newsletter dedicated to broadband. These newsletters are aimed at educating the public on topics related to broadband and also to keep the public informed on the progress of the effort to get better broadband.
- Outreach Meetings. One of the most successful ways to reach the public is what CCG calls

outreach. This means sending a spokesperson to meetings of the local organizations to talk about broadband issues and to answer questions. This can be any sorts of groups – PTAs, church groups, service organizations, youth groups, etc. Most organizations will allow time for a short presentation. It's vital to have a prepared presentation to get across whatever message you want the public to know. These outreach meetings are best done by those who are strong broadband proponents or who have specific knowledge about broadband.

Pre-marketing Efforts

If the broadband effort reaches the second phase, one of the most important steps is to identify potential customers for a broadband network. The biggest concern that every ISP has about a new market is knowing if they can get enough customers to be successful. We already have an inkling of the support in the cities from the residential survey. The pre-marketing efforts go a layer deeper and ask residents and business to pledge support for a new network. There are several techniques that communities have used to understand market demand.

Statistically Valid Surveys. You've already undertaken a residential survey. Before launching a municipal business, you would likely consider an additional survey that asked the public about the proposed products and prices.

Canvass. A canvass is similar to a survey but has the goal of reaching out to everybody in the community. Communities often undertake a canvass at the point where there is a decision to move forward to implement a broadband solution. A canvass can have several goals. The simplest goal would be to create a list of broadband supporters. A canvass could also be used to get homes and businesses to pledge to buy broadband if a network is built. Such pledges are typically non-binding but can provide good support when the community is looking for funding

Canvasses can be done in several ways. A canvass often starts with an online invitation to support a broadband initiative. Canvassing can also be done by mail. We've seen communities engage groups like the PTA or service organization to get people to participate in the canvass. We've seen communities that send volunteers door-to-door to ask citizens to participate in a canvass.

Other Areas of Broadband Concern

Often when communities are looking at attracting a broadband solution, this raises a few issues related to but separate from getting a broadband network. Communities often embark in research and community outreach on these issues in addition to the broadband issue.

Computers for Students. One of the reasons that communities often build broadband networks is to solve the homework gap, where students don't have computers or broadband at home to do homework. Even if a community solves the broadband issue, they still need to find a solution for the computer issue. Sometimes this is accomplished by having the schools give a computer or tablet to every student. Other communities have undertaken a program to get a computer into each household that needs one.

Focus on the Digital Divide. Communities also often undertake programs to make sure that everybody can take advantage of the new broadband network. This can manifest in numerous ways. That might mean getting computers and WiFi into public housing. It might mean beefing up computers and broadband in libraries. It might mean establishing numerous outdoor WiFi hotspots around the community. It might mean starting basic computer literacy classes. It might mean looking for a solution to bring affordable products to qualifying low-income homes.

D. Benefit / Risk Analysis

The RFP ask us to look at the benefits to the community of building fiber and also at the risks to the cities should you decide to build a fiber network.

Community Benefits from a Fiber Network

Many of these benefits occur regardless if the city or a private entity builds a new fiber network. There are additional benefits that come from a city-controlled fiber network. The question that must be answered is if there are benefits that a citywide fiber network brings to the city that cannot be satisfied by the existing broadband providers.

<u>Choice</u>. Customer choice is going to become a significant issue in the coming decade. AT&T and other big telcos have made it clear that they are not going to continue to repair and maintain their copper networks, and at some point in time they are likely to decommission the copper network and DSL service in the cities. That would leave every neighborhood with only a single cable company ISP, and broadband monopolies are always bad for a community. Verizon has already started to dismantle copper networks and AT&T has made it clear that they would also like to get out of the copper business. In fact, as of October 1, 2020 AT&T announced it would no longer connect new DSL customers.

<u>Price Competition</u>. We know that overall prices are lower in markets that have multiple fast broadband networks. A fiber network in the community would mean a major new competitor to Charter and WOW! One only has to compare broadband products in prices in places where Google Fiber or a municipality has built a fiber network to see that it makes a difference in prices and customer service. The cable companies will compete by lowering prices and by providing better customer service when forced to do so by competition.

<u>Upload Broadband Speeds</u>. This issue was described in detail in the broadband GAP analysis. The COVID-19 pandemic has highlighted a problem with the broadband in the cities and in much of the rest of urban America. Cable companies and AT&T all offer technologies that offer meager upload data paths. This has historically not been important to most residents. However, as employees and students were sent home to work, it became obvious that many homes don’t have a good enough upload data path to support multiple people simultaneously working from home.

High quality upload data paths are required to connect to office or school networks. Good upload speeds are needed to connect to Zoom and similar video chat applications. Good upload speeds are also needed for telemedicine in visiting with doctors from home. Good upload speeds are also now needed for many gaming applications when the biggest game companies moved games to the cloud over the past few years.

Fiber networks can provide symmetrical uploads data speeds that can easily handle the newly created demands from homes. There is a lot of consensus among industry experts that a lot of the uses we’ve found for upload broadband are not going to go away when the pandemic is over. Many companies now understand that employees can be productive working from home, while saving the company from operating expensive office space. Telemedicine is likely going to become a routine way to connect with doctors for visits that don't require a physical examination. Video chat has now become a routine way for people to communicate.

Improved Medical Care. The report has already discussed how telemedicine connections need a solid quality upload connection. Telemedicine is likely to become a routine facet of healthcare.

Broadband also is opening up new technologies that will benefit communities immensely. For example, good broadband can support a suite of monitoring and communications technologies that will allow the elderly to stay in their homes for more years. Good broadband is also proving to be beneficial for supporting monitoring devices after surgeries and procedures. A number of studies show significantly improved results for patients that are closely monitored after surgery by identifying problems early.

Improved Education. It's likely after the pandemic that a lot of schoolwork will continue to be offered online. Already before the pandemic, 37% of all graduate degrees contained a significant portion of the coursework online. Fiber is one of the only technologies that allows for busy households with multiple family members to easily pursue online schoolwork or training.

Digital Divide/Affordability. In every city there are households that can't afford broadband. The surveys that were part of this study suggests that between 10% and 15% of the homes in the city don't have a home broadband connection today.

A municipal network might afford the opportunity to bring broadband to these citizens. Cities that build their own fiber networks usually include solving the digital divide as one of their goals. Cities understand that the community will be stronger if everybody is connected to the Internet. That will be more important in the future as cities start implementing smart city technology to provide better digital access to city services.

Economic Development. Many cities claim huge economic development benefits from building fiber. Cities also often use a fiber network to offer low-cost connectivity as a lure to bring new businesses. Many cities claim to have attracted significant new businesses and jobs as a consequence of fiber broadband. Providing city fiber to business districts can be a huge boon to the business community and result in more jobs.

One of the biggest benefits of fiber today is that it enhances the work-at-home market. Even before the pandemic we've been seeing cities where 10% to 20% of homes have at least one family member that routinely works from home. That number is likely to climb significantly in the future. Communities that can attract work-at-home workers will see enhanced tax revenues and see the benefits from families with improved earnings.

Reduced City Communications Costs. With a fiber network all of the government locations within the city would be connected without payment to outside ISPs. Most cities that provide fiber establish gigabit speeds within the City, which brings numerous benefits for working between departments and for connecting with the public.

Better Cellular Networks. 5G is going to allow for faster cellular networks. However, the 5G spectrum that will be used must be closer to customers than today's cellular network and this is going to mean placing cellular transmitters on utility poles and light poles throughout the city. A city with a fiber network will be able to accommodate the best 5G network since cellular companies will be able to place small cell sites in the optimum locations.

Ubiquitous WiFi. Many cities provide some WiFi access to citizens in places like libraries, city hall, and perhaps in a few locations like parks or other commonly used public spaces. However, with a fiber network a city could offer WiFi in many more places since the WiFi transmitters could be tied into the underlying fiber network.

This idea also comes with a word of caution. Many cities have been sold on the idea that they can generate enough revenues from public WiFi systems to cover the cost of the network. We have never heard of a WiFi network that was able to generate enough revenues to cover costs.

Smart City. There are a lot of new digital technologies categorized loosely as "smart city" that are intended to allow cities to better serve their citizens. There are a wide variety of technologies being tried, many of which can be greatly benefit from having a community fiber network. Here are just a few examples of technologies that some cities are implementing:

- Smart Traffic. Many cities have had traffic controls that allow them to change traffic light patterns by time of day. Now cities are considering traffic control systems that analyze traffic in real time and can adjust traffic lights to best accommodate traffic flows. These systems can speed up the ability for traffic to navigate the city, which means a greener city, more efficient commerce, and numerous other benefits. Smart traffic can also be used to analyze dangerous traffic situations. For example, cameras can record and report "near-misses" in intersections between vehicles, bicycles, and pedestrians so that the city can understand dangerous traffic situations before a tragedy reveals it.
- Surveillance/Safety. Cities are installing cameras and other devices to enhance law enforcement. Surveillance cameras are now widely in many cities to solve crimes. This ability in enhanced with high-definition cameras fed by good broadband that can see in much more detail than older generations of camera technology. Cities are also installing systems like gunshot detectors that can pinpoint the location of a gunshot.
- Smart Grid. The report discusses smart grid elsewhere. Smart grid is a set of monitoring technologies used to control utility networks like electric and water systems. The technologies can be used to enhance efficiency and improve the quality of life in a community. For example, an electric smart grid system can be used to pinpoint the location of network outages, which can greatly speed up repairs and restore power outages. Monitoring water networks can pinpoint water leaks that can otherwise cost the community by wasting water. While most smart grid technology today uses wireless connections to smart grid devices, having a fiber network can benefit a smart grid deployment in the city.
- City Intranet. One interesting function provided by cities with fiber networks is the creation of a robust intranet for those connected to the city fiber. For example, in Lafayette, Louisiana all customers connected to the city-owned fiber network can communicate at gigabit speeds with anybody else on the city network. Even if a household buys a slower speed to connect to the outside

Internet, within the city workers can connect to the office or students can connect to the school with gigabit speeds.

Risks of Creating a Municipal ISP

Competitive Risks. If a city builds a fiber network, there is always the risk of a significant response from existing service providers. For example, it hasn't happened many times, but there are a few examples where incumbent service providers engaged in a serious price war with a new ISP. In a price war, prices can go so low that all service providers in the market lose money. Large incumbents can ride out the operating losses in a price war, while a new operator can't.

There is also the risk that a competitor could overbuild a new fiber network. It doesn't happen often, but it has happened. For example, in Monticello Minnesota, the incumbent telephone company TDS reacted to a municipal fiber network by building a second fiber network. In parts of the North Carolina research triangle and in Austin, Texas, both the incumbent telephone company and the cable company built some fiber-to-the-home as a reaction to fiber built by Google Fiber. That means a few lucky households are served by three gigabit fiber networks.

In your market there is always the possibility that a pending fiber network might prompt providers like WOW! or AT&T to build more fiber, at least to the neighborhoods that the companies think are the most lucrative.

Existing cable companies often pull out all of the stops to make it hard for a new competitor to thrive. For example, they might offer low rates in a special and lock up customer in 2- to 3-year contracts before a new ISP is open for business. They often saturate the market with advertising and have been known to use negative advertising against new market entrants.

There is an interesting new competitor that has been mentioned several times in this report. Verizon is already building fiber-to-the-curb with its FWA product that delivers near-gigabit speeds with fiber on the streets paired with wireless connection to the home. It seems unlikely that Verizon would build this technology where there is an existing fiber-to-the-home network, but that might launch the product as a preemptive strike to dissuade a city from building a new fiber network.

Financial Risks. There are a number of financial risks for a city building a fiber network:

- It can be challenging to raise the needed funding if that requires a public referendum.
- Fiber networks are expensive, and any bond debt used to finance fiber would last for twenty to thirty years, which would tie up the borrowing capacity of the cities to fund other priorities.
- There is no guarantee that a new fiber business will make enough money to be financially self-sufficient. Most cities would be unhappy if they needed to provide an ongoing subsidy to support a fiber venture. A city needs to be prepared to dip into municipal funds to cover shortfalls. Cities with electric utilities sometimes cover these losses by using electric cash reserves or even by raising electric rates. Otherwise, cash shortfalls would have to be covered using tax revenues.

Operational Market Risks. Earlier in the report was a description of some of the key steps required to successfully launch a new fiber business. There is an operational risk come failing to perform any of the needed tasks well. For example, a new ISP might build a world class fiber network but stumble badly in the sales and marketing process or some other key component of the business.

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 their video product. This was due to their 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 period the business fell significantly short of their business plan projections. Over time the city regained a reputation as a quality service provider and today is financially successful and is expanding into the surround suburbs. But that one mistake badly hurt the launch of the business.

The Cost of Success. In the telecom world there is a phenomenon CCG calls the cost of success. It’s costly 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. The alternatives are to borrow more money to fund the growth, or else make customers wait until the project generates enough cash to cover customers in a queue. It’s often not practical for a municipality to borrow extra money past the original bond issue.

Local Rules and Regulations. Cities that build fiber are often surprised to find government barriers to the construction process. For example, the rules for building fiber along county, state, and federal roads might differ significantly from rules for city streets. There also can be challenging obstacles to building across bridges, across railroad tracks, or through Interstate exit interchanges.

Cities are also sometimes flummoxed by their own rules, when as a fiber builder they must follow the same processes they’ve required of other utilities.

Municipal Purchasing Rules. There is a big pile of contracts to negotiate and materials to buy in order to build a fiber network and we’ve seen cities who struggled badly with the process when coping with municipal purchasing rules. While these rules have the goal of making sure that a municipality doesn’t overpay for good 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 – 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.

Political Risks. 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. The City of 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 into a quick dive in terms of cash creation, and in the year following the rate decrease, the City Council was forced to raise rates higher than the original rates 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.

C. Roadblocks to Serving MDUs

The financial analysis looks at some of the issues involved with serving MDUs with fiber. CCG works with a number of clients that serve MDUs and we have learned that the cost to serve an MDU with fiber can vary widely according to a number of different factors. It's possible for two nearly identical MDUs of the same relative age to have drastically different costs to bring fiber. Therefore, this section of the report is going to look in more detail at the factors and the roadblocks that affect the ability and the cost of serving MDUs.

Following is a discussion of the primary kinds of roadblocks that we see in the MDU market. This is not an all-inclusive list and there will be some MDUs with issues not listed here, but this list should cover most of the kinds of issues encountered with bringing fiber to MDUs.

Exclusive Arrangements. A few years ago, the FCC put some restrictions on cable companies and ISPs from entering into certain kinds of exclusive arrangements with property owners. It was a fairly common practice, for example, for an ISP to share customer revenues with a property owner in exchange for a long-term exclusive right to serve the building. The FCC largely forbade the most egregious practices where ISPs forced exclusivity. However, the FCC did not ban all such practices. For example, exclusive arrangements are still possible when prompted by the property owner, and under FCC rules and various court rulings, property owners are not required to allow access by ISPs to their building.

It's likely that there are existing exclusive arrangements with ISPs in the cities. Anybody thinking of building a fiber network would want to investigate this by talking to apartment owners and property managers.

Financial Roadblocks. Property owners can create financial roadblocks to ISPs, including such practices as:

> High Access Fees. Property owners can charge a significant fee to an ISP to gain access to their buildings. This could include excessive fees to connect facilities into basements or rooftops. Alternatively, they might charge high rent to use communications spaces.
>
> Forced Revenue Sharing. Property owners might demand that any ISP entering their building must share customer revenue with them. This is of particular concern for a municipal provider because there is a good chance that such practice wouldn't be allowed. CCG has numerous municipal clients that could not find a way to pay commissions in the same manner as is done by commercial ISPs.
>
> Partial Services Allowed. Sometime property owners include some basic level of telecommunications service in the rent. For example, they might already include a video package that they receive from satellite and distribute to apartment units. Such arrangements might be a financial roadblock if they make it hard for ISPs to profitably provide other services to tenants.

Ownership of Existing Communications Infrastructure. Property owners don't always own the existing telecom infrastructure in a building. Sometimes such infrastructure was installed by the cable company or other ISP and those entities maintain ownership through a contractual arrangement with the property owner. There are several categories of assets where ownership by somebody other than the property owner can be a roadblock.

> Existing Wiring. A cable company, telephone company, ISP, or CLEC might own the existing telephone copper, coaxial cable, category 5 cables, or fiber. Private owners don't have to make their facilities available to anybody else. In some cases, businesses within multi-tenant buildings own their own wiring inside their rented space, but that is rarely a roadblock for the business owner to choose to change service providers.
>
> Normally a fiber overbuilder is not going to want to use the existing wiring if they want to offer gigabit speeds. However, there are times when that might be desirable. For example, one of the technology options explored in this report is using G.Fast, which can be delivered over telephone copper or coaxial cable. While this doesn't deliver a full gigabit, it can deliver 300–400 Mbps broadband, which many property owners would find desirable. However, that technology can't be used if the wires are owned by somebody other than the business owner. There are also buildings which will be "pre-wired" for broadband. Most of these will have category 5 or category 6 cable, although new building might luckily have fiber. However, there is the same issue if this wiring is owned by somebody other than the MDU owner.
>
> Existing Conduit. An existing ISP may have installed conduit or ducts within a building and won't allow access to other ISPs. This could be conduit between floors of a building (referred to as riser infrastructure), conduits between different buildings in a campus environment, or conduit distributing cables along hallways and other pathways.
>
> Other Existing Infrastructure. An existing ISP might own other key telecommunications infrastructure. This might include communications cabinets or boxes that tie into existing wiring. It might mean they own the racks that take up all of the existing space in a telecommunications closet. Alternatively, it could mean towers or other rooftop infrastructure.
>
> Entrance Facilities. Larger buildings will often have an existing entrance facility of some sort used to provide access to all utilities from the street into the building. This could be owned by the property owner or owned by one or more of the existing utilities, including non-telco utilities such as the electric or water utility. It's sometimes an issue to gain access to these entrance facilities. For example, an electric utility might be leery of allowing more than one ISP into their existing facility due to perceived safety or risk issues.

Pathways to Reach Units. One of the biggest issued faced in multi-tenant buildings is how to provide the broadband connection between the building entrance and individual tenants. There are numerous issues associated with this access.

> Unusable Existing Wiring. Even when there is usable wiring in a building it might not be usable for a new ISP. For example, there are many different ways that a building can be wired—there can

be "home-run" wiring that has a separate path from a central hub to each tenant, or at the other extreme wires can be strung in series through multiple apartment units. Some existing wiring schemes create technical roadblocks for using the existing wiring for G.Fast.

Riser and Other Conduit. Often the pathways to tenants are blocked due to lack of usable infrastructure. For example, there might be existing riser conduit between floors that is already full, with no room for additional cables. Moreover, there might not be room to add another riser conduit.

Owner Requirements. Property owners often have other restrictions that make it difficult to enter and wire buildings.

Buried Utilities. Property owners might not allow any outdoor wires above ground. This would mean that drops and connections between buildings must be buried. In many cases, that would mean boring connections under driveways and parking lots—which is not always a safe process since the locations of other utilities are not always well known or marked on private property. The expected industry requirements for utilities using public rights-of-way may not be followed on private property. For example, buried conduit and fiber in public rights-of-way generally require some use of a technology that allows the infrastructure to be detected by anybody trying to locate existing technology. However, infrastructure without such marking technology would be invisible to a locator.

Aesthetic Issues. Probably one of the biggest roadblocks encountered when wiring MDUs is the aesthetic requirements of the property owner. For example, one of the more common techniques for adding new fiber in hallways is to place the wiring in the corners of the ceiling and cover it with some kind of protective strip. Sometimes the only path to reach units might be to string wires in some manner on the outside of the building. If a property owner won't allow the use of these techniques for aesthetic purposes then it either means the building can't be wired with fiber, or it can be wired only at a much higher cost than expected.

Boxes on the Outside of Buildings. Property owners might not allow boxes, cabinets, or other equipment terminals to be attached to the outside of buildings or even to rooftops.

Access Issues. Another impediment encountered by ISPs is one of access, or the ability to undertake the steps needed to best serve tenants. This includes:

Type of Building Construction. There have been numerous construction techniques used over the years in building MDUs, and some of the methods used in older buildings can add significant costs to serving the buildings. For example, older buildings might have old wood and plaster walls between units and for ceilings that can add cost or make it impossible to drill holes for new wires. Some old buildings have solid concrete slabs between floors through which the property owner might not allow drilling of new holes.

Access to Communications Space. ISPs generally need a space within a multi-tenant building to place hub electronics needed to serve the building. Such equipment is most commonly placed in a space reserved for telecommunications equipment that might be in a small room or closet. Problems can arise when existing communications space is full and there isn't room for a new ISP.

Access to Power. ISPs need access to power. This can present a problem if it's hard to provide separate electric meters or to otherwise supply the specific power needs of the ISP.

24/7 Building Access. Property owners often make it a challenge for an ISP to gain access to their equipment.

Access to Apartment Units. Property owners sometimes create roadblocks making it hard to ISPs to install or repair facilities inside of apartments. Some property owners only allow access when accompanied by an MDU employee. That's something the MDU might charge for. More commonly there can be costly delays when there is nobody available to accompany a technician.

Restrictions on Sales and Marketing. It's fairly routine that ISPs are not allowed to sell or market inside MDUs in the same manner that is done for single-family homes. For example, there might be no solicitation rules in MDUs that don't allow for door-knocking sales campaigns.

Security Issues. ISPs want their equipment to be kept safe from the public and from other ISPs. This means providing secure space. Ideally that means being able to put a cage or lockable box around gear in space used by multiple service providers. Sometimes this is not possible to do because of space or other limitations.

Administrative Issues. ISPs have identified administrative issues that present challenges such as:

Business Requirements. Property owners often have specific legal or other issues they expect ISPs to follow:

- Surety. Property owners may require ISPs to be bonded or to have a set level of insurance. This kind of bonding or insurance is not something that many ISPs are able or willing to obtain, making it a challenge to satisfy such requirements.
- Contracts Required. Property owners may require ISPs to agree to a standard contract before entering a building. This can be a problem because there are often some legal terms in standard commercial contracts that municipalities are unable to legally agree to.
- Dispute Resolution. Property owners might want an ISP to agree to arbitration or some other way to solve disputes that might be a problem for a municipality.

Conclusions. It's important to understand these various roadblocks because almost any item on this list could add to the complexity and cost of bringing fiber to a building. For example, there might be a willing MDU owner that wants fiber, but then once they realize that adding the fiber will violate their aesthetic requirements, it may turn out that it's too costly to get fiber to the building. CCG has clients who have heard things like, "We'd love to have fiber in our building, but I don't want any of my tenants to see the wires or electronics used to get it to their unit."

However, sometimes it's even smaller issues that might make it impossible to serve a given MDU. For example, it can be impossible to serve a building if the overbuilder doesn't have a secure location to place core electronics or doesn't have access to building entrance facilities.

Most ISPs that serve MDUs have a detailed checklist listing the specifics of the above issues. An ISP will generally walk through the MDU and determine the best wiring plan and then go over the checklist with the MDU owner. It's not uncommon to find one or more issues that are a roadblock to implementation. Sometimes roadblocks can be overcome by the ISP spending more money to solve the issue. It's also the case that sometimes the roadblocks cannot be overcome.

It is all of these reasons that make it impossible to discuss the "typical" cost to rewire an MDU. Until the full checklist and design are done, an ISP won't understand the issues present at a given MDU. In the analysis as part of this report we used "typical" costs for wiring MDUs. However, these costs only represent the costs of getting to buildings where the access is reasonable. Our analysis assumes that there are some buildings where the cities will not gain access. That could be for the reasons discussed above—there might be an arrangement with another ISP that keeps out the overbuilder, there might be a physical impediment that makes it too costly to rewire, or a property owner might have aesthetic, financial, contractual, or other requirements that can't be made to work for a municipal network provider.

EXHIBIT I: RESULTS OF THE RESIDENTIAL SURVEY

Total Surveys - 380

1. Residency:

	Number	Percent
I live in Farmington, MI	61	16%
I live in Farmington Hills, MI	319	84%

2. Who provides internet service to your home now?

	Number	Percent
Charter/Spectrum	190	50%
AT&T	127	33%
WOW	6	2%
Only use my Cell phone data	21	5.5%
Don't have Internet	36	9.5%

3. Who is your current Cable TV provider?

	Number	Percent
Charter/Spectrum	196	52%
AT&T U-verse	108	28%
WOW	6	2%
Satellite Dish	15	4%
Over the Air (OTA) antenna	22	6%
Only Watch On-line, such as Netflix	20	5%
Don’t watch TV	13	3%

4. Who is your current landline provider?

	Number	Percent
Charter/Spectrum	185	48%
AT&T	116	30%
Voice over IP	7	2%
WOW	4	1%
Do not have a landline	68	18%

5. What do you currently pay for the following?

Standalone Cable TV

	Number	Percent
$25 - $35	16	47%
$36 - $45	2	6%
$46 - $60	5	15%
$61 - $75	3	9%
$76 - $90	6	17%
$91 - $110	2	6%

Standalone Telephone:

	Number	Percent
$0 - $20	6	13%
$21 - $35	28	61%
$36 - $45	9	20%
$46 - $60	2	4%
$61 - $75	0	0%
$76 - $90	1	2%

Standalone Internet

	Number	Percent
$30 - $45	8	31%
$46 - $60	11	42%
$61 - $75	3	11%
$76 - $90	2	8%
$91 - $110	2	8%

Bundle

	Number	Percent
$50 - $74	8	3%
$75- $99	7	2%
$100 - $124	52	17%
$125 - $149	43	14%
$150 - $200	161	54%
$201 - $250	20	7%
$251 -$300	4	1%
$300+	3	2%

6. Do you know the download internet speed you should be receiving?

	Number	Percent
Don't Know	260	76%
0 - 50 Mbps	11	3%
51 - 100 Mbps	32	9%
101 - 200 Mbps	32	9%
201 - 300 Mbps	1	0%
301 – 400 Mbps	3	1%
Highest speed offered	5	2%

6b. Do you know the upload internet speed you should be receiving?

	Number	Percent
Don't Know	307	89%
0 - 20 Mbps	32	9%
41 - 60 Mbps	4	1%
Highest speed offered	1	1%

7a. Do you know the download internet speed you are receiving?

	Number	Percent
Don't Know	291	84%
0 - 50 Mbps	2	1%
51 - 100 Mbps	22	6%
101 - 200 Mbps	22	6%
201 - 300 Mbps	2	1%
301 - 400 Mbps	2	1%
Highest speed offered	3	1%

7b. Do you know the upload internet speed you are receiving?

Upload	Number	Percent
Don't Know	317	92%
0 - 20 Mbps	23	7%
40 - 60 Mbps	1	0%
Highest speed offered	3	1%

8. Are you satisfied with the internet speed you currently have in your home?

	Number	**Percent**
Yes	198	58%
No	146	42%

If not, why not?

Slow, unreliable, inconsistent, poor customer service, buffers, slow streaming, can't play games with the internet, can't use multiple devices, too expensive for the internet provided, freezes up

9. Does anybody in your household use the Internet connection to work from home?

	Number	**Percent**
Full Time	26	7%
Several Days per week	43	11%
Occasionally	79	21%
No	232	61%

10. Do you have students in the home that use internet for school?

	Number	**Percent**
Yes	123	32%
No	257	68%

11. What factors might influence your decision to become a customer of a new fiber network?

	Number	**Percent**
Faster speeds for the same price	184	48%
Lower price than I pay today	295	78%
Same price / better customer service	92	24%
More reliable service	111	29%
No data cap	22	6%

12. Do you have a preference as to how a new fiber optic network is owned and operated? Which of the following do you prefer?

	Number	**Percent**
The cities own / operate the network	174	46%
The cities partner with a private entity to fund and operate the network	23	6%
The cities own the network and invite multiple service providers to compete on the network	104	27%
A private entity owns and operates the network	22	6%
Don't Know	23	6%
Doesn't matter as long as prices are lower	6	2%
Not interested	27	7%
Not interested - it will raise taxes	1	0%

EXHIBIT II: SUMMARY OF FINANCIAL RESULTS

		Assets	Take Rate	Debt	Equity	Total Financing	Cash End of Year 10	Cash End of Year 20
	Both Cities							
	City as the ISP							
1	**GO Bond**	$107.6 M	50%	$121.4 M		$121.4 M	$ 5.78 M	$22.38 M
2	**Higher Interest Rate**	$107.6 M	50%	$123.6 M		$123.6 M	$ 1.98 M	$12.86 M
3	**Lower Interest Rate**	$107.6 M	50%	$119.3 M		$119.3 M	$ 8.69 M	$30.08 M
4	**30-Year Term**	$107.6 M	50%	$121.4 M		$121.4 M	$12.99 M	$39.71 M
5	**55% Penetration**	$109.2 M	55%	$122.9 M		$122.9 M	$11.49 M	$38.48 M
6	**45% Penetration**	$105.9 M	45%	$120.2 M		$120.2 M	-$ 0.21 M	$ 6.13 M
7	**Breakeven Penetration**	$106.2 M	46%	$120.2 M		$120.2 M	$ 0.45 M	$ 8.96 M
8	**Higher Prices**	$107.6 M	50%	$121.4 M		$121.4 M	$11.65 M	$37.76 M
9	**Lower Prices**	$107.6 M	50%	$121.4 M		$121.4 M	-$ 0.78 M	$ 6.42 M
10	**5% Higher Fiber Cost**	$110.7 M	50%	$125.1 M		$125.1 M	$ 3.91 M	$18.08 M
11	**5% Lower Fiber Cost**	$104.4 M	50%	$117.7 M		$117.7 M	$ 6.95 M	$26.08 M
12	**Revenue Bond**	$107.6 M	50%	$133.9 M		$133.9 M	-$ 1.12 M	$12.57 M

EXHIBIT II: SUMMARY OF FINANCIAL RESULTS

		Assets	Take Rate	Debt	Equity	Total Financing	Cash End of Year 10	Cash End of Year 20	Notes
	Farmington **City as the ISP**								
13	**GO Bond**	$13.1 M	50%	$15.1 M		$15.1 M	-$ 3.13 M	-$ 5.44 M	
14	**Higher Interest Rate**	$13.1 M	50%	$15.4 M		$15.4 M	-$ 3.55 M	-$ 6.53 M	
15	**Lower Interest Rate**	$13.1 M	50%	$14.8 M		$14.8 M	-$ 2.76 M	-$ 4.42 M	
16	**30-Year Term**	$13.1 M	50%	$15.1 M		$15.1 M	-$ 2.23 M	-$ 3.39 M	
17	**55% Penetration**	$13.3 M	55%	$15.1 M		$15.1 M	-$ 2.55 M	-$ 3.23 M	
18	**45% Penetration**	$12.9 M	45%	$14.8 M		$14.8 M	-$ 4.08 M	-$ 7.82 M	
19	**Breakeven Penetration**	$14.2 M	50%	$15.8 M		$15.8 M	$ 1.29 M	$ 4.55 M	
20	**Higher Prices**	$13.1 M	50%	$15.1 M		$15.1 M	-$ 2.11 M	-$ 2.87 M	
21	**Lower Prices**	$13.1 M	50%	$15.1 M		$15.1 M	-$ 4.17 M	-$ 8.02 M	
22	**5% Higher Fiber Cost**	$13.4 M	50%	$15.5 M		$15.5 M	-$ 3.26 M	-$ 5.82 M	
23	**5% Lower Fiber Cost**	$12.8 M	50%	$14.7 M		$14.7 M	-$ 3.01 M	-$ 5.07 M	
24	**Revenue Bond**	$13.1 M	50%	$16.6 M		$16.6 M	-$ 3.95 M	-$ 6.49 M	

EXHIBIT II: SUMMARY OF FINANCIAL RESULTS

		Assets	Take Rate	Debt	Equity	Total Financing	Cash End of Year 10	Cash End of Year 20
	Farmington Hills City as the ISP							
25	**GO Bond**	$95.2 M	50%	$107.7 M		$107.7 M	$ 1.91 M	$18.19 M
26	**Higher Interest Rate**	$95.2 M	50%	$109.7 M		$109.7 M	-$ 1.10 M	$10.01 M
27	**Lower Interest Rate**	$95.2 M	50%	$105.9 M		$105.9 M	$ 4.84 M	$25.92 M
28	**30-Year Term**	$95.2 M	50%	$107.7 M		$107.7 M	$ 8.62 M	$33.84 M
29	**55% Penetration**	$96.7 M	55%	$109.0 M		$109.0 M	$ 7.59 M	$33.30 M
30	**45% Penetration**	$93.9 M	45%	$106.8 M		$106.8 M	-$ 2.35 M	$ 4.13 M
31	**Breakeven Penetration**	$94.7 M	50%	$107.4 M		$107.4 M	$ 0.34 M	$12.57 M
32	**Higher Prices**	$95.2 M	50%	$107.7 M		$107.7 M	$ 7.36 M	$32.38 M
33	**Lower Prices**	$95.2 M	50%	$107.7 M		$107.7 M	-$ 3.45 M	$ 4.15 M
34	**5% Higher Fiber Cost**	$98.1 M	50%	$111.1 M		$111.1 M	$ 0.57 M	$14.58 M
35	**5% Lower Fiber Cost**	$92.4 M	50%	$104.4 M		$104.4 M	$ 3.31 M	$21.80 M
36	**Revenue Bond**	$95.2 M	50%	$118.8 M		$118.8 M	-$ 3.82 M	$ 9.91 M

EXHIBIT II: SUMMARY OF FINANCIAL RESULTS

	Both Cities	Assets	Take Rate	Debt	Equity	Total Financing	Cash End of Year 10	Cash End of Year 20	
	Partner for Hire								
37	**Commercial Partner**	$107.6 M	50%	$121.4 M		$121.4 M	$ 2.50 M	$14.39 M	
38	**Non-Profit Partner**	$107.6 M	50%	$121.4 M		$121.4 M	$ 4.98 M	$20.89 M	
39	**Cooperative**	$107.6 M	50%	$116.0 M	$ 7.1 M	$123.1 M	$ 0.51 M	$ 6.53 M	Reduces Rates by $8
	Open Access								
40	**City Financials**	$102.8 M	45%	$118.7 M		$118.7 M	-$26.39 M	-$59.59 M	
41	**Collective ISP Financials**	$ 2.6 M	45%	$ 1.8 M	$ 0.3M	$ 2.1 M	$22.08 M	$56.78 M	
	Partner Leases Network								
42	**City Financials**	$105.8 M	50%	$119.7 M		$119.7 M	$ 1.00 M	$ 0.91 M	
43	**Partner Financials**	$ 0.6 M	50%	$ 2.3 M	$ 0.3M	$ 2.6 M	$ 2.89 M	$16.78 M	
	Customers Pay $3,500								
44	**Customers Pay $3,500**	$104.4 M	40%	$ 70.0 M	$49.5 M	$119.5 M	$ 0.43 M	$ 4.13 M	Reduces Rates by $26
	Partner + $3,500								
45	**Commercial Partner**	$104.4 M	40%	$ 70.0 M	$49.5 M	$119.5 M	$ 1.28 M	$ 4.64 M	Reduces Rates by $21
46	**Non-Profit Partner**	$104.4 M	40%	$ 70.0 M	$49.5 M	$119.5 M	$ 1.34 M	$ 4.94 M	Reduces Rates by $24
	Open Access + $3,500								
47	**City Financials**	$102.8 M	40%	$ 70.0 M	$49.5 M	$119.5 M	$ 2.89 M	$ 1.41 M	
48	**Collective ISP Financials**	$ 2.6 M	40%	$ 1.9 M	$ 0.3M	$ 2.2 M	$17.85 M	$46.17 M	Reduces Rates by $5