Davis California

Final DRAFT

Broadband Feasibility Study

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Finley Engineering
CCG Consulting

Table of Contents

List of Tables

Executive Summary

CCG Consulting (CCG) and Finley Engineering submit this report of our findings and recommendations from the feasibility study conducted to understand the potential for bringing a fiber broadband network to Davis. Our two firms looked at the feasibility from a number of different angles. Finley Engineering estimated the cost of building fiber everywhere in the city using two different fiber electronics technologies. CCG undertook research that told us more about the competitive landscape in the city that included a) research on existing competition and the incumbent broadband providers, b) discussions with key broadband stakeholders in the city, c) an analysis of actual customer broadband bills, and d) the results of speed tests taken by Davis citizens that measured their actual broadband speeds. Next, CCG created numerous financial projections that looked at different business plan scenarios for operating a broadband network in the city. Finally, the study answered various questions asked by the original RFP such as defining the benefits and risks of having a fiber network in the city.

The key finding from our analysis is that it doesn't look feasible to build and operate a fiber network and business in the city that would be 100% funded by a single bond issue. Instead, it looks like the only viable way to finance a fiber network would be to fund some portion of the new network with some other form of funding, such as tax revenues derived from sales taxes, property taxes, or some other source of municipal revenue.

There are a number of reasons for this finding. First, the cost of building a network in Davis is high for various reasons including: a) the condition of poles, which means that the network will have to all be buried; b) the high housing density in the city adds to the cost; and c) high wages in the area mean expensive fiber construction (which is primarily driven by labor costs). The high construction costs then create high debt costs if the project is 100% bond-funded. Operating costs also look to be high in the city, driven again by high labor rates. However, even with higher construction and operating costs, the rates that can be charged to customers are no higher than in other parts of the country, meaning that a fiber business in the city will achieve average revenues but will incur higher-than-average costs.

Nevertheless, there are significant benefits from fiber that make it worthwhile to explore if there are feasible ways to move forward. As DSL broadband on the AT&T telco network continues to decline in the market, Comcast will become more of a monopoly broadband provider in the city. There is ample national evidence that having a second fiber network provides customers with choice and holds down prices compared to communities without a competitive fiber network. The study found some intriguing options for a city network that might enable the city to find ways to address the digital divide and bring broadband to all households in the city. The study explored numerous business operating structures and, since the city doesn't want to be a retail ISP, the best option looks to be partnering with a single operating ISP to operate the business. The option of open access—allowing multiple ISPs to operate on the network—doesn't look to be financially viable.

This report makes a number of specific recommendations on next steps for the city to consider if it wants to further explore fiber broadband options.

Report Summary

Project Overview

Project Description. Finley Engineering and CCG Consulting were hired to do a feasibility study for bringing fiber broadband past every home and business in the community. The project included a number of components including 1) a market analysis of the current products and prices offered in the market, 2) an engineering analysis and estimate of the cost of building and lighting a fiber network, 3) a discussion of the possible operating models to be considered to operate a government-sponsored fiber business; 4) the development of various financial business models to quantify the operating costs and potential profitability of the various operating models, 5) a sensitivity analysis to quantify the impact of varying the most important assumptions and variables supporting the financial models, 6) a discussion on possible funding mechanisms that can be used to fund fiber, 7) an analysis of the likely competitive response of the incumbent providers, 8) the benefits to the community from operating a citywide fiber network, and the financial and execution risks that must be considered. The study culminated in this report which describes the steps taken to meet those goals, a description of the significant facts we found that will influence a decision to pursue fiber, and a list of specific recommended next steps to take next after completion of this report.

Fiber Network Design. Finley Engineering considered several designs before designing a reasonably efficient network for bringing fiber to the whole community. The network consists of a series of huts that house electronics that are connected to a fiber ring to provide redundancy and to protect the network from failure in the case of a fiber cut (see map on page 142). Finley considered both passive optical technology (PON) and active Ethernet technology (AON) – the two primary technologies used to serve fiber to a community. The base analysis is based upon active Ethernet. The network built from the neighborhood huts to reach customers is designed for flexibility and each customer has a separate fiber connection back to a hut. This means that today either of the core technologies can be used to serve any individual customer and this design makes the network ready for future fiber technologies as they are developed.

The full cost of the assets need to operate the network are as follows. This represent a scenario where there is one network operator (could be the city or somebody else), and the business has a 50% penetration of homes, businesses and MDUs (multiple dwelling units) in the market. These figures represent the assets in place by the end of the fourth year after launching the business – the date by which all of the customers will have been connected to the network:

	50% Penetration
Vehicles	$ 231,800
Tools	$ 80,000
Buildings	$ 2,181,440
Furniture	$ 25,500
Computers	$ 55,265
Voice Gateways	$ 245,940
Data Servers	$ 102,500

Cable TV	$ 1,053,926
FTTH Electronics	$ 11,946,563
ONTs	$ 6,650,091
Fiber Drops	$ 10,584,956
Fiber Network	$ 65,864,087
Fiber Contingency	$ 6,566,409
Elect. Contingency	$ 406,775
Inventory	$ 350,000
Capitalized Software	$ 395,670
Total	$106,742,422

Note that the required assets vary according to the number of customers connected the network as well as by the number of employees required for the various scenarios that were studied.

Business Models Considered. We considered several different operating models:

- Single Provider. This model looks at the cost of operating the business by a single entity. This could be the city or an operating partner chosen by the city.
- Open Access. This operating model would open the network to multiple service providers to use the network to provide products and services to customers.
- Public / Private Partnership. In this operating model the city would partner with a commercial entity which would provide some of the capital needed to build the network.

Our Approach to the Financial Analysis.

- A base model was created for each operating model. We arbitrarily chose a 50% market penetration (the percentage of customers using the network) at 50% for each base model. We don’t have any idea how many customers a new fiber business might win and chose the 50% penetration as typical of other municipal and similar commercial fiber overbuilders.
- All projections were built to reflect a 25-year period in order to match the expected time frame for financing with bonds.
- All projections include projected financing costs for borrowing the money needed to build and launch the network. The base studies anticipated financing with revenue bonds that are backed by the full faith and credit of the city.
- The engineering estimates are conservatively high. As an example, we added a 10% construction contingency to the cost of building a fiber network as well as a 5% contingency for the cost of electronics. But the underlying costs estimates of the network are based upon our best estimate that considers the local market conditions in Davis and of California.
- All studies also include an estimate of future asset costs that are needed to either connect future customers or 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.
- The models all offer the triple play of broadband, cable TV and telephone service. The assumption is that most people buy broadband and far fewer buy the other products. We also project that the customers buying telephone and cable TV will drop over time. The projections also predict a modest amount of margin from other unspecified future

products that might include such things as security, smart home, managed WiFi and others.

- Products were priced at a modest discount from the existing prices of products sold in the market today. The expectation is that the internet speeds offered on the network will be significantly faster than the speeds offered by competitors. The projections include no future price increases.
- The estimates of operating expenses represent our best estimate of the actual cost of operating the fiber business and are not conservative. Again, we based these costs on local Davis conditions including such things as typical salaries and benefit costs in the area.
- Most operating expenses are adjusted for inflation at 2.5% per year.

Key Financial Study Results

A summary of the financial results of the various scenarios studied is included in Appendix VI, on page 175. That appendix includes a table showing key facts such the cost of building the network under each scenario, the cost and method of financing the scenario and the amount of cash generated by the scenario over 25 years. After the table is a description of the key assumptions made for each scenario studied.

Base Study. The results of the financial projections for building fiber within the city were not as good as the city had hoped for. For example, the cash losses range from $34.1 million over 25 years at a 60% customer penetration to $81.4 million at a 40% customer penetration (page 64).

There are several primary reasons for these losses:

- The fiber network is more expensive to build in Davis due to the fact that the network is going to have to be almost entirely buried. The existing utility poles in the city mostly run through yards and it looks to be too expensive to string fiber on most poles.
- Any construction done by the city must be done at 'prevailing wages'. This means at the wages for similar work in the major cities in California. It would be possible to find contractors that pay a lower wage rate – but that is prohibited by law to help ensure that most construction work goes to California companies.
- Much of Davis has a residential density (how close homes are together) like larger cities. In many cases it will be cheaper to build fiber on both sides of residential streets than to bore under the streets to reach homes if there was fiber on only one side. This adds to the construction cost of the network.
- The salaries and benefits for the employees of the business are set at levels reasonable for Davis. But these costs are higher than might be experienced by a fiber network built in another state with lower salaries.

Funding with Tax Revenues. We show that it is possible for a fiber network to be profitable if some portion of the network is built using tax revenues. That might be some external funding source such as revenue from increasing sales tax. Our study doesn't make any assumption about the type of tax revenue used. We calculated the amount of tax revenue needed to reach cash breakeven - that is a scenario where the business always has enough cash to operate during the whole 25-year window of the bond financing. The amount of needed tax revenues varies with the customer penetration rates and range from $33 million at 60% penetration rate to $59.7 million at a 40% customer penetration rate. These results are shown on pages 65-66.

Reasonable Case Study. Many of the assumptions used in the base study were conservative. This is always done in feasibility studies to make certain that the projected costs of entering the business are high enough so that if the project was financed with bonds there would be sufficient cash.

We looked at a 'reasonable case' scenario that softened some of the most conservative assumptions. The most significant assumption change was that the construction contingency wouldn't be needed. Making that kind of change in bond financing would mean doing enough extra engineering before funding to more precisely estimate the cost of the network. The results of this analysis are shown on pages 66-68 of the report.

Compared to the base case described above with a 50% customer penetration, the reasonable case assumptions reduced the amount of external tax financing required from $37 million to $24 million.

Open Access. We also explored an open access scenario. This is a scenario where the city builds the network and then allows multiple ISPs onto the network. This network costs the same in an open access network and the big financial difference is that the city collects 'access fees' from the ISPs for using the network, while the retail revenues instead go to the ISPs. The other big change is that the city would have only a few employees under this scenario. Staff that supports customers would be hired by the various ISPs.

The losses in an open access scenario are significantly larger than the one-provider scenario shown above. Losses range from $102.3 million over 25 years at a 60% customer penetration to $128.5 million at a 40% customer penetration. This is because the lost revenues in this scenario are greater than the efficiencies from having the ISPs pay for the staffing. This scenario is summarized on pages 68-70 of the report.

Public / Private Partnership. A public / Private Partnership (PPP) is a scenario where the ISPs cover some of the cost of the network. There are nearly endless possibilities of how a PPP might be structured. The studies looked at the simplest scenario where the operating ISP funds the assets needed to support employees (trucks, computers, furniture, etc.) as well as the assets at the customer premise including the electronics (ONT) and anything inside customer premises like settop boxes.

This scenario has a significantly beneficial impact on the city's cash position. The loss at a 50% customer penetration reduces over 25 years from $53.9 million to $3.4 million. However, this scenario would be unattractive to an ISP partner which must fund $11.5 million of the project, with projected losses over 25 years at $23.2 million. This scenario is summarized on pages 71-72 of the report.

Again, there are many other potential PPP models. But any model that reduces the capital outlay of the ISP operator would shift costs and losses back to the city.

Digital Divide Scenarios. Finally, we considered digital divide scenarios. These scenarios look at the cost to build the network to everybody in the city. They also offer lower prices in order to get more homes and businesses onto the fiber network.

For example, we looked at a scenario where the city would offer a $10 broadband connection to homes that qualify. That qualification could be done any ways, such as allowing the low-cost connection for the elderly or for homes that qualify for some subsidy program such as food stamps or reduced-price school lunches.

This scenario increased losses over 25 years, but not drastically so. For example, the losses at a 50% customer penetration for unsubsidized broadband customers increased from $53.9 million in the one ISP partner scenario to $60.6 million. With a substantial amount of external tax financing this scenario could be cash positive. This scenario is summarized on pages 73-74.

Key Findings

Customers in Davis Have Broadband Options Today. We asked existing customers to take speed tests to see how their achieved broadband speeds compare to what they are purchasing. Speeds on AT&T's DSL network have a maximum speed of 50 Mbps. A significant percentage of AT&T customers are getting less speed than they are paying for. We did find one AT&T customer that was buying and receiving a gigabit broadband connection on fiber.

However, there are customers in the city buying speeds today as fast as 300 Mbps on Comcast. And, unlike with AT&T, customers using Comcast mostly receive the speeds they are subscribing to, and sometimes a little bit more. Comcast says they will be increasing download speeds in the city and that customers will have speeds up to 1 Gbps by the end of 2018. For both providers upload speeds are significantly slower than download speeds.

Recently AT&T has slowed promotions for DSL and many industry analysts think they are now starting the slow process of withdrawing from that business line. The company is instead putting effort into selectively building fiber and there are some AT&T fiber customers in the city today. Over time as the AT&T DSL product diminishes in the city many customers will only have the choice of using Comcast for fast broadband, making them a virtual monopoly.

There Are Some Broadband Gaps in the City. There were several businesses in downtown Davis that were not able to buy the broadband speeds they want, or that are being quoted high prices to build broadband to their location.

The university also identified locations where they would like faster broadband. For example, they buy space in apartments throughout the city for about 600 underclass students and have also located a number of administrative functions in the city. The University says that both of these groups do not share the same broadband experience as the rest of the campus.

Fiber Construction Costs Are High. The most expensive component of building a fiber network is the cost of the fiber that would be built on each street of the city to reach potential customers. The fiber network is estimated to cost more than $72 million. The overall costs of building fiber are higher than what we see in some other cities, for the following reasons:

- Because of the nature and location of existing poles it looks like the best design is to bury the entire network. Buried fiber is the most expensive kind of construction; burying the entire network drives up the cost of the network.
- The housing density in Davis adds to the cost of the network. Fiber construction is most efficient in suburban and small towns where there is 'moderate' housing density. In Davis some parts of the city are as dense as what we see in larger cities and this adds to the construction cost. For example, there are streets in Davis where it will be necessary to build fiber on both sides of the street to most affordably reach homes.

In general, wages in California are higher than in much of the rest of the country. Since the cost of fiber construction is primary from labor costs this adds to the costs of building fiber.

The Best Network Design Should Be Flexible. The city asked us to provide a network design that would have capacity to provide 1 Gbps broadband speeds to all customers. The base electronics design uses active Ethernet (AON) technology that delivers at least 1 Gbps to each customer location. But the outside fiber network was designed to accommodate both PON electronics and AON electronics for any customer (these technologies are described in detail later in the report). This would allow for delivery of shared or dedicated bandwidth to any customer, as needed.

There are Significant Benefits to Building a Citywide Fiber Network. These include: expanding customer choice; extending opportunity to connect to the University network where needed in the city; offering a chance to address the digital divide issue; provide affordable broadband options; enhance economic development opportunities; and support smart city initiatives. Examples of these initiatives include use of a citywide network of connected devices, smart sensors, and big data analytics to implement new solutions in safety, energy, climate preparedness, transportation, health, and education (see pages 104-108). A citywide network could also enable better outdoor WiFi, reduced city telecom expenditures, and prepare the city for better future cellular networks.[1]

But There Are Also Risks. The primary risk is in not performing financially with a city-owned fiber network and creating a situation where the city would have to subsidize the broadband network. There is also a risk that other broadband technologies become available during the long time period required to pay for the network. Finally, there are the risks involved in working with an operating partner and maintaining that relationship for the life of a potential 25+ year bond issue, or other long-term partnership

Partnering with One Service Provider is the Best Option. The financial analysis shows that operating a retail network by partnering with one service provider produces the best financial results. This could be a nonprofit such Davis Gig or a commercial ISP. It would also be possible to partner with a newly-formed cooperative, although a coop would need to find much of their own funding.

[1] https://obamawhitehouse.archives.gov/the-press-office/2015/09/14/fact-sheet-administration-announces-new-smart-cities-initiative-help

Financing the Network Will Require Tax Revenues. In the financial analysis we did not find a financial model that could be funded solely with bonds. The only feasible-looking scenarios use some other source of city tax revenues to fund some portion of the cost of the network. For example, if the network was expected to get a 50% customer penetration rate, then $36.5 million of the funding would have to come from some source other than the revenues of the business.

There are Intriguing Digital Divide Scenarios. There are scenarios where the city could extend fiber to low-income homes and neighborhoods. For example, a scenario that is funded with equal amounts of bond and other tax revenues would be able to provide a $10 broadband product to low-income homes in the city.

Probably even more intriguing is the idea of lowering the cost of broadband for everybody. For example, we looked at a scenario similar to what has been proposed in San Francisco. This scenario would provide $50 gigabit product, a $20 100 Mbps product, and a free low-speed broadband connection to anybody that wants it. This scenario requires significant tax funding and would be feasible with a $43 M bond supported by the broadband business and $89 M of other tax funding.

Open Access Looks Hard to Justify. It looks hard to justify an open-access network. This is a network that allows access to multiple ISPs and provides more options for customers. The operating losses for the scenario are much greater than if one ISP operates the network because it splits the potential revenue. This scenario could only be made to work with significant funding ($80 M) or more from tax revenues.

MDU Penetration Rates Are Challenging to Forecast. The report looks in depth at the issues associated with providing broadband to multi-dwelling units (MDUs). There are a number of challenges that must be overcome to make sure that all MDUs have fast fiber broadband. First, it's the property owner's choice to allow connection to a city-owned fiber network. Many MDU owners will elect to connect instead to Comcast, AT&T, or other providers that specialize in serving MDUs. The cost to wire and distribute fiber in MDUs also varies significantly in MDUs depending upon a number of factors which are described in more detail on pages 37-39.

Timing of Network Launch. It should be reasonable to build a citywide fiber network within three years from the date of funding, with the first customers on the network after 18 months.

Recommended Next Steps

Residential Survey. Our analysis shows that the most important variable affecting the financial feasibility of building fiber is the potential number of customers. For example, getting 40% rather than 50% of residents on the network makes a big difference in expected future revenues.

We recommend that the city undertake a residential survey to understand interest in a fiber network. CCG Consulting has found that a well-designed random residential survey is a good predictor of the number of residential customers that might be interested in using city-provided fiber. We've been able to see a significant correlation when comparing the results of initial surveys to the actual customer penetration rates.

Since the study results show that some amount of tax financing is likely going to be needed to fund a fiber network such that it will be cash flow positive, it’s vital to predict the percentage of households that might be interested in fiber. Knowing the range of possible customer penetration rates will allow the city to then better quantify the amount of tax revenues that are needed to fund each scenario.

MDU Analysis. The report looks in detail at the issues associated with providing service to MDUs. Since MDUs represent a big percentage of the living units in the city, understanding the potential for serving MDUs is needed to fully assess potential revenues of a fiber business. The city might want to undertake a deeper analysis of the MDU market. The more you know about that market the more you will be able to understand how a Davis-owned fiber network might benefit this market.

Ideally the city might want to know the following things about the larger MDUs in the city:

- <u>Census of MDUs</u>. Identify the owners, local managers, and decision makers at each MDU that might be involved in making the decision to connect to a city fiber network.
- <u>Cost to Wire with Fiber</u>. The report describes the many factors that are involved with distributing fast bandwidth within an apartment building or complex. The city might want to ask MDU owners of differently sized MDUs to allow the city (with the help of engineers) to make an on-site estimate of the cost to upgrade their MDU to fiber. This report looks at some theoretical costs to wire MDUs of various sizes and technologies, but we also discuss the various factors that can affect the specific costs of upgrades. If the city were able to examine MDUs of various sizes you would be able to better estimate the cost of providing fiber broadband to the MDUs.
- <u>Survey of MDU Owner Interest / Penetration Rates</u>. It would be useful to understand the broadband intentions of MDU owners. Ideally the city would like to know how many MDUs already are connected to fiber and the intentions or goals of those that are not connected. It might be difficult to collect this information since many MDU owners would not want their intentions to be discoverable through a public information request. But we know other cities that have gathered this information through an anonymous questionnaire that doesn’t identify responses with specific MDU owners. But since MDUs represent such a significant percentage of the housing units in the city, an effort should be made to better estimate penetration rates.

Understanding the Funding Options. The analysis shows that financing costs are a major cost component for any of the fiber business models. It is essential for the city to understand its financing options in more detail. This might include steps like:

<u>Assessing the Use of Revenue Bonds</u>. Probably the predominant portion of funding would come from revenue bonds that are backed by city tax revenues. The city should talk to bond advisors to understand the possibility of using this kind of bonding as well to understand any nuances

<u>Investigate the Possibility of Using Tax Revenues</u>. The financial analysis shows that it will be necessary to finance at least some of the cost of building a network using tax

revenues. Tax revenues could come from a variety of city cash flows such as sales taxes, property taxes, or some sort of utility fee. If the city wants to proceed after this study then it's going to be necessary to understand the possibility of using tax revenues. There are a number of steps needed to understand the potential for this kind of funding. This might include:

- An analysis of the various types of such funding that might be available;
- A legal and financial analysis of any issues with using such financing to pay for a fiber network;
- Public outreach to understand the public's willingness to use these kinds of financing for fiber. This probably would entail a large public education campaign and probably eventually result in a ballot measure – so it's a major undertaking.
- Consideration of other City infrastructure needs.

<u>Investigate Other Revenue Sources</u>. The vast majority of a fiber network will have to be financed by the above two kinds of financing. But there are often opportunities to get some funding from other sources. For example, we've seen cities get transportation grants for smart traffic signals that can be used partially for fiber. We've seen public safety grants that were able to fund some fiber. We've seen homeland security grants that were able to fund some fiber. It's hard to know what might be available in Davis since these kinds of grants vary from year to year – but there might be grant opportunities if you are willing to explore all of the grants available. Such funding would not likely cover more than a few percent of the cost of the network, but even that would lower financing costs significantly.

Choose a Business Model. The business plan that looks to be the most promising from a financial perspective is for the city to build the network and to partner with a nonprofit or commercial entity to operate the triple-play business. There are two options for that operating model. One is to build only to customers that buy a product on the network. A second option to build to everybody also looks intriguing. A larger build would allow the city to tackle the digital divide and other social goals for the network.

But there are other possible operating models and the city should first narrow down the options. There are four basic business models to consider:

- The city becomes the ISP and hires staff and operates the business.
- The city hires an operating partner that operates the business on behalf of the city. This partner would be a vendor and all of the revenues of the city would belong to the city.
- The city builds the network and charge one or more ISPs to use the network (open access). There is one nuance of this model which would be to start with one partner to jump-start the business with the ultimate goal of having multiple ISPs in an open access environment. For example, this is how Huntsville. AL (Google Fiber) and Westminster, MD (Ting Broadband) have launched.
- Finally the city can partner with an ISP that is willing to make a significant investment into the network, a model that's referred to generically as a public private partnership.

One of the early next steps needs to be to have the policy discussions to pin down the potential operating model, hopefully to just one of the above options, but to no more than two. Each business model is unique and it would be difficult to explore all of them at the same time.

Identify Potential Partners.

If the city chooses an option other than the city acting as the ISP, then a natural next step is to talk to potential partners.

Some cities have engaged in this process by issuing an RFI or other similar document that asks potential partners to describe their interest. We don't like this approach because we know that many ISPs will not put their intentions into writing and thus many potential partners might not respond to an RFI. The alternative process is to open direct discussions with potential partners that you know. Another alternative is to mix the two processes—issue a short RFI that asks for potential partners to identify themselves but then leave the more detailed discussion to be done on a one-on-one basis with each respondent.

The steps needed to reach an agreement with a partner are fairly well defined in the industry. It would include such steps as:

- Identify the Specific Roles of Both Parties. There are a number of ways that a city can work with an operating partner. For example, it is possible for the city to operate the network and a partner to provide services to customers. However, a partner could also do everything including operating the fiber network. We've found that the best way to define roles is to create a detailed checklist of functions and responsibilities so that the two sides clearly understand their specific roles.
- Define the Financial Relationship. There are also multiple possible financial arrangements. We would expect, for instance, that the financial arrangements would be different for a nonprofit partner like Davis Gig versus a commercial partner. Financial arrangements can vary widely and might include management fees, profit sharing, or leasing the network to a partner.
- Define Operating Metrics. It is essential to establish the expectation for operating the business and this is usually defined through the use of metrics. There might be metrics to cover a range of operating parameters such as network performance, customer installation times, sales goals, customer service response times, etc.
- Negotiate an Operating Agreement. Once the roles, the financial relationship, and the operating metrics have been negotiated, the end result is generally some kind of operating agreement that encapsulates the relationship.

Community Education/Buy-in. If the city decides to continue with investigating the fiber business then a step that most cities take is to undertake a community education process to get feedback and gain buy-in of the concept.

Cities go about this in different ways. Making this report public is a good first step. Communities often hold workshops or other kinds of public presentations to answer the public's questions. It's common to build a web site that discusses the fiber initiative and which can be used to answer the typical questions citizens have about fiber.

Consider Implementation of Fiber Network in Phases. One of the ideas mentioned in the report is to look at undertaking the network in phases. For example, the city might want to consider first building fiber for the purpose of providing additional connections between city facilities. That idea could be expanded further to build to better connect the city and the University. Another phase could be building fiber to a few key business districts such as University Research Park, Second Street research and development/light industrial area, Downtown and perhaps to some large MDU complexes.

It’s worth noting that many of the existing municipal fiber networks were built in phases. For example, both the Chattanooga, TN and the Lafayette, LA network began with a fiber network to serve city locations, then expanded to serve key business districts and finally expanded to serve everybody. Also, while there are less than 150 cities that have built fiber to everybody, there are many hundreds of cities that have built networks to serve city facilities or to reach business districts – this is a common municipal fiber model. As part of looking at a phased approach the city might want to talk to cities of similar size that have undertaken the phased approach.

This study was intended to quantify the opportunity for building fiber everywhere. A separate study would be required to quantify the option to build something less than that. For example, if the goal was to look at a network that served larger business and MDUs on a wholesale basis, an analysis and design would need to be determined of the layout of the fiber network to accomplish that goal. This requires a bit deeper engineering analysis than was done in this high-level feasibility study. Such a study should also be done in conjunction with the next step identified above of better understanding the MDU market.

In-Depth Review of City Practices (that affect fiber). Like every city, there are practices and processes in the city that impact the initial cost of building a fiber network. This would include such things as permitting, franchise requirements, traffic control, construction inspection, etc. Cities often review all of these practices before tackling a fiber network to see if any practices can be streamlined.

Any changes in these practices would also impact existing telecom providers as well as a potential city fiber network, and so the city would want to invite the existing ISPs and incumbents into the discussion.

There are a number of ways to go about this. One approach is to hold workshops with affected stakeholders to get input. Another approach would be to instead get an external review by engineers or others who can compare the city’s current practices with what’s found in other cities. A third approach would be to find out what cities that have built fiber networks have done (or wish they had done after they went through the process of constructing the fiber network).

Keep an Eye on Broadband Prices. There is speculation in the industry and Wall Street that Comcast and the other big cable companies are going to significantly increase broadband prices over the next few years. The sensitivity analysis shows that prices are among the most important and sensitive variables in the business plan, and the projected financial performance would improve with higher prices. However, this also has to be tempered with a policy question of whether a city-owned network would charge a lot more than today just because Comcast does.

Our base analysis does not suppose any broadband price increases. But we looked at several scenarios that increase prices over time and found that higher prices can significantly improve the cash flow of any of the operating models. But we caution strongly against building a business plan that requires significant price increases to succeed. While there is a general expectation that Comcast and other large ISPs are going to raise broadband prices over time, this does not mean that they would raise prices in a market where they are competing against a competitive fiber network. For example, we've seen big ISPs drop rates in markets where Google Fiber or other municipal fiber networks have been built and it's not a far-fetched scenario to think that the ISPs will suffer with lower rates in the handful of competitive markets and make up for it with higher prices everywhere else.

I. Background Research

Following is a discussion of some of the general research undertaken in preparing this report.

A. Speed Test Results

As part of the analysis we asked broadband users in the city to take a speed test. We elected to use a speed test provided by Ookla at speedtest.net, which we believe is the most commonly used speed test in the world. However, there are numerous other tests available such as dslreports.com, speed.io, the BandWidthPlace, and TestMySpeed. Many ISPs also make a speed test available to their customers.

A speed test is one of many ways to measure a broadband connection. Speeds tests in general measure the speed between a user and a remote test site router. Speed tests are generally routed regionally and we would expected that almost everybody participating in the Davis speed test would have measured their speeds to the same regional hub.

Every speed test uses a different algorithm to measure speed. For example, the algorithm used by Ookla discards the fastest 10% and the slowest 30% of the results obtained. By discarding the slowest readings they might be masking exactly what drove someone to take the speed test, such as not being able to hold a connection for 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. This could mask a congestion problem a user might be having with the local network.

Another issue to remember with any speed test is that it measures the connection between a customer's device and the speed test site. This means that the customer portion of the network, like the home WiFi network, are included in the results. A lot of ISPs claim that poor in-home WiFi accounts for the majority of the speed issue problems reported by customers. So a slow speed test doesn't always mean that the ISP has a slow connection.

We know that ISPs often give customers a burst of faster data for the first minute of two of a broadband connection. Since many web transactions are short in nature, this practice makes the customer experience feel faster. However, the practice also makes speed tests look faster than the sustained speeds a customer can achieve.

With all of this said, a speed test is a good way to compare the performance of customers using different ISPs. They are all trying to make a connection to the same distant place and seeing the variation in download speeds, upload speeds, and latency can tell us interesting things about the broadband in a given market.

In the Davis speed test we got results from a number of ISPs, with the three biggest being AT&T, Comcast, and Omsoft.

It's important to note that the results from our test are not a random sample, and as such it makes no sense to tabulate the results or try to somehow quantify the results. For various reasons we can't make any definitive statements like "the average speed on Comcast is X." Instead, the speed tests are most useful in comparing customers in order to spot some interesting trends. The speed tests asked for three statistics from users: download speeds, upload speeds, and latency.

Download Speeds

We asked customers what speed they thought they were purchasing—and we found that there is a lot of customer confusion about the speeds they are buying. This is not unusual and we see it everywhere. For example, a customer might quote a speed that they purchased years ago, but for which the ISP has made faster over time. For example, there were customers who thought they were buying 25 Mbps download from Comcast but were getting speeds between 50 Mbps and 90 Mbps. The customer may have had a 25 Mbps connection at some time in the past but has been upgraded, either by asking for faster speeds or perhaps as a unilateral upgrade by Comcast. It's been our experience in working across the country that Comcast does not maintain a wide array of legacy broadband products and they periodically upgrade customers to faster speeds, sometimes without telling them. Customers reported buying Comcast products of 10, 25, 50, 55, 75, 100, 150, 200, and 300 Mbps download, and there are not that many Comcast products available.

By contrast, there was a big array of product being reported by AT&T customers and it's possible that many of these products are still active in the market. AT&T customers reported they were buying products on DSL that range between 1.5 Mbps up to 50 Mbps. AT&T customers claimed to have be buying products with speeds of 1.5, 3, 5, 6, 12, 15, 18, 24, 25, 45, and 50 Mbps. It's possible that a few of these speeds might represent a faulty memory of the person taking the test, but it's also possible that customers bought these speeds and have remained on the original product they were sold years ago.

We found many examples of a Comcast broadband product that overdelivered. For example, roughly half of the customers buying a Comcast 100 Mbps product are getting speeds faster than that. By contrast there are very few AT&T broadband connections that outperformed what people said they were buying.

It's worth noting that there are a lot of people who took the speed test that are paying for and receiving relatively slow download speeds. For example, many customers are buying and receiving speeds like 1.5 Mbps and 6 Mbps. By comparing the prices these customers pay with others in the speed test it looks like they could get a speed upgrade simply by calling their ISP and asking for it, since these slow users are often paying about the same prices as faster customers. We know from experience that a customer might have an old legacy modem that is not capable of faster speeds and that they won't get a new modem unless they ask the ISP for one. The point to emphasize here is that there are households that are happy with slow speeds and not everybody feels like they need faster broadband.

There was one user that reported having a 1 Gbps connection from AT&T on which they were getting 942 Mbps download and 944 Mbps upload.

Upload Speeds

Reported upload speeds as measured by the speed tests were universally relatively slow. This is done on purpose by ISPs. There is a fixed amount of potential broadband that can be allocated in a broadband connection and ISPs using DSL or cable modems allocate most of that capability to download speeds, since that is what customers generally care most about.

However, there are many customers that now also care about upload speeds. There are some applications that need a reliable upload link including gaming, security cameras, and online video chatting. There are numerous companies working on applications that will require significantly faster upload speeds. For example, there is a lot of research being done to create telepresence, which is the ability to create a hologram of somebody in a remote location in order to facilitate business meetings or visits with family members. This technology will use some version of enhanced reality technology and will require a larger upload link than is available to a lot of households today.

The AT&T upload speeds were consistent with the download speed being purchased. Customers buying slow download speeds, such as 1.5 Mbps or 6 Mbps also had the slowest upload speeds of roughly 1.4 Mbps. Faster download products come with faster upload speeds. For example, customers buying 24 Mbps got upload speeds a little less than 5 Mbps; those buying 50 Mbps download got upload speeds in the range of 10 Mbps.

Comcast upload speeds look to be consistently grouped around two different speeds. Those buying products slower than 100 Mbps roughly get upload speeds around 6 Mbps while those buying faster products have upload speeds in the range of 12 Mbps.

Latency

The speed tests also measure latency, which is the measure of the time it takes for a data packet to travel from its point of origin to the point of destination. Latency is measured using milliseconds (MS) which is one thousandth of a second.

Speed tests measure latency because it tells a user about the quality of their connection. The lower the latency the better the connection. There are many real-time web applications that need relatively low latency in order to maintain the connection between a user and the online service. This includes applications like VoIP, gaming, live connections for online training, connections to corporate WANs when working at home, etc.

There are a lot of underlying causes for delays that increase latency—the following are primary kinds of delays. Total latency is the combination of all of these delays.

- <u>Transmission Delay</u>. 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 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 a signal travels. 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 try 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.

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. This is slightly different than what is measured in a speed test, which measures the latency the whole way to the speed test router.

It is these latency differences that cause people to prefer fiber. The experience on a 30 Mbps download fiber connection "feels" faster than the same speed on a DSL or cable network connection due to the reduced latency. It is the technology latency that makes wireless connections seem slow. Cellular latencies vary widely depending upon the exact generation of equipment at any given cell site. However, even 4G latency can be as high as 100 ms. In the same FCC test that produced the latencies shown above, satellite was almost off the chart with latencies measured as high as 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. The one thing that is clear is that the lower the latency the better the connection.

The speed tests showed the following about latency in Davis:

- The latency on the majority of AT&T connections varied between 25 ms and 40 ms, which is faster than the results seen in the FCC latency tests a few years ago.
- Most Comcast customers had a latency of between 11 and 15 ms. However, about a fourth of the tests showed latency as high as 40 ms. These results are consistent with the FCC test results. When we see latency that varies this much it's generally due to two reasons. First is the time of day and a network will have higher latency when under peak demand. But there are also physical and electronic difference in various parts of the network. For example, not all of Comcast's network is the same in terms of capacity, electronics, condition of the coaxial cable, etc.
- The 1 gigabit fiber customer had a latency of 6 ms.

Overall, these latency results are acceptable. Most web applications can maintain a real-time connection as long as the latency is less than 90–100 ms.

Summary

There are a few big-picture takeaways that can be derived from the speed tests:

- Comcast consistently offers faster speeds than AT&T. However, there are some Comcast customers with slow connections, which is probably due to still having an older generation cable modem in their home.
- For slower speed products Comcast generally underperformed a little and delivered less speed than what customers are paying for. For the faster products Comcast appears to over perform and to provide more speed than people are buying.
- Most AT&T products underperform, but there a few exceptions. This is not uncommon and the company probably has a wide range of different vintages of DSL modems in the field, with older modems choking performance.
- Upload speeds are consistently slower than upload speeds and it looks like upload speeds are relatively consistent for customers buying similar products with the same ISP.
- There are customers buying speeds on Comcast as fast as 300 Mbps, which is priced at $200. However, there are numerous customers buying 100 Mbps and 150 Mbps products priced between $50 and $95 per month.
- AT&T's fastest speed is 50 Mbps. Since this is DSL the distance a customer is from the DSL hub affects the speed on the product. If Davis is like other communities, not every customer in town can buy the 50 Mbps product, based upon their distance from a DSL hub and the quality of their copper wiring.

CCG has conducted the same test in many other states and cities, so we can also put these results in context of the bigger picture.

- The results here for AT&T are as good as any we have seen elsewhere. That can be attributed to two things. It indicates that the copper wiring in Davis is probably in better condition than the network in some other cities. But it also speaks to the housing density in Davis where customers are likely within a reasonable distance from a DSL hub. In less dense cities a lot of customers experience degraded DSL just due to the distance from the hub.
- This is also as good of a result as we've seen from Comcast anywhere else. First, they are offering a range of products as fast as 300 Mbps—something that they don't do in many markets. They are also overdelivering broadband speeds, something they don't do everywhere, and that probably is a good indicator that the coaxial network in Davis is in relatively good condition, at least compared to other markets. We do note that Comcast generally outperforms most other big cable companies. For instance, we've seen markets served by other cable companies where almost every customer is getting significantly less speed than they pay for. There are also a lot of markets today where the fastest product available to customers on a cable network is still somewhere between 60 Mbps and 100 Mbps.

B. Customer Bill Analysis

As part of the analysis we asked for customer bills for any or all of the triple play services they buy today. We received just over 100 telecommunications bills from Davis customers. The bills were from three different service providers—Comcast, AT&T, and OmSoft.

We reviewed bills for several reasons. First, we wanted to understand the prices charged for broadband in the city today. However, we were also interested in the transparency of the service providers and we were looking to see if there were fees that were charged separately that are also part of the basic products being sold in the city.

Comcast Xfinity

Comcast is the incumbent cable TV provider in Davis. They market and bill services to customers using the "Xfinity" brand name. The company offers the traditional triple play of cable TV, internet, and voice services. The bills we received were a mix of standalone broadband bills as well as various types of bundles of multiple services.

As we expected from our analysis of Comcast bills in other markets, not all customers pay the same price for the same product. These differences can generally be attributed to

- Customers who have bought from Comcast during a sales promotion and who get a lower price for some period of time. The prices then revert to the 'list' price at the end of the promotion, meaning whatever prices are in place at Comcast at that time.
- Customers who are able to negotiate special rates. Comcast is willing to provide incentives for customers to not leave them, in what they call the win-back process. The amount of discount is negotiated with the customer and this means that there are a wide range of such discounted prices. Normally these negotiated prices also revert back to list prices after some period of time, although that is often not as rigidly defined as the promotional pricing.

Stand-Alone Internet. Even with promotional and negotiated prices we were able to identify the following 'list' prices for the basic standalone broadband products. Except for the 25 Mbps download product, the name of the product and the customer bills do not tell a customer the speed they are buying. We saw a lot of confusion from customers about the speeds they were supposed to be getting as part of the questions we asked those who took the speed tests as part of our analysis.

Tier or Upgrade	Price
Performance 25 Internet	$59.95
Performance Plus Internet	$64.95
Performance Internet	$74.95
Speed Increase Blast! Internet	+ $14.50
Speed Increase Performance Pro Internet	+ $15.00 or $30.00
Wireless Gateway	+ $10.00
Speed Increase Blast! Pro Internet with 12-month agreement	+ $30.00 - $10.00 credit = $20.00
Speed Increase Performance Pro Internet with undefined term	+ $15.00 - $5.00 credit = $10.00

The 'Blast' product adds a burst of Internet speed for a short time at the beginning of each web event. For example, if a customer who buys blast does a Google search, that search, if completed quickly, is done at the faster speed, after which the Comcast service reverts to the base speed. A better example might be a download of a large file. The first part of the download is done at a faster speed and after some predetermined time (generally a minute or two) the download speed falls back to the base product speed. Since most things that we do on the internet are of short internals, a blast product makes the broadband speed feel faster—and it is faster... but just for a minute or so.

It is this Blast product that accounts for the wide range of speeds we saw during the speed tests. At least for new customers, Comcast only offers a handful of different speeds, but any customer adding blast will appear to be even faster when taking a speed test, which typically takes less than a minute.

The Internet-only bills from Comcast are fairly straightforward. Most customers are charged for a Wireless Gateway (WiFi modem), although a customer can provide their own WiFi. There were no other fees or taxes. This is largely due to FCC rulings over the years that have prohibited taxes on broadband service.

Comcast has data caps. Their fastest products are capped at 1 terabyte of download per month (1,000 gigabytes). There are various lower caps that apply to slower speeds and to grandfathered legacy products. However, the bills do not mention these caps. The company does not apply these data caps consistently, both by region of the country and also even within a given market. We did not see any billing for customers that exceeded their data caps, so we don't know if they are being applied to any customers in Davis.

Comcast Bundles. It is an understatement to say that billing transparency is not Comcast's strong suit. It is not easy to understand the products being sold to customers buying a bundle. We didn't see any bundled bills that identified broadband speeds. In addition, it's often hard to understand if a bundle contains one, two, or more additional products (Comcast today bundles more than just the triple play).

We observed bundles with significantly different prices between customers for seemingly the same set of products. This is partially due to the promotions and negotiated prices that we saw with standalone broadband pricing. The Comcast nomenclature for bundles is also confusing because they change the names of their bundles over time, or for different promotions, and so there are similar bundles with different product names on bills.

The other variable that enters into package pricing are the various additive fees and charges that are layered on top of the base bundled prices. Here are a few of the more significant fees and charges we saw on bundled bills:

- DVR service (sometimes called X1 DVR) - $9.95
- Additional digital adapter - $3.99
- Additional digital converter $9.95
- HD Technology Fee - $10.00
- Broadcast TV Fee - $5.00 or $7.00

- Regional Sports Fee - $5.00

The digital adapter, the digital converter, and the DVR fees are for various set-top boxes. With the Comcast technology today every home needs at least one set-top box. This is sometimes included as part of the bundled price, and sometimes charged separately. The digital adapter is a smaller and simpler version of a set-top box that can be used to provide cable service to an additional TV. The digital converter fee is for a full-sized and full-featured settop box. The DVR service is generally added on top of the fee for the base settop box and is the charge for settop boxes that have the capability to record and save programming.

The other fees shown above represent Comcast 'unbundling' some of the costs of cable TV service. Most other large cable companies have taken this same strategy and they now show multiple components for the cost of cable television. For example, the 'Broadcast TV Fee' is just a part of basic cable service; every customer with a cable product is charged this fee. However, unbundling this 'fee' allows Comcast to advertise a lower price for its base products. These fees are particularly deceptive in that customers often believe that these fees are taxes rather than just part of the products they have purchased. As an example of how this works, a customer buying a $60 cable product will actually pay $70 when they are billed for the Broadcast TV Fee and the Regional Sports Fee.

There is another similar fee that is charged to telephone customers—the Subscriber Line Charge. Carriers often refer to this by other names, but it a fee that they keep and it is not a tax. Regulated telephone companies like AT&T have been required to bill this as a separate component of telephone service—it represents customers paying for their share of the cost of the long distance network. This requirement doesn't apply to any other service providers, yet most elect to show this as a separate charge, although it is part of basic telephone service. This is generally done to make their base telephone rate more easily compared to AT&T. However, a customer paying $20 for a basic phone and $6.50 for a Subscriber Line Charge is really paying $26.50 for the telephone line.

Finally, the Comcast bill is similar to other carriers in that it includes a number of taxes and fees that are not revenue for the company. These various taxes and fees are billed to customers and forwarded to various tax agencies. There are a few taxes that apply to cable TV, the largest being a fee to recover franchise taxes. There is a long list of taxes that apply to telephone service that include a fee to fund the 911 network, a fee to support hard-of-hearing customers, and a fee to fund the FCC's Universal Service Fund. Carriers are free to name these taxes differently and so it often is hard to compare taxes charged by different companies. For example, there might be a fee called 'Regulatory Recovery surcharge' that might be used to recover multiple taxes.

<u>The Power of the Comcast Bundle</u>. It is important for anybody that wants to compete against Comcast to understand the power of their bundles. The most obvious reason for giving bundles is to entice customers to buy more than one service from the company, and so Comcast provides increasing discounts for customers that buy multiple products.

However, the bundles also then punish customers for dropping a bundled service. Consider the following simplified example of how this works: Suppose that a customer purchased a $60 broadband product and a $60 cable product and is charged $100 for the bundle. If a customer goes to drop either of these two products the bundle would revert to the list price of $60. This means that the savings from dropping a product is only $40—not half of the cost of the bundle.

This is one of the primary reasons that a competitor to Comcast needs to offer cable TV. Otherwise, if a customer tries to change their broadband to the new provider but leave cable TV with Comcast they are charged a $10 - $20 ‘penalty’ for breaking the bundle. Once customers recognize this many of them won’t change to a competitor since they may not achieve any savings and might end up paying more than by staying with Comcast.

As Comcast continues to broaden the bundles to include things like cellular service, home security, smart home services, and solar power it become harder for customers to switch one or two products from Comcast.

AT&T

AT&T is the incumbent landline telephone provider in Davis. While AT&T still sells traditional telephone service and older legacy DSL under the AT&T brand name, customers with faster DSL or with fiber are marketed under AT&T’s U-verse brand.

The majority of households in the city are still served by telephone copper facilities. However, AT&T now has some fiber to residences and has also provided fiber to some MDUs and - businesses in the city.

AT&T recently purchased DirecTV. AT&T is in the middle of a transition and now bills some customers under the DirecTV brand and others under the U-verse brand—even for landline customers. It appears that the company plans to phase out the U-verse brand.

Stand-Alone Internet. The bills we reviewed showed several different internet speed tiers at different price points. As with Comcast we found customers paying different prices for similar services. This is likely due to the same sort of reasons as Comcast—promotional special pricing and customer-specific negotiated pricing. Following are the speeds and prices we identified on bills:

Tier	**Price**
Internet 1.5	$37.00
Internet 12	$52.00
Internet 18	$62.00
Internet 24	$60.00
Internet 24	$50.00 - $10 off promotion
Internet 100	$99.00 - $39 off promotion
Internet 1000 (12-month Promotional Price)	$80.00
Internet Equipment Fee	$7.00

The Internet Equipment Fee is the DSL modem. It appears that AT&T bills this to some customers but not to others. Unlike with a Comcast cable modem, a customer cannot provide their own DSL modem and must get it from AT&T.

The AT&T broadband bills mention data caps. Many bills reference a data cap of 1,024 GB, but then also mention “unlimited data” on the same bill. We don’t know if the company is charging for data overages in Davis. The bills for fiber service make no mention of a data cap.

<u>Bundled Packages</u>. A handful of AT&T bill that were provided included bundled packages that included telephone service or cable television. Most were bundled with the DirecTV brand for television although a few were bundled with U-verse TV. AT&T has been migrating DSL customers off the landline U-verse product and forcing them into getting a satellite dish to keep TV service. This is being done to free up the entire DSL connection for broadband service.

We saw one bill that was bundled with AT&T wireless service. We don’t think this is a common practice and generally AT&T cellular is billed separately from AT&T wireline services. AT&T doesn’t treat bundling discounts the same for all customers. In some cases the bills only show a package price for service. In other cases they shown the individual price for each service and then show a negative amount as a bundle discount.

The only cable fee on the U-verse bills is a Broadcast TV Surcharge of $5.99. There were no such side fees for DirecTV customers.

Omsoft Technologies

The only other company for which we received bills was Omsoft Technologies, a reseller of DSL internet and voice services.

<u>Stand-Alone Internet</u>

Omsoft bills clearly identify the broadband speeds. The fees we saw for standalone internet were as follows:

3.0 Mbps DSL-Residential	$39.95
6.0 Mbps DSL-Residential	$47.95
Static IP address	$5.00
DCN Disk Space	$5.00

These bills had no additional fees or taxes other than for the broadband services.

<u>Bundled Internet (Fusion)</u>. Omsoft also offers a bundled service that includes telephone service. Bundles are billed under the brand name ‘Fusion.’ The bundled bills do not show the speed of the broadband and instead just show the price of the bundle. All of the bundled residential bills we saw were for $30.45 monthly for internet of an unknown speed and $10.00 for each phone line.

Like with the other ISPs, there are numerous taxes and fees added on for telephone customers—including the Federal Subscriber Line Charge (which is not a tax) as well as numerous taxes.

Summary

We can make a few observations about the bills we reviewed. It is a real challenge for a customer in Davis to compare the offerings of different providers based upon the billing. The bills often contain a confusing and inconsistent tangle of regular prices, promotional prices, and bundled packages. There were very few examples where two customers were paying the same overall price, although we think we were looking at customers with identical services.

For the most part the bills don't disclose the broadband speed a customer is getting. This causes obvious confusion as witnessed by the responses for the speed test where customers reported buying speeds that were significantly different than what they were actually receiving.

The ISPs also show 'fees' that customers likely believe are taxes, but which the ISPs pocket as part of the products being sold.

Interestingly, it appears that customers that have been with an ISP longer pay the highest rates. The specials and promotions are generally only given to new customers. While older customers who are willing to fight their way through the customer service process can often negotiate a discount, it appears like there are many customers without any discounts.

Overall this makes it a challenge for a new competitor because there is no one 'price' for the existing products in the market. Prices vary due to promotional discounts, negotiated customer rates, and different amounts of bundling discounts.

Other Residential ISPs

There are a few other residential ISPs operating in Davis.

<u>Aria Communications</u>. This local company primarily focuses on serving broadband to MDUs.

<u>Cal.NET</u>. There were a few residential customers of Cal.NET who took the speed test. This is a DSL provider using technology similar to OmSoft.

<u>Sonic</u>. They are a DSL-based ISP that operates from AT&T collocated equipment in central offices over a wide area including San Francisco and Sacramento. They offer DSL services to customers in Davis and also provide the core network used by OmSoft. We didn't get any bills from Sonic customers, but the reported prices on the web for DSL are $40 per month.

<u>EarthLink</u>. We got a few speed tests from Earthlink customers. They are another reseller of DSL services. This is a nationwide company that offers broadband ranging from dial-up to DSL and fiber-based business services.

<u>Instaconnect</u>. This is a brand name used by Aria Communications to provide WiFi hotspots in some public places and apartments in the city. It appears that some apartments include access to

Instaconnect in the rent. The company also sells customer access to any of their hotspots for prices between $14 and $25 per month.

WISPs. There are several wireless ISPs operating in the area and we saw receivers on a few homes during our drives around the city. We didn't get any bills or speed tests from identified WISP customers.

Larger Carriers

Like in any city today there are also a number of competitive carriers providing broadband and voice services in the city. These various carriers typically serve the larger businesses in the city or businesses that are part of a national or regional chain. As an example, all branches of a major bank or hotel chain might use one service provider nationwide for telecom services. That makes it easier for them to create a company cloud, to provide VoIP between branches, etc.

It's rare in a city like Davis for these carriers to own their own fiber, although it's possible that there could be some limited fiber in the city owned by somebody other than AT&T or Comcast. However, generally these carriers lease broadband from the incumbent providers and then carry specialized services to their customers.

In doing our research we ran across connections in the city today provided by CenturyLink, Verizon, Consolidated Communications (formerly SureWest), and Level 3. Because of nationwide businesses in the city there are bound to be others, and in a city of this size we would expect at least a dozen wholesale carriers. Most of these companies don't have local sales or technical staff in a market like Davis and hire technical maintenance out to subcontractors.

C. Interviews with Stakeholders

CCG Consulting interviewed numerous larger shareholders in the community so that we could understand any issues they had with broadband. We are not going to report on specific conversations we had, but rather have distilled the results of the interview process down to the following findings and observations:

Downtown Davis Lacking in Broadband Infrastructure

We talked to two businesses that were struggling with the speeds in the older parts of downtown Davis. One business had requested a fiber connection from Comcast and was quoted a construction cost of $50,000 plus a price of $5,000 per month to get the speeds they wanted. Another business wants to expand and place employees downtown but is hesitating because of the lack of fast broadband there.

This issue highlights the fact that the availability of broadband in a city is not the same everywhere. There are always pockets that don't have the needed infrastructure to provide broadband. In this case, it's likely that Comcast didn't build downtown years ago, because when they only offered cable TV they were not required to do so by the franchise agreement. They would have built to all residential neighborhoods but not to business districts, and they face expensive construction costs to now reach those areas. The same is true with AT&T. There are parts of the city within reasonable reach of their fiber and others that are not.

There Are Unserved Segments of the Community

The Davis Library reports that they have a lot of people coming to the library to get access to broadband. It can be easy to forget when considering building a fiber network that there is already a sizable demographic in the city that can't afford broadband today.

This same concern was also voiced by the educational community. They know that a significant percentage of K-12 students don't have access to broadband at home and they know these students are disadvantaged compared to their peers.

Almost every city we have ever worked for has wanted to solve the digital divide, but we aren't aware of any city that has yet solved this problem.

The University Could Be a Good Partner

There is a stark dividing line for broadband at the boundaries of the University. The University offers significant broadband on campus. They have their own fiber network on campus and can deliver speeds of up to 10 Gbps to departments of the University that need that much bandwidth. Classrooms and offices on the campus have 100 Mbps connections unless they can demonstrate the need for more.

One of the most pressing needs for the University is to find fast broadband solutions for segments of the University that are located off-campus. For example, the campus buys space in apartments throughout the city for about 600 underclass students, and has located a number of administrative functions in the city as well. The University reports that both of these groups do not share the same broadband experience as the rest of the campus.

There has been pressure from professors to gain faster broadband at their homes off campus to enable them to work on research and tie into University networks from their homes. As a major research university there are project on campus that require huge amounts of bandwidth and these programs would benefit greatly if professors, staff, and students could gain access to them from anywhere in the city.

The University already works collectively with the city on a number of projects that include broadband. For example, they jointly operate a public safety network using the 800 MHz spectrum used for 911 and public safety.

We see this same situation nationwide around other campuses and there are examples of universities that have become proactive partners in community broadband. Perhaps the most proactive is the University of Illinois which is an active partner in fiber expansion in Champaign and Urbana, Illinois.

Some Businesses Are Limited by Current Broadband Products and Prices.

We talked with many of the major businesses in the city. As would be expected in a city with a research university, many of these businesses are high tech and have been absorbed by national and international businesses.

These larger businesses don't buy the same broadband products as residences or small businesses. They instead buy 'dedicated' broadband connections, meaning that they have purchased a dedicated path between their businesses and some distant other branches of their company.

These businesses also don't use broadband in the same ways as smaller businesses do. They tend to be part of VoIP systems that tie all national or worldwide employees into the same voice platform. For the enhanced productivity of their dispersed workforce they tend to use software and systems that are located in the cloud, rather than stored locally.

This means that these businesses can be crippled by a broadband outage since almost everything they do on a daily basis is tied into functions in the cloud or at some distant location of their company.

Most of the businesses said that they can get by on what they have today, but they all would like to have better broadband options. The things they were most concerned about include:

- Data Speeds. The businesses we talked to are buying dedicated bandwidth pipes between 50 Mbps and 200 Mbps. Every one of them said that while these connections are adequate most of the time that there were times when data capacity limits them. For example, there are times when they send big data files that they have to limit other broadband uses. One business occasionally has files that take 'days' to transmit and synchronize with other branches of the business. Every business also said that their broadband needs are growing and that they foresee needing faster data connections to the world. Every company we talked to said they would like faster connections, but in some cases there is no faster alternative.
- Redundancy. Every business we talked to said that they would like to have a redundant connection, meaning a second broadband connection from a different ISP. This would provide protection in case their primary connection goes out of service. Almost every business we talked to said that 'uptime' is critical and that they can't afford to be without broadband. A few stakeholders also said that they have occasional network 'slowdowns' that can harm their business and that this could be alleviated with a second redundant connection. None of these businesses have a redundant connection today.
- Price. Price is always of concern. What these companies are talking about is comparative prices. These businesses don't expect to get the $70 Gigabit connections being offered by Google Fiber in residential markets. They have requirements for a dedicated data connection that has more stringent technical requirements. When they say they want to see cheaper prices they are talking about the price they pay for dedicated connections in

Davis compared to branches of their businesses that are elsewhere in the country or in the world.

- Bidirectional Speeds. Several stakeholders were frustrated by broadband connections without faster upload speeds. They said this was limiting them from fully utilizing VoIP and videoconferencing.
- Service. We were told that the technical support varies widely among the current ISPs and that the ability to identify, troubleshoot, and solve technical network issues is of concern to them.
- Expansion and Growth. Almost every business we talked to has hopes and plans to grow (which is great news for the city). However, one of their concerns about growing is getting enough additional broadband to satisfy future needs (along with finding land and office space).

Desire for Faster Residential Broadband

A number of the major shareholders we interviewed wanted better residential broadband. Many want the ability for employees to work at home and still have access to the computer networks in the office. A number of the stakeholders we talked to are high-technology companies that don't view what they do as a 9 to 5 job but want their employees instead to be able to work remotely.

This desire was also strongly voiced by the medical community where doctors increasingly need to have the ability to see large medical data files from home. More interestingly, we talked to some in the medical community that think we are on the verge of having technology that will allow for 'aging in the home' instead of having to send the elderly to retirement homes. They don't think these new broadband services are going to work with today's small residential upload speeds.

Tech Community Leery of Government-Operated Broadband Network

In an interesting finding that we haven't seen in other communities, we were told by a number of stakeholders that the local tech community is leery of having a government-operated broadband network. This is not necessarily in conflict with the city's goals for fiber since the city prefers to find a commercial ISP partner to operate the network and the ISP business.

II. Engineering Design and Cost

A. Network Design

The first step in any network design is to collect the raw facts about the community to be served in terms of number of potential customers, miles of fiber that must be built, existing assets, etc.

City of Davis GIS System

Davis 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), empty conduit locations, and more. We utilized this data extensively to determine potential fiber routes, crossing locations for major roads and railroads, equipment locations, and other items that will be detailed later in this report. We designed several different types of areas such as light and heavy residential, commercial, etc. to arrive at average costs that could be applied to other similar areas around the city. This will allow us to obtain some level of accuracy without actually designing the entire city which would take significantly more time, resources, and cost.

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. The engineers looked at several different sources of data on passings including the Census and other data such as the number of water meters and GIS statistics. Our engineers settled on the following as the count of potential passings in the city:

Residential	14,509
Multi-dwelling Units	12,283
Business	2,685
Government, Medical, Educational	231
Other	150
Total	29,858

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.

- 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. This comprises a large portion of the potential subscribers with unique challenges (see page 37-39).

- Businesses: 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 and they would not be likely to independently purchase services. The city GIS system shows 580 commercial and 50 industrial structures in the city. US Census data shows that there are 4,463 businesses in the community.

For various reasons neither of these is a good estimate of business passing for purposes of this study. There are several reasons why the GIS count is probably too low and the census numbers are too high. These factors include but are not limited to:

1. Home businesses will often not take dedicated broadband service and skew Census numbers high.
2. Multitenant business structures skew building counts low.
3. Some small businesses may operate out of an apartment or home that are not specifically noted for that use.

For the study we elected to use a total of 2,685 total business passings. We consulted with the city and after reviewing the city business directory the number of passings was estimated by excluding specific types of businesses that operate from home or require a business license (realtors) and also excluding businesses with obvious home or apartment addresses. We know the number of businesses is greater than the number of meters. We also looked at similarly sized cities and this appears to be in proportion with other business counts in other cities.

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.

- 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. These were all evaluated for potential needs and accounted for accordingly.

Network Design.

The first major assumption in the network design is that there would be a core fiber ring encompassing the city to connect multiple electronics sites. Due to the size and density of the city, several smaller rings would be fed from this core ring to reduce the size, cost, and complexity of the electronics sites. The city has expressed a desire to have the sites be as small and unobtrusive as possible.

The core fiber ring was designed to utilize redundant 100Gbps channels. This means that traffic will be routed in both directions around the ring. This ring will also be able to add multiple

100Gbps channels in the future at a minimal cost to upgrade the electronics. This will allow a provider to grow into the ring and purchase upgrades as needed. The new ring consists of provisioning communications equipment at six nodes. These nodes would house the core network equipment and could also feed very high-speed connections (10Gbps and faster) directly to high usage subscribers. See Appendix IV (page 142) for a network diagram of the proposed new ring.

Each of the six node buildings on the ring can be used as a point of presence (POP) for making direct connections to other ISPs or to allow ISPs to tie into the optical network. There would also be a Network Operations Center (NOC) that would be the main point of control for the entire network. We have designated the City Hall location for this purpose, although it could be located at any of the nodes within the network without affecting costs. Each node location will contain all necessary power equipment and FTTP access equipment where the connections are made from the fiber ring to neighborhood fibers.

Each of the smaller subrings will be fed with multiple 10Gbps connections. Again, this is a system that can be grown into in the future by adding more optics and cards at a relatively low cost.

These rings and subrings are designed to be redundant, meaning that if the fiber in the ring is cut the whole ring will continue functioning. Rings are self-healing, meaning that the electronics immediately react to a fiber cut since traffic on the ring travels continuously in both a clockwise and counterclockwise direction, thus bypassing a single fiber cut.

Davis is a densely populated city and fiber sizes can add up quickly and become expensive and unwieldy. When designing the fiber routes we decided to divide the city into serving areas that roughly contain 1,000 potential address points or structures. Along with the nodes there are also several electronics sites throughout the city that would provide fiber to potential subscribers. These electronics sites would be connected to smaller redundant subrings that would provide services to these serving areas. The electronics sites would likely be either a larger outdoor cabinet or a small building to house power and FTTH equipment for the network.

The distribution fiber is designed in a homerun configuration, meaning that there is a straight shot of fiber from nodes or electronics sites to any given subscriber (excluding MDUs). If one of the homerun fibers is cut then the subscribers served by that fiber will be out of service until the fiber is repaired.

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 nodes and Electronics Sites were designed based on the following parameters:

1. They were sized to house fiber frame equipment large enough to provide a home run fiber from the hut to each neighborhood with potential customers.

2. Each site includes DC power and batteries to protect against power outages as well as either generator connections or permanent generators for extended outages.
3. They are big enough to allow for collocation with multiple providers if needed.

The study looks at multiple options of who might operate the network. For instance, if a new provider that was not already operating in the area was going to operate the network then they might need to construct a cable TV headend. An ISP that is already operating in the region probably would not. There is a similar issue with providing a business office. A new provider would clearly need to have a location to house customer service and management employees while an existing ISP in the region might or might not need a new building.

Network Electronics

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 we are not suggesting that the city use any one vendor. Rather, our experience is that the cost of the FTTH 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 nodes and electronics sites throughout the city. These will contain a variety of different equipment including:

- 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 that will notify the operator 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 to last 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 one of the node sites is $40,000. This is based on a single outdoor stand-alone diesel generator. There may be cases where a generator is not necessary or impractical to implement. In these cases we have at a minimum included a generator connection and transfer switch where a portable generator could be connected to temporarily power the facility and charge the battery banks.
- Service Aggregator. This is a network level router (layer 2/3) with optical connections that can aggregate network traffic from multiple pieces of equipment and send it out for transport around the network. It would also allow network operators to manage individual, multiple, or virtual data streams to combine or separate networks as needed.
- Remote Transport Electronics. This equipment is capable of transporting data from different points in the network through the main fiber ring and secondary rings.
- 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. The models will calculate equipment and parts needed such as cards, optics jumpers, splicing, and more. Refer to the tables below for cost estimates on a sample opinion of cost for a node and an electronics site.

Table 1 – AON Node Electronics Costs

AON Node Electronics			
Description	**Unit Cost**	**Qty**	**Ext. Cost**
Building Renovations			
Existing Building Renovations (sf)	$ 187.00	300	$ 56,100.00
AC and DC Power and Battery Backups	$ 60,360.00	1	$ 60,360.00
Service Aggregator	$ 283,187.00	1	$ 283,187.00
FTTH Electronics	$ 139,836.75	1	$ 139,836.75
Fiber Frame and Terminations	$ 90,221.36	1	$ 90,221.36
		Total	**$ 629,705.11**
AON Electronics Site			
Description	**Unit Cost**	**Qty**	**Ext. Cost**
Remote Building			
Pre-Fab Building and Transport	$ 66,000.00	1	$ 66,000.00
AC and DC Power and Battery Backups	$ 50,360.00	1	$ 50,360.00
FTTH Electronics	$ 139,399.25	1	$ 139,399.25
Fiber Frame and Terminations	$ 89,471.38	1	$ 89,471.38
		Total	**$ 345,230.63**

Network Technologies

The network design assumes the use of Active Ethernet technologies. While an Active Ethernet Network is more expensive than other technologies, it provides the ability to have a truly dedicated 1Gbps connection to each potential subscriber. The desire for 1Gbps as a baseline service was the major factor in choosing an Active Ethernet Technology. Another advantage is that customers can be upgraded to 10Gbps connections by simply changing the optics and customer equipment.

The alternative is a Passive Optical Network (PON) design that utilizes splitters which are nonelectrical devices (passive optical) that allow a feeder fiber to serve up to and beyond 32 homes. These splits can be distributed in splitter cabinets in the field, which don't have to be powered or in a centralized location. A PON network generally lowers equipment and electronics pricing by 10-20% due to the need for fewer optical transceivers, electronic lasers, and powered equipment sites in the network. Since we have utilized a homerun fiber design, the outside plant fiber costs are identical between an Active and Passive Network.

If a PON network were desired then the smaller electronics sites could be converted to passive splitter sites with all equipment residing in the Nodes. These technology options are explained in more detail later in this report. Refer to the table below for a similarly sized GPON node and electronics pricing.

Table 2 – GPON Node Electronics Costs

GPON Node Electronics			
Description	**Unit Cost**	**Qty**	**Ext. Cost**
Building Renovations			
Existing Building Renovations (sf)	$ 187.00	300	$ 56,100.00
AC and DC Power and Battery Backups	$ 60,360.00	1	$ 60,360.00
Service Aggregator	$ 283,187.00	1	$ 283,187.00
FTTH Electronics	$ 58,400.00	1	$ 58,400.00
Fiber Frame, Splitters, and Terminations	$ 2,674.40	1	$ 2,674.40
		Total	**$ 460,721.40**
GPON Electronics Site			
Description	**Unit Cost**	**Qty**	**Ext. Cost**
Remote Building			
Pre-Fab Building and Transport	$ 66,000.00	1	$ 66,000.00
AC and DC Power and Battery Backups	$ 50,360.00	1	$ 50,360.00
FTTH Electronics	$ 49,405.25	1	$ 49,405.25
Fiber Frame, Splitters, and Terminations	$ 95,006.44	1	$ 95,006.44
		Total	**$ 260,771.69**

Multi-Dwelling Units (MDUs)

There are a number of issues that affect your ability to bring fiber to multi-dwelling units (MDUs), which are apartment and condominium complexes. This is discussed in more detail on pages 99-103. 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 these savings.

Davis has a high number of MDUs of different sizes. We put the various MDUs into the following categories based roughly on the difference in the cost of serving different sized buildings, as follows:

	Buildings	Units
5–10 Units	57	450
11–19 Units	33	485
20–49 Units	43	1,614
50+ Units	80	7,677

In the study we have assumed that the cost of serving an MDU customer with fewer than 4 units is roughly the same as serving an equal amount of single-family homes (a triplex would cost the same as 3 homes for example). The most cost-efficient way to serve these units is to bring fiber directly from the street to the individual units. There is typically no common space to terminate fiber or locate equipment and the scale is so low that no advantage is gained by treating them differently from a single family home.

Structures with 5-12 units will be handled similarly to those with fewer than 4 units. However, instead of multiple drops to the units these would have a 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 these units 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. Following is an example of applying these engineering cost estimates to a 10-building unit:

Table 3 – Sample Installation Cost for 10-Unit MDU

10 Unit MDU with Fiber			
Description	**Unit Cost**	**Qty**	**Ext. Cost**
MDU ONT's			
Fiber Wiring Cost per Unit	$ 450.00	10	$ 4,500.00
Indoor ONT 1GE, 1POTS	$ 105.00	10	$ 1,050.00
SFU Power Cord and Fiber Jumper	$ 32.00	10	$ 320.00
			$ 5,870.00
		GRAND TOTAL	**$ 5,870.00**

The cost components are different for a larger MDU. Electronics must be utilized to keep fiber sizes down. MDUs with greater than 12 units typically have some common spaces where fiber can be terminated and electronics can be stored. The next cost model shows the cost to build fiber to each unit in a 35-unit structure. This model should scale on a per unit basis from 13-50 units. The downside of these types of units is that the construction costs are much higher. There is more work and coordination required to route fiber within finished spaces. Refer to the table below for cost model.

Table 4 – Sample Installation Cost for 35-Unit MDU

35 Unit Building				
Description	Unit Cost	Qty		Ext. Cost
Electronics Closet				
DC Power and Battery Backup	$ 1,260.00	1	$	1,260.00
FTTH Chassis Package, & Fiber Mgmt.	$ 856.00	1	$	856.00
E7-2 Active Card W/ 2 10G, 24 GE using Bi-Di SFP's	$ 3,896.00	2	$	7,792.00
FTTH GE BIDI, 20Km, Tx 1490nm	$ 158.00	18	$	2,844.00
10GSFP+, Single-Mode dual Fiber Trasnceiver, 10km	$ 980.00	2	$	1,960.00
48" Wall Mounted Fiber Frame W/ Cassett Shelf	$ 633.00	1	$	633.00
Patch and Splice Cassettes	$ 154.00	12	$	1,848.00
2m Fiber Jumpers	$ 8.75	50	$	437.50
Fiber Management	$ 250.00	1	$	250.00
Installation Turn-up and Testing	$ 2,500.00	1	$	2,500.00
			$	**20,380.50**
MDU ONT's				
Fiber Wiring Cost per Unit	$ 750.00	35	$	26,250.00
Indoor ONT 1GE, 1POTS	$ 105.00	35	$	3,675.00
SFU Power Cord and Fiber Jumper	$ 32.00	35	$	1,120.00
			$	**31,045.00**
		GRAND TOTAL	**$**	**51,425.50**

The larger the MDU, generally the more obstacles to construction. Structural components of these larger units such as concrete floors and beams create barriers that are difficult to penetrate and drive up rewiring costs. Below is a model of what a 100-unit building would cost to rewire.

Table 5 – Sample Installation Cost for 100-Unit MDU

100 Unit Building				
Description	Unit Cost	Qty		Ext. Cost
Electronics Closet				
DC Power and Battery Backup	$ 1,260.00	1	$	1,260.00
FTTH Chassis Package, & Fiber Mgmt.	$ 856.00	3	$	2,568.00
E7-2 Active Card W/ 2 10G, 24 GE using Bi-Di SFP's	$ 3,896.00	5	$	19,480.00
10GE Copper Cable W/SFP+, 1M, I-Temp	$ 67.50	2	$	135.00
FTTH GE BIDI, 20Km, Tx 1490nm	$ 158.00	50	$	7,900.00
10GSFP+, SM dual Fiber Trasnceiver, 10km	$ 980.00	2	$	1,960.00
48" Wall Mounted Fiber Frame W/ Cassett Shelf	$ 633.00	1	$	633.00
Patch and Splice Cassettes	$ 154.00	12	$	1,848.00
2m Fiber Jumpers	$ 8.75	120	$	1,050.00
Fiber Management	$ 250.00	1	$	250.00
Installation Turn-up and Testing	$ 4,000.00	1	$	4,000.00
			$	**41,084.00**
MDU ONT's				
Fiber Wiring Cost per Unit	$ 840.00	100	$	84,000.00
Indoor ONT 1GE, 1POTS	$ 105.00	100	$	10,500.00
SFU Power Cord and Fiber Jumper	$ 32.00	100	$	3,200.00
			$	**97,700.00**
		GRAND TOTAL	**$**	**138,784.00**

The last option is to utilize existing copper wiring in MDUs where possible. In the past few years G.Fast technology has emerged as a powerful tool to serve these larger facilities. G.Fast technology leverages both fiber drops to these MDUs and the existing copper wiring within the building to provide Gigabit services under optimal conditions. The actual speeds, however, vary depending on a number of factors including loop length, type and age of copper wiring, and number of subscribers. In reality, many users may not be able to obtain true gigabit services. However, in many cases users would see significant speed increases compared to other DSL technology available today without requiring costly rewiring. This still may require significant rewiring of any MDU that does not have suitable wiring. For the purposes of this study we have assumed that a portion of these will need to be rewired with Cat5 wiring. Below is an example of what a 35-unit MDU might cost to rewire with G.Fast.

Table 6 – Costs for 35-Unit MDU 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	$	2,099.00	2	$	4,198.00
Installation	$	1,200.00	2	$	2,400.00
				$	**4,745.00**
MDU ONT's					
Copper Wiring Rehab	$	150.00	35	$	5,250.00
G.Fast Modem 1GE, 1POTS	$	95.00	35	$	3,325.00
Power Cord	$	17.00	35	$	595.00
				$	**20,513.00**
			GRAND TOTAL	**$**	**25,258.00**

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 laser and which can connect to the fiber optic signal using 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. There is also an ONT that can be placed indoors and which 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. 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 will be 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: 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. Generally providers offer a basic ONT like the one used in this study or a more fully featured ONT with up to 4 Ethernet ports and managed WiFi.
>
> Business: Many small businesses can use the same ONT as residences, but larger businesses have sometimes required 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. We assumed that 10% of business, government, and medical subscribers would use these larger ONTs. The number of subscribers that buy traditional telephone service is declining every year as more businesses convert to IP-based telephone service.
>
> Battery Backup: Historically many FTTH 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.

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 are described in more detail in the financial business plan analysis (see page 161).

Open Architecture

One of the business options that was considered is open access. This would be a business where the city built the fiber network and then gave access to multiple ISPs to serve customers.

A full open-access network would mean offering a wholesale connection to each residence and business in the city. **From a network perspective there is not a lot of cost difference between a retail network and an open-access network**. Both use the same fiber network, customer electronics, and fiber drops. There would need to be a platform of servers used to accommodate providing access to multiple ISPs, but this is more of a software than a hardware issue and those servers would not have a significantly different cost than the servers and routers used in a retail network.

B. Network Cost Estimates

Following is a discussion of issues that affect the cost of the network as well as a description of how the cost of the network was estimated.

Issues with Buried Fiber

Rock/Soil. During field observations there did not appear to be a significant amount of rock in the soil that would raise costs.

Conduit. The design assumes that all underground fiber would be placed in conduit/duct. Some existing conduit is mapped on the city's GIS mapping system. However, no conduit survey has been performed to determine the viability of using this conduit. To keep our study conservative we only assumed the use of conduit marked as empty. A detailed engineering analysis may reveal that some of the currently occupied conduit could be used, which could reduce construction costs. It is also worth noting that conduit doesn't always suit a full residential fiber deployment. One of the major cost issues for using an existing conduit is gaining access to the conduit where it's needed. If conduit was constructed to make connections only between two locations, then it is likely not going to be of use for a network that would need multiple connections between the existing endpoints. It's often more expensive to add access points to existing conduit than to install new conduit.

Issues with Aerial Fiber

There is an extensive aerial and pole network within the city for power and other communications. The use of poles is regulated by both the FCC and the state and rules are generally set up for new providers to be able to access these poles. However, in practice there are many other issues that may make it not feasible to construct an aerial network.

1. Pole Attachment Fees: Anyone that attaches to poles must rent space in the form of attachment fees.
2. 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.
3. Placement on Poles: There are regulations about 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 attachment to the pole. Field observations noted that much of the aerial infrastructure currently in place does not comply with existing regulations.
4. Make Ready Costs: Many of the poles were not in a condition to be able to attach fiber today. This is due to a number of issues such as pole condition, clearance, tree trimming, etc. This would require extensive work to establish suitable conditions to attach a new fiber network to these poles (also referred to as make ready costs). These costs must be borne entirely by the new provider. There would also be substantial time added to the project as existing providers would need to form new agreements to move up or down the pole to make space for new fiber. These make ready costs would easily offset any savings.
5. 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 nonconductive 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.
6. Regulations: Due to California General Order 95, a load study would be required on each pole; this would add significant cost to an aerial network. Additionally, California Rule 20 promotes undergrounding of utilities by requiring providers to annually locate funds to place overhead facilities underground. These are clear efforts

by the state to promote undergrounding of utilities. The city has significant public space and right of way areas that would make buried fiber much easier than aerial fiber from a regulations perspective.

Field observations quickly determined that the existing poles in Davis have a multitude of issues. The make ready costs alone would drive up costs dramatically. These poles are also owned by others and would likely require leasing fees in addition to make ready costs. Engineering costs would be significant as a Pole Load Study would be required for nearly every pole in the city. These costs would likely place aerial construction at or above the cost of a buried network. The make ready costs, regulations, and higher reliability of buried fiber has led us to plan for an all-buried network.

Fiber Costs

Fiber prices were estimated by using a sampling technique. With assistance from the city, Finley estimated the cost of construction in the city by looking at several different study areas that contain multiple types of construction.

The purpose of this exercise was to look at specific issues in the city that can affect the cost. This includes all sorts of different issues such as the distance between subscriber points, the average drop length to get from the street to buildings, etc. The results of these studies were used to determine a specific estimate of the cost to build fiber in the city, expressed as a cost per mile, for both aerial and buried fiber. These costs per mile were then applied to the rest of the city.

Attached to the study as Appendix IV is a map that shows the locations of these four study areas.

Following is a more detailed description of each study area:

Area 1: Downtown

- Between B Street and L Street from 11th Street down to the Union Pacific Railroad tracks

Area 2: Covell Park

- The area between Sycamore Lane, Catalina Drive, and West Covell Boulevard.

Area 3: Slide Hill Park

- The area between Pole Line Road and Monarch Lane and between Loyola Drive and East Covell Blvd.

Area 4: Mace Ranch Park

- Between Mesquite Drive, Mace Ranch Park, and 5th Street.

The design then looked at specific costs in each area and in extrapolating costs to the whole city the following issues were considered

- The varying types of subscribers in different parts of the city.
- The density of subscribers in different parts of the city.

- The assumption that all buried fiber would be placed in conduit.
- Additional fiber pairs to be able to accommodate planned future growth in areas defined by the city such as Nishi Gateway, Mace Ranch Innovation Center, West Davis Active Adult Community Project, and others.

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

- The backbone ring is designed with 144 fibers.
- The smaller rings have 96 fibers.
- Customer drops use 4-12 fibers, depending on the type of customer (industry standard).

These larger fibers would not necessarily be constructed as separate cables, but would rather be combined into larger sheaths with other fibers that would need to be located on the same streets.

As discussed previously, the core fiber ring was designed to utilize redundant paths with room for future bandwidth expansion. The new ring would also touch each of the main six nodes. These nodes would house the core network equipment and could also feed very high-speed connections directly to high usage subscribers. There is a network diagram of the proposed new ring included as Appendix IV to this report.

In order to keep costs down and reduce the size of fibers, smaller electronics sites were designated in the serving areas. These electronic sites are connected to the main nodes on smaller secondary or subrings that also have a redundant path between each other. This is a system that can be added to by extending secondary rings and new electronics sites.

These rings and subrings were laid out and designed on a per-mile basis and adjusted for local labor rates and prevailing wage requirements. We also included costs for handholes, splicing, installation, etc. to determine overall pricing for these rings.

The distribution fiber is designed in a homerun configuration, meaning that there is a straight shot of fiber from nodes or electronics sites to any given subscriber (excluding MDUs). If one of the homerun fibers is cut then the subscribers served by that fiber will be out of service until the fiber is repaired. Although there are approximately 160 road miles in Davis, we would likely have to go down both sides of many roads as multiple crossings per block would be more expensive.

Below is a summary of the fiber costs to build the fiber network. Note that this is the cost for the fiber materials and installation and the total includes costs for engineering, construction management and construction contingency.

Table 7 – Summary of Fiber Costs

OSP Fiber Costs							
		Cost per Mile			Extended Cost		
OSP	**Rt Miles**	**Labor**	**Material**	**L & M**	**Labor**	**Material**	**L & M**
Fiber Rings							
Primary Ring	14						
Fiber and Installation		$ 10,545	$ 6,537	$ 17,079	$ 147,630	$ 91,519	$ 239,149
Conduit		$ 132,543	$ 9,615	$ 142,158	$ 1,855,602	$ 134,610	$ 1,990,212
Hard Surf. Cut & Rest.		$ 142	$ 38	$ 180	$ 1,988	$ 532	$ 2,520
Handholes & Splices Cases		$ 447	$ 750	$ 1,197	$ 6,258	$ 10,500	$ 16,758
Splicing		$ 38,880	$ 648	$ 39,528	$ 544,320	$ 9,072	$ 553,392
Total Primary Ring					**$ 2,555,798**	**$ 246,233**	**$ 2,802,031**
Secondary Rings	20.5						
Fiber and Installation		$ 25,553	$ 4,118	$ 29,676	$ 523,831	$ 84,411	$ 608,242
Conduit		$ 67,065	$ 4,138	$ 71,203	$ 1,374,833	$ 84,829	$ 1,459,662
Hard Surf. Cut & Rest.		$ 398	$ 74	$ 472	$ 8,159	$ 1,517	$ 9,676
Handholes & Splices Cases		$ 2,947	$ 1,464	$ 4,411	$ 60,414	$ 30,012	$ 90,426
Splicing		$ 8,992	$ 188	$ 9,180	$ 184,336	$ 3,854	$ 188,190
Total Secondary Rings					**$ 2,151,572**	**$ 204,623**	**$ 2,356,195**
TOTAL FIBER RINGS					**$ 4,707,370**	**$ 450,856**	**$ 5,158,226**
Distribution Fiber	244.5						
Fiber and Installation		$ 12,430	$ 5,800	$ 18,230	$ 3,039,135	$ 1,418,100	$ 4,457,235
Conduit		$ 102,850	$ 6,010	$ 108,860	$25,146,825	$ 1,469,445	$26,616,270
Hard Surf. Cut & Rest.		$ 6,650	$ 1,800	$ 8,450	$ 1,625,925	$ 440,100	$ 2,066,025
Handholes & Splices Cases		$ 20,860	$ 35,930	$ 56,790	$ 5,100,270	$ 8,784,885	$13,885,155
Splicing		$ 15,410	$ 260	$ 15,670	$ 3,767,745	$ 63,570	$ 3,831,315
TOTAL DISTRIBUTION FIBER					**$38,679,900**	**$12,176,100**	**$50,856,000**
Total FTTP (Distribution and Rings)					**$ 43,387,270**	**$ 12,626,956**	**$ 56,014,226**
Engineering							$ 4,147,848
Construction Management							$ 5,502,013
SUBTOTAL							$ 9,649,861
Contingency							$ 6,566,409
Total Fiber Costs							**$ 72,230,496**

Drops are the fibers that connect the distribution fibers to the home or 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 150 feet, accounting for parking and driveways in front of many businesses. Some businesses are further from the road. Our estimate of drop distances was derived by sampling homes and businesses using the provided city GIS maps. Once the average length was determined we added costs for handholes, grounding materials, conduit, Network Interface Device, 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.

Table 8 – Cost of Fiber Drops

Drops, NIDs, Splicing, & Cutover	Labor	Material	L & M
Single Family			
Fiber	$ 360.00	$ 16.20	$ 376.20
Materials, NID, Grounding	$ 125.00	$ 60.00	$ 185.00
Splicing	$ 60.00	$ 1.00	$ 61.00
Cutover	$ 600.00	$ 200.00	$ 800.00
		Total	**$ 1,422.20**
MDUs <4			
Fiber	$ 360.00	$ 16.20	$ 376.20
Materials, NID, Grounding	$ 125.00	$ 60.00	$ 185.00
Splicing	$ 60.00	$ 1.00	$ 61.00
Cutover	$ 600.00	$ 200.00	$ 800.00
			$ 1,422.20
MDUs >4			
Fiber	$ 800.00	$ 50.00	$ 850.00
Materials, NID, Grounding	$ 191.00	$ 60.00	$ 251.00
Splicing	$ 60.00	$ 1.00	$ 61.00
Cutover	$ 600.00	$ 200.00	$ 800.00
		Total	**$ 1,962.00**
Government, Medical, & Educational			
Fiber	$ 800.00	$ 50.00	$ 850.00
Materials, NID, Grounding	$ 191.00	$ 60.00	$ 251.00
Splicing	$ 60.00	$ 1.00	$ 61.00
Cutover	$ 600.00	$ 200.00	$ 800.00
		Total	**$ 1,962.00**
Businesses			
Fiber	$ 800.00	$ 50.00	$ 850.00
Materials, NID, Grounding	$ 191.00	$ 60.00	$ 251.00
Splicing	$ 60.00	$ 1.00	$ 61.00
Cutover	$ 600.00	$ 200.00	$ 800.00
		Total	**$ 1,962.00**
Other (Transportation, Religious, Community, Recreational)			
Fiber	$ 360.00	$ 16.20	$ 376.20
Materials, NID, Grounding	$ 125.00	$ 60.00	$ 185.00
Splicing	$ 60.00	$ 1.00	$ 61.00
Cutover	$ 600.00	$ 200.00	$ 800.00
		Total	**$ 1,422.20**

Construction Contingency

In our cost estimates we added a 10% contingency to the cost of constructing the fiber. This is routine when performing a feasibility study like this one where the overall goal is to make sure that we have estimated a high enough cost for the network. The contingency might cover various situation such as inflation in the cost of building the network, adding a few streets into the city between this study and the start of construction, or just covering meeting unexpected hurdles during the construction process. Before bonding for the project we would expect the city to undertake another round of engineering analysis to better pin down the cost of building the fiber network. But that extra effort is not justified at this early stage of the feasibility. Note that since the cost of the fiber network is the most expensive asset to be constructed that some fiber builders bid out networks on a do-not-exceed price so that the cost of the fiber can't exceed the borrowing used to pay for the network.

We've also added a 5% contingency for the network electronics. This is a conservative assumption in that the cost of electronics has historically dropped over time.

Construction Inflation

We have not included any inflation in the cost of building the fiber network. If the fiber construction is started within the next few years we think this is a reasonable assumption. However, the longer it takes to begin construction, the greater the chance that the cost of fiber will increase over our estimates. We have probably more than covered any inflation through the use of the construction contingency.

We would note that the overall cost of build new FTTP networks has not increased on a per passing basis for at least the last decade. While there have been some increased in the labor component for building fiber, we've seen the costs drop for the fiber cable and for the various FTTP electronics. This past experience might not continue, but we not seen any net inflation in the cost of building and lighting fiber networks.

Prevailing Wages

One issue that is impacting the cost of constructing fiber is the issue of paying prevailing wages. California's Prevailing Wage Law, codified at California Labor Code 1720 provides that contractors and subcontractors performing work on state, municipal or local public works projects with a value of over $1,000 pay their workers not less than the general prevailing rate of per diem wages for work of a similar character in the locality in which the public work is performed as set by the California Department of Industrial Relations ("DIR"). The basis for these laws, which have been in effect since 1931 is to discourage contractors for municipal projects from importing cheaper labor from out of the area or the State. All of our labor estimates include prevailing wages.

Interestingly, a charter city in California is allowed to avoid the prevailing wages for a project funded by the city. But Davis voters rejected becoming a charter city on a 2008 ballot measure.

C. The Options for Fiber Technology

As mentioned earlier, there are two basic technologies used to provide fiber broadband—Passive Optical Networks (PON) and Active Optical Networks (AON). One of the first decisions to be made when looking at a fiber network is determining if it is better to use active or passive fiber electronics. This is a key decision because it impacts the way the fiber network is constructed.

The Active Optical Network (AON) dedicates a fiber for each user between the customer location and the electronics equipment in a hub. This means each customer has a dedicated path to the electronics and does not share bandwidth directly with another customer in the neighborhood. An AON network has many more field lasers than a passive network since there are two lasers for each customer at the two ends of the network.

In an AON network, everything is encoded as data between the electronics and the customer. This means all services must be digitized and delivered as an IP data stream to the user. The AON uses only 2 wavelengths on each fiber—one for transmission of data to the users and one for transmission of data from the users.

Since everything on an AON network is digital, the only possible video product is IPTV. IPTV delivers one channel at a time to each TV in the house as customers request it. This is a different model than normal broadcast TV and minimizes the number of channels that are being broadcast on the network. With traditional cable TV the system sends all the channels all the time to everybody. With IPTV, a customer must have a settop box for each TV that wants to receive its own channels.

The current vendors making Active Optical Network equipment includes Cisco, Calix, Adtran, and Nokia-Alcatel-Lucent. Since PON equipment has won a much greater market share than AON equipment this part of the industry has been in a bit of a decline for a few years.

The other choice is to build a Passive Optical Network (PON) which uses passive hardware to "split" the signals so that a single high-powered laser can be shared by up to 128 customers (more typically 32 customers). This technology requires less fiber than an AON since many customers in an area share the same single fiber over which the information carried on the fiber is 'split' into 32 individual fiber drop paths for delivery to homes or businesses. In construction, one feeder fiber "feeds" a passive splitter that takes the information that is transmitted onto the feeder fiber and distributes it across 32 or 128 individual fiber drops similar to the way water in a single pipe can be sent to 32 individual locations by placing a 1-to-multiple pipe junction on a single feeder water pipe.

PON technology uses bandwidth on the fiber differently than AON. The PON electronics divide up the optical wavelengths on the fiber to allow 1 wavelength to transmit data and voice to the users, another wavelength to receive data and voice from the users, and a third optional wavelength to transmit RF video (like traditional broadcast Cable TV video on a cable network) to the users over one fiber strand. In this manner, the PON network can transport both analog signals and digital cable signals into the home.

A PON network has the ability to transmit video at the RF level and have it split into multiple fiber drops. This means that a PON that is delivering analog TV would not require a settop box. A PON also uses existing wiring more easily since the video signal is delivered in the same way as the existing cable TV video is delivered by the cable company. This gives easier access to existing telephone and cable wiring.

The current vendors for PON equipment include Alcatel-Lucent, Adtran, Zhone, Nokia, and Calix. Today passive optical networks use the GPON (Gigabit Passive Optical Network) technology. This technology uses Ethernet signaling for the customer delivery path. In a GPON system there is still the capability for three separate data streams—one for cable TV and two more for downstream and upstream data. The currently available GPON technology can deliver 2.4 Gbps of downstream data and 1.2 Gbps of upstream, which is shared by the number of customers on a splitter. As an example, a 1x32 splitter would mean that 32 customers would share a single 2.4Gbps downstream and 1.2Gbps upstream connection.

Active Optical Network

Advantages:

- Can serve customers up to 36 miles from last active field device.
- Does not require as much complex pre-planning and engineering. With AON there is a separate fiber to each customer, making it easier to engineer as you go.
- A single point of failure will often affect fewer customers
- Offers truly non-blocking 1Gbps and beyond speeds.
- Easily upgradeable to 10Gbps by switching optics.

Disadvantages:

- Cannot support RF video broadcast TV (only IPTV). An AON system requires every customer to get a settop box (a settop box for every separate TV, in fact), thus increasing video capital costs.
- Shares data and CATV bandwidth in the same data stream. Today an AON 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 the AON 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.

Passive Optical Network

Advantages:

- Lower Cost (typically 10-20% less than Active for the core fiber electronics)
- Can support both RF Broadcast TV and digital IPTV.
- Can deliver analog TV without a settop box.
- Has a separate bandwidth stream for CATV and data services.
- Much 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. By contrast, a typical cable TV system shares 150 Mbps with up to 500 homes and an AON shares bandwidth farther into the core network.
- For the most part you can use 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 major hubs or huts, where the provider places electronics.
- Can easily provide traditional T1s for larger business customers using business ONTs.

Disadvantages:

- Customer must be within 12 miles of hub when using 1 X 32 splitter. This means with very large installations that multiple hubs are required. For many cities, including Davis, this is not a limitation since the higher density requires a design with neighborhood huts that are close to customers.
- More customers potentially are affected by a fiber failure in the field.

The Finley Engineering design of the network allows for the easy use of either technology. Finley has designed the network such that neighborhoods are served from huts that then have a fiber from the hut to each home or business. This means that the network could be configured to serve each customer with the technology that best suits them.

Our initial design and basic business plan Active Optical Network technology two major reasons First, AON allows a dedicated 1Gbps data path to each customer. This contrasts with a GPON network where the network would probably share a 2.4 Gbps path between 16 customers. Such customers would almost always be able to make a gigabit connection, but it's not always guaranteed. Second, an AON network can more easily be scaled in the future to larger bandwidth. For example, it's relatively easy already today to provide 10 gigabit service to a large customer using AON.

Why Not NG-PON2?

The RFP asked us to consider the use of NG-PON2. This is the next generation of PON technology on the horizon. There is a lot of debate within the industry about the direction of the next generation of last-mile fiber technology. There are three possible technologies that might be adopted as the preferred next generation of electronics—NG-PON2, XGS-PON, or active Ethernet. All three technologies are capable of delivering 10 Gbps streams to customers.

Everybody agrees that the current widely deployed GPON is hitting a technology wall. That technology delivers 2.4 Gbps downstream and 1 Gbps upstream for up to 32 customers, although most networks are configured to serve 16 customers at most. This is still an adequate amount of bandwidth today for residential customers. However, many ISPs already use something different for larger business customers that demand more bandwidth than a PON can deliver.

The 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 of 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 almost always 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 and the key issue 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 seems to be touting the technology, but there is some doubt if they alone can drag the rest of the industry along. 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 big 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 is uses a fixed laser which is far less complex and costly. Unlike Verizon, these two companies are building a lot more FTTH networks than Verizon.

While all of this technology is being discussed, ISPs today are already delivering 10 Gbps data pipes to customers using active Ethernet (AON) 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—one at the core and one at the customer site—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 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 in terms of the study is that we chose to not consider NG-PON2. Today the technology is too expensive, and if it’s never accepted widely in the industry it might not be supported by vendors. Instead the study uses active Ethernet which is capable of delivering up to 10 Gbps, with options available to go faster for larger customers.

D. Other Engineering Issues

Permitting

Our engineering design estimates 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 as 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. Note that the cost of permitting is included in our estimate of engineering costs. The city will require a minimum $50,000 CUP deposit, (or equivalent in projected city project costs), against which city employee time will be reviewed. A private sector or City initiated project would go through the City’s development review process. This is an extensive process that would be difficult to estimate and we have included more to cover these costs. There will also be various permits for building sites, ROW use, encroachment, etc. Again, these are only costs required by the city and costs to file and prepare documentation are covered by the engineering fees.

Table 9 – Permitting Costs

Permitting Costs	Cost	Quantity	Subtotal
Crossing Permits			
Railroad Crossings	$ 4,000.00	4	$ 16,000.00
State Highway	$ 1,000.00	2	$ 2,000.00
Interstate	$ 1,000.00	2	$ 2,000.00
County Highway	$ 400.00	8	$ 3,200.00
City Permitting	$ 150,000.00	1	$ 150,000.00
		Total	**$ 173,200.00**

Engineering Costs

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 city of Davis 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 12–16 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 2-year construction period with a crew of 5 inspectors, 1 supervisor, and 1 office/support person, with inspectors having ability to complete inspections for 8-10 boring crews working at the same time. 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.
6. All labor rates are based on Finley Engineering's standard rate sheet and adjusted for California prevailing wage requirements.

These are all assumptions that would need to be verified with the project owner and the city of Davis. The amount of personnel required could also change depending on the contractor or contractors that take on this project and the amount of personnel required for construction management to oversee the completion of the network buildout. Below is breakdown and estimate of these costs.

Table 10 – Engineering Costs

Engineering Costs	
Description	**Cost**
Project Coordination and Preliminary Meetings	
Project Review, Planning and Kickoff with City of Davis	$ 9,585
Overall Project Coordination	$ 406,380
Contingency, Reimbursables	$ 41,597
Subtotal	**$ 457,562**
FTTP Equipment Engineering	
Review of Requirements	$ 7,310
Prepare Plans and Specifications for Access Equipment	$ 30,840
Prepare Plans and Specifications for Switches and Routers	$ 33,720
Prepare Plans and Specifications for Power Equipment	$ 20,140
Prepare Plans and Specifications for Remote Equipment Huts/Buildings	$ 51,400
Prepare Plans and Specifications for Fiber Terminations and Management	$ 20,428
Equipment Installation and Integration Oversight	$ 129,150
Final Review and As Built Documentation	$ 31,440
Contingency, Reimbursables	$ 32,443
Subtotal	**$ 356,871**
Outside Plant Design Services	
Project Review, Planning and Kickoff with City of Davis	$ 11,280
Prepare Overall Design and Budget (Remaining 200 Miles)	$ 54,280
Buried and Underground Field Detailing Services (245 Miles)	$ 1,329,600
Prepare Construction Drawings	$ 871,200
Prepare Permits	$ 253,350
Traffic Control Plans	$ 388,200
Easement and Land Services Assistance	$ 61,475
MDU ISP Design	$ 333,500
Prepare OSP Plans and Specifications, Bid Project	$ 51,920
Contingency, Reimbursables	$ 335,481
Subtotal	**$ 3,690,286**
Outside Plant Construction Management	
Resident Construction Observation Manager	$ 892,500
Resident Construction Observation Assistant Manager	$ 728,250
Resident Construction Observer	$ 670,650
Resident Construction Observer	$ 670,650
Resident Construction Observer	$ 670,650
Resident Construction Observer	$ 670,650
Administrative Assistant	$ 269,200
Pre-Construction Meeting	$ 12,280
Review Test Results	$ 89,400
Plant Records	$ 260,400
Final Documents	$ 67,200
Contingency, Reimbursables	$ 500,183
Subtotal	**$ 5,502,013**
Grand Total	**$ 10,006,731**

III. Financial Business Plan Analysis

This section of the report examines the financial aspect of bringing a fiber business to Davis.

A. Studies Considered

We considered the following three major business plan scenarios.

- Retail Model - City with One ISP Partner: Since it is clear that the city doesn't want to be a retail ISP, we created the base scenario to reflect the city partnering with one ISP to operate the network and to run the retail business to sell directly to customers. We consider this scenario as the base study because if this scenario doesn't generate enough profits to be financially self-sustaining then the other scenarios below cannot succeed. It's important to understand how profitable an ISP business would be in the city operated by one provider before considering other options such as partnerships or an open-access network.

- Open Access: This scenario would open up the market to multiple ISPs, which would provide retail products to customers. Under this scenario the city's only source of revenue is from providing wholesale connections to ISPs to use the network.

- Public Private Partnership: In a public/private partnership (PPP) the city would find a partner that is willing to fund some portion of the cost of serving customers. There are almost endless variations on this concept, but we chose the most common such relationship where the city would provide the fiber networks and electronics and the partner would cover all costs inside the customer locations plus any costs for providing the triple play services. The partner would also assume all costs of operating the business.

We also looked at variations on the above studies in what we label a sensitivity analysis. We looked at how changing some of the major variables in the business plans would change the financial results. We considered the following variations:

- Providing Public Financing. We looked at how the business plan would be improved by introducing some other form of public financing into the funding process. This could be sources like sales taxes or property parcel taxes. Using public financing would reduce the direct bond debt for the fiber project and provide an easier opportunity for the fiber business to thrive.

- 100% Coverage. Per the city's request we examined a scenario where the fiber network would be extended to everybody in the city and not just those residents and businesses that elect to buy services from the network.

- Different Fiber Technology. The basic network design used active Ethernet (AON) technology. We also looked to see how using passive optical technology (PON) would affect the study results.

- Customer Penetration Rates. At this early stage there is no way to know how many customers in the city might elect to buy services from a fiber network. So we varied the predicted number of customers to understand how that affected the projected financial performance.

The original goal of these studies was to determine the minimum penetration rate that would be required for the business to break even. If the financial models looked feasible using only bond funding we would have been able to calculate the amount of revenue (and customers) needed for the fiber business to be self-sufficient under each scenario.

However, none of the scenarios produced results where bond funding alone would be able to support the network. The expected revenues from the fiber business are not nearly high enough to cover financing costs for the bonds, meaning that the fiber business would need a significant subsidy from the City to make bond payments. Instead, it looks like the city would have to fund at least some portion of the network with some other kind of tax revenue. Because of that we cannot calculate a breakeven penetration rate. The question to now ask is how much tax revenue would be required to support a given customer penetration rate and we have made that calculation for a 50% customer penetration. The same calculation could be made for each model at other levels of customer penetration.

This is why one of our primary recommendations is for the city to next consider a residential survey if it is considering moving forward. It's vital to understand the community interest in a fiber network before having any meaningful discussion of how much tax revenue might be needed to support a given scenario.

- General Obligation Bonds. Our base assumption is that the city would try to finance a fiber project using revenue bonds. These are bonds that only have recourse to the revenues of the fiber business and which would have no claim against city tax revenues should the project not generate enough revenue. However, general obligation bonds, which are backed by tax revenues are less costly, so we looked at the difference in performance using both types of bonds.

- Interest Rates. Another important variable in financing a fiber network is the interest rate paid on bonds. The city has not floated a major bond project of this magnitude for a long time, meaning it's hard to know the specific bond rate that the city might be able to borrow at. Due to this, we looked to see how changing the interest rates affected financial results.

- Changing Customer Retail Rates. In the retail scenario we looked to see how the projected results changed by using different retail broadband rates.

- Number of MDUs on the Network. One of the biggest unknowns in this study was estimating the number of MDUs (multiple dwelling units, or apartments and condominiums) that might use the fiber network. We looked at the impact of varying these assumptions.

- No Cable TV. We looked to see the impact on financial performance if there was no cable TV product offered in the retail scenario.

B. Services Considered

The RFP required that our network should consider a list of different products that could be offered over a fiber network. Following is a discussion of the products listed in the RFP as well as a few others that we considered.

Internet Based Live Television (IPTV)

The feasibility studies assume that the retail provider in the market will provide a TV product.

IPTV is a specific TV delivery technology that transmits only those channels that a customer is watching. The closest analogy to this would be to compare it to the way that Netflix sends programming over the Internet—they only send you the show you are watching. IPTV is far more bandwidth efficient than traditional television transmitted over a cable TV network. A cable network sends all channels to a customer, using a large amount of bandwidth, and the settop box then selects the channels a customer wants to watch from the larger video stream.

While traditional television can use as much as a dedicated gigabit of data speed to each customer on the network, IPTV sends individual video streams that vary between 1 and 4 Mbps depending upon the level of compression for any given channel (action movies and sports use more bandwidth than 'talking head' news shows).

The feasibility study made the assumption that the new fiber network would buy cable TV programming from a headend located outside of Davis. A fully functional IPTV headend (the electronics needed to receive signal from satellites and transmit to customers) including all the needed bells and whistles can cost as much as $4.5 million, and we no longer see clients installing new headends unless they expect to eventually get 20,000 or more video customers.

There are several ways to obtain wholesale cable TV. First, there are several vendors that sell this as a product. A more common approach would be to share a headend with some other cable headend owner in the region. Sharing a cable TV headend requires leasing a large data pipe, in the range of 10 Gbps, to connect from the new network to the remote headend. This cost is far less expensive over time than building a new headend.

The studies assumed in the retail scenario that the city (or a partner ISP) would share a remote headend.

Traditional Broadcast Live Television (RF Video)

As just mentioned, a traditional network provided by the cable companies uses a technology that sends all TV channels to a customer. The settop box at a customer's TV then selects the desired channel out of the full lineup that has been transmitted to the home.

Traditionally these systems were called RF video, meaning that some or all of the channels were transmitted as analog signals. That means raw signals that are not compressed or otherwise manipulated and are send to the customer in the same format as received from satellites. Today most cable company networks have converted all programming to a digital format. This has been done to fit more channels into an existing slot on the cable network. For example, a common compression technique can fit six digital channels into the same bandwidth that was used to transmit one analog channel.

In our study we decided to not consider traditional cable TV transmission due to the costs. There was a time in the past when channels could be sent in an analog format, meaning that customers didn't need a settop box to watch TV. But today most programming comes from the satellites in digital format and it is expensive to try to convert it back into an analog format. Since all of the major video providers, both cable companies and telcos now use digital formats it would be challenging to try to construct a traditional analog TV offering.

Another reason we didn't include traditional cable TV is cost. Traditional cable TV requires a standalone 1 Gigabit of bandwidth path to each customer. The PON (Passive Optical Network) technology can accommodate a traditional cable TV signal by providing the separate 1 Gbps path just for the TV signal. But the electronics required to carry the signal in this manner adds about $400 in electronics cost to every customer that wants TV. That cost includes a more expensive ONT (customer terminal) as well as electronics at each neighborhood hut that is used to place the cable signal on the path to customers. When considering the slim margins on cable TV, and the relatively small number of cable customers that might be on the network this seems like an unreasonable added cost.

Video on Demand (VOD)

Video on Demand is a cable TV product that allows customers to watch TV on a delayed time basis. This is a standard product on most cable systems and most of the major cable networks offer at least some of their programming on a delayed basis. For instance, if you are an HBO subscriber then you can watch live programming, but they also have a massive line-up of older programming available to customers using VoD.

Delayed viewing is extremely popular and Nielsen, the company that tracks TV viewing says that around 25% of all traditional TV content is watched on a time-delayed basis. Much of the delayed viewing today is done using settop boxes that record content to watch later. Most video providers now offer 'cloud DVR' (which is an updated term that also is nearly the same as VoD) where customers can watch shows on a delayed basis and where the video content is stored at servers at the headend. The study assumes that any cable TV product you buy wholesale will include the normal industry VOD content. It would also be possible for the city to create your own library of VoD content. This could be any local programming you think the community might like that could include videos of government meetings, content created by the schools and the University and almost any local content imaginable.

Another related product that would be a standard feature with any TV offering is TV everywhere. This is the generic term used to describe the ability to watch content on devices other than a television. Programming networks today make some (but not all) of their content available for paying subscribers to watch on PCs, tablets, smartphones and other devices. This feature ought to be included in any video offering you establish.

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 now for a few decades. The first major seller of VoIP was Vonage which still today delivers VoIP over 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.

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 a number of studies that it’s hard to justify buying a switch and paying for interconnection costs unless a service provider expects to serve at least 4,000 telephone customers.

However, landline telephone continues to drop in popularity as a product and nationwide only about 45% of households still have a landline. We would expect in a college town for that percentage to be much smaller. If the city ever got enough voice customers and thought you could retain them, then a voice switch could be introduced in the future as a cost savings.

The only other reason an ISP might want to own a voice switch is to use it to directly serve complex business customers. For example, the telephone services required for a business as complex as a large hospital or for the University are more complex than the wholesale VoIP products available. We’ve found that most large complex businesses of this type own their own voice switch, called a PBX, and don’t buy complex voice products from the local ISP or telco.

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 that CCG knows have backed out of most or all of these business lines. None of these functions are really 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 with 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 mess up the ISP functions.

The feasibility studies assume these functions are largely 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.

Bandwidth on Demand (BOD)

A decade ago this was a major product line for some ISPs, particularly those that served customers that required large bandwidth. ISPs created numerous mechanisms that allowed customers to get the bandwidth they needed.

For example, a common product was a burstable product. A customer would pay for a fixed amount of data speed, but then pay extra if they ever exceeded the base allotment. Another product was more properly called bandwidth on demand because ISPs gave customers the ability to change their data speeds to fit their needs. Businesses that had periodic needs for more bandwidth would upgrade bandwidth as needed and then change back to a less expensive data product. There were also managed bandwidth products where a customer, like a school system, could shuttle a fixed amount of bandwidth to specific schools or classrooms as needed.

Nevertheless, these kinds of products have largely disappeared due in part to the fact that big bandwidth has gotten a lot less expensive, but also due to the technologies used in networks. For example, it's much easier today for a school network to manage bandwidth than it was ten years ago. We also see less demand today for burst products where customers only need big bandwidth a few times per month. That was done when computers still largely did things using batch processing and a factory might send all of its records to corporate headquarters once per week or once per month. Today, with faster data speeds, these kinds of backups and transmittals are usually done continuously, or done at slow times like at night, meaning there are few giant batch processing events. However, they can still occur. We have one client that serves oil fields that occasionally have huge data transmissions when they are running seismic tests searching for new oil. We have another client that houses a Hollywood animation studio that periodically ships terabit-sized files of raw uncompressed video to other sites.

There is nothing to stop an ISP from working with a few large customers with such needs. In a university town there are likely to be some occasional huge data needs. Nevertheless, in current networks an ISP can change a customer’s speeds within minutes if needed, up to the bandwidth limitations of the customer electronics. Still, there is not enough of a demand for this kind of product to predict a revenue stream for it.

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

Subsequent to the RFP it was expressed to Finley Engineering that the city preferred a network that had the capacity to provide any customer with a gigabit of speed. This is not to say that the city expects an ISP to only sell gigabit broadband, but rather than any customer or any part of the network should be configured to allow for gigabit speeds. It was that requirement, for example, that influenced Finley to settle on an active Ethernet (AON) electronics design.

Supervisory Control and Data Acquisition (SCADA) / Smart Grid

SCADA is a monitoring network that is used in electric and water networks. The SCADA system collects data from various nodes in the network and also monitors for system outages and other problems. SCADA requires a data network and most utilities choose for security reasons to have much of their SCADA system private and separate from other kinds of networks.

A newer version of the technology is referred to as smart grid. The simplest definition of smart grid is that it extends the SCADA alarm and monitoring processes to the customer premise and not just to neighborhood nodes.

There are numerous advantages of a smart grid network. For example, monitoring at the home allows an electric utility to do real-time meter reading which might allow for billing different electric rates at different times of the day to reflect the cost of power or to promote energy savings. One of the biggest savings cited by smart grids is the quick responses that can be made to outages since the electric company often knows the exact location of a problem due to feedback from smart grid monitors.

Smart grid technology began to be implemented during the last decade. When the concept was first suggested there was major industry debate about whether a smart grid network needs to be wired or wireless. Over the last decade the debate has largely been resolved in favor of using wireless technologies.

This is not to say that there is no benefit to smart grid from having a fiber network. A ubiquitous fiber network will provide the best access and deployment to a wireless smart grid deployment.

But it’s difficult to estimate any specific revenue stream coming directly from a smart grid deployment. The city might consider a smart grid deployment for the water system as part of a larger smart city deployment. It’s impossible to predict the long-term intentions for smart grid by Pacific Gas and Electric, the power utility in the city. The financial analysis doesn’t predict any smart grid revenues, but this doesn’t mean that they might not exist someday.

Other Future Products

Today most broadband network providers offer some variation of the triple play products of telephone, cable TV, and broadband. In addition to these, ISPs are now expanding their product lines to make up for the shrinking number of customers they are experiencing with both landline telephones and cable TV.

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 recently begun testing a cellular product and announced that they already have 200,000 customers. Comcast also recently announced that they will start bundling solar panels with their other products.

We find it likely that any ISP operating a fiber network in Davis 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 including virtual reality and holograms.

It's impossible to build a business case for products that have yet to be developed, yet it's also fairly easy to believe that any sizable ISP will offer new products over time. Thus our business plans incorporated a generic revenue for 'new products' which is undefined. The assumptions used will be described under the revenue assumptions below.

Wholesale Broadband

A fiber network the size of the one in Davis will almost certainly sell wholesale bandwidth to telecom companies, government organizations, and large businesses. Today broadband for large businesses and for businesses with a nationwide footprint is largely provided by a small number of telephone companies, cable companies, or CLECs (competitive telephone companies). For example, it's likely that the one ISP provider will serve all of the nationwide branches of a hotel chain or a large bank. These service providers don't own network everywhere and want to buy broadband access from a local network.

There are also other typical wholesale broadband customers in most markets. There may be an opportunity to provide bandwidth to cellular towers, although in Davis these are likely to already all be connected to fiber. There may more future opportunity to sell bandwidth to 5G wireless networks since they are supposedly going to rely on small neighborhood transmitters mounted on poles or buildings rather than just the giant tall cellular towers in use today. There are also often opportunities to sell bandwidth to connect schools together or to connect government locations together. Moreover, in the case of Davis it's likely that the University could be a customer for wholesale bandwidth to connect remote student housing and other off-campus locations back to the University network.

Wholesale connections can be provided either with dark fiber (fiber that doesn't include electronics, which must be provided by the customer) or lit fiber, which is similar to the broadband products sold to other customers.

C. Business Plan Results

The underlying assumptions used to create the financial projections are included in Appendix V starting on page 143.

Financial Reports in the Forecasts

The financial forecasts were created to follow basic GAAP accounting. This means that intangible expenses like depreciation and amortization is applied to assets like bond financing costs. Each projection includes three standard financial reports—an income statement, a balance sheet, and a statement of cash flows. Each projection also includes balance sheet items such as accounts receivable and accounts payable in order to more accurately predict cash balances.

The models assume interest income on accumulated cash, earned at an interest rate of 1.5% annually. Over a long time-horizon that interest rate could vary. There is a general model assumption that cash is never paid out as dividends but always retained for the 25-year period. It is typical to show models that retain cash to make it easier to compare different scenarios. However, in real life cash is generally not retained in a business.

The summaries below introduce a few new terms:

- Positive Net Income: This is when the books of a business show a positive profit. This is the standard way that commercial companies define a profit. A positive net income shows that the business is covering operating expenses as well as interest, depreciation, amortization, and taxes. Net income does not consider repayment of debt principle and annual operating capital. Still, this is an important milestone for a new business, because it measures when a commercial business is profitable for accounting purposes. Just note that it is possible to have a positive net income and still not have enough cash to operate the business.
- Debt Breakeven: This is when the business has generated enough excess cash that the remaining debt could be fully paid-off and retired.

The best way to measure profitability differs according to the structure of the business. A municipal business, for example, typically defines financial success by generating enough cash to operate the business without any external subsidy. However, a for-profit business would generally use a measurement like net income to measure profits, which is similar to the IRS definition of profitability.

It is vital that any business always have cash in the bank to meet its obligations. The business plans were built with a goal of trying to always have some reasonable level of operating cash to provide a cushion against nonlinear expenditures. A cash cushion is needed since not all expenditures are spent evenly throughout the year and so a business needs to have a cash reserve to allow for those times of the year when the expenses are higher than normal or the revenues are lower than normal. For example, in a Davis ISP it might be expected that revenues would be smaller in the summer when many of the students are gone.

Results with One ISP Partner

These are the results for the scenario where the city builds the network and then partners with one ISP to operate it. The results are shown for three different levels of customer penetration.

	40% Penetration	50% Penetration	60% Penetration
Asset Costs	$102.5 M	$106.7 M	$111.0 M
Cost per Passing	$5,165	$5,377	$5,593
Bond Debt	$130.6 M	$136.0 M	$141.4 M
Penetration Rates	40%	50%	60%
Years Until Positive Net Income	Never	Year 17	Year 13
Years Until Cash Covers Debt	Never	Never	Never
Cash After 25 Years	($81.4 M)	($53.9 M)	($34.1 M)

It’s obvious from this summary that this scenario does not generate enough revenue to cover the costs of operating the business.

It’s also obvious that the business performs better with more customers. The losses per year at a 60% penetration ($1.4 million per year) are significant smaller than at a 40% customer penetration ($3.3 million per year). One of the findings of this report will suggest that the city conduct surveys to better understand the potential customer penetration rates.

The long number of years for these scenarios to reach a positive net income is also telling. A fiber venture that is self-sustaining will generally reach a positive net income 4 to 5 years after launch.

In looking deeper at the numbers there are a few reasons for this poor financial performance. The primary issue is the cost of the fiber network. The city has 19,845 passings. This number of passings counts each MDU building as a passing. The calculated cost per passing varies between $5,165 and $5,593 depending upon the number of MDUs that we predict will be added to the fiber network (note that landlords don’t have to allow a connection to a city fiber network and ones that already have fiber might not connect to a new network). The industry target goal is roughly $1,000 less than these costs.

What are the factors that are making the cost per passing so high in Davis? There are several:

- It looks like the entire network must be buried and must be bored. That is the most expensive type of fiber construction. In a lot of cities some decent portion of a fiber network can be put onto poles, which is usually significantly less costly. However, using the poles in Davis looks to be too challenging, and even if they could be used would not likely result in much of a decrease in cost.

- The layout of the streets means that much of the city needs fiber on both sides of the street. This is a case where the density in the city adds costs. It's easy to assume that the denser a fiber network the better. It's certainly cheaper per passing to build in a suburb than in a rural area because of the number of customers per mile of fiber. However, much of Davis is as dense as major metropolitan areas and this adds to the cost of the construction. At some point density becomes more expensive. Higher density means needing a lot more access points to the fiber. And in the case of Davis, it means that it requires fibers up both sides of densely populated neighborhoods since that is still less costly than constantly crisscrossing the street from a fiber built on only one side of the street.
- Another significant factor is the fact that any municipal fiber network in California must pay prevailing wages for the construction crews. Without debating the social benefits of this policy it's important to recognize that it adds significant extra costs to the fiber construction. CCG and Finley work in numerous other cities across the country where we see far lower costs to build fiber.
- The high network cost then leads to high debt costs. For example, in the 50% penetration forecast the annual cost of debt service is almost $8.3 million per year. Total revenues of the business reach approximately $14 million per year, and that is not high enough to cover this much debt.

Retail Model Partially Funded by Tax or Other Financing

Since none of the scenarios is self-sustaining with 100% debt financing, we next looked to see how the fiber projections would change if there was an assumption that some of the financing came from some source other than bond debt. This was a scenario that the Broadband Task Force has asked that we consider, even before knowing the results.

Other funding could include funding from other government revenues such as a sales tax or property tax. It could also mean cash infusions from grants or other sources. Sources of financing will be discussed in more detail in Section III.G of the report. A short description of this concept might mean, for example, that the city raises the sales tax for a few years to pay for part of the fiber network. This would require a general obligation bond to monetize the sales tax revenues up front to build the fiber network. The fiber business would then only have to cover the cost of the bonds that are financed directly for the fiber project. This is not an unusual business model and many communities have done this or are considering this.

In each case we calculated the amount of other financing that is needed for each of the above scenarios to reach breakeven. In this case breakeven is defined as a financial projection that always has enough cash on hand to operate the business.

One of the key assumptions in this analysis is that the external funding would be brought into the business first. As an example, this means that a bond based upon something like sales taxes would be used to begin the launch of the business. That bond would get the construction process underway. Then, perhaps a year later the fiber revenue bonds would be sold, to be used when the proceeds from the first bond are exhausted. This delay saves paying interest on the second bond for a year, which is a major financial benefit to the business plan. If both bonds were raised simultaneously then the amount of borrowing would be higher than shown here.

	40% Penetration	50% Penetration	60% Penetration
Asset Costs	$102.5 M	$106.7 M	$111.0 M
Tax or Other Financing	$54.2 M	$36.5 M	$33.0 M
Bond Debt	$59.7 M	$83.1 M	$91.6 M
Penetration Rates	40%	50%	60%
Years Until Positive Net Income	Year 13	Year 13	Year 6
Years Until Cash Covers Debt	Year 21	Year 21	Year 20
Cash After 25 Years	$15.0 M	$23.8 M	$37.3 M

The results show that the anticipated customer penetration rates are still a critical factor in getting a network built. The higher the customer penetration rate, the greater amount of the project that can be supported by fiber revenue bonds. As mentioned earlier, it's going to be vital to both understand the potential customer penetration rates and also to get community buy-in to consider this kind of financing.

The analysis also shows that a significant amount of other revenues is going to be needed to build and operate a retail fiber network. At an anticipated 40% customer penetration rate nearly half of the cost of the project would need to be supported by another revenue source than the fiber project. At a 60% anticipated customer penetration rate that reduces to just over one-fourth of the cost of the project, but that is still a significant amount of external funding required.

Each of these scenarios generates excess cash by end of the 25-year study period. Each of the scenarios is a breakeven scenario, meaning that if the funding was any lower the business would run out of cash somewhere in the first few years of the business. That means that with creative financing the amount of each of the sources of funding could be done a little differently. However, in these projections we used only straight-line bond assumptions, meaning that it was assumed that the bonds would be repaid in the same manner as a home mortgage. Nevertheless, there are creative ways to structure bonds that might be used to slightly reduce the amounts that must be borrowed.

'Reasonable Case' Scenario

We did a variation on the one-provider model that is based upon using somewhat less conservative assumptions. The big change in these scenarios was eliminating the construction contingency. The purpose of these studies is to get a glimpse at what can happen if the business does better than expected in the conservative base studies.

These study results come with a warning of caution. It will be tempting to use these scenarios to justify getting into the fiber business. For now, at this feasibility stage of the study process that would be premature. But with more research the city should be able to pin down the cost of building the network, and that will hopefully be less than what we've used in the base study. But the base studies show better results mostly as a result of eliminating the construction contingency, and that could be lower than the ultimate cost of building the network.

Further, the companies that sell bonds will push the city to borrow enough money to cover a conservative business plan. The odd nature of bond financing compared to other kinds of financing is that 100% of the money must be borrowed up-front in a lump sum. There are usually serious consequences if the initial borrowing is not enough to complete the network and it's not always easy or feasible for a city to get a second round of financing if funds are short. So the natural inclination of bond sellers (who must sell the bond offering to investors) is to be conservative and make sure that they've raised enough money to complete the project.

We looked at several scenarios for the 'reasonable case' based upon looking at different levels of broadband rate increases, as follows:

- The first version has no rate increases.
- The second version keeps rates the same for the first three years and then has annual rate increases of 50 cents.
- The third version holds rates steady for ten years and then has annual rate increases of 50 cents.

Since the 'reasonable case' scenario assumed lower asset costs we were also able to change the amount of funding that was needed from some other tax source, as appropriate for each scenario.

The 'reasonable case' is best compared to the base study with a 50% market penetration (same penetration rate used in the 'reasonable case'.

Following are the results of the 'reasonable case' scenario compared to the original base case with a 50% customer penetration.

	50% Penetration	Reasonable Case @ 50%
Asset Costs	$106.7 M	$97.3 M
Tax or Other Financing	$37.0 M	$24.0 M
Bond Debt	$86.0 M	$89.1 M
Total Financing		
Penetration Rates	50%	50%
Years Until Positive Net Income	Year 13	Year 13
Years Until Cash Covers Debt	Year 25	Year 24
Cash After 25 Years	$4.4 M	$11.0 M

The impact of using less conservative assumptions is dramatic. While requiring roughly the same amount of bond financing the requirement for external tax funding drops from $37 M to $24 M.

We also looked to see the impact of increasing customer broadband rates over time. In the sensitivity we quantify the impact of raising rates by $5. But here the scenarios contemplate annual small rate increases. As discussed earlier, there is no real way of knowing if rates can be increased in this manner. And even if rates can be increased, the city might decide not to raise rates in order to keep rates affordable in the community. These scenarios ask the interesting policy question – if Comcast raises rates over time would the city do the same? It's not an easy answer. The purpose of these scenarios is to understand how rate increases can affect the financial performance of a fiber business, and is not a recommendation to raise rates.

Again, the delayed rate increases represent maintaining the original rates for 10 years and then raising broadband rates 50 cents per month each year after that. The annual rate increase scenario raises rates starting in the fourth year. To put these rate increase into perspective, in the delayed rate increase scenario, the starting lowest-price broadband product increases from $45 per month at the launch of the business to $52.50 at the end of 25 years. In the annual rate increase scenario that initial rate increases to $56.00.

	Reasonable Base	Delayed Rate Increases	Annual Rate Increases
Asset Costs	$97.3 M	$97.3 M	$97.3 M
Tax or Other Financing	$24.0 M	$24.0 M	$24.0 M
Bond Debt	$89.1 M	$89.1 M	$89.1 M
Penetration Rates	50%	50%	50%
Years Until Positive Net Income	Year 13	Year 13	Year 13
Years Until Cash Covers Debt	Year 24	Year 23	Year 22
Cash After 25 Years	$11.0 M	$18.9 M	$25.6 M

This shows that the impact of slow and steady rate increases can be dramatic. Raising rates by only 50 cents per month starting after the end of the network build-out increases cash by year 25 by $14.5 M. Even waiting ten years to increase rates modestly increases year 25 cash by $7.9 M.

Wholesale Network—Open Access

In this scenario the city would build fiber everywhere and would then invite multiple ISPs to provide services over the network. In the industry this is referred to as an open-access network.

In this scenario the city would provide the fiber network everywhere in the city and would also provide the fiber drop and the ONT (the fiber electronics at the customer). The city would not provide any of the electronics needed to provide the triple play or any other services. The city would have a minimal staff that would operate and maintain the network. There would be no customer service representatives or any of the employees needed to interface with customers, since those functions would be provided by the ISPs.

	40% Penetration	50% Penetration	60% Penetration
Asset Costs	$91.3 M	$92.9 M	$94.6 M
Bond Debt	$116.3 M	$118.4 M	$120.5 M

Penetration Rates	40%	50%	60%
Years Until Positive Net Income	Never	Never	Never
Years Until Cash Covers Debt	Never	Never	Never
Cash After 25 Years	($128.5 M)	($114.1 M)	($102.3 M)

This analysis shows gigantic losses for the open-access scenario. There are two primary reasons for the size of the losses, over and above the issues defined earlier about the overall high cost of the network.

First, in looking at the experience of all of the existing open-access networks in the country it's obvious that the rate of customer acquisition of a fiber network is far smaller than with a retail network. In a retail scenario the company building the network is highly motivated to market to customers early and to get them onto the network as quickly as possible. In fact, today most fiber overbuilders pre-sell to customers so that they can connect customers as the network is constructed. Those early revenues contribute significantly towards making the network a financial success.

Yet for a variety of reasons the ISPs that operate on an open-access network go much slower. Part of this is due to the fact that they are not under financial pressure to make debt payments like the network owner. However, the primary reason seems to be that most of the small ISPs operating on open-access networks are tiny companies. They generally don't have the money available for widespread advertising and so they grow more organically through word of mouth.

It's certainly possible that over a long enough time period that an open-access network will get as many customers as a retail network; that has not been the case on any of the larger open-access networks in places like Provo, Utah; Tacoma, Washington; Chelan County, Washington; and Grant County, Washington. Those networks have seen not only slow customer growth over the years, but none of them has as many customers as similarly sized municipal retail networks.

There are other reasons the ISPs don't do as well in aggregate as a direct retail provider. Many of the ISPs only sell to niche markets. Perhaps they only want to sell to business customers, or they might be happy to only offer a high-priced product with high margins and are happy with a small number of customers.

In any event, this slow expected rollout on an open-access network limits the amount of capital that can be funded by the bonds. By law bond funds must be used within 5 years, meaning that customer growth after that time must be funded from customer revenues.

Nevertheless, there is a much more fundamental reason why these results are not as good as the retail scenarios above. The city has to borrow almost as much money for the open-access network as for the retail network, but there are far smaller revenues to pay for it. In an open-access environment the city would save some money by not being in the retail business. That means fewer needed employees and none of the expenses or assets required to support the triple play products, but the savings on expenses and assets are not nearly large enough to offset the huge difference in revenues. In the retail scenario discussed earlier, the scenario at a 50%

penetration grows to around $14 million per year in revenues by the sixth year with a corresponding $7 million of operating expenses. That results in an operating margin of $7 million per year. In the open-access environment the revenues in year 6 are only $3.5 million with operating expenses of $1.6 million. That leaves an operating margin of only $1.9 million which still is expected to cover almost as much debt payment as in the retail scenario.

This is the dilemma faced by every open-access network. Instead of having customer revenues that might average $120 per month they have wholesale open-access revenues that average $20 per month. Even though expenses are lower, the margins are massively smaller.

At CCG we have worked with or are knowledgeable about all of the major open-access network in the country. They all share this same issue in that they are generally able to generate revenues to cover operating expenses, but they don’t generate enough revenue to pay back the cost of building the network. That means that an open-access network would need to be heavily subsidized or funded from a source other than the fiber business.

Most of the open-access networks in the country are operated in cities that also have a municipal power utility. The ones that continue to operate have subsidized the network with electric rates, which is a subsidy that is not available to Davis.

Open-Access Model Partially Funded by Tax or Other Financing

The next scenario examined looked to see how much tax or other source of funding would be needed to make the open-access scenario viable. The following scenario looks at the breakeven scenario, meaning the amount of alternative funding needed for the open-access model to always have a positive cash flow.

	50% Penetration
Asset Costs	$92.9 M
Tax or Other Financing	$80.0 M
Bond Debt	$25.0 M
Penetration Rates	50%
Years Until Positive Net Income	Never
Years Until Cash Covers Debt	Year 25
Cash After 25 Years	$7.9 M

This shows that it would be possible to fund an open-access network if the city was willing to do mostly with a revenue source that was not supported by the fiber business.

From a policy perspective that seems like a huge price to pay to get competition. The primary benefit of an open-access network is that citizens can choose from more than one ISP. We wonder, though, if the public would be willing to pay a significant amount of money in sales or property taxes in order to get competition. Customers that elected to stay with an incumbent provider would not see much benefit from the competition, other than perhaps some price decreases for service.

Of the biggest concern would be MDUs, since apartment buildings don't automatically benefit from open access. For example, many MDU owners will still seek a bulk billing arrangement and their tenants would not get a choice of multiple ISPs. There are also physical limitations on MDU equal access and it would only be realistically available to buildings that were completely rewired with fiber. The technical solution to allow open access on technologies like G.Fast are not so clear.

Public/Private Partnership

Following are the base results of the PPP scenario, shown both from the perspective of the city and of the commercial partner. These numbers assume that the private commercial partner would guarantee bond payments and would also reimburse the city's capital expenditures after the end of the bond-financing period.

	City	Partner
Asset Costs	$102.3 M	$ 4.6 M
Bond Debt	$114.2 M	
Commercial Debt		$ 9.2 M
Equity		$ 2.3 M
Penetration Rates	50%	50%
Years Until Positive Net Income	Year 13	Never
Years Until Cash Covers Debt	Year 26	Never
Cash After 25 Years	($3.4 M)	($23.2 M)

The first thing to notice is that the losses from this scenario are smaller than the first scenario where the city partnered with ISP. The difference is due to the manner in which this scenario is funded. If the city is the operator then they must issue bonds sufficient to cover all assets plus losses during the start-up period. However, in this scenario the partner covers early operating costs. They cover some of those losses with equity (meaning no direct interest expense) plus with commercial loans taken for shorter time periods.

The net result of this is that the city's bonds are much smaller at $114.2 million in this scenario compared to $136 million when the city financed everything. The smaller bonds reduced annual bond debt payments by around $1.2 million per year and over 25 years accounts for the difference in the losses between these two scenarios.

That is not to imply that smaller losses would make this attractive to a commercial partner. It's always important to remember the difference in expectations between a municipal and commercial partner. The city would be happy with a scenario where they build a fiber network and get enough revenue to make the bond payments. In the scenario shown here the city still has a small loss over time, but probably an acceptable one.

But a commercial partner would not be happy just breaking even and in order for them to find this opportunity attractive they not only want to make a high return on their investment in the businesses, but they also want to be compensated for the management effort required to operate this business. While the losses here are smaller, it makes it is obvious that there is no real opportunity for the city to consider a public private partnership. That was actually obvious once it was clear that the first scenario with the city as the operator (with a partner) was not cash positive. A PPP only makes sense when the operating business can generate a profit after covering operating expenses, debt costs, and operating capital.

Public Private Partnership Partially Funded by Tax or Other Financing

It would be easier to find a commercial partner if the city could somehow guarantee that partner a profit. This scenario calculates the amount of tax-based or other funding that the city would have to use for both the city and the commercial partner to reach breakeven.

	City	Partner
Asset Costs	$102.3 M	$ 4.6 M
Bond Debt	$ 89.6 M	
Tax or Other Funding	$ 25.0 M	
Commercial Debt		$ 4.8 M
Equity		$ 1.2 M
Penetration Rates	50%	50%
Years Until Positive Net Income	Year 13	Year 5
Years Until Cash Covers Debt	Year 26	Year 9
Cash After 25 Years	$ 0.8 M	$ 8.8 M

This shows that if the city reduced the needed bonds by infusing $25 million of tax-based or other funding into the project then both the city and the partner would be cash-positive. I still don’t think that a commercial partner would tackle the project for an $8.8 million cash return over 25 years, so if this scenario was to be considered the city would have to infuse more tax revenue than shown here.

This particular scenario might be a hard sell to the public. They would be asked to pay more in property taxes or sales taxes to get a fiber network, but it would be operated by one new commercial partner that would likely charge similar prices to the incumbents already in the market.

Digital Divide Scenarios

The BATF asked for scenarios that provide fiber to everybody. These scenarios would borrow enough money up front to connect fiber to every home and to those MDUs that will allow the fiber network.

Digital Divide Scenario 1

This scenario adds a $10 broadband product onto the base business plan. We've made the assumption that an additional 22% of homes would be eligible to buy the subsidized broadband product.

Following compares this scenario to the base retail scenario above. There are two scenarios considered for funding—100% bond debt, and a mix of bond and tax revenue funding.

		Digital Divide Scenario 1	
	Base Retail Study	Bond Funding	Bond and Tax Funding
Asset Costs	$106.7 M	$115.2 M	$115.2 M
Bond Debt	$136.0 M	$146.7 M	$ 62.9 M
Tax or Other Funding			$ 62.9 M
Penetration Rates	50%	72%	72%
Years Until Positive Net Income	Year 17	Year 17	Year 13
Years Until Cash Covers Debt	Never	Never	Year 17
Cash After 25 Years	($53.9 M)	($60.6 M)	$ 46.1 M

These are interesting results. They show that adding a substantial number of subsidized households lowers the cash flow over 25 years by only $6.7 million.

Even more interesting is that the scenario is cash flow positive with 50% tax funding. This demonstrates that there is a scenario that can solve the digital divide in the community if there is a willingness to subsidize the effort through tax revenues.

Digital Divide Scenario 2

This scenario is more aggressive and lowers broadband rates across the board. This is close to the scenario contemplated by San Francisco. They have shown that adding a $25 per month 'utility fee' to households would provide a broadband connection to everybody, allow free broadband at a low speed to anybody that wants to have it, and provide lower-price broadband to every household.

This scenario assumes that a 100 Mbps connection would cost $20 and a gigabit connection would be priced at $50.

Following compares this scenario to the base retail scenario above. There are two scenarios considered for funding—100% bond debt, and a mix of bond and tax revenue funding.

		Digital Divide Scenario 1	
	Base Retail Study	Bond Funding	Bond and Tax Funding
Asset Costs	$106.7 M	$121.6 M	$121.6 M
Bond Debt	$136.0 M	$154.8 M	$ 43.0 M

Tax or Other Funding			$ 89.0 M
Penetration Rates	50%	90%	90%
Years Until Positive Net Income	Year 17	Never	Never
Years Until Cash Covers Debt	Never	Never	Year 25
Cash After 25 Years	($53.9 M)	($134.2 M)	$ 3.6 M

This shows that lowering the broadband prices across the board has a huge impact on cash flow and the losses over 25-year increase by over $80 million.

This also demonstrates that something like San Francisco's plan is possible. It shows that, given the assumed prices, the business could break even if funded by $43 M in bonds and $89 M in tax revenues. If this was 100% funded with tax revenues then the broadband prices could be set even lower.

The city foresees huge social benefits from this scenario since almost everybody in the city would benefit from the fiber network. The San Francisco study suggests that the amount paid in taxes should be largely offset by the reduced cost of broadband. This scenario would be a huge step towards eliminating the digital divide, although many homes would still need a computer or other Internet-capable device.

It seems like this concept could face a stiff legal challenge that would ask the courts to opine on whether a community could provide subsidized broadband and displace the incumbent providers. This has been done in some tiny communities such as Leverett, Massachusetts where there was no incumbent broadband provider, but no town of any size has tried this.

D. Sensitivity Analysis

Sensitivity analysis is the process of examining the impact on the financial performance of the business due to changes in the key variables that impact bottom line performance. In creating the business plans we probably made a thousand different assumptions, but only a small handful of these assumptions have a big impact on bottom line. Every assumption is important, but a few are more important than the rest. Since CCG has created many hundreds of similar business plans over the years we have come to understand which variables have the most impact.

The most important variable is the customer penetration rate and that was already examined in the above results. We looked at the following additional variables to see how changing each would change the projections:

- We looked at the impact of financing with general obligation bonds instead of revenue bonds.
- We looked at the impact of having to pay a higher interest rate on bonds.
- We looked at increasing customer broadband prices by $5 per customer per month.
- We looked at an assumption that fewer MDUs would want to connect to the network.
- We looked at the assumption that the business would not offer a cable TV product.
- We looked at the impact of using PON technology instead of active Ethernet.

We made all of the comparisons to the first scenario shown above which assumes that the city would operate the business with a vendor ISP partner, with a customer penetration rate of 50%. The purpose of the sensitivity analysis is to understand the incremental difference created by changing the key variables.

Following are the results of each sensitivity analysis compared back to that base case.

Financing with General Obligation Bonds

This scenario looks at the bottom line impact of using general obligation bonds. This scenario increased the customer penetration rates by 1% upward so that the penetration rates are: single-family homes at 41%, apartments and condominiums at 31%, and small businesses at 41%.

Effect of this Change

	Base Case	Revised Study
Bond Financing	$136.0 M	$126.2 M
Interest Rate	3.0%	3.0%
Debt Term	25 Years	25 Years
Positive Net Income	Year 17	Year 25
Debt Breakeven	Never	Never
Cash After 25 years	($53.9 M)	($53.4M)

This shows there is little practical difference between funding with general obligation bonds versus revenue bonds.

In this scenario the interest rate was kept the same between the two scenarios. For a city like Davis that has an AAA bond rating there would likely be a small interest rate difference between the two kinds of bonds. For cities with lower bond ratings that difference could be more significant.

The primary difference between general obligation and revenue bonds for a fiber project is that a revenue bond is almost certainly going to require surety in the form of a Debt Service Reserve Fund. This is money that would sit in escrow for the life of the bond and be used in the case the project couldn’t make that required payments. While that results in a smaller bond issue for the general obligation bond, that benefit is largely offset by the fact that the amount in escrow can earn interest income for the life of the bond.

Of course, the big difference between the two kinds of bond is that the taxpayers are on the hook with city tax revenues should a project financed with a general obligation bond fail to generate enough cash to make bond payments.

Paying a Higher Interest Rate

We looked at the impact of raising the interest rate by 100 basis points (one full percent).

Effect of this Change

	Base Case	Revised Study
Bond Financing	$136.0 M	$142.6 M
Interest Rate	3.0%	4.0%
Debt Term	25 Years	25 Years
Positive Net Income	Year 17	Year 23
Debt Breakeven	Never	Never
Cash After 25 years	($53.9 M)	($80.1M)

As would be expected, a higher interest rate means lower profits and cash. This shows that this business plan is very sensitive to a change in interest rates. Just a 1% increase in interest means borrowing an additional $6.6 million and also means that by the end of 25 years the cash generated drops by $26.2 million in order to cover higher debt payments.

We have enjoyed a lengthy period of low interest rates, but it’s always something to keep an eye on because higher interest rates can kill a fiber project.

Increasing Customer Prices

This scenario increases the monthly broadband prices by $5 for all data products for both residents and businesses.

Effect of this Change

	Base Case	Revised Study
Bond Financing	$136.0 M	$136.0 M
Interest Rate	3.0%	3.0%
Debt Term	25 Years	25 Years
Positive Net Income	Year 17	Year 13
Debt Breakeven	Never	Never
Cash After 25 years	($53.9 M)	($39.9M)

This shows that the prices charged is also one of the most important variables. Raising rates by $5 increases the cash over the 25 years by $20.0 million.

This provides a cautionary tale. One of the first things a new business will often do when getting started is to lower the prices compared to the business plan in an attempt to be more competitive and get more customers. The impact of lowering the prices temporarily for new customers, such as through an introductory special, would be minor. However, as this analysis shows, lowering the prices permanently can devastate the business plan. This also demonstrates the danger of getting into a price war with the competition.

Fewer Large MDUs

This scenario looks at how the business would change if the city expected to get fewer large MDUs. Davis has a much larger percentage of households in MDUs compared to most other cities of your size. Not only that, but most of the MDU housing units in the city are in large MDUs of 50 units or larger. This shows the impact of getting only half of those MDUs as assumed in the base case.

Effect of this Change

	Base Case	Revised Study
Bond Financing	$136.0 M	$132.3 M
Interest Rate	3.0%	3.0%
Debt Term	25 Years	25 Years
Positive Net Income	Year 17	Never
Debt Breakeven	Never	Never
Cash After 25 years	($53.9 M)	($73.9M)

This shows that serving (or not serving) the large MDUs is critical to the business plans. In this case, if the city expected to get fewer MDUs you would borrow a little less. However, the revenue drops from those MDUs would reduce the amount of cash generated by $20.0 million.

This speaks to two issues. First, it's mandatory that if the city were to build a fiber network that you get the large MDUs on board somehow before raising the money. This also is a cautionary tale about competition. Both Comcast and AT&T value the large MDU market and both either have already, or are likely to build fiber to serve them. Just as we were preparing the study one of the largest MDUs allowed AT&T fiber into their buildings.

No Cable TV

This scenario quantifies the impact of not offering cable TV. The two scenarios still compare a 50% overall customer penetration rate and doesn't try to quantify the lower number of customers that might be on the network if there wasn't a cable TV product available. Instead, it just measures the impact of losing the margin on cable TV. There is a small savings in capital costs since the business would have to buy settop boxes or insert local programming into the network. Mostly, dropping cable TV means losing both the revenues and the associated expenses needed to sell the product.

Effect of this Change

	Base Case	Revised Study
Bond Financing	$136.0 M	$134.4 M
Interest Rate	3.0%	3.0%
Debt Term	25 Years	25 Years
Positive Net Income	Year 17	Never

Debt Breakeven	Never	Never
Cash after 25 years	($53.9 M)	($57.2M)

This shows the margin impact of cable TV is minor and over 25 years dropping cable TV would only lower cash flow by $3.3 million. This affirms the industry belief that there is now little or no profit in the cable business.

However, most of the industry still think a cable is a needed product to maximize the number of customers. The impact on the business from not offering cable TV would be huge if the result of not having a cable product meant having significantly fewer customers on the new fiber network.[2]

Using PON instead of Active Ethernet

This scenario quantifies the impact of using PON technology instead of active Ethernet technology. This difference is entirely a difference in the cost of the core electronics needed for the two technologies.

Recall that the fiber network design was designed in such a way as to accommodate either technology. This was done by making room in the neighborhood huts for the PON splice cabinets, meaning that the fiber from a hut to the customer is a homerun configuration. Thus, the only change required for this scenario is to use PON core electronics instead of AON electronics. The ONT at the home can work on both technologies.

Effect of this Change

	Base Case	Revised Study
Bond Financing	$136.0 M	$133.3 M
Interest Rate	3.0%	3.0%
Debt Term	25 Years	25 Years
Positive Net Income	Year 17	Year 17
Debt Breakeven	Never	Never
Cash after 25 years	($53.9 M)	($49.5 M)

This change decreased capital costs by $2.1 M at a 50% customer penetration. This shows there would be an overall savings from using PON technology.

E. Summary of Financial Findings

Financial models are important and can tell us some key things about a potential business. The results show the big picture and show the relative amount of money needed to build and operate a fiber network in the city. The various options explored also show which variables are the most important and how changes in those assumptions impact the amount that needs to be funded and the eventual cash generated.

[2] See Page 94 discussing Comcast as a competitor.

A Few Words of Caution

Before discussion of the specific things learned from the various business plans, it's important to talk about a few things that always remain unknown until a business is formed. There is always a danger in quoting the numbers derived from the business plans, such as "it's going to take us X million dollars to get this done." As can be seen with the sensitivity analysis, changing a few major variables can greatly change the projected results. That means that a city would need to do a lot more research before launching a fiber business to better understand things like the likely customer penetration rates. The more that the sensitive variables can be defined, the lower the risk of the project. Consider the following issues that affect the accuracy of the forecasts and the risk of the business plans:

Customer Penetration Rates: These models show a range of customer penetration rates varied from 40% to 60%. There is no way to know at this early time what the customer interest in the network is likely to be. But obviously before building a network it's mandatory to understand potential customer demand. Residential customer demand is usually measured using statistically valid market surveys.

However, there is an added variable in Davis that makes it harder to understand the potential customer penetration rates over time—the large number of students in the community. While surveys might show you the interest from the current student population, that population turns over regularly and there is no way to predict if future students might see the same need for a home fiber connection while in college. For example, over the next 25 years the speeds for cellular service might improve enough that many students would find that to be a reasonable substitution for wire-based broadband.

We are often asked if there is not a similar way to understand potential business penetration rates. Unfortunately, we have never found a tool like a survey that works for the business market. Many of CCG's clients have undertaken business surveys and none found them to be effective – the results of the survey did not match the number of business customers that eventually connected to the network. This is for several reasons. First, the decision for a business to change telecom providers is not an easy one. We have found that business usually care more about reliability than price, and so they won't commit to moving their telecom service to a new network until they have assurance that the new network is reliable.

Further, a survey is only valid if the person responding is a decision maker. It does no good to ask the wrong person in the company if they would be interested in moving service to a new network. Many businesses don't even know who the decision maker will be until the opportunity to change providers arises. It may be that decisions are made by one person or by a committee.

This leads to a natural question of how one might justify building fiber to a business district. The good news is that network providers who have a stable and reliable network will get business customers as long as they have the right sales model. Almost universally sales of broadband and telecom to businesses is done using the consultative sales model. This involves meeting with a business several times. It means getting to understand their business enough to recommend the best solution for them – which might be quite different than what they buy today. Companies that listen to business customers and that craft a solution that best fits them will be successful in the market. We've seen this work many times.

<u>A Commercial Partner</u>: A few of the scenarios assume that the city would find a partner of some sort. The issue of finding a partner is complicated and any final models would need to be changed to meet the expectations of an actual partner. For example, the base study assumes that a nonprofit partner, somebody like Davis Gig, would operate the fiber network instead of the city. That sort of arrangement would lower the cash flow of the business since it would lower the allocated overheads that would hit the business if the employees were part of the city government. Before settling on a business plan that sort of arrangement would need to be negotiated and the models changed to reflect the results of the actual partnership.

<u>Actual Performance</u>: We can create business plans all day, but the actual way that a business is launched can have a huge impact on the ultimate success. To give an example, when Lafayette, Louisiana launched their fiber network they tried a new technology called IPTV to deliver cable TV. There were significant problems with the performance of the cable TV electronics and software and they didn't get nearly as many customers in the first few years as they had anticipated. The poor performance of the cable product hurt their brand name. They eventually got the cable working right and consequently over the years have grown to be financially successful, but their early start was far slower than their financial projections.

Sometimes success isn't due to anything in particular that a company does. Consider that Google is launching gigabit fiber networks all over the country. They offer the same products and prices everywhere. Nevertheless, they do better in some markets than others and this must be accredited to the local differences in each broadband market.

<u>There Are Always Risks</u>. If the city was to become the ISP or was to contribute a bond to a PPP then there is both financial and political risk. A lot of the risk can be mitigated by doing all of the needed homework and market research upfront to make sure that the market wants what the fiber network is selling. However, these are very long-term businesses and businesses can fail over time for many reasons. It's just as important up front to look at the downside of each business plan as it is the potential upsides. A city needs to make sure they are willing to accept the identified risks.

Even with all of these caveats there is a lot that can be concluded by examining the multiple financial business plan results we've created. We make the following observations from the analysis as follows:

Straight Bond Funding Will Not Work

Probably the most surprising result of the studies is seeing that straight bond funding will not work in Davis. There doesn't seem to be any reasonable scenario where the fiber business can support the amount of debt needed to build the network. There are various issues that make the network more expensive in Davis—the density of the city, the need to bury the whole network, and the large number of MDUs.

In the CCG proposal we proposed to calculate the breakeven for each scenario, in terms of how many customers a given business plan need to be cash self-sufficient. However, that turns out not to be possible when there aren't any cash-positive scenarios.

So instead we calculated how much tax revenues (meaning a bond financed by tax revenues of some sort) were needed to make each scenario work. The problem with that is there is no one single breakeven amount of needed tax revenue since that varies along with the assumed customer penetration rates. This makes it extremely important to understand the potential customer demand.

Funding with tax revenues will be a challenge. The desire for funding a fiber network from tax revenues would be competing against all of the other ways the city might use tax revenues. Getting fiber funding by tax revenues would undoubtedly require a major effort to educate the public and get community buy-in.

Performance in Large MDUs Matters

One of the key variables identified by the sensitivity analysis is how well a new fiber network might do in the MDU market, particularly with the largest MDUs.

That market is high risk because it's certain that both AT&T and Comcast have identified that same market as an important one. In fact, while this study was underway one of the larger MDUs in town got fiber from AT&T. If the incumbents believe that the city is going to build a fiber network the incumbents are likely to race you to that market before you ever get into business—and that might already be happening anyway.

Competition is a Risk

The risks associated with the project are covered in more detail in Section IV.D of the report. While Davis is like most cities in that the primary broadband provider is the cable company, everybody in the city has access to fast data speeds today at market rates (as defined nationally). There might be some MDUs without 100 Mbps speed, but everybody else has that available today from Comcast. Moreover, Comcast will be increasing speeds up to gigabit within a few years. Comcast is also a fierce competitor. While they have a bad reputation for customer service, they have a bundle of products that many households love. In cities with competition they are reported to have improved the customer service experience. In addition to the triple play the company already offers a full suite of home security and smart home products. They are just now getting into the cellular business and say they will offer low prices. They also just announced that they are going to start offering home solar power systems as part of the bundle. They are not going to be easy to compete with.

AT&T is quickly losing out on the single-family home market as their DSL product is eclipsed by the speeds available by Comcast. However, the company is currently in the process of building fiber to 14 million residential passings, which most are either greenfield new developments or large apartment complexes. You can expect them to compete fiercely in those markets.

In addition, there are several new technologies on the horizon that must be considered. These technologies are discussed in Section IV.D of the report. It's always hard to know which technologies might pan out. However, there is risk from 5G last mile connections that could deliver a high-speed radio signal to a home. This is different than 5G cellular and is best described as a wireless loop. Moreover, 5G cellular itself is also a threat, particularly in a college town where students might find faster cellular service to be an acceptable alternative to wire-based broadband. Then there are the wild cards like the low-orbit satellite network being discussed by Elon Musk that might be able to deliver 100 Mbps to a lot of customers.

Regulatory Risk

There is always a chance of regulatory changes that could affect the viability of a fiber business plan. For example, there have been several bills introduced into Congress that would preclude municipalities from building or operating retail fiber networks. These bills have not gotten traction, but there is always the risk that regulations will product adverse effects (but there is also always the possibility that regulatory changes could make things easier). At CCG we follow federal regulations closely and there are no specific proposed regulatory changes on the horizon that would materially impact the scenarios contemplated in this report.

Open Access Is Not Economically Viable

The analysis shows that an open-access network looks like a terrible investment. There is no customer penetration rate that could support open access and the cash losses are largest for this scenario.

Why 100% Bond Funding Doesn't Work for Davis

These results show that it is not going to be financially viable to create a fiber business in the city that is 100% funded with bond revenues. Following is a discussion of the factors that created this outcome.

Density. There is a maxim in the telecom industry that it's not economical to build fiber networks where the density is too low. This means that it is exceedingly difficult to build fiber networks in rural communities and farmland.

However, there is a corollary to that maxim in that there is a point where the density is too high and adds too much to the cost of a fiber network. This is the reason that you see the big fiber overbuilders like Verizon FiOS building in the suburbs of major cities but not in many of the areas in downtown cities. The density and other related factors—such as a network having to be 100% buried—drive up the cost in urban areas.

From a density perspective Davis looks more like a larger city. The city has grown by infilling buildings in all of the available space rather than sprawling like the majority of cities. While this density benefits the city in numerous ways, it works against building an affordable fiber network.

Why does high density add to the cost of building fiber? Here are a few examples. Normal fiber construction builds fiber on one side of a street with boring done underneath to reach the homes on the other side. With a high home density the cost of boring the crossings can be higher than the cost of building a fiber on both sides of the street. In Davis there are a lot of residential areas where the streets in the city are so heavily packed with homes that the lowest-cost solution is going to be to build fiber up both sides of the street. This means doubling the cost of fiber on those streets.

The cost is also increased when handholes are close together. Fiber is always built to a depth that makes it unlikely that the fiber will be cut by expected work in the right-of-way. In most cities that desired depth is at least 3 feet deep. The likely construction method in Davis is to use boring, which means digging a hole to insert a boring device which then bores a hole horizontally to get to the next needed handhole or access point to the fiber. Ideally, once a boring location has been created it's most efficient if the ensuing bore goes a reasonable distance away before the process has to be restarted again. In Davis the homes and the needed handholes are so close together on many streets that this setup process to start a new bore will have to be restarted to cover relatively short hops. This makes the cost of building a mile of fiber in Davis higher than communities where the handholes are further apart.

There is one advantage to a high density that reduces costs. Davis has some of the shortest drop lengths (the distance from the street to the home) that we have ever encountered. Nevertheless, the savings from shorter drops is not nearly enough to offset the cost of the primary fiber construction.

100% Buried Network. The city has a significant amount of buried utilities and in those neighborhoods the fiber network will also have to be buried. Where there are poles they look to be largely unusable for fiber. Rather than follow streets or alleys the existing poles cut through backyards and cross over the top of homes. The poles are often overgrown with trees. In addition, the poles are already relatively full of existing wires from other utilities. Getting access to build on these poles looks to be even more expensive than burying the fiber. We have never seen a city with this particular pole issue. The end result is a 100% buried network, or else perhaps mixing in some building on poles which would be just as expensive. We compare this to most communities where it's generally less expensive to build on poles. Moreover, most communities also have a significant portion of their utilities on poles—which means a composite cost of aerial and buried fiber means an overall lower cost to build a fiber network.

High Labor Costs. Another factor that contributes to the cost of building fiber in Davis is the high cost of labor in California in general. We see labor rates, particularly the prevailing labor rates required for government-funded projects that are as much as double the rates that are paid in many other parts of the country. Since labor is the primary cost component of building fiber the higher labor rates drives up the cost of fiber.

Not Higher Prices. While the costs to build a network in California is higher than the national average, the prices charged for the triple play services are not higher in California than elsewhere. Companies like Comcast and AT&T charge basically the same prices nationwide and they set these rates to recover their composite costs nationally. That means they have a lower margin in California than in lower-cost markets, but they view profitability on a nationwide perspective. A company trying to build only in California is disadvantaged on operating margins by definition due to starting with a higher than average cost network.

Bond Financing Is Expensive. While municipal bonds generally are financed at lower interest rates than commercial loans, the overall cost of using municipal bonds is higher. This is for several reasons:

- 100% Financing. Municipal bonds almost always finance the entire project with borrowed funds. However, commercial lenders are expected to bring equity to a project and to cover some of the cost of the project. The use of equity can significantly reduce the overall amount of interest incurred on a project.
- Construction Financing. Commercial networks are generally built with construction financing. This means that the lender only pays interest for the money that has been used to build the network. For a commercial lender the amount of interest paid increases each month as the network is constructed. However, municipal bonds generally borrow all of the money up front and they incur interest on the full amount borrowed from the first day of the bond issue. This adds significant interest costs during the first few years of a fiber project.
- Capitalized Interest. Since municipal bonds are a 100% loan that incurs interest from day one, bonds for projects like building a fiber network include capitalized interest. This means borrowing the interest payments up front to cover the interest payments due to bondholders for the first 3 or 4 years of a project. A commercial lender will cover these interest payments using their equity. Capitalized interest adds to the cost of the bonds and over time the project ends up paying interest on this extra borrowing over the life of the bond (interest paid on top of interest).
- Surety. For revenue bonds lenders always want some kind of surety. This usually means borrowing an amount equal to a year's bond payments to keep in escrow should the project not have sufficient cash to make future bond payments.
- Overall impact. A commercial builder providing 20% equity ends up financing 80% of the cost of the network. The commercial lender will use that equity to cover early-year interest payments and early operating losses. A bond-funded project can end up borrowing as much as 150% of the cost of the network after accounting for everything that is funded by the bond.

F. Funding Considerations

One of the most significant costs of building a broadband network is the financing cost needed to raise the money to pay for the network. This section of the report looks at ways that other communities have been able to fund a broadband network.

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

- Public Financing (bonds)
- Private Financing (loans)
- Grants
- Federal Programs
- Tax/Customer Financing
- Public Private Partnerships

Public Financing

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 to 30 years. Second, bonds can be used to 100% finance a project, meaning that no cash or equity needs to be put into the business up front. One downside of bond financing is that many kinds of bonds require voter approval.

> **Revenue Bonds**: The primary historic source of public money used to finance this sort of telecommunications system is through the issuance of municipal tax-exempt bonds. Most of the municipal fiber networks that have been built have been financed through revenue bonds. Revenue bond are backed by the revenues and the assets of the fiber network and the associated business. With a pure revenue bond the city would not be directly responsible for repaying a revenue bond should the project go into default. With that said, having a default would be a financial black eye that might make it hard to finance future projects. Therefore, to some degree the city would still be on the hook for the success of revenue bonds, at least tangentially.
>
> However, it is getting harder to finance a project with 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 usually outweigh the interest rate benefit 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.

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 5 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 1 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 at least the last decade the interest rates charged to bonds has been lower than the interest rate on commercial loans. However, that has not always historically been the case. The difference between bond interest rates and commercial interest rates both change over time; that difference is referred to in the industry as the "spread." Sometimes the spread favors bonds and at other times it favors commercial borrowing. Interest rates are 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.

Variable Rate Demand Obligations (VRDOs): The only other kind of bond we have seen used to finance a municipal communications network is a VRDO. These are bonds where the principal is paid in a lump sum at maturity. This is sometimes referred to as a balloon payment. 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. The only time we know of this being used for municipal telecommunications was in the city of Alameda, California.

Private Financing

The traditional way for commercial ventures to get financed is through bank loans. The interest rates on such loans are generally higher than bonds. Still, there are some ways to mitigate the financing costs so that a project doesn't have to rely on only bank loans. Here are some thoughts on financing the fiber business if it is a nonmunicipal venture:

Equity: Most forms of private financing require some equity. Equity means that the borrowing entity 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 an interest rate.
- 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 generally has to be assigned a market value by an independent appraiser.
- Nonrecourse Cash: Nonrecourse cash would be taking cash in an obligation that is not guaranteed to be paid back. To give an example, in Sibley and Renville counties in Minnesota, a fiber business was recently launched in the form of a cooperative. The local government provided an economic development bond to the business as a nonrecourse 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 who issued the bonds would have to make bond payments. The other sources of financing for that project looked upon these bonds as a form of equity.

Bank Loans: While there are around 150 municipal fiber ventures in the country that largely have been financed through bonds, most of the other fiber networks in the country have been financed with commercial lending sources. Most fiber projects have been built by for-profit communications companies or by cooperatives.

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. Prior to 50 years ago, banks would fund things like power plants, electric and water systems, and other long-term revenue-generating assets. However, various changes in banking laws, which have required banks to maintain larger cash reserves, along with a general desire to go after higher interest rate projects mean that banks have largely stopped doing this kind of lending. It's not impossible to finance an infrastructure project at a traditional bank, but the general parameters of bank loans make it a challenge.

Most banks prefer not to make loans with a term much longer than 12–15 years, and very few telecom projects can generate enough cash in that time period to pay for the original investment. Bank loan rates are generally a few percentage points higher than bond rates, which also makes it harder to prove feasible.

In addition, bankers generally expect a significant amount of equity from the borrower. The banking industry has gotten much more conservative over the last decade and they now might require 40% equity where a decade ago for a similar project they might have required 20% equity. Since fiber projects are relatively expensive, it's difficult to raise the kind of equity needed to make a project work.

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 of them to be too risky. Banks are also somewhat adverse to start-ups and prefer to make these kinds of loans to existing businesses that already have a proven revenue stream.

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. 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.

The final source of bank financing is local banks. Historically local banks were the source in many communities for car and home loans. However, 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.

One of the issues of borrowing from a local bank is that they are going to have a relatively small lending limit. Most local banks won't make an individual loan for more than one or two 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. Banks who do this usually take part in consortium loans for a number of projects. These smaller banks see this as a way to make loans to quality projects and quality customers that they could not loan to on their own.

To make this work you generally must start with a bank that is local to the project and let them help you put together the consortium. They essentially become the sponsor of the deal. This approach takes some extra work to put together, but there are many examples of this working for financing good projects.

Comparing Bond and Bank Financing

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

- The term of the bond can match the expected life of the assets and it is not unusual to find bonds for fiber projects that stretch out for 25 to 30 years. It's difficult to finance a commercial loan longer than 15 years. The longer the length of the loan, the lower the annual 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. 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 1 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 prepay an insurance policy at the beginning of the bond that will cover some defined amount of payments in case of a default.
    - Capitalized Interest: Bonds typically borrow the interest payments to cover bond payments for some period of time, up to 5 years.

- Construction Loans. Another reason that commercial financing usually results in smaller debt is through the use of construction loans. 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 mean 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 often will be structured so that there are no payments due for the first year or two. This contrasts with bonds that borrow the money required to make these payments. Fiber projects, by definition, require several years to generate revenue and deferring payments significantly reduces the size of the borrowing.
- Retirement of Debt: It's generally easy to retire commercial debt, which might be done 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.

Grants

We don't know of any specific grant programs that might benefit building a fiber network in Davis.

Federal Grants. There are a few federal grant programs that are aimed at bringing broadband to the poorest communities in the country. The most consistently available grant is the Department of Agriculture 'Community Connect Grants'. However, these grants generally go only to communities with extreme poverty such as on Indian reservations.

Federal Infrastructure Funding. There is still a lot of buzz in Washington DC about creating a large infrastructure program that would include substantial funding for broadband. However, the discussion coming out of Washington suggests that these funds, if ever approved, will be aimed at communities without broadband.

California State Grants. The state has had a number of grant programs over the years:

> Broadband Infrastructure and Improvement Grants (BIIG). This grant program, which is awarded year-by-year by the legislature, provides funding for schools and school systems to build better broadband infrastructure. The grants are mostly aimed at schools with little or poor broadband and schools that don't have enough bandwidth to administer the California Assessment of Student Performance and Progress (CAASPP) assessment get priority in the grant awards.
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> New Grant Program As this report was being written the governor signed a bill, AB 1665 that created a $330 million grant program to expand broadband access and digital literacy in communities deprived of a reliable internet connection.
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> The press is reporting this bill as a giveaway to the large incumbent telcos. The grants appear to be aimed at communities that have little or no existing broadband and it's hard

to see any applicability in communities like Davis. However, one aspect of the grant program will be to help close the 'digital divide' and so there might be some funding to help solve broadband issues for those in Davis that can't afford internet access.

There have been similar state grant programs over the past decade and the grants were generally awarded to the most rural communities in the state.

<u>Federal Loan Guarantee Programs</u>

Another way to help finance broadband projects is through federal loan guarantees. A loan guarantee is just what it sounds like. Some federal agencies 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 offer significantly lower interest rates.

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. 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 part 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 loaning or guaranteeing up to 50% of the total loan.

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

Rural Utility Service (RUS): This is a part of the Department of Agriculture. They also can provide loan guarantees. These come with the same sorts of issues associated with the loans. However, these loans and loan guarantees can only be used in communities have populations of less than 20,000, which would exclude Davis. Nevertheless, it might be possible to consider this funding if the city wanted to build to the rural areas surrounding the city.

Tax Financing

When all else fails, an idea that we have seen work in other communities is to use tax revenues of some sort 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. However, 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:

- Leverett, Massachusetts. In Leverett the citizens all voted to raise property taxes to fund and build a municipal fiber project. This is a relatively small town of about 2,000 people, but there was enough demand for broadband that a ballot initiative passed easily to use property revenues to pay for the fiber.
- UTOPIA, Utah. UTOPIA is a consortium of a number of small towns in Utah that banded together to get fiber. They also have 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 fund part of the matching funds needed to build the grant.

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. However, there are some examples to consider:

- <u>Contribution to Aid in Construction</u>: 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. We are aware in the broadband area of numerous cases where small pockets of rural home raised the needed money to get connected to a nearby broadband network.
- <u>Ammon, Idaho</u>: 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. This program is just getting started and it reportedly has a few hundred homes interested. However,

it's an unusual combination of a city prompting citizens to pay for the needed network themselves.

- San Francisco. The city has floated the idea of charging every home and business a 'utility fee'. This fee would be used to generate bonds to pay for the construction of a fiber network. The city would then open up the new network to all ISPs in an open-access environment. The ISPs would get free (or very inexpensive) access to the network, allowing them to offer broadband at affordable low rates.

Combining Public and Private Financing

There are benefits to combining the two kinds of financing, such in the case of a Public Private Partnership.

- 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.
- Both municipalities and commercial telcos have a natural borrowing limit—meaning that there is always some upward limit on the amount of money they can borrow. Combining both kinds of financing can mean that neither partner has to hit their debt ceiling. Just as an aside, the debt ceiling is often the main impediment to funding project 100% with bonds. Fiber projects are generally large projects and the required funds can easily exceed the ability of a government to fund it 100%.

IV. Other Considerations

A. Competitive Responses from Incumbents

This section of the report looks at the expected competitive response from AT&T and Comcast, the two large incumbent providers in the market.

Comcast as a Competitor

We have several historic examples of how Comcast has reacted to a significant competitor.

- First consider Tacoma, Washington. There, the government-owned cable company went many years without raising cable rates. Over time the cable rates in Tacoma grew to be as much as 40% below the cost of cable TV in nearby markets like Seattle. Comcast always matched the city's rates, even when they were significantly below market.
- Something similar happened in Alameda, California where the city-owned cable company also had rates that were lower than in nearby Oakland and San Francisco. Comcast matched the city's lower rates within the city limits of Alameda. Further, the city determined that Comcast customers in Alameda were given priority access to customer service, calls placed to Comcast from an Alameda phone number went straight to the top of the Comcast customer queue and got answered immediately while calls places from elsewhere in the region went into the normal queue.
- Comcast is now competing head-to-head with Google Fiber in Atlanta. Comcast lowered prices in Atlanta, but not with the same terms as Google Fiber:
    - Comcast offers a gigabit of speed for the same $70 per month as Google—but that price requires a 3-year contract. Customers with no contract are charged $139.95 per month, plus Comcast imposed their 1 terabyte data cap.
    - Comcast is advertising against Google's WiFi router and says that Google's WiFi router capabilities are 30 Mbps while their own is 725 Mbps (an untrue claim). Comcast has also been widely distributing flyers that tell people in Atlanta not to fall for the 'Google hype.' This is the first time in years that Comcast has negatively advertised against a competitor (since the early marketing wars of telco DSL versus cable broadband).

Comcast also is aggressive in competition for MDUs. Already today they are building fiber directly to larger MDUs and effectively making an apartment complex into a node on their network. As the company increases to DOCSIS 3.1 nationwide (something they have promised everywhere by the end of 2018), they will be able to offer gigabit speeds. While the FCC has prohibited some anticompetitive contractual arrangements, Comcast is still free to offer concessions and revenue-sharing with an MDU owner that a city might legally not be allowed to match.

Finally, Comcast is stepping up its game everywhere in anticipation of seeing competitors like Google Fiber in more markets and perhaps 5G fixed wireless competition. Consider all of the following improvements that Comcast has made over the last few years:

- They've created Comcast Labs (similar to Bell Lab). This group of scientists and engineers are concentrated largely on developing products that improve the customer experience. No other telecom company has a research arm of this size and focus.
- One of the first things out of Comcast Labs has been the proprietary X1 settop box, which has rave customer reviews. It has easy-to-use menus and is voice activated. It integrates the Internet into every TV. In addition, it includes a growing list of unique features that customers seem to really like.
- Comcast has also now integrated Netflix and Sling TV into their settop box to keep customers on their box and platform. It looks like they have a goal of becoming what the industry is calling a superbundler. There are around 100 OTT offerings on the market today and over time they are likely to integrate more of them into their ecosystem.
- Comcast has been exploring a skinny bundle (cable packages offered on-line) that are aimed at keeping cord cutters within the Comcast product sphere.
- Comcast owns a lot of programming like NBC, MSNBC, Bravo, USA Network, Syfy, Chiller, and Sprout, which gives them a big margin advantage over other cable providers.
- Comcast has found great success with their smart home product. This is probably the most robust of such products on the market and includes such things as burglar and other alarms, smart thermostat, watering systems, smart blinds for energy control, security cameras, smart lights, smart door locks, etc. All this can be easily monitored from the settop box or from a smartphone app. They recently said they have over 2 million smart home customers nationwide.
- Comcast has been an industry leader in unilaterally increasing customer data speeds. They moved their base broadband product from 25 Mbps to 50 Mbps to 75 Mbps, with plans to raise it again to 100 Mbps after the DOCSIS 3.1 upgrade. After the DOCSIS 3.1 upgrade they will be able to match anybody's download speeds (but not upload speeds). Comcast says they will be upgrading download speeds to 1 Gbps in the Sacrament region, and most of the country in 2018.
- Comcast is now building fiber-to-the-home to new developments.
- Comcast also operates an extensive WiFi network and they claim to have 16 million WiFi hotspots. These are free to use for any Comcast broadband customer. Most of the hotspots are generated from WiFi routers in residential homes, but in a city that is served by Comcast that means there is a somewhat weak WiFi signal almost everywhere, which is still a nice benefit for somebody who wants to grab a WiFi signal when out of the home or office.
- They are now starting to offer bundled cellphone service. Their pricing is lower than the base products of Verizon and AT&T. Analysts predict that over 5 years they could capture as much as 30% of the cellphone business in their markets. They recently bought a lot of spectrum that will help them improve margins on this new business line.
- One of the new Comcast cellular products is being marketed as 'Xfinity on Campus.' This service is only available to students and provides unlimited access to a number of channels of live programming, plus students can store up to 20 hours of content on a cloud DVR to watch later.
- Comcast also just announced that they will be bundling solar roof panels with their other services. Comcast has been doing a trial with Sunrun, a solar panel maker from San Francisco. Comcast found during this trial that their customer satisfaction and customer retention rates rose significantly with customers who bought the solar panels. Comcast

has now entered into an exclusive 40-month marketing deal with the company. It's been reported that Comcast will get 10% of Sunrun's stock if they can install 60,000 solar customers. Comcast has committed to spend $10 million on sales and marketing for the solar panels and will get a share of the customer revenue from the product.

- Comcast spends more on marketing than most competitors. It's not unusual in a competitive market for Comcast to saturate the airwaves and television with ads and also to constantly mail promotional materials to potential customers.

Nevertheless, Comcast also faces some hurdles with customers. They are always rated near the bottom for all US corporations in terms of the quality of customer service. However, the company is putting a lot of money into making their customer service better. They are quickly moving away from making everybody call their customer service centers and now have a decent customer service process using texting. They now allow people to ask and resolve questions by chat from their web site. Each of these improvements satisfies a niche of their customers and relieves the long wait times for a customer service rep. The company is also moving a lot of customer service back to the US, finally understanding that the cost savings of using foreign reps is not worth the customer dissatisfaction.

Comcast is also betting heavily on the belief that within 5 years there will be a decent artificial intelligence system for handling customer service. This will not be like the dreadful systems used today by airlines and banks. The expectation is that an AI will be able to satisfactorily handle the majority of customer service calls without needing a human service rep. Comcast will have these systems long before smaller competitors, giving them a big cost advantage and perhaps erasing a lot of their negative image (if it's done well).

The summary of all of this is that Comcast is a formidable competitor. While it's clear that many of their customers hate their customer service, there is a lot less dissatisfaction with their products. As the company continues to create nontraditional bundles they make it harder for customers to drop their service. It's one thing to cut the cord and drop cable TV service, but it's a lot more complex for a customer to drop Comcast if they are also the cellphone company, the provider of security and smart home products, and even are leasing a solar power system. All of these bundles have been created to be profitable, but more importantly they are aimed at reducing customer churn. The Comcast bundles punish customers if they try to drop only one or two products and keep other ones—the bundle savings basically disappear when a customer breaks the bundle and the savings are always less than hoped for.

However, they are still not the perfect competitor and any new market entrant will be able to attract customers that dislike Comcast. We've seen that percentage vary by market and range between 20% and 30% of customers. Nevertheless, winning customers beyond this 'low-hanging fruit' threshold is hard work—and Comcast works hard to keep customers and to lure back customers who leave them.

AT&T as a Competitor

AT&T is an interesting competitor. For now they have largely given up on the residential market for landline services. They still have DSL service in Davis and probably will for many years.

However, that technology is becoming obsolete with download speeds even on ideal copper at only about 50 Mbps. The cable companies like Comcast have been steadily taking AT&T's residential customers for many years.

Nevertheless, the company has made a concentrated effort to build fiber to those places where they can make their desired margins. As part of the agreement to buy DirecTV, AT&T committed to the FCC a few years ago to build fiber past at least 12 million customers. Moreover, they seem to be on a path to meet and probably beat that commitment. However, the company is selectively building to key pockets of customers—large MDUs, business districts, and new residential subdivisions. In those market segments they will be a fierce competitor.

AT&T is also aggressively exploring 5G point-to-point radio technology that can deliver 1 gigabit of download speed for 2 miles or 2 gigabits of speed for about 1 mile. They view this as a fiber substitute and probably will use it to serve large MDUs and large businesses without the need to build costly last mile fiber. AT&T already has cellular tower space in most markets that will be able to support this new 'wireless local loop' technology. There is no economic business case for using this for residential competition today, but it's possible that can evolve after a few generations of the technology.

AT&T is also counting on faster cellular speeds to make them more competitive with some segments of landline broadband. This might be particularly effective in a college town like Davis where many students might be happy with using only cellular data as long as they have occasional access to faster broadband.

We are just now finally starting to see the implementation of real 4G broadband. That technology, when fully deployed, delivers about 15 Mbps download, which is sufficient for most single-use applications for a cellphone or tablet. It's expected that 5G cellular will increase speeds everywhere to 50 Mbps. It's possible that in some environments that 5G can be made to go much faster by combining multiple frequencies and multiple antennas in a cellphone. However, there is a long way to go before that becomes a widely spread commercial application.

The main roadblock for cellular data to be an economic substitute for landline has been the stingy data caps. AT&T's new 'unlimited' data plans (which are not unlimited but which have data caps at 20–25 gigabytes per month) are making it easier for customers to use the cellphone as a primary broadband connection.

AT&T's Future Plans. As part of the research for the project we talked with the regional External Affairs Office of the company in Sacramento. As part of that discussion they provided the following response to one of the questions we asked of them:

Question: Today AT&T largely serves broadband in the city with U-verse DSL. We know you are undertaking a big nationwide expansion plan of fiber-to-the-premise. Does the company have any specific plans to bring more fiber to Davis in the next few years?

The following response was provided to CCG from AT&T related to this study:

The key assumptions for deploying a fiber network include:

- *Sufficient customer demand for ultra-high speed broadband to compensate for the required investment.*
- *Neighborhood fiber deployment costs are reasonable.*
- *Access to multi-tenant buildings is readily available.*

At a high level, there are three customer location types with potential serving architectures and business models:

- ***Single family residential**: The desired serving arrangement is FTTP, where customer demand is expected to compensate for the cost to deploy and operate the network. Deployment would be guided by anticipated customer demand for very high-speed broadband and the cost of deploying in each neighborhood, aided by efficient network deployment.*
- ***Residential MDUs**: The most appropriate commercial offers to serve MDUs are subject to the availability and condition of building wiring, forecasted penetration, and churn, among other factors affecting customer experience. The service coverage of MDUs will be conditioned on the ability of AT&T to agree to terms with the MDU property owners.*
- ***Businesses**: Serving some business locations with a fiber gigabit network would likely be part of a FTTP deployment described above for residential areas; businesses are often part of neighborhoods that would meet a deployment threshold. But serving additional business customers would likely require deploying a FTTB network. Areas where multiple businesses are located, e.g., multi-tenant office buildings, could be served by cost sharing the special construction to bring fiber into the building. In some situations, with the landlord's permission, the network (fiber and electronics) could be pre-provisioned (in advance of customer order) to business buildings. The Town could facilitate the discussions with landlords about the program and the required Point of Entry for building access, and provide expedited responses to permit requests.*
    - *We did respond to a RFI the city issued for Fiber-based Broadband Deployment for North Davis Meadows County Service Area this year.*

In both the speed test and the customer bill analysis we encountered a few residential customers in the city that now have gigabit broadband from AT&T. Gigabit deployment doesn't appear to be widespread and these speeds are likely only available to customers who live close to an AT&T fiber node and who ask for the service. The company's ongoing strategy is to build fiber only where there is enough proven demand to provide a reasonable return on the investment. This makes it unlikely that the company will ever build fiber throughout the community, but will instead only build to pockets of the community that make financial sense. This is not an unusual strategy and we see this also being done by Verizon and CenturyLink, the other two big telcos in the country.

Summary

Davis faces more potential competition from the incumbents than would occur in many other cities. Comcast has really stepped up their game in the last few years, mostly in terms of selling bundles of products that are hard for customers to break. With the introduction of Comcast's cellular service and solar roof panels this is going to increase as an issue and there is going to be a sizable percentage of customers that will be hard for any competitor to win.

Both Comcast and AT&T have made it a priority to serve large MDUs, which is a major piece of the Davis residential market. As this report was being written AT&T brought fiber to a large MDU in the city. Our expectations are that if the city announced that you were going to build a fiber network both companies would step up efforts to bring faster broadband to MDUs to lock the city out of that business.

While AT&T is not going after the residential market today for broadband, they will remain a fierce competitor for the business market. Again, if they know the city is bringing fiber they are likely to respond by building more fiber to businesses before your network is constructed.

There is also the concern over the next few years as cellular speeds improve that both AT&T and Comcast, as well as other carriers like T-Mobile, might offer packages to students that will be viewed as an adequate alternative to landline broadband.

B. Roadblocks to Serving MDUs

The financial analysis looked 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.

We've been told by city staff that they believe there are not a lot of exclusive arrangements with ISPs in Davis. However, there are probably some, and there could be new ones implemented in the future, so it's always something to be aware about.

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. Such 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 that 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 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 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. They 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 city 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.

C. Benefits of Broadband

When looking at the benefit of broadband the question to be asked is what benefits a citywide fiber network would bring to the city that cannot be satisfied by the existing broadband products available in the city (and those that are expected to be available in the reasonable future). In cities without existing broadband there are generally a list of community benefits that include things like allowing people to work at home, the ability for students to do homework, etc. However, in a city that is served ubiquitously by Comcast many of these kinds of basic broadband capabilities are already available widely throughout the city. Nevertheless, there are significant benefits of fiber that would enhance the city of Davis.

Choice

Customer choice is going to be a significant issue in the coming decade. Now that AT&T and other telcos have made it clear that they are not going to continue to promote their DSL service, it's not hard to imagine a time when they quietly let DSL die in communities like Davis. Already today Comcast and the other big cable companies have the majority of data customers in a community and they continue to take data customers from the telcos every month.

This trend means that Comcast will become a virtual monopoly in Davis and elsewhere. At some point there will be so few DSL customers remaining that Comcast will be the only realistic option. Communities everywhere are nervous about the behavior of any broadband provider that has monopoly power. That generally leads to higher prices and less concern with customer service.

A fiber network in the community would mean competition for Comcast. We've seen vigorous competition in markets that have a high-speed alternative to the cable network. One only has to compare broadband products in prices in places where Google Fiber or a municipality has built a second network to see that it makes a difference. For example, a second network might mean $70 gigabit broadband in the city instead of something much higher. It might also mean that competition will hold down broadband price increases in the future and more reasonable options for the community.

Extend University Everywhere.

The University would like to connect all locations, both on and off campus, into a ubiquitous network so that students and staff are not disadvantaged from being located off campus. Having a citywide fiber network could provide this kind of ubiquitous connection since fiber connections could be established with remote sites in the city that would be securely in the University network. This same kind of connection is more difficult and less secure when those outside the campus try to connect into the University network from connections provided by other ISPs.

The University also has the goal of providing each of its users with the bandwidth they need, which today ranges from 100 Mbps connections to 10 Gbps connections. Since Davis is a research university, having the ability to provide speeds higher than 1 Gbps would allow the University to connect to high-bandwidth users such as a hi-tech business - an option not easily and affordably available today from other commercial sources.

Digital Divide/Affordability

In every city there are households that can't afford broadband. Since national broadband penetration rates are now a little higher than 80% this means that the percentage of residents that want broadband but can't afford it is probably between 10% and 15%.

The issues associated with not having home broadband are well known. It's hard to raise kids in a home where they can't do electronic homework. It's now harder to exist in a society where so many of the things we do have moved online. Someone without broadband at home can't easily work from home. They can't interface with online city services. They can't easily hunt for a job if unemployed. They can't take online job training. They can't even save money by shopping online.

A municipal network might afford the opportunity to bring broadband to these citizens. Cities that build their own fiber networks usually have solving the digital divide as one of their primary goals. They 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.

The need for home internet access to every single K-12 student is vital. With 21st Century schools and the rapid speed of digital learning, students without internet at home are at a significant disadvantage. Presently, there are areas in and around Davis that are serviced by either Comcast or AT&T, but at a significant cost. Access to those programs that provide discounted service require families to jump through hoops to get home internet installed and serviced.

We caution in saying that none of the larger municipal networks that have already been built have fully solved the digital divide issue—but a number of them are now looking at the issue. Cities with fiber networks have made some progress. For example, many cities have brought broadband to public housing. Many have provided WiFi hotspots to provide better access to the Internet. Nevertheless, none other than some tiny communities have yet found a way to afford to connect everybody to fiber.

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 benefit from having a community fiber network. Here are just a few examples of technologies that some cities are implementing or considering 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. For example, surveillance cameras have recently been used widely in many cities to solve crimes. This ability in enhanced with high-broadband cameras that can see 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. Cities wrangle with surveillance systems in balancing the ability to support law enforcement without impinging unduly on citizen privacy, and many are finding that balance.
- 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 which can otherwise cost the community by wasting water. While most smart grid technology today uses wireless connection to many smart grid devices, having a fiber network can help to support a smart grid deployment in the city.
- Citizen Interface with City Services. Cities have a tremendous amount of information at their disposal that can benefit citizens. However, it's always been a challenge to make information readily available in a usable format. Cities are working on systems to make data available. For example, some cities are making all of the digital educational resources in the schools available to everybody. There are cities that are tying vehicle fleets to GIS information so that citizens can see the location and progress on routes of trash trucks.
- More Efficient Citizen Services. Cities are automating interfaces with city services. They are making it easier to get permits. They are letting customers review and correct information about them so that they and the city are working from the same data. Cities are making it easier to use libraries online, as well as other similar city systems.
- City Intranet. One interesting thing done 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 in the community. This data traffic is not sent first to the open Internet, but instead communications between homes and businesses is done for free. Something similar in Davis could provide a tremendous benefit to University researchers who want to work on data intensive projects off site or at their homes.

It is worth noting that in almost all areas of smart city technology there is a movement to accomplish these tasks without a fiber network. Since the majority of cities don't have their own fiber networks most of the smart city applications are being created to work with wireless networks.

There is also a movement in the technology world to move back from cloud computing to edge computing. About a decade ago corporations and cities moved a lot of their data into the 'cloud' meaning that information was kept, stored, and used at some centralized repository that was often somewhere other than at corporate headquarters or city hall. However, as the need for broadband communications increased it's been realized that it is a lot more efficient to process data at the edge. Take the example of using cameras to monitor intersections and change traffic lights. It is far more efficient if computer power at the intersection can process most of what's needed rather than requiring a gigantic data pipe to send everything to the cloud for processing. This move back to edge computing means that the amount of data that must be moved between city systems and the core, between a smart grid and the core, between law enforcement systems and the core is being greatly reduced—which means it's more easily done with wireless than with fiber.

Ubiquitous WiFi

Many cities provide some WiFi access to citizens. This may be offered in the libraries, city hall, and perhaps even 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 broadband throughout the 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. However, except perhaps in a few locations like Manhattan, no other cities have been able to monetize a WiFi network, so this would be a public service, not a revenue-generating business.

Reduced City Communications Costs

Davis is like many cities in the US that has had some of its communications needs provided today from the local cable company as a result of franchise agreement negotiations. The city has broadband connections between its various locations that are provided for free or for a reduced price as part of the franchise process. However, those agreements are ending across the country and most cable companies are no longer willing to provide these services for free.

It will be costly when the city has to purchase the connectivity between locations at commercial rates. If the city has a fiber network then it can make all of these connections for free. Many cities have looked at the cost of building a fiber network only for their own use and there are now hundreds of cities that provide their own connectivity between their own buildings. Therefore, if a larger fiber network is not feasible the city should consider building fiber for your own purposes. Such a fiber network could be expanded to also satisfy the connectivity needs between the city and the University.

Economic Development

Cities can use a fiber network as a tool for economic development. One of the best examples of this in Davis would to provide fiber in downtown Davis to support businesses there. As part of this project we report talked to several businesses in downtown that are unable to get or afford the broadband they need. Providing city fiber to business districts can be a huge boon to the business community and can benefit the community by supporting more jobs. Since Davis attracts and supports a number of high tech businesses, a fiber network can provide the basis for these businesses to locate anywhere in the city or to expand existing businesses.

Cities also often use a fiber network to offer low-cost connectivity as a lure to bring new businesses to the city. That might be less of an incentive in Davis than in many cities due to the already tight real estate situation, but this is still something that the city could use selectively. Perhaps the best use of fiber as an economic development tool would be if the city grows by annexation and adds more land to the city.

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 is going to accommodate expansion of faster cellular since the city could sell wholesale fiber connections to cellular providers.

However, this will be somewhat of a mixed blessing, because a faster cellular network will compete to some degree with landline broadband connections, particularly with students, and the city might lose more retail revenue from the expansion of faster cellular than can be made in leasing the wholesale connections.

D. Financial and Execution Risks

The RFP also asked us to consider the risks the city might encounter in launching a broadband network. In a city the size and sophistication of Davis there is a lengthy list of potential risks. We want anybody reading this report to understand that this list is not trying to discourage the city from finding better broadband. Instead this is a list of issues that must be considered when contemplating taking on an undertaking as major as building a citywide fiber network.

Competition from Other Technologies

While fiber is considered as the ultimate technology, meaning there is no realistic cap on the amount of bandwidth that can be delivered over fiber, there are other technologies that will compete with fiber in the market place. While many of these technologies may not be as fast as the capabilities of fiber, to the extent that they satisfy the broadband needs of segments of the market they will make it harder for a fiber network provider to generate revenues.
DOCSIS 3.1—Gigabit Cable Network

Comcast uses a technology called DOCSIS (Data Over Cable Service Interface Specification) to insert broadband onto its coaxial copper network. The technology was developed by CableLabs, which is a research and standards organization that the cable companies have created for research and development purposes. DOCSIS 1.0 was first issued in 1997 as a standard and created the basis for cable modems. Since then the technology has undergone several major upgrades that were named DOCSIS 2.1 and DOCSIS 3.0. Comcast currently uses the DOCSIS 3.0 in Davis which allows broadband speeds up to about 300 Mbps. In the speed tests we saw numerous Comcast customers getting speeds in excess of 200 Mbps and even a few getting 300 Mbps.

Comcast is now upgrading nationwide to DOCSIS 3.1 and says their whole footprint will be upgraded to the new technology by the end of 2018. This new technology allows for unlimited bonding of empty channels in a Comcast network that can be used to provide broadband.

DOCSIS 3.1 will allow Comcast to immediately offer gigabit data speeds to customers. Theoretically they could provide speeds as fast as 6 Gbps, but that would mean not carrying any cable TV on their network.

Comcast has already started upgrading some cities and offers gigabit speeds in some of their markets. For example, in eastern markets like Philadelphia they now offer a base price for gigabit service at $104.95 per month, with a price of $79.99 per month for a customer signing a 1-year contract. There is also a lot of industry speculation that Comcast will use the technology upgrade to increase minimum broadband speeds for all customers to speeds of 100 Mbps to 150 Mbps, meaning that would be the lowest speed they would sell to a new customer. They have not made this change yet in any of the DOCSIS 3.1 markets, but the company has a track record of unilaterally increasing broadband speeds across-the-board for all customers. They seem to do this every few years to buffer the company from competition and to reduce customer complaints about broadband.

5G Millimeter Wave Microwave

There are two different technologies being referred to as 5G. The one that will be seen in the market first is the use of 5G standards and millimeter wave spectrum to deliver gigabit microwave to customers. For the past twenty years this same technology has been referred to as wireless local loop, but in the broadband world the term 5G has marketing cachet. The technology involves transmitting a microwave beam from a tower or similar location to the customer premises.

This technology has been around for a long time, and in fact it was the use of microwave radios in the 1970s that helped MCI break the Ma Bell monopoly. However, the new technology will carry significantly faster broadband than current technologies. This is due to the type of spectrum being used. In what is already being called the 5G Order, in Docket FCC 16-89 the FCC released a lot of new spectrum. Quoted directly from the FCC Order the new spectrum is as follows:

> *Specifically, the rules create a new Upper Microwave Flexible Use service in the 28 GHz (27.5-28.35 GHz), 37 GHz (37-38.6 GHz), and 39 GHz (38.6-40 GHz) bands, and an unlicensed band at 64-71 GHz.*
>
> - *Licensed use in the 28 GHz, 37 GHz and 39 GHz bands: Makes available 3.85 GHz of licensed, flexible use spectrum, which is more than four times the amount of flexible use spectrum the FCC has licensed to date.*
>   - *Provides consistent block sizes (200 MHz), license areas (Partial Economic Areas), technical rules, and operability across the exclusively licensed portion of the 37 GHz band and the 39 GHz band to make 2.4 GHz of spectrum available.*
>   - *Provides two 425 MHz blocks for the 28 GHz band on a county basis and operability across the band.*
> - *Unlicensed use in the 64-71 GHz band: Makes available 7 GHz of unlicensed spectrum which, when combined with the existing high-band unlicensed spectrum (57-64 GHz), doubles the amount of high-band unlicensed spectrum to 14 GHz of contiguous unlicensed spectrum (57-71 GHz). These 14 GHz will be 15 times as much as all unlicensed Wi-Fi spectrum in lower bands.*

The US is the first country to authorize specific use of the spectrum in these upper bands, which have commonly been referred to as millimeter wave spectrum. Moreover, the FCC isn't yet finished. Along with the Order, the FCC issued a Further Notice for Proposed Rulemaking to look at how it should deal with other blocks of spectrum, including existing space in the 24-25 GHz, 32 GHz, 42 GHz, 48 GHz, 51 GHz, 70 GHz, and 80 GHz. The FCC also asked for comments on how it might provide access to spectrum above 95 GHz.

By definition, the higher a radio frequency, the more data can be transmitted. This is due to the fact that radio technology uses the peaks and valleys of the radio waves to transmit the digital ones and zeroes needed to pass information.

However, there is a trade-off for using higher frequencies in that the higher the frequency, the shorter distance the frequency can be broadcast before it spreads and loses signal integrity. This means that 5G millimeter wave transmitters will need to be relatively close to customers. That means that 5G networks are going to require a lot of fiber close-by to customers.

For now these radios are relatively expensive and it's unlikely that the technology will be used to serve residences and small business. Instead, this technology will be used to serve larger business, MDUs, and other users that spend a lot for big bandwidth pipes. Effectively, this new technology is a last-mile competitor for fiber. That would make millimeter wave radios a competitor to a city-owned network in that this could be used to provide service to MDUs and to the largest businesses in the city.

The first use of this technology is being done in urban downtowns where transmitters can be placed on the top of tall buildings to create gigabit paths to other buildings. However, there are a number of hurdles that must be overcome before this technology makes it suburbia or to smaller towns like Davis:

- One of the primary issues will be finding a place to place the transmitters. In smaller cities without big high rises this will mean somehow placing transmitters on poles—and it requires those poles to be fiber-fed. There is a huge nationwide discussion of how to streamline the process of providing access to poles for the wireless transmitters. However, absent from much of that same discussion is to ask who is going to build the fiber to get to the poles.
- The technology needs pure line-of-sight and there can be zero impediments between transmitter and receiver (such as foliage). These frequencies are disrupted by almost everything and can't pass through walls or anything else.
- These radios are relatively expensive and the prices will have to drop significantly before this technology can be considered for any but the largest broadband customers.

<u>5G Cellular</u>

The other use of 5G is as the next generation of cellular service. Unlike the transition from 3G to 4G cellular, the new 5G is not expected to replace 4G, but rather to work in conjunction and enhance cellular broadband.

There are already field tests of the 5G millimeter technologies discussed above. However, the conversion to 5G cellular will be on a much slower path. Following is the expected industry timeline:

- 2017: Definition, specification, requirements, technology development and technology field tests
- 2019/20: Formal specifications
- 2021: Initial production service rollouts
- 2025: Critical mass
- 2030+ - Phase-out of 4G infrastructure begins

There is a lot of discussion of 5G cellular being capable of gigabit speeds. Theoretically this is possible, but there are a lot of reasons why this isn't going to happen for decades, if forever.

- To achieve that kind of speed requires combining a lot of different frequencies into one transmission. That requires complicated and sophisticated antennas. That is always going to present a challenge for cellphones because supporting multiple frequencies adds to the cost, the power consumption, and the size of a cellphone.
- The frequencies used only travel a few hundred feet on a broadcast basis (about the same distance as a WiFi hot spot). That means there would have to be multiple cellular transmitters everywhere to achieve the needed coverage. We are a long way from developing inexpensive cellular transmitters that could meet this requirement.

- The technology also needs pure line-of-sight. This is easier to achieve with a fixed microwave path, but hard to achieve in use of a cellphone. A person's body would effectively block the signal, and that means needing a lot of small transmitters so that one could see a cellphone at any given time.
- Finally, this means building fiber everywhere. While this kind of technology might make sense in dense urban business districts, it's hard to envision somebody spending the needed investment in fiber to bring this technology to residential streets or open areas in cities. Deloitte recently estimated that the cost to build the fiber to support a 5G cellular network is $160 billion.
- Finally, this takes economy of scale. Nobody is going to build the handsets if there aren't enough places where this would work. Nobody will build the networks if enough people don't have the handsets. There are some analysts saying this might never happen.

For these various reasons it's unlikely that we will have 5G gigabit cellular for a long time. However, there will be the use of 5G cellular coming within a few years. The specifications for the 5G standard establish the goal of providing large numbers of cellphones in a given area able to receive 50 Mbps speeds. The goal is to eliminate the blocking that happens today when people can't make a connection in a busy environment.

50 Mbps cellphones will probably be significant competitor for landline broadband networks, particular for younger consumers (particularly in a university town). To put that in perspective, the average 4G connection today is between 10 Mbps and 15 Mbps (depends on who is measuring the speeds). Even those speeds are adequate today to watch a single video stream on a cellphone. The 5G standard also has the goal to significantly lower latency, and the latency on a cellphone is the primary reason that a cellphone connection feels slow today. With no latency, a 15 Mbps satellite connection would feel a lot faster.

<u>Satellite Broadband</u>

Late last year Elon Musk announced that his SpaceX company is moving forward with attempting to launch low earth orbit (LEO) satellites to bring better satellite broadband to the world. His proposed to the FCC to launch 4,425 satellites around the globe at altitudes between 715 and 823 miles. This contrasts significantly with the current HughesNet satellite network that is 22,000 miles above the earth. Each satellite would be roughly the size of a refrigerator and would be powered by a solar array.

Musk's proposal has some major benefits over existing satellite broadband. By being significantly closer to the earth the data transmitted from satellites would have a latency of between 25 and 35 milliseconds—about the same experienced in a cable TV broadband network. This is much better than the 600 millisecond delays achieved by current satellites. This means that Musk's proposed network could support VoIP, video streaming, or any other live Internet connections like Skype or distance learning.

The satellites would use frequencies between 10GHz and 30GHz, in the Ku and Ka bands. The FCC filing is technical, but an interesting read: https://cdn.arstechnica.net/wp-content/uploads/2016/11/spacex-Technical-Attachment.pdf

The specifications say that each satellite would have an aggregate capacity of between 17 and 23 Gbps, meaning each satellite could theoretically process that much data at the same time, although realistically they would probably max out at 80% of that capacity (as do all broadband transmission methods).

The specifications say that the network could produce gigabit links to customers, although achieving that much speed would require making simultaneous connections from numerous satellites to one single customer. Moreover, while each satellite has a lot of capacity, using them to provide gigabit links would chew up the available bandwidth in a hurry and would mean serving far fewer customers. It's more likely that the network will be used to provide speeds such as 50 Mbps to 100 Mbps to a lot of customers.

Depending upon how this is priced this would create another competitor to landline broadband networks. A customer would need a dish to receive the broadband, similar to the dishes used to receive satellite TV today.

It's an intriguing idea, and if it was offered by anybody else other than Elon Musk it might sound more like a pipedream than a serious idea. He's said the idea requires at least $10 billion to launch, but Musk has shown the ability to launch cutting-edge ventures before. There is always a ways to go between concept and reality and like any new technology there will be bugs in the first version of the technology. Nevertheless, assuming that Musk can raise the money, and assuming that the technology really works as promised, this could change broadband around the world. The real beneficiaries of this technology, if it happens, are places with no broadband—rural America and a lot of the third world.

<u>PG&E Fiber</u>

While not a new technology, it's possible that fiber deployed by PG&E, the giant electric utility, might create additional fiber competition. The company has filed with the California Public Utility Commission to become a fiber provider in its many markets. The company owns an extensive fiber network that is used today to provide communications between PG&E facilities and wants to leverage that network to generate revenue.

The company says it intends to provide telecommunications service to carriers, large businesses, government, and educational enterprises. They do not have plans to enter the residential market. Having another active fiber network in a community the size of Davis would add pressure to a city-owned ISP. It's likely that the PG&E network already goes to locations that are not served with fiber by AT&T and Comcast, and as such they would be a direct competitor with a new fiber network for the sale of high-end transport, wavelength, and dark fiber services. Adding even one new fiber provider in a community tends to push down wholesale prices charged by carriers and such competition would make it harder for a new fiber network to sell high-margin data products.

Competitive Market Risks

Comcast Gigabit Speeds. It's impossible to talk about broadband speeds without acknowledging that Comcast will be upgrading its networks to support gigabit broadband everywhere. In doing so it's likely that they will also increase the speeds on their base products. We might only be a few years away from having the minimum speeds on the cable network at 100 Mbps, with other broadband products up to a speed of a gigabit or more.

There are those that argue that fiber broadband is superior. On fiber it's easy to offer symmetrical speeds. This would be a challenge for a cable network, even with DOCSIS 3.1, but it's theoretically possible. We can already see today in the speed tests that Comcast is delivering roughly 10% of the download speed as the upload speed. That means a 10 Mbps upload speed for a 100 Mbps connection and 100 Mbps upload speed for a gigabit connection. Most customers (but not all) are going to find these speeds to be adequate. This is not likely going to be a factor that will make fiber broadband into a 'must buy' for most households. Moreover, if Comcast ever feels like it is losing market share due to upload speeds, with a DOCSIS 3.1 network they could increase upload speeds at any time.

Land Grab for MDUs. Both AT&T and Comcast have made it a priority to serve larger MDUs. They view this as a more lucrative long-term business than serving individual homes. During research on this project we've been told by multiple people that most of the MDUs in the city do not have exclusive arrangements with Comcast or AT&T. However, both companies are now actively pursuing this market segment. There are also a few nationwide companies that are concentrating only on MDUs as a business plan.

If the city announced the construction of a citywide fiber network it would probably goad the other competitors into accelerating signing existing MDUs.

Cherry Picking. One of the more troubling phenomenon we see all over the country is what we call cherry picking in the industry. Broadband providers like AT&T are selectively building gigabit fiber to only those areas in each market that they view as most lucrative. In their case that means only parts of the city where they feel they can get sufficient revenues, but it also means the places that are the least expensive for them to build.

As mentioned elsewhere in this report, AT&T is actively expanding fiber throughout its footprint and is doing so by cherry picking. We already saw in the speed test and billing analysis that there are some gigabit customers served by AT&T fiber.

The problem with cherry picking from the viewpoint of competition is that the most 'lucrative' places in towns are likely to already have fast broadband before a new network is built. This might mean business districts, large businesses, MDUs, or residential neighborhoods with relatively low construction costs.

Competing Against Comcast Bundles. As noted elsewhere in this report, Comcast has embarked on selling new products as part of their bundle. Already today they offer a wide range of home security and smart home products. They are just now starting to introduce cellular phone service as part of the bundle. In addition, they recently announced adding home solar power systems to the bundle.

From the viewpoint of a competitor, any customer buying these new Comcast products in a bundle is going to be hard to dislodge.

Erosion of the Traditional Triple Play. Both cable TV service and telephone service are declining as revenue-generating products for ISPs. Nationwide the number of households that have a telephone landline is down to a little over 40%. The penetration rate in a university town has to be significantly lower.

In the cable market the much talked-about phenomenon is cord cutting. It's estimated that over the last year about 2 million homes have dropped traditional subscription cable service—either from a landline cable company or one of the satellite TV providers. This phenomenon seems to be accelerating.

Cable TV service is not going to disappear for a long time. So far this has hardly been much more than a blip on the industry and there are still over 90 million homes with a cable subscription. Moreover, it's important in Davis to recognize that Comcast is the only cable company that has not yet lost overall customers due to cord cutting. In fact, they have been adding a small number of cable customers while the rest of the industry is seeing losses.

The trends in both of these market segments has to be of concern to a fiber network builder. Today, since over 80% of homes buy traditional cable, a new network provider is obligated to offer cable TV to be a success. Google Fiber learned in Kansas City that a lot of homes won't change without cable as part of the new bundle.

The financial concern is that these products generate margins that help to pay for a network. The costs of operating a fiber network increase over time due to inflation. Since it's likely that a fiber network build would be financed for a long period of time, perhaps 25 years, there has to be a concern that the loss in margin from these products doesn't put the company at risk over such a long time period.

Nobody has a crystal ball and can predict what might happen to cable TV. For example, it might become possible for cable companies to offer a la carte cable lineups (selling just those channels that customers want to buy). That's not allowed today by federal cable rules established by Congress and regulated by the FCC. However, there could be a change that would result in some different version of cable TV service to be around and be successful for a network operator. Nevertheless, traditional cable TV could also go the way of landline telephones and continue to shed customers year after year until it is greatly diminished.

Shifting Demographics. It's becoming clear that the younger generations in the US don't watch as much video as their parents and grandparents. Nielsen, the company that tracks TV viewership, recently published a report that quantified the difference in generational viewing of video content.

What might surprise a lot of people is that Generation Z and the Millennials together now make up 48% of the US population—and that means their viewing habits are rapidly growing in importance to the cable TV industry. The biggest finding from the Nielsen research is that the daily time spent using various entertainment media that includes such things as TV, radio, game consoles, and surfing the Internet varies significantly by generation.

For example, the average monthly TV viewing for those over 65 is 231 hours of live TV and 34 hours of time-shifted TV. However, for people aged 12-17 that is only 60 hours live and 10 hours time-shifted. For ages 18-24 it’s 72 hours live and 12 hours time-shifted. For ages 25-34 it’s 101 hours live and 19 hours time-shifted. The amount of viewing by Generation Z is decreasing from quarter to quarter.

Other research done by Nielsen over the last few years suggests that the viewing habits that people pick up as kids stick with them for life. Therefore, we need to recognize that the youngest generations are not likely to value traditional programming, or ISPs that offer traditional cable, as much as current adults.

There hasn’t been this kind of massive study of broadband usage by generation. Nevertheless, the surveys and research that has been done suggests that Generation Z is largely satisfied with the level of broadband they get in a cellphone. Over time this might mean downward pressure on home broadband connections. It might mean fewer broadband sales to college students in Davis. This trend might be further exacerbated by a few other trends. First, we see that cellular providers are starting to include video content as part of the cellular package—such as T-Mobile recently including Netflix. Moreover, as discussed earlier, we also ought to see cellular data speeds improve over time, making them a reasonable alternative to landline broadband for some segment of demographics.

Operational Market Risks

There are also a few potential operational issues that the city needs to think about as part of considering building a fiber network.

<u>City As the ISP</u>. The number one issue that would always be concern is the one of not operating the business well. There are several factors that don’t point to the city as a good choice to be an ISP. First, most of the successful municipal ISPs were already municipal electric companies and had the technical expertise involved in operating a large complex network. That expertise gave them a big head start when launching a fiber business. Since the technical aspects of the electric business and fiber business are somewhat similar, these cities also had experience with a lot of needed day-to-day knowledge on how to operate this kind of business. They know how to operate and manage a fleet of outside technicians; they know how to staff and operate a customer service call center; they know how to make quick network repairs to keep the network operational. These and a long list of other lessons were learned from being in the electric business

There is also the issue in Davis of controlling costs due to the high labor costs in the city. Interestingly, the cost of broadband products are similar nationwide while the cost of running a network vary widely according to local labor costs. A company like Comcast or AT&T can average their costs across many markets. However, even they are less profitable in California cities like Davis than they are in similar sized markets in states where labor costs are lower. The operational risk is that labor costs over time can make it hard to get and stay profitable in Davis.

Partnership Issues. To some extent the issue of the city being an ISP is probably a moot question since the city prefers a scenario where they partner with an ISP partner to operate the network.

However, there are also risks in partnerships. First, there is always the risk that there might not be the ideal partner available. Partnerships in broadband are mostly local and it's likely that any partner will already be operating somewhere nearby in California.

There is also a risk that the city could partner with somebody who is not fully experienced in launching a new network from scratch. Many of the ISPs in the area have not overseen building a big business from scratch—something that mostly comes from having done it. For example, a telephone company that built their network over the last hundred years might not be good at the challenge of building a network in Davis. An ISP that has mostly resold services and operated on other company's networks might not make the transition well.

Therefore, any partnership needs to have a way out for the city. One of the worst scenarios possible is that the city partners with somebody who does a bad job and the city can't break the partnership.

Launch Issues. One lesson that has been learned a number of times in the telecom industry is that it's hard to overcome a poor network launch. If a new network owner makes big mistakes at the beginning it can take many years to recover the confidence of the public in the network and in the business. Early network issues can be of many kinds. For example, we've seen new networks launched that had numerous network outages for the first year until the operator become fully comfortable with all of the nuances of their specific network. While network electronic technology has made great strides since FTTH was introduced, it's still a complex network and little issues can cascade to outages if not controlled properly.

New network providers can get a poor reputation in other ways. In an example mentioned earlier, the FTTP network in Lafayette, Louisiana suffered from huge problems with their video product. This was due to their vendor, Alcatel, not delivering the product that was promised in their response to the original RFP. The TV was so bad that many customers dropped the product and a lot more customers decided not to try the new network. The city fixed the video problems in a year or two but it took many more years to overcome the launch problems and the public perception of the fiber business.

Sales and Marketing. One of the biggest risks of launching a new broadband venture is a poorly executed sales and marketing program. A network can't succeed without getting the needed customers. As discussed elsewhere in this report, a new network can generally count on getting some level of customers that either dislike the incumbent providers or who perceive huge value in the new fiber technology. However, after that first wave of customers, getting the rest of the customers needed to be successful is hard work.

Risks of Operating Losses. It's always of concern for any city-owned venture to lose money. The city needs to have a plan up front for how it will handle a situation where the revenues generated from the business don't cover the cost of the debt used to build the network. Many new fiber ventures find themselves with operating losses. Cities with electric utilities sometimes over these losses by using electric cash reserves or even in raising electric rates. Commercial ventures that are part of a larger company can be covered for a while by the parent company.

However, standalone fiber ventures, either municipal or commercial, run a much greater risk. A standalone commercial venture that runs out of cash generally folds. In a municipal venture the only recourse might be to somehow cover losses from tax revenues.

A city can try to shield against operating losses by using revenue bonds that can shield tax revenues from shortfalls. But if a revenue-supported fiber network fails, and if the city won't jump in and support it with tax revenues, then the new venture will have to go out of business just like a commercial operator. So a city venture, even if funding with revenue bonds needs to ask the question up front of how it might cover operating shortfalls.

Choice of Business Model. The financial analysis shows that there are differing levels of risk with different operating models. For example, it looks a lot harder to cover costs with an open-access network than with a launch as the operating ISP. Using partnerships falls somewhere in between the two extremes. The city would need to balance the desire to have a specific operating model with the level of risk associated with the model.

The Cost of Success. In the telecom world there is a phenomenon we call 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 fiber owner could find themselves without the funds needed to add new customers.

One way to handle this situation would be by issuing a second bond to pay for adding more customers. However, that is not always practical or possible for a city. Moreover, in most places, even a small bond takes a long time to approve and issue.

On the flip side, you don't want to borrow too much money and have the extra funds create interest costs for 25 years.

Operating Life of Fiber. How long does the fiber in a new network last? The answer is—it depends. There are a few factors that influence the life of fiber.

One important issue is how the fiber is installed. While fiber is tough, it can be stressed during construction, which can significantly shorten its life. The number one cause of fiber damage during construction is damage caused when pulling fiber through ducts. There is almost no damage caused by either blowing or pushing fiber, making those the safest installation techniques. However, it's possible to overstress fiber when pulling, which will eventually result in it developing opacity. The opacity in fiber grows over time as very tiny cracks and stress points in the fiber grow larger and start deflecting light.

The second biggest problem affecting the life of fiber is the number and quality of splice points. Over time, as fiber expands and contracts from temperature changes, each splice point can shift tiny amounts and degrade the connection. Luckily, some of the damage from shifting splices can be fixed by resplicing the fibers as they go bad over the years.

The biggest problem does not come from the original splices, assuming they were done correctly, but the splices added later to the network to make repairs for fiber cuts or to add a new customer in a location not contemplated by the original design. Any given fiber run deteriorates a tiny amount every time a new splice is introduced. Over time, too many splices can ruin a given strand of fiber.

Fiber has gotten better over the years as manufacturers have improved techniques. Today's fibers are nearly perfect out of the manufacturing process and ought to last longer than fibers made thirty or forty years ago. The manufacturers have adopted techniques such as pre-stressing fiber during the manufacturing process (pulling it slightly) which pulls out any tiny flaws to keep them from getting bigger.

Material scientists have been studying fiber since the 1980s and they have built models to predict how long fiber will last if properly installed. They look at all of the factors that can cause failure—how it was made, the presence of tiny flaws, factors that can cause cloudiness, the protection provided by the sheath, etc. What they found is reassuring. Studies have shown that properly installed fiber will only have a chance of failure at a rate of 1 in 100,000 per kilometer per year over a 40-year operating time frame. Statistics like that are hard to grasp for a layman, but it means there should be few outright fiber failures for a normal fiber installation during that time frame. This means that fiber ought to easily last forty years and far beyond. Nobody will yet say how much further beyond, but I talked once to a few scientists from Corning and they told me their best guess is at least 75 years; we are going to all have to wait around to see if that is true.

The same scientists have studied real life applications of fiber and have calculated that the chances of buried fiber being cut is 1 in 1,000 per kilometer per year. This means it is 100 times more likely to cut a fiber than to have it fail from inherent flaws. Again, statistics like this aren't straight-line ratios, but it you operate a 500-mile fiber network, this tells you that you can expect a fiber cut every year or so. Of course, some networks do worse than that. Outages from fiber cuts and the consequent weaknesses created by the repair splices are a far greater threat to your fiber network than any degradation of the fiber. So bury it deep!

Electronics Obsolescence. Fiber electronics don't last nearly as long as the fiber and have to be replaced periodically. The questions that should be asked up front are how long the first set of electronics used will last, and how the business will afford to upgrade when the time comes. There are a few reasons in the industry for replacing electronics—functional obsolescence, technical obsolescence, and vender obsolescence.

Functional obsolescence comes from a time when the electronics stop working well and problems cause too many outages. When FTTP electronics were first introduced the industry the maxim was that most electronics would last 7–8 years. However, the state of electronics has changed significantly since 2000 when the industry began. Electronics today are largely solid state and much of the brains of most electronics are embedded in chips. Older electronics had a lot more circuit boards that contained multiple electronics components, and circuit boards would shrink or grow a little, even with small temperature changes and often had problems eventually. Solid state electronics in general last a lot longer.

Functional obsolescence comes from the electronics no longer meeting the demand of the network. We see this most commonly on the electronics that are used to provide bandwidth between the network core and the neighborhood huts and nodes. When FTTP networks were first built, most connections between the core and huts were designed to carry 10 Gbps capacity. Over the years, as customers use more data, these links often have grown too small to handle the needed traffic volume and networks have had to upgrade these links to something faster. The same thing happened on the customer end with the first generation of FTTP electronics that was called BPON. That technology delivered a little less than a gigabit to share with the customers on a PON node (up to 32 homes). In many cases that grew to be too small and networks upgraded to GPON which more than doubled bandwidth. Today there are some network owners contemplating upgrading the customer connections to have a 10 Gbps capacity, and eventually this is likely to become the new standard. But most networks more easily solved this issue by not putting too many customers on a given PON. Cutting the customers from 32 to 16, for example, has the same practical result of doubling the laser speeds.

Finally there is vendor obsolescence, which is always the most frustrating. Vendors sometime fail and go out of business, meaning that a network owner can only find replacement electronics on the open market (like on eBay). More commonly, vendors stop supporting older generations of electronics. The lifecycle of an electronics vendor is that they always have to be improving what they sell. They need to make electronics smaller, faster, or less costly, and over time they keep tweaking electronics to make them better.

At some point they've made enough changes that the newest equipment might not be backwards compatible with older systems (meaning you could no longer buy a newly-manufactured replacement for a given component.) At that point vendors often stop supporting older equipment. This means they no longer manufacturer it. It also means they stop making improvements to the discontinued electronics. They no longer make software updates. They often lose the experts who understood the older equipment.

Network owners always have a choice of what to do with vendor obsolete electronics. Generally, it's still working well. The network owner just needs to decide if they feel comfortable that they would be able to keep the network running if they encounter a big problem. Therefore, availability of spares and replacement components generally are the major issues that drive a network to replace electronics that have become vendor obsolete.

<u>Keeping up With Annexation</u>. One of the unique issues that a Davis network will have to consider will be having a fiber network keep up with any future annexation plans. One would think that the residents and businesses in any annexed areas will want to have the advantages of the fiber network as part of being in the city. That means that any annexation plans would also have to consider how to fund fiber network expansion.

Municipal Purchasing Rules. We've seen that municipal purchasing rules can add to the cost of building a network. While these rules have the goal of making sure that a city doesn't overpay for things they purchase, the rules can add costs when buying something as complex as a fiber network.

The majority of networks built in the country are constructed by commercial companies and this means that the vendors in the industry are not used to working with municipal purchasing rules. We've seen that this generally leads to them padding their prices in a response to a municipal RFP to make sure they can be profitable. They are generally concerned that working with a city will be more difficult and so they build safety against unexpected cost increases into their bids.

Commercial companies are free to negotiate prices with vendors. In addition, they often work with the construction contractor to find ways to reduce costs during the build. For example, a commercial builder will likely have a representative in the field to discuss the lowest cost way to build each street or to engineer around impediments discovered during the construction process. The municipal purchasing process often makes this kind of real-time adjustment to the build process difficult or impossible. We've seen purchasing processes that allow for change orders to the original specifications that have added significant cost to a project.

Rules Affecting Construction. Cities like Davis have numerous rules that affect the fiber construction process. For example, you have rules that define managing traffic during construction. You have rules that restrict the hours when construction can be done. You have rules that require a contractor leave the environment the same after construction than before construction. Moreover, you have inspectors that will check on the construction process to make sure the rules are being followed.

Contrast this with a large unincorporated suburb of a large city. They might have almost none of these rules. This makes it a lot less expensive to build where there are no rules. The inspection process alone can significantly slow down the construction process if work crews are put on hold waiting for inspections.

We are not suggesting that the city shouldn't have rules governing construction. Instead, we are pointing out that those rules add to the cost of construction. However, those rules also mean that traffic is not snarled badly during the construction process. They mean that the contractor doesn't allow dirt run-off during rainstorms. They mean that streets and people's yards are put back as closely as possible as before construction.

Demographics. The demographics in a university town will result in lower revenue per customer. We know that students are not likely to buy telephone and cable TV service, at least nearly to the extent of other demographic groups. We also know that many students are on a tight budget and are likely to seek economic alternatives to landline broadband. Many of them will get by with a cellphone plus access to fast broadband on the campus.

There is also a big issue with selling to college students due to the big annual churn of masses of students leaving and coming to the city each year. We have other clients that work in university towns and the sales process to students is difficult. Many of them will have prearranged utilities, including broadband, before ever coming to the city and may not even be aware of a city-owned network alternative. We have clients that have done well with student populations, but even the ones that do well report that they have a significantly lower penetration rate among students than with full-time single-family homeowners.

<u>MDUs</u>. The percentage of MDUs in the community adds to the challenge of being successful. Our analysis shows that it roughly costs about the same amount of capital to reach an apartment unit as it does a single family home. While there is some savings on fiber drops with MDUs there is additional electronics costs and wiring costs to offset the savings.

In general, for most apartments the average revenue per customer will be less than with single-family homes. This is due to the likely interface with MDU owners. Some of them will only want to buy a large broadband connection and then distribute this to tenants. Others will instead buy ‘bulk’ services that they likely will then include in the rent. In both of those cases the average revenue per unit is lower than revenues that would be expected from a single family home.

<u>Seasonality</u>. Seasonality might be a risk. Seasonality in the telecom industry is when there are significant number of customers that buy service for something less than a full year. This is often seen in resort areas, but it’s also something that might occur with a significant student customer base since students are often not in the city during the summer.

There would only be a seasonality issue if a significant number of apartments go vacant each summer. That would result in at least some percentage of customers not paying for a whole year of service—which mean our financial projections are slightly optimistic. However, this might not be a huge issue in Davis due to the extremely low vacancy rate. If empty apartments are snagged quickly then there might not be as much of a seasonal impact in Davis that might be seen in a university town that has a glut of rental units. In addition, the majority of MDU units in Davis require a one-year lease that are renewed in September each year aligned with the start of UC Davis Fall Quarter.

E. The Basic Business Models

This section of the report looks at the three basic business models considered in the study: a retail model, an open-access model, and a public private partnership (PPP). For each scenario there is a description of the basic way the business model operates along with discussion about the pros and the cons of each model. There was also interest from the BATF (Broadband Advisory Task Force) to consider a cooperative structure, so there is also a discussion of that business model. The following looks at the pros and the cons of each of these business models.

Retail Business Model

We heard repeatedly during the study process that the city doesn’t want to become a retail ISP and sell services directly to customers. However, the city is interested in considering a model where the city builds a network and finds a commercial entity to operate the network and the business.

There are only a handful of public private partnerships that operate this manner. One is RS Fiber, a cooperative that was formed partially with funding from local governments. The business is operated through a vendor relationship by Hiawatha Broadband, which is a for-profit ISP owned by the Fastenol Foundation.

This is a common model in the municipal electric market. There are numerous municipal electric systems that have hired an external vendor to operate the business.

Advantages

> Achieving Community Goals. Communities that choose the public ownership option generally have specific goals and values. These generally include community betterment and community investment. Communities generally have a goal to solve the digital divide and to bring affordable broadband to every home that wants it. Most communities also hope to use a fiber network to spur economic development and to make it easier for existing businesses to operate in the community. Hiring an operating vendor/partner would not hinder the ability of a city to meet its goals.
>
> Local Ownership. Communities often choose this option to provide for local accountability and on reaping the benefits of operating a fiber network from within the community. There are numerous benefits to a community from operating a business using all local employees. Communities also like the idea of not sending profits from telecom spending to the giant ISPs that are located in far-away cities.
>
> City Control. In this operating model the city would get to establish the general policies and goals of the business and change those goals over time as needed.

Disadvantages

> Financial Risks. The biggest disadvantage of building and operating a fiber network is the potential financial risks. Before building a fiber network a city ought to be able to answer the question of what happens if a network does not perform well financially. There are some ways to manage this risk.
>
> The city can finance with pure revenue bonds that are backed only by the revenues of the fiber business. Those bonds are getting more difficult to find since there have been a few defaults of municipal fiber projects around the country. Moreover, even revenue bonds are not risk-free for a city. First, the bonds eat into the credit limit for a city and tie up lending capacity for a long time. Basically, money borrowed to finance fiber restricts a city's ability to borrow money for other purposes. More importantly, a default of a revenue bond is stilled viewed as a default by the city in the financial markets. A city that defaults on a revenue bond is going to be viewed as not being credit-worthy when trying to finance other kinds of bonds. Because of this we've seen cities that use tax money to

cover a shortfall in a revenue bond project in order to preserve their band rating and credit worthiness.

Nonperforming Vendor/Partner. One of the biggest risks of operating through a vendor relationship with an ISP is getting rid of them if they don't perform well. In a vendor relationship the operating partner would completely operate the business. They would hire and manage employees. They would use their own software systems to manage the business. They would probably be supplying the triple play services from headends located outside the city. They would have contractual relationships with all of the vendors needed to make the business operate like TV programming, Internet backbone, etc. It would be challenging to replace an operating vendor without majorly disrupting customers.

Political Interference with the Business. While having city control of a fiber business can mean using the business to meet community goals, there is also the potential for politics to interfere with the profitability of the business. For example, there are a number of examples of municipally owned telecom utilities that require the city Council to approve rate increases. Since politicians don't want to vote for higher rates we've seen cities where the profitability of the business suffered due to an unwillingness to raise rates. In today's industry anybody that offers cable TV has to raise rates every year to keep up with increasing program costs. Therefore, cities need to take steps to shield the business from direct political control.

Added Costs. If the vendor/partner that operates the network earns some sort of management fee this would add to the costs of operation beyond what would otherwise be the case if the management were assembled and run as a core part of the business.

Open-Access Model

Open access refers to a business model where a city builds a network and then sells access to multiple ISPs. The city's only revenues derive from selling this wholesale access and the various ISPs provide broadband and other services directly to customers.

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, much as has happened here. However, 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 dozens of major ISPs willing to consider the model. There are now large open-access networks in places like Amsterdam and Paris as well as hundreds of open access networks in smaller towns and cities. The big networks have over a hundred ISPs competing for customers—many of the ISPs with niche businesses going after a very specific tiny slice of the market. Due to that level of competition, the European fiber networks get practically every customer in their market since even the incumbent providers generally jump to the new fiber network.

That hasn't happened in the US. There is not one example in this country of a large telco or cable company agreeing to operate on somebody else's network to serve residential customers. The large ISPs here will lease fiber outside of their footprint to serve large business customer, 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 a long time, 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 today has only one local ISP that is 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. It's hard to even call the Chelan County network open access any longer.

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 really open access—because the whole purpose behind open access is to provide customer choice.

US Open-Access Networks. Following is a list of many of the other municipal open-access networks in the country:

- The PUDs in Washington State. These are countywide municipal electric companies. The PUDs are restricted to being wholesale providers for broadband due to legislation passed a number of years ago. There are numerous different open-access models being tried at various PUDs, with the largest being Chelan PUD, Grant PUD, and Douglas 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 has had significant financial problems since inception. Utopia doesn't charge ISPs to get onto the network. Instead, when a household joins Utopia, a customer accepts a lien on their home, and has the option to pay $300 down and $30 per month for 10 years, zero down and $25 per month for 20 years, or a flat payment of $2,750. Arrangement allows ISPs to offer services like 250 Mbps fiber for $35 per month.

- A similar law was passed in Virginia after Bristol Virginia Utilities (BVU) built a retail fiber network. The legislation grandfathers BVU as a retail provider but 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 a wholesale 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 is a network in Urbana and Champaign Illinois that purports to be open access operating under the name UC2B. The backbone network for this project was built from the Broadband Stimulus Grants that were awarded in 2009. The network is owned jointly by the two cities plus the University of Illinois. UC2B has not yet built a citywide fiber network, but works with various ISPs to build fiber one neighborhood at a time to the network. So rather than being open access, it's more like negotiated deals with different ISPs to operate in different parts of the city.
- 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 service business customers. An example of this is AXcess Ontario in Ontario County, NY.
- 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 since they were unable to find ISP partners they now offer full retail services directly to residents.
- There are other cities that are considering open-access networks. The largest of these is San Francisco, which is considering funding the network entirely through a 'utility fee' charged by the city to every home and business in the city. The plan envisions offering free or low-cost access to ISPs.

<u>Advantages</u>

<u>Customer Choice</u>. The most appealing aspect of an open-access network is that it offers a variety of choices to customers over the same fiber network. Many cities hope to offer open access for this reason.

<u>Disadvantages</u>

<u>Retail/Wholesale Revenue Gap</u>. As described above, there is a big difference in the revenue stream between collecting the retail revenue stream (all customer revenues) and a wholesale revenue stream (the fees charged to the ISPs for access to the network). Unfortunately the cost of the network for an open-access network is only a little smaller than the cost of a retail network, and so the lower revenue stream makes it exceedingly difficult to cover the financing costs of the network.

Many open-access networks have operating revenues that are sufficient to operate the network, but we don't think any of these networks are generating enough revenue to cover the cost of building the network**. That means open access is only reasonably possible if the network is paid for by some revenue stream other than the open-access revenues**.

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 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 low-margin customers. In real life practice we see the ISPs in an open-access network only pursue business customers and high-end residential customers.

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. Every open-access network we know of has gotten fewer customers than they predicted. This is due to both the cherry picking by ISPs, but also due the fact that many small ISPs don't have the money or experience to operate effective marketing campaigns. They tend to spread more by word of mouth.

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 the many ISPs don't make this same effort. Therefore, over time there grows to be a lot of homes and businesses that have gotten a fiber drop and ONT housing that are no longer used and are not repaying the cost of installation. One of the larger open-access networks has 20,000 active customers but also 5,000 of these abandoned customer investments.

Public Private Partnership

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 city, mostly funded by a commercial entity, or funded jointly by both.

PPP Funded Mostly by a City. There are not many examples of this in the US, but there might be a few such arrangements. The details have not been published, but it's likely that in the Google Fiber partnership with Huntsville, Alabama that Google Fiber is responsible for the costs inside the customer premise. The partnerships between Ting and cities like Charlottesville, VA and Westminster, MD probably also meet this definition.

PPP Funded Mostly by the Commercial Provider. There are probably thousands of examples where a commercial provider has brought fiber to a city but don'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 directly.

A city and an ISP can work together to create a PPP even if the ISP pays for the full cost of the network. To be a PPP would require that the city provides something of value to an ISP in return for concessions of some sort. The first few markets for Google Fiber are probably this type of PPP. While the details of the arrangements have never been made public, it's widely believed that Kansas City provided concessions to Google 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. If the city gave Google anything of value, then this arrangement starts looking like a PPP.

For this to be a more traditional PPP, however, a city would have to get something in return for the concessions they make to an ISP. This could be almost anything that the city perceives to be of value. It might be free or reduced telecom prices provided to the city or fibers connecting city locations together. It could also be the ISP agreeing to help the city meet some social goal, such as building out to parts of the city that the ISP might otherwise would not have considered.

PPP Funded Jointly. When both the city and an ISP 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 which is being used to fund about 25% of a fiber-to-the-premise system. They are partnering with a new for-profit cooperative that will own and operate the 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.
- 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 city can make to somebody else's fiber network. This could include cash, real estate, excused fees, or sweat equity. Cities can allow a commercial provider to use parcels of lands or give them an existing building. Excused fees might mean the city won't charge for something that would normally be due to them, such as permitting fees or property taxes. The city 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 to 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 for such a business model 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.

In addition, the city partner needs to get enough revenue to cover its costs. Commercial providers have significantly different goals for a fiber business than a municipal or nonprofit entity. Municipal providers count a government business as a success as long as the revenues generated exceed the costs of operating the business. While the government might hope for any even better, i.e., profitable, solution, breakeven is good enough.

<u>Advantages</u>

Smaller City Contribution. The extent to which the private partner funds the business 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.

Disadvantages

Matching Goals and Expectations. One of the primary reasons why there are not a lot of telecom public private partnerships is that it's often difficult to reconcile the differing goals of the two sides. The commercial partner is generally going to be very focused on the bottom line and returns while the community part of the business often has goals like community betterment and lower rates. It's often very difficult to put together a structure that can satisfy most of these needs. Even when PPPs have been formed there are numerous examples of partnerships that broke up after a few years when the two sides were unable to reconcile their differing goals.

Expensive Money. Since commercial partners generally want to make at least 20% returns 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.

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. Cities 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.

Cooperatives

Cooperatives are governed and protected under federal law by the Capper Volstead Act. There are generally additional state laws that govern forming and operating a cooperative. A cooperative is a legal entity owned and controlled by its members and members often have a close association with the enterprise as producers or consumers of its products or services. Cooperatives are typically based on the cooperative values of self-help, self-responsibility, community concern, and caring for others. Cooperatives generally aim to provide their goods or services at close to cost while any excess earnings tend to be reinvested in the enterprise or returned to individual patrons based on patronage of the cooperative.

Cooperative governance usually takes the form of a Board of Directors elected by patronage members of the cooperative. Generally any customer that buys services from a cooperative business is eligible to become a patronage member of the cooperative.

Cooperatives formed to operate technically complex businesses like telecoms generally hire qualified staff to operate the business. The staff reports ultimately to the Board of Directors.

Cooperatives are limited in the way they can use proceeds of the business and accumulated cash generally must be reinvested back into the business or returned to members as patronage dividends.

One interesting model to consider would be for the city to make a contribution to help start a cooperative. This was done in Minnesota with RS Fiber where the local governments contributed 25% of the funding needed to start the business. That funding then allowed the cooperative to pursue traditional commercial funding sources.

<u>Advantages</u>

> <u>Owned by Customers</u>. Members generally like the fact that they can have some say in how the business operates. Customers also like patronage dividends, but in a telecom cooperative it could easily be a decade or more before dividends are paid. Cooperatives generally see little customer churn, meaning that once somebody becomes a patron they are not likely to leave the cooperative in response to a competitive offer from some other telecom provider.
>
> <u>A Cooperative is a Community Asset</u>. This means that the revenues of the business are spent locally and the profits from the business are kept locally. A telecom cooperative would add value to the community just by being local. Local ownership is historically more responsive to community needs and offers the promise of better services to customers through local accountability.
>
> <u>Avoids Any Municipal Issues</u>. A cooperative is a commercial business and as such is free from any restrictions that might affect a municipal system. For example, a cooperative is not subject to municipal purchasing practices. A cooperative doesn't have to make its intentions public.
>
> <u>More Options for Funding</u>. Since cooperatives are commercial businesses they can get funding from many different sources.

<u>Disadvantages</u>

> <u>Lack of Control</u>. If a city made a contribution to help start a cooperative the city would then have no say in how the business is operated since it's owned by customers. Once the business is given to customers it can never be taken back.

Starting a Coop is a Challenge. There is a lot of work needed to for a cooperative and raise the funding needed to build a fiber network. That requires significant time commitments from prospective cooperative members to tackle these tasks on a non-compensated basis. There is also an early need for a number of citizens to step forward and take on roles as the cooperative board to set direction and launch the business.

Need for Equity. One of the biggest challenges to starting a cooperative is that commercial lenders will expect the new business to contribute equity. That likely means raising a significant amount of money from the community to get started.

V. Implementation Timeline

The RFP asked us to provide a possible timeline for the project. The first big steps that the city would face would be to make the decision to build the fiber business and then raise the money to pay for the network. We have no way of predicting that timeline because every city faces different issues during that process. However, we can provide a general outline of possible (recommended?) next steps and discuss the timelines that can be expected once bond funding is received. Below our discussion focuses on these two different time periods, before and after bond funding.

A graphical depiction of these steps and implementation timeline is included as Appendix III on pages 140-141.

Decision to Move Forward – Phase II

I am calling Phase II the time between getting this study and having the bond or other revenue on hand to begin the launch of the fiber network and business. The first thing that has to happen in a community is that a decision has to be made somehow that the community ought to tackle finding a broadband solution. No two communities that have formed a community broadband solution have gone about this in the same way.

There are a number of steps that would need to be taken before the city could make the decision to move forward. Some of the most immediate next steps required are included in our list of 'Next Steps.' This includes things like considering a residential survey and doing more investigation of the MDU issues identified in this report. We would categorize this next phase of work as the second phase of the study process, with the work done on this report being the first phase.

Phase II

<u>Next Steps</u> (Short-term)

- Residential Survey
- MDU Analysis
- Understanding Funding Options
- Choose a Business Model
- Identify Potential Partners
- Community Education / Buy-in
- Consider Implementation in Fiber Network in Phases
- In-depth Review of City Practices (that affect fiber)
- Keep an Eye on Broadband Prices

However, there are a lot of other things that would have to be done before bond closing. This could include things like:

- Bring politicians and staff up to speed on broadband and the issues involved with getting into the fiber business.

- Develop specific goals for the project such as providing a product for low-income households.
- Decide on the specific business plan to be pursued.
- Educate the public on the topic.
- Engage a financial advisor to look at the specific issues associated with funding.
- Hold a public referendum to approve the bonds if that is required.
- If an operating partner is part of the solution, then identify the operating partner and undertake the negotiations and contracts needed to have them on board before bonding.
- Choose the primary vendors and contractors. Bond funding makes it necessary to move quickly to build the network after funding is received, so the city would want to issue RFPs and choose the engineer, construction contractor, and possibly other major vendors so that they are on board when the network is funded.
- Choose the sites for any needed huts and acquire the land if that's needed.
- Revise the financial business plans to recognize the facts discovered in working with a financial adviser and vendors/partners.
- If alternate financing is to be used, such as tax financing, then explore all of the issues related to making that happen.
- Sell the bonds and or close on alternate financing.

Even in small communities we rarely see this process being done in less than a year, and we've often seen this take a lot longer.

Timeline from Date of Funding

Once funding is received the process of building a fiber network is something that can be planned on a relatively tight timeframe. Assuming that you engage experienced engineers and contractors who have built fiber networks before this is relatively straightforward. However, that comes with the caveat that no two cities are the same. There are going to be local issues that affect the timeline and that will let you go faster or slower than normally expected. For example, one of the many steps, like locating existing fibers, might take longer in Davis than in other communities. Nevertheless, that sort of thing should all be discovered before the product launch and built into your specific timeline.

The business plan projections used in this study assume that the first customer could be added to the network 18 months after launch. That is a reasonable and achievable goal in most cases. That doesn't mean the whole network will be complete by then, but it would mean that the network core is completed, that at least one neighborhood node is completed, that employees are on board, and that all software and operating systems are in place.

There is one step that can really speed up the timeline. If a city is willing to begin the engineering process before bond closing then the construction company can begin building sooner than is shown below.

Major Milestones in Launching a Fiber Network – Phase III

Following is description of the major tasks required to launch a fiber network and fiber business. These tasks would vary somewhat if the city was launching a retail versus a wholesale network and the tasks below are for launching a retail network. The tasks and timeline are similar for both business models, with the wholesale open-access model replacing customer-related tasks with ISP-related tasks. This timeline begins on the day that bond or other financing is closed and money is available to begin building the network. A graphical representation of these tasks is included as Appendix III on pages 140-141.

First Quarter after Funding

- Operating partner on board on day one to manage the launch process.
- Engineers immediately begin the detailed network design with the first goal being to do enough engineering to hire a construction contractor.
- At end of quarter the engineer issues RFP to hire construction contractor.
- First vehicle, computer, etc. purchased.

Second Quarter After Funding

- Contractor hired and contract negotiated.
- Contractor or engineer begins to order fiber materials (depends on who is going to do this).
- Staging area readied to receive, store, and disperse construction materials.
- Work begun to prepare sites for huts.
- Engineers get ready for construction management.
- By end of quarter the contractor begins the first fiber construction on the backbone fiber network between the core and the first hut.
- RFPs issued for electronics.

Third Quarter After Funding

- Technical Operations Manager hired.
- Construction on fiber backbone continues.
- Construction begins by the end of the quarter on the fiber in the first neighborhood node.
- Hut construction started.
- The location for the core electronics is made ready (rehab existing government building or start building a new one).
- Electronics vendor chosen.

Fourth Quarter After Funding

- Inside technicians hired.
- Construction finished on backbone fiber rings.
- Construction continues on first network node and probably started in a second node.
- Core hub site completed and made ready to provide service.
- First hut completed and in place including electronics and power.
- Preliminary testing of the network begins.
- Office space made ready.
- Storefront location identified.
- OSS/BSS software preparation begins needed to operate the business.

- Pre-sales marketing campaign started (done on web).

Fifth Quarter After Funding

- First installers hired and trained.
- First node fiber completed and testing begins.
- First installation of FTTH electronics made for first node hut and testing begins.
- Internet backbone to the world put in place and tested.
- Operating partner begins making connections to deliver voice, video, and broadband products.
- Premarketing sales continue and customers residing in the first node are identified.
- By end of the quarter a few ‘test’ customers are identified.
- Product pricing finalized.
- Software systems fully loaded with company data and testing begins.
- Processes are all specifically designed. Responsibilities for every phase of customer process assigned and tested.
- Fiber construction continues.

Sixth Quarter After Funding

- Test customers installed at the beginning of the quarter. They are given the triple play products which are all vigorously tested.
- Customer service representatives hired and trained.
- By end of quarter orders are being taken for customers who pre-signed for service.
- Testing on all aspects of provisioning tested (process of taking orders and doing installation).
- Company finished testing on first node and takes ownership from contractor.
- Sales and marketing campaign kicks into full gear.
- Store front readied and open by end of quarter.
- Billing process tested and made ready.
- Fiber construction continues.

Seventh Quarter After Funding

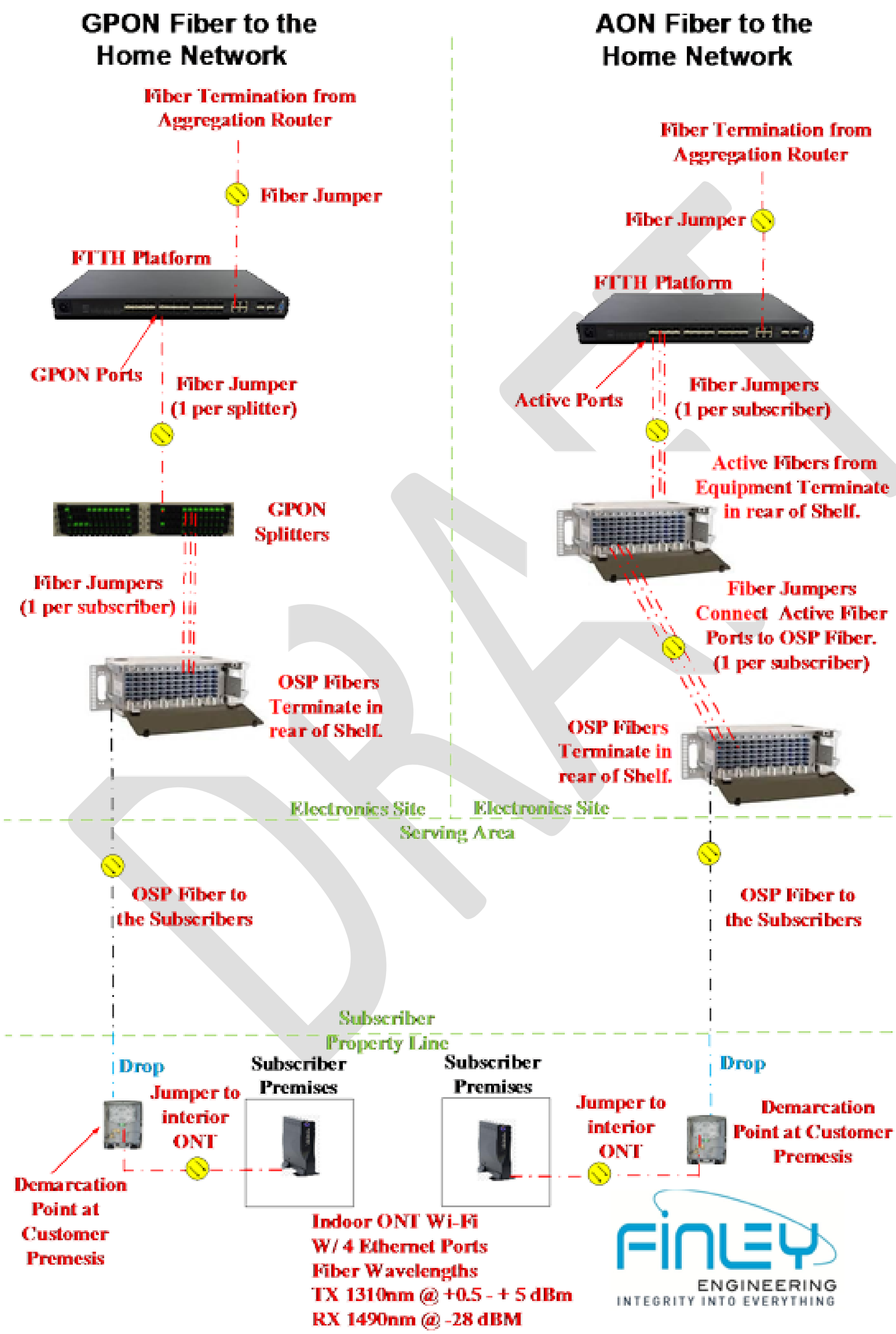
- First live customer sold and installed. Probably install just a few customers the first month to work out any kinks in the installation process. Then installations tackled in earnest.
- Customer service, help desk, trouble call processes all activated.
- 100% review done on all end-to-end customer processes to make sure processes are working as planned. Remediation undertaken to fix any problems/issues.
- Company begins taking ownership of additional nodes as they are completed and tested.
- Fiber construction continues.

After This

- It would probably require 2.5 to 3 years until construction is complete and the city takes ownership of all neighborhood nodes.

138

Appendix I: Comparison of AON and PON Networks



Appendix II: Glossary of Terms for Appendix I

Active Port: An Active Ethernet port is an optical port in an AON network that establishes the light connection between the FTTH core platform and the customer ONT. Ports typically have replaceable optics that are capable of 1 Gbps upstream and 1 Gbps downstream, but faster speeds are available. Ports create a one-to-one connection with the subscriber ONT and are not shared, meaning that each subscriber receives a full 1 Gbps connection.

Aggregation Router: A hardware device that combines and distributes inbound and outbound transmissions from customers. Common vendors are Cisco and Juniper.

Active Ethernet: In the FTTH arena this is the same as AON, just below.

AON: Stands for Active Optical Network. An AON network uses powered switching equipment like a router to direct optical signals to customers. Each subscriber in an AON network has a dedicated connection and doesn't share last-mile bandwidth with other subscribers.

Cutover: This is the industry term for the installation process. The installation of a customer generally requires work to construct a drop, to connect the customer electronics (inside or outside of the premise, install needed devices inside the premise (like settop boxes), modifying existing wiring inside the premise if needed, and making the needed changes at the neighborhood hut.

Demarcation Point: This is the point that defines where the fiber network ends and customer wiring begins. This is typically a plastic shell with a pre-terminated fiber connection.

Drop: Fiber optic cable that connects the outside fiber network in the right of way to the demarcation point at the subscriber premises. This is typically a 4-fiber cable.

Fiber Jumper: A fiber jumper, sometimes called a fiber patch cord is a length of fiber cabling fitted with a connector at each end. Jumpers are used to connect network hardware devices or network hardware to the structured cabling system.

FTTH Platform: Fiber-to-the-Home (also referred to as FTTP, Fiber-to-the-Premise). The FTTH platform refers to the whole set of electronics used to power and deliver bandwidth to nodes in the network and to customers. Common vendors include Nokia, AdTran, Calix, and Zhone. This equipment at the FTTH core is typically sold as a chassis with network cards that can be added as needed. These cards can utilize different technologies such as AON or GPON.

Gbps" Stands for Gigabits per Second. It's a measure of the speed of data transfer and 1 Gbps represents delivery of 1 billion bits in a second.

G. Fast: This is a technology used on telephone copper to increase bandwidth. It uses higher frequencies than historic DSL and can deliver as much as 500 Mbps bandwidth for several hundred feet. The short distances make it most useful in moving bandwidth around a home, apartment or office.

GPON: GPON stands for Gigabit Passive Optical Network. A GPON network uses optical splitters to route signals to multiple customers sharing a fiber. The technology is called passive because the splitters are not powered. This technology allows one laser at the core to be used to serve up to 32 customers.

GPON Port: A GPON Port is the laser and electronics used to connect the FTTH Platform to the splitters. A port can communicate with up to 32 ONTs. GPON ports typically have replaceable optics that are capable of 2.5 Gbps upstream and 1.2 Gbps downstream, and subscribers on a splitter share this bandwidth.

Keysystem: This is a small private telephone switch, mostly used by businesses to provide business calling features such as call holding, call transfer, etc.

Mbps” Stands for Megabits per Second. It’s a measure of the speed of data transfer and 1 Mbps represents delivery of 1 million bits in a second.

NID: Network Interface Device. This is the industry term for the small box placed on the outside of a home or business to house the external electronics. There is no need for a NID if the customer electronics are put inside the premise.

NG PON2. This is the next anticipated generation of passive optical devices that increase customer bandwidth to as much as a symmetrical 10 Gbps.

ONT: Optical Network Terminal (ONT) is a powered electronics unit that converts optical signal from the fiber network to an electrical signal for use inside the subscriber premises. ONTs can have different capabilities to support multiple Ethernet ports, voice ports, video transmit and receive ports, and WiFi. Some ONTs are capable of operating on both AON and GPON networks.

OSP Fibers: Outside Plant Fibers are the fiber network built to traverse city streets and can be either aerial on poles or buried. The OSP network typically is comprised of various sizes of fibers with differing numbers of fiber strands. The network is routed through terminal devices like handholes or pedestals to provide points of access to customer drops.

Overbuilder: an overbuilder is a company that utilizes or builds on an existing tele-communications operator’s network.

PBX: Private Branch Exchange. This is a larger private telephone switch used by businesses and governments to supply calling features to large numbers of telephone sets within the business. This is larger than a keysystem, although there is no official cutoff defining each kind of device.

Splitter: Splitters allow a single GPON interface to be shared among many subscribers. The number of subscribers is defined by the split ratio which is typically 1:16 or 1:32. Splitters contain no active electronics and don’t require power to operate. Optical Splitters are located between the FTTH Platform and the subscriber ONT.

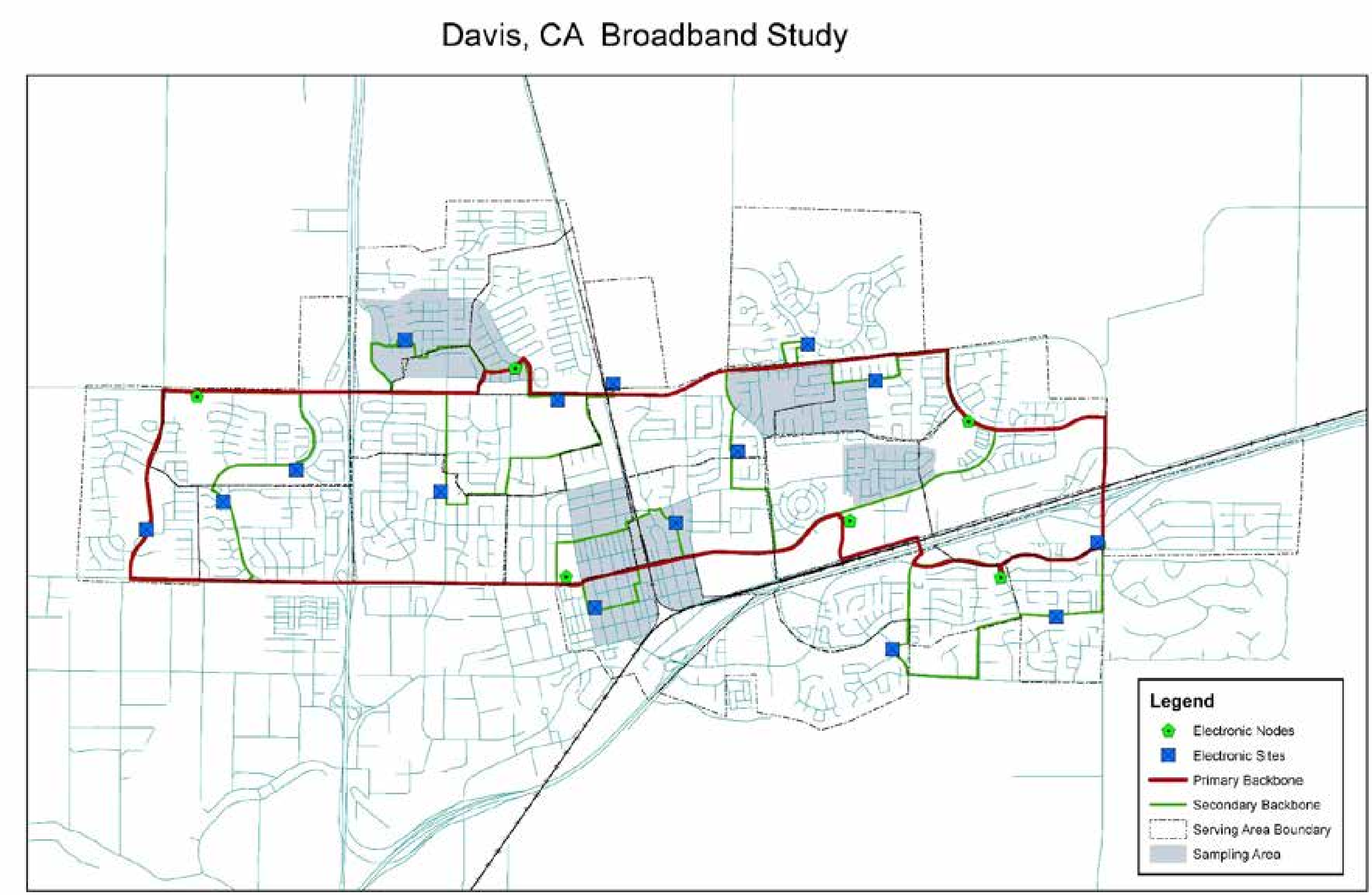
XGS PON: This is the first new generation of passive optic electronics that would deliver 10 Gbps download and 2.5 Gbps upload to a premise.

Appendix III: Typical Implementation Timeline – Phase III

City of Davis Project Launch Time Line	Pre-Funding Year				Year 1				Year 2				Year 3			
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
Decision to Proceed	*															
Identify Operator	■	■	■	■												
Obtain Funding	■	■	■	■												
Identify Engineer			■	■												
Hire General Manager				*												
Close on Funding					*											
Engineering Design					■	■	■	■	■							
Choose Contractors						■										
Construction Readiness						■	■									
Obtain Hut Sites						■	■									
RFP for Electronics						*										
Hire Ops Manager							*									
Build Fiber Rings						■	■	■								
Prepare Core Headend							■									
Hire Technicians								*								
Construct Huts								■	■	■						
Fiber Construction								■	■	■	■	■	■	■		
Ready Office Space								■								
Ready Storefront								■								
Test OSS/BSS Software								■	■							
Pre-Sales Campaign								■	■							
Hire & Train Installers									*							
Network Acceptance									■	■	■	■	■	■	■	

City of Davis **Project Launch Time Line**	Pre-Funding Year				Year 1				Year 2				Year 3			
	Q1	**Q2**	**Q3**	**Q4**	**Q1**	**Q2**	**Q3**	**Q4**	**Q1**	**Q2**	**Q3**	**Q4**	**Q1**	**Q2**	**Q3**	**Q4**
Install Node Electronics									■	■	■	■	■			
Tie to Internet									*							
Triple Play Turn-up									■	■						
Test First Customers									*							
Establish Prices									■							
Test all Software									■	■						
Establish Work Flows									■							
Hire Cust. Service Reps										*						
Take First Live Orders										*						
Test Provisioning										■						
Full Sales Campaign										■	■	■	■	■	■	■
Storefront Opened										*						
Test Billing System										■						
First Live Customer											*					
Technical Backoffice											■					
Install Customers											■	■	■	■	■	■

Appendix IV: Map of the Study Areas Showing the Proposed Network Design and Fiber Ring



Appendix V: Business Plan Assumptions

Following are the major assumptions used for each of the three primary business models.

A. Retail Model - with One ISP Operator:

The basic premise of this financial model is that the city would finance and build the fiber network and would choose one ISP partner to operate it. The purpose of this model is to generically understand the potential for any one provider to profitably offer services on a fiber network; this scenario could just as easily be created to consider a for-profit ISP building the network.

In this scenario it was assumed that the relationship with the ISP is a vendor relationship. This would be a city-owned network and business, just operated by somebody else. The scenario also assumes, for simplicity's sake, that the operating ISP is a nonprofit. This was done so that the results of the study would not be distorted by assuming some split of profits between the ISP and the city. However, there is no reason that an ISP partner could not be a for-profit ISP.

Revenue Assumptions

Setting retail rates in a financial forecast is always challenging for a few reasons.

- For example, consider something as simple as a home landline telephone. The prices charged by AT&T and Comcast are not easy to compare. As mentioned previously in this report, both companies disguise the real cost of their voice products on bills. There are several 'fees' for telephone service that are part of the price of the product, but which most customers assume is a tax of some kind. In addition, both companies, particularly Comcast, include their products in bundles in such a way to make it hard to know what any one component of the bundle really costs.
- Not all customers pay the same rate. In looking at bills we see prices that differ widely within the same market. Many customers have taken advantage of specials or promotions to get temporarily low rates. Other customers call in yearly to negotiate for lower rates. Interestingly, it is the long-term steady customers of the big companies that typically pay the most.
- There are often 'grandfathered' products, meaning products that a customer purchased years ago but which are no longer available to a new customer.
- The hardest products to make sense of are residential broadband. For example, as with the phone bills, the broadband products from Comcast and AT&T are hard to compare. It's also not untypical for incumbent providers to sell 'up to' speeds where all they promise is the best effort to deliver the advertised speeds, while the real data products are often much slower than these advertised speeds, so we strive to understand the real speeds in the market compared to the advertised speeds. Comcast also sells 'blast' products that are faster for the first minute of two of each connection but then revert to the normal product speed.

We set rates in the forecasts based upon the following:

- First, we gathered a number of actual bills from customers to see what they are really paying. Since we look at customer bills often we usually can distinguish between fees that the incumbents keep and those that are really taxes. This research is described in more detail in Section I.B of this report (pages 22-27).
- CCG performs a number of feasibility studies every year and so we are often also able to see what companies charge elsewhere. We've found that big companies like AT&T and Comcast tend to be similar (but not entirely the same) everywhere in the country. They probably do this in order to be able to handle customer billing and inquiries.
- Pricing products for an overbuilder is somewhat of a philosophical issue. For example, some ISPs try to have the lowest prices in a market and compete on price. Others try instead to charge just below market prices and hope to capitalize on offering better service. We even know some ISPs that do well while charging more than the incumbent providers. We have tried to set prices that are modestly lower than the prices charged by the incumbents. That is the philosophy we see adopted by most of our clients. Most of our clients have come to understand that setting prices really low may help to win more customers, but will do so by sacrificing profitability. If the city was really going to get into this business you would want to develop a pricing philosophy early on in the process since this analysis shows that the performance of the business in Davis would be sensitive to changes in prices.
- CCG also works with hundreds of ISPs in the retail triple play business and our choices of prices represents what see from many of them. Many of our clients compete against the same incumbents that are in Davis and we can look at a lot of real life examples of how they have decided to set prices.

Following are the specific assumptions for triple play prices used in the forecasts.

<u>Telephone Rates</u>: Telephone service is one of the hardest products to price in a market for the reasons described earlier. It's often hard to understand what people are paying for landline voice from AT&T or Comcast. To a large extent, most of the incumbent AT&T telephone products have been detariffed in the state. This means that the company is allowed to charge whatever they want, within some parameters. More importantly it means that different customers pay different prices for an identical product.

The models assume simple pricing for residential phone service:

Basic Local Line	$18
Line with Unlimited Long Distance	$25

Both lines would include a full package of features like voice mail, caller ID, etc. The basic line would only be able to make free local calls plus have access to 911. For Davis that is a fairly restricted area that includes the city and nearby surround areas as well as the Dixon and Woodland areas. A customer with a basic line would need to use a calling card or some other method to pay for long distance calls if they wanted to make them. The $25 voice product includes unlimited long distance nationwide. Anybody who still uses the home phone to make many calls would likely choose this product.

The models assume that these prices are all-inclusive and there would not be any add-on fees other than required taxes. There would be no separate Subscriber Line Charge or any other hidden fees that the incumbents or other competitors might charge.

Business telephone rates vary more than residential rates. To a large extent business telephone rates have been deregulated. That means a telco or competitive provider can charge any rates they can negotiate. There are also a number of different kinds of business telephone lines. Businesses can buy bare lines with no features to use for fax machines, lines with features in the same way that a residence can buy them, and lines where the telephone company provides business features like call transfer, call hold, and those functions associated with business telephone service.

It's relatively easy for a competitor today to support most of these types of telephone lines. They can easily sell the newest kinds of digital phones that businesses want. The business should also be able to support customers who have their own in-house phone systems, referred to in the industry as a keysystem or PBX service. The product for this service are the outgoing lines that connect the systems to the telephone world.

We have assumed that the city ISP would not sell voice services to large business customers. First, many large businesses are part of nationwide or large regional companies and that use one vendor for all locations. That makes it hard to sell voice to hotels, banks, grocery stores, and numerous other businesses that are part of a larger corporation. Moreover, we've also seen that other large businesses with complex voice needs, such as a hospital or university, will only buy service from a company with broad experience in serving complex businesses. We've seen repeatedly that for larger businesses quality of service is more important than price.

By looking at the experience of many other clients the assumption was made that the smaller businesses in town will spend an average of $50 per month for voice while somewhat larger (but still not big) businesses will spend around $100 per month. Those prices represent a mix of businesses that buy more than one voice line as well as a mix of features and long distance.

Cable TV Products: The primary issue with selling cable TV service is that programming costs—the costs to buy all of the content on cable lineup—are expensive, meaning that the product line doesn't have a lot of margin.

Because of the low margin most competitive providers don't compete with lower-than-market prices for cable TV. Nevertheless, most fiber ISPs have found that they still need to offer cable TV. When Google Fiber first launched in Kansas City they only had broadband product and they found few takers of their product. Since then they also introduced both a cable TV and a voice product in order to get enough customers.

The models start with today's market rates for cable TV along with today's market costs for programming for a normal channel line-up.

Since programming costs increase significantly every year, ISPs offering cable have to raise cable rates each year to cover those cost increases. The models make the assumption that the new ISP would pass on all programming cost increases to customers—thus maintaining the same margins as today moving forward. The easiest way to achieve this in the model was to not increase either prices or programming costs. That assures that the gross margin remains the same throughout the models.

Nobody in the industry thinks that cable TV is going to remain in its current form over the next decade or further into the future. Yet there is no consensus of how it might morph. The television industry is seeing dropping customers due to cord cutting. They are seeing the youngest American generations watching a lot less traditional television, meaning the average age of TV users is rapidly rising. They are seeing reduced advertising revenues and there is now more spent on web advertising than on TV advertising. They are seeing companies like Netflix, Amazon, and other start-ups produce a lot of great original programming. They are seeing standard cable networks migrating content to the web on platforms like Sling TV, and are seeing other traditional cable networks like HBO and Disney/ESPN move to the web.

It's almost certain that the cable TV products assumed in these models will not reflect the market in a decade. Therefore, the most conservative assumption was to hold the product assumptions steady and assume that there will remain some sort of cable product on networks that will also make a modest margin. Note that one of the sensitivity studies examines the margins from offering cable TV. The good news is that removing cable doesn't decrease the overall bottom line by much. Nevertheless, we also know that today a network without a cable product will have a hard time gaining new customers.

The forecasts assume the following products. The models assume the same products for residents and businesses.

Basic Cable: $27. This is the line-up of network channels like ABC, NBC, CBS, FOX, and PBS plus a few other local channels.

Expanded Basic: $70. This includes about 75 channels. It includes the basic lineup and adds the most popular cable networks like ESPN, Disney, the Comedy Channel, etc.

Premium: $81. This would include roughly 200 channels and would match the top tier offering by the satellite or local cable companies.

Movie Channels: These are extra and the models assume that the rates charged for these networks just barely cover the cost of buying the programming (which is true for cable providers today).

Settop Box Fees: The models assume there will be a charge for the cable settop boxes to recover those costs. The cable companies now charge as much as $8 per box, but the model assumes a monthly fee of $5.

DVR Service: There forecasts assume that some customers will want to rent a DVR settop box from the ISP to record shows. The assumed an additional monthly rate of $6.95 for the DVR.

Broadband Products: Discussions with the Broadband Advisory Task Force led to the decision to offer a simple set of broadband products. There was a strong feeling that anybody on the fiber network ought to get a fast speed. There are many companies that share this view and we've assumed the same two products offered by Google Fiber as an example.

For residences the models assume a 100 Mbps symmetrical data product for $45 and a gigabit product for $75.

For small businesses the models assume a 100 Mbps symmetrical data product for $70 and a gigabit product for $125.

It would be possible to offer a wider array of different speeds, but the only real way to do so would be to offer some slower speed at a lower price. The problem with doing that is that we know that in most markets that anywhere from 75% or more of customers will choose the lowest cost broadband product as long as it is viewed to be adequate. If the new ISP had a product of something like 20 Mbps for $30 then a majority of the residents of the city would probably choose that product, and that would create a drastic reduction in the revenues needed to pay for the network. This dilemma makes it hard to create a product for low-income households.

We've also seen repeatedly that few customers are interested in products with speeds between 100 Mbps and 1 Gbps, so adding more middle products won't entice customers to spend more.

Residential	Price	% that Buy
100 Mbps download	$45	90%
1 Gbps download	$75	10%
Business		
100 Mbps download	$ 70	70%
1 Gbps download	$125	30%

These speeds are not a firm recommendation and a better way to think of them might be as fast and faster, with the speeds to be made fast enough to provide a competitive advantage in the market.

The forecasts do not suppose any future rate increases for broadband. This is a controversial topic in the industry today. To a large degree there have been very few rate broadband increases from the major ISPs over the last decade. While prices have held fairly steady, the ISPs with good networks, like the cable companies, have unilaterally increased speeds several times while maintain the same rates.

However, there is a lot of current industry speculation that Comcast and the other big cable companies are contemplating significant increases in broadband prices. The big ISPs are starting to feel earnings pressures. They are continuing to lose cable TV and landline voice customers. They are seeing drops in advertising revenue. There is a big hope among the largest ISPs that they will be able to monetize their customers' data, which will to allow them to complete with Google and Facebook in the targeted advertising business.

The big companies have posted increased earnings each quarter for many years due to the ever-growing number of broadband customers in the market, but overall broadband penetration is now over 82% of all households and the rate of annual customer growth is finally starting to slow down.

Since the big cable companies and telcos are publicly traded companies they are going to do everything possible to maintain their stock prices. That means that broadband prices will have to increase.

This does not automatically mean that the city would also raise rates—this would be a policy decision. However, if you raise rates then the financial forecasts improve significantly. We chose to be conservative and not raise future rates.

<u>Wholesale Bandwidth</u>: The model assumes that wholesale bandwidth would be sold to CLECs, wireless carriers, and other ISPs. These are probably the most difficult rates to predict because these are generally set in each market based upon the demand and the fierceness of competition. For instance, if some other service provider is able to reach most businesses with fiber then the rates might be competitive. However, if the new fiber network is the only one reaching many businesses then rates might be higher than what has been assumed in the forecasts. The wholesale transport rates assumed for a connection between the network and one customer location are as follows:

1 Gigabit	$ 275
10 Gigabit	$ 750
100 Gigabit	$1,500

While these prices might feel higher than the retail broadband rates suggested above, it's important to understand the differences between the two products. These wholesale rates are for a dedicated transport rate between two points. That means that customer has full access at all times to the bandwidth and can use it for any purposes they wish. The price includes tying to the wholesale customer at both the headend and at the customer location.

The basic residential and small business broadband rates are shared bandwidth. While those products are assumed to be able to achieve the marketed speeds almost all of the time, those speeds are not 100% guaranteed. It’s also assumed that a customer of those products would not use them 100% of the time.

One thing that CCG has learned from working in cities of all size is that there is a natural market cap for potential wholesale revenues in each city that is determined by the overall size of a city and also by the degree to which a given city is a local major business hub.

First, in larger cities there are always opportunities to connect multiple branches of the same business, such a multiple bank or grocery store locations. Nevertheless, the real opportunity comes in cities that are major regional business hubs, meaning that they contain a higher-than-average number of large businesses that are either major employers or that are huge bandwidth users. Davis is not a major business hub today and that means that you have fewer wholesale fiber opportunities than many other cities of similar size. The City has a goal to promote economic development by taking advantage of the growing number of high-tech start-ups and research and development companies that are arising due to proximity to the University. It’s possible in future years for the wholesale fiber opportunities to expand if the city is successful in expanding the high-tech business base.

One criticism that we almost always get from cities that review our business plans is that we have not forecast enough wholesale revenues. Nevertheless, in our experience we think the amounts we have forecast are reasonable for the current size and business profile of the city. It’s worth noting that even if our projections are significantly low, and if wholesale revenues were $1 million higher per year than we are projecting, it would not materially change the projections.

<u>Penetration Rates</u>: Penetration rate is the industry term for quantifying the percentage of customers in the total market that buy a given product.

The models are based upon broadband as the core product. It’s assumed that almost every customer on the network would buy broadband. It was then assumed that telephone and data products would have a lower penetration rate.

Since at this early stage it is impossible to know how many broadband customers might buy from the network it was necessary to establish some starting point for the forecasts to make it easy to compare the results between different scenarios.

> <u>Broadband Penetration Rates:</u> The base penetration rate for single-family homes and for MDUs of 4 units and smaller was set to grow to 50% by the fourth year and stay at that level moving forward. The penetration rates for MDUs is a lot more complex and will be discussed below. The assumption was also made that the broadband penetration rate for small businesses also grows to 50%, although it takes longer to get to that level.
>
> The model assumes that the retail business would not directly serve the largest businesses in the city, but that those would more likely be served by CLECs and

other competitors, many of which would, hopefully, buy wholesale bandwidth from your new fiber network. Most of our clients do not serve many large businesses since those businesses tend to choose service providers that can provide them with more complex solutions than just bandwidth and who can provide such things as cloud services and other complex data products and arrangements.

Cable TV Penetration Rates: Davis is largely a university town, and as such it has a much younger demographic that most other places in the country. It's clear now that millennials are not buying traditional cable TV packages to anywhere near the extent of older generations. In addition, most overbuilders are now seeing cable TV penetration rates for new customers at much lower levels than just a few years ago. There is speculation that the event of changing to a new network gives customers the chance to more easily elect to become cord cutters.

To be conservative and to reflect the younger demographic I have set the cable TV penetration rate for single-family homes and small MDUs at half the normal expected 60% rate, or at 30% of those households buying broadband.

The only way to really understand cable penetration rates would be with a market survey. However, even that would be risky because we see cable penetration rates starting to plummet everywhere. A survey done today would probably be optimistically high for a network that was built a few years from now.

The assumption is that only about 7% of businesses buy cable TV. Note that businesses that show TV in a public place cannot buy the same TV product that is offered at home. Many of the programmers will not let their programming be shown for 'free' in a public setting. Therefore, most places like restaurants, bars, and businesses with a TV in a waiting room are generally buying that package from one of the satellite TV providers.

Telephone Penetration Rates: The models assume that single-family home telephone penetration rates peak at about 34% of data customers but drop to 24% of data customers over time.

The model assumes that a lot of small businesses will buy telephones from the new ISP. These providers like having all telecom products under the same provider. That generally gets them better prices, but it also means better service. Many businesses remember the time back in the early 2000s when CLECs offered competitive telephone while the telcos sold broadband. It was not unusual for the two companies to blame each other for service problems.

Future Products: As described earlier, nobody that builds a fiber network today believes that they will only ever sell the triple play of voice, data, and cable TV. It's obvious that both telephone service and cable TV service are declining products. A decade ago 98% of homes had a telephone and a recent FCC report shows this has dropped nationwide to

45% and is still dropping. People have made the transition to the cell phone and this trend will undoubtedly continue. Cable TV just recently started a similar decline. For the most recent year ending in June of 2017 the cable industry as a whole lost over 3 million customers, or a drop of 2.5% of all customers in a year. A year earlier the drop was 1%; the rate of decline of the industry is clearly accelerating.

There are going to be new revenue opportunities over time that arise from having a fiber connection in homes. This might include such things as security, energy management, home automation, the Internet of Things, or some form of wireless phone service. It also might involve things like health products that help seniors stay in their homes longer, or better data platforms for gamers. CCG already has some clients that are successfully selling IP-based security systems and home automation systems.

The business plans include a small amount of unspecified new products starting in the third year of the business plan and growing slowly over time. The model does not predict what these future revenues will be, there will be new products sold over time. Since we can't understand the margins of each business plan the assumption has been used to show just the margins from the new business. We think the assumption used is modest and by the 25th year in the model these revenues grow to a margin of $15.50 per month for 36% of the customers on the network.

Churn: Churn is the industry term that refers to customers that leave the network. Churn is of major concern with an FTTH network because there is significant investment at each customer location for the fiber drop and electronics. When a customer comes on the network and then leaves before that investment is recovered it means that other customers have to make up for that shortfall.

Churn is a bit tricky to estimate in a market that has a constant turnover in students. However, a residence or apartment that changes students but retains the services is not a case of churn. Churn represent customer locations that leave the network and don't return.

The models assume that there is churn at a rate of about 3% of broadband customers each year. That may not sound like a lot, but over a 25-year business plan it would mean building a significant amount of fiber to homes that don't have service. A lot of financial models don't account for this and end up grossly underestimating the annual capital needed in future years to add new customers, even when total customer counts are not growing. The assumed churn for telephone and cable TV is higher and assumed at 5% per year to reflect customers that leave those services and don't buy again. Customers can obviously drop these services while keeping a broadband connection.

MDU Revenue Assumptions

One of the major issues to deal with in this study is how to treat MDUs (multiple dwelling units such as apartments and condominiums). MDUs that have 5 or more units represent over 38% of all housing units in the city. There are also a significant number of MDUs with 4 or fewer units, and in the forecasts these are treated the same as single-family homes in terms of the sales model and revenues. The percentage of larger MDUs is high since Davis is a university town and most communities of the same size have far fewer MDUs.

Even those MDUs are a diverse universe of different sizes and ages of buildings. MDUs by size are as follow:

	Buildings	Units
5–10 Units	57	450
11–19 Units	33	485
20–49 Units	43	1,614
50+ Units	80	7,677

Providing broadband to MDUs can be challenging. This is such an important issue in Davis that the report looks in depth at issues associated with serving MDUs in Section IV.B. pages 99-103.

There are multiple business models for selling telecom services to MDUs and it's likely that all of these will be used in the city. These sales models are distinct from the technology and cost of connecting to MDUs and look at the different ways that ISPs sell services to MDU owners.

<u>Direct Sales</u>. Some MDU owners will allow an ISP to sell to tenants in the same manner that is available to single-family homes. If the ISP provides new fiber wiring to a building and the wiring from the telephone and cable companies stay in place, an owner can let tenants choose their ISP. Tenants in this kind of MDU would be able to mix products from the new fiber network, Comcast, or AT&T as they choose.

Nevertheless, even in this environment the sales process often has restrictions. For example, many MDU owners do not allow door-to-door salespeople, a sales technique that is commonly used by an ISP when they first rollout a new fiber network.

<u>Bulk Sales</u>. In a bulk sales model the property owner buys wholesale services and includes them in the rent for all tenants. For example, a property owner might provide 100 Mbps service to everybody. This kind of arrangement requires exclusivity and property owners choosing to buy bulk services rarely allow other ISPs to connect or sell to customers.

<u>Wholesale Access</u>. There are ISPs today that specialize in selling to MDUs. There is already this kind of competition in the city today with ISPs that largely provide services to MDUs. If the city builds a fiber network, that might attract other similar ISPs, and there are a number of major companies nationwide that specialize in selling only to MDUs.

It's also possible that a sophisticated property owner might buy a wholesale connection. They could act as the ISP and provide broadband to customers. They might get cable TV from one of the satellite cable providers—a common MDU arrangement.

The business models assume wholesale sales of broadband access to other ISPs consisting of selling the wholesale data circuit from the fiber network of perhaps 1 Gbps or 10 Gbps. This kind of wholesale access is identical to the sales the fiber owner might make to a cellular company to bring bandwidth to a cellular tower or a large CLEC to bring broadband to a bank or other large business customer.

Not Connected to the Fiber. We also have to recognize that not all property owners are going to connect to the fiber network. They may already have a bulk billing and revenue sharing arrangement with somebody else that they like. There are also going to be older MDUs that are too expensive to wire with fiber (or that the property owner won't allow to be wired) that will never get the fiber.

It's easy to get enamored with the idea that MDUs need fiber to have fast broadband, but Comcast says that they are going to have gigabit broadband available to their whole footprint within a few years. Many property owners are not going to distinguish between the ability to provide 100 Mbps broadband to tenants over coaxial cable or over fiber. Those products will be perceived as being identical.

This is also a market where there will be significant competition. As we were working on this study we learned that a large MDU in the city just got a direct fiber connection from AT&T. AT&T has a business plan to bring fiber access to 12 million customers in their footprint and the large majority of these customers are in MDUs.

Segmenting the MDU Market. There is a big difference between the likely business case for selling to smaller and larger MDUs. For example, there is a much larger likelihood of small MDU owners allowing direct marketing to tenants than in large MDUs. Larger MDUs must deal with issues like allowing technicians to gain access to apartment units and other security issues that make them tend to discourage direct interactions between tenants and ISPs. However, many smaller MDUs allow tenants to deal with ISPs directly. For instance, smaller MDUs might not get involved in the process of allowing technician access but would expect the tenant to do so in the same manner as a single-family homeowner.

In the study we had to make assumptions about how the various MDUs would be segmented into the four different business model choices. In the base study we made the following assumptions, with the percentages representing buildings, not units.

	5-10 Units	11-19 Units	20-29 Units	50+ Units
Direct Sales	60%	40%	33%	5%
Bulk Sales	10%	18%	22%	35%
Wholesale	0%	12%	15%	20%
Not Connected	30%	30%	30%	40%

It seems unlikely that there will be a lot of bulk sales or wholesale access arrangements made for smaller MDUs. This isn't going to be too attractive to the ISPs with that sales model and the cost of the wholesale arrangements are too high for the MDU owner to gain economy of scale.

These assumptions are probably the most difficult assumptions we had to make in the study. There are no industry statistics that track how MDUs are connected to broadband. Even if there were, we know from experience that interactions with property owners are on a case-by-case basis and that these statistics will differ widely from city to city. We take an alternate look at these assumptions as part of the sensitivity analysis that will be described below.

It's also important to note that it's really possible to set the MDU customer penetration rate to a given level, in the same manner that we looked at different penetration rates for single family homes. For example, bulk sales are all or nothing—a property owner that agrees to a bulk sale arrangement provides services to all tenants. Our various studies do vary the penetration rate for customers in MDUs that will allow direct sales to customers.

<u>MDU Revenue Assumptions</u>. We made the following assumptions about the revenues that would be generated from MDUs.

<u>Direct Sales</u>. We treated tenants in direct sales MDUs the same as single-family homes. Such tenants would be free to buy products from the business at the same rate as other customers. Any MDU that allows the fiber network to compete with other providers fits into this category.

<u>Bulk Sales</u>. We assumed that bulks sales would be made at a discount to the normal retail rates. This is a normal arrangement in the industry and one that property owners will expect. Generally, while the rates are lower than retail rates, it's also common that the property owner contracts for the products for all units, not just those with tenants. However, in Davis where there is an extraordinarily high occupancy rate for MDUs there would not be much difference.

The assumed bulk rates are:

Broadband	$35
Telephone	$14
Cable TV (Basic only)	$17

<u>Wholesale Access</u>. These are identical to the rates shown earlier:

1 Gigabit	$ 275
10 Gigabit	$ 750
100 Gigabit	$1,500

<u>Seasonality</u>. We elected to not try to deal with the issue of seasonality in the study. The telecom industry uses the term seasonality to deal with customers that don't buy services for an entire year. That could be residents in a resort area that are typically only in the

area for part of the year or, in the case of Davis it would consider students who are not in the city for the whole year.

Seasonality could affect the revenues in several ways. Some ISPs offer discounted rates for months when a seasonal customer is out of the market. For example, a student could lower their broadband bill in an apartment if the apartment was to be vacated for the summer. But generally these discounts require that the service never be used during the discount period and if a tenant used broadband for even a day during a month they would be charged the full price.

A more likely scenario is that some apartments will be empty for a few months in the summer as one batch of students leaves and another set comes and takes their place. With the extraordinarily low MDU vacancy rate in Davis we assume that apartments don't sit vacant too long. Nevertheless, there obviously is a seasonality impact in the market. This means that the projected revenues in these models might be somewhat overstated, but we don't think it's overstated by much.

Expense Assumptions

Following are the various major expense assumptions used in the models.

Employees: Labor is generally either the largest or second largest expense of operating a broadband network (cable TV programming is the other large expense). The models all assume that the business will employ a local staff to operate the network and to run the business. The retail model assumes that these are all employees of the ISP selected to operate the business. Salaries are set at market rates which we got by talking with city staff as well with exiting ISPs in the market. All salaries assume an annual wage increase at 2.5% inflation. Benefit loading is set at 32% of basic annual salary. That covers payroll taxes, other taxes like worker's compensation, as well as employee benefits. If this scenario was done with the city as the ISP that loading would be higher.

Following are the specific employees assumed for the retail scenario. These are the counts by the end of year 3 when the business would be fully staffed.

General Manager	1
Office Manager	1
Accountant	1
Marketing Manager	1
Operations Manager	1
Inside Technicians	2
Engineer	1
Installers	4
Billing/CSR Manager	1
Customer Service	5
Total	18

CCG chose this level of staffing based upon the number of expected customers and our experience with hundreds of clients in the triple play business. The wages in California are higher than in much of the rest of the country, but the prices for products are not higher. That puts a lot of pressure on an ISP in the market to work with a lean staff. That means that the ISP cannot afford things like 24-hour automatic repair services or 24/7 customer service. ISPs of this size rarely can afford those things, but they generally provide more personalized customer service despite not being open 24 hours per day.

City Overhead Costs. In all of the scenarios we assumed that all employees are hired and paid by the ISP. However, it would be possible for the city to hire some of these employees. For example, the city might elect to directly hire a few of the technicians who take care of the network.

We looked at the cost of allocated overheads for city employees. For 2016 the city allocated a little over $50,000 of city overheads per year to each city employee as part of the city accounting process. These allocated costs include the costs of operating the city and are intended to allocate the overhead costs of supporting each employee position for such expenses as accounting, human resources, IT resources, city administration, facilities, utilities etc. The city makes these allocations so that they can track the full cost of every employee by function so that they can understand the fully allocated costs of each city function.

If any of the employees in this analysis were to be considered as city employees then these overhead costs would have to be added to the financial analysis. This is a significant cost and for the 18 assumed employees for the full retail fiber venture that would add nearly $1 million per year in additional expense to the analysis.

Aside from this expense issue, we don't recommend that the city consider a fiber venture where some of the employees are city staff while others are employed by an external entity. We've seen cities try this before and it inevitably led to organizational problems when different employees had different chains of command. For a fiber venture to be successful everybody needs to be on the same team and report to the same ultimate boss.

Start-up Costs: There are considerable start-up costs included in each scenario. It's our experience that there are a number of one-time expenses associated with launching a new business and rather than list them, they have been included generically as start-up costs.

Cable TV Programming: Almost all small cable operators purchase cable signal from the National Cable Television Cooperative (NCTC), a cooperative of small cable providers. NCTC currently provides programming to nearly 20 million subscribers, meaning they get some of the best prices for programming in the industry.

The retail model assumes that the ISP would use a headend owned by somebody else. However, it would still be necessary for the ISP to pay for the programming. This might require joining the cooperative or the ISP might be able to buy programming from the headend operator.

As discussed earlier, the models make the assumption that cable TV rates are never increased or programming costs are never increased. This means that the margins built into the study will remain constant over time—meaning that the ISP would have the philosophy of passing all increases in programming costs to customer. For the past 6–8 years programming costs have risen steadily by around 7% per year. However, in the last two years programming costs have climbed an alarming 9% or more for most operators.

The initial assumed programming costs are as follows:

	Retail Rate	Programming
Basic Cable	$27	$10.70
Expanded Basic	$70	$61.00
Premium	$80	$66.35

Wholesale Voice: The models assume that the ISP buys wholesale VoIP from a quality provider. We obtained recent quotes for these costs and used a price of $8 per voice line per month. This price included a basic telephone line including a full array of expected features like voice mail and caller ID. This price also includes unlimited long distance to the continental US plus some places in Mexico and Canada. The wholesale voice would be delivered to the ISP over the Internet Connection to the world, using a VPN (virtual private network) to ensure high quality of the connection. That means there is no additional transport needed for the voice product.

Facility Related Expenses. The ISP would incur the expected facility-based expenses to operate a business. It would include such expense as:

- Vehicle expense
- Computers and software for employees
- Tools
- Building rent for both the equipment space as well as a small business office.
- Utilities like power and cellphones
- The forecast assumes rents for a storefront office and working space for other employees.

Maintenance Contracts: It is typical for small ISPs to buy maintenance contracts. These contracts provide for annual updates of all software and other improvements to electronics plus some base level of technical assistance from the vendors. The study assumes maintenance contracts for the FTTH electronics.

Ongoing Network Maintenance: A fiber network needs continued maintenance after it’s constructed. One of the primary costs of maintenance is the labor costs of the outside technicians and the vehicle and other support expenses needed to support them. However, there are other costs. These have been included in the study under network maintenance expense and include such things as the cost needed to repair cut fibers, the cost of replacing electronics that go bad, the cost for testing the network and many other kinds of maintenance that are necessary to keep the fiber network functioning.

Internet Backbone: ISPs need to buy a large data pipe to the Internet to provide connectivity to the open Web. This is referred to in the industry as an Internet backbone connection.

The model shows internet expenses in two parts: transport and bandwidth. The model predicts that transport costs will grow at the rate of inflation but that the costs of the Internet port connections and bandwidth will drop over time. This has been the trend for a number of years and is expected to continue. This is probably the hardest thing to estimate in the study because the cost varies widely by market depending upon the availability of affordable transport to the outside world. We would expect that since Davis is part of the Sacramento metropolitan area that there should be affordable backhaul available, but that is never a certain thing and can change from year to year.

Our predictions of cost are probably conservatively high. However, these costs can't be easily known until an entity is seriously ready to negotiate to buy transport. It's also hard to predict this going into the future. We know in the industry that overall broadband demand has been doubling every 3–4 years and so the amount of bandwidth needed will increase rapidly over time. Interestingly, we don't see that resulting in big price increases for the cost of backbone. CCG has customers that have been paying roughly the same price for bandwidth for the last 5 years although their network usage might have gone up four times during that period. The industry seems to keep adjusting prices to roughly match the explosion of bandwidth demand. But there is no guarantee that will continue and it's possible that the time might come when these prices could rise sharply. This is one of the few costs in the forecasts that need a crystal ball to predict.

The quality of bandwidth delivered to customers is measured in the industry by use of an oversubscription factor. Oversubscription is the sharing of bandwidth between customers. For example, if there was only one customer on the network, then the network would not be oversubscribed and the oversubscription ratio would be 1:1. However, since customers don't all use the Internet at the same time to download or upload, a network can easily share a data pipe among multiple customers. The large cable and telephone companies are believed to use an oversubscription ratio of as much as 200:1 or even higher, meaning that at least 200 customers share a data pipe to a neighborhood. These models assume an oversubscription rate of 100:1. This is a reasonably high-quality oversubscription ratio and most customers would get the bandwidth they want almost all the time.

Also included in the study is a 10-gigabit transport pipe to carry the wholesale cable TV signal to Davis.

Help Desk: The forecasts use the term help desk to include numerous functions associated with monitoring the overall network performance as well as assisting customers with network issues. In the market today an ISP can buy the full suite of ISP back office services for about $4.50 per customer per month. This includes all of the ISP functions like DNS routing, email servers, spam filtering, security, etc. This price also includes NOC (Network Operations Center) monitoring, meaning that technicians are available 24/7 to monitor and react to network issues and outages. The full fee also includes full first tier broadband customer service where customers can call and discuss issues with their data connection.

The forecasts assume a medium level of these services at $3.00 per customer per month. That would likely include NOC services, some of the ISP services, and perhaps after-hours first tier customer service. We've assumed that the ISP operating the Davis network would probably prefer to handle some of these functions locally.

Lease of Cable TV Headend: We've assumed a cost of $3.00 per cable TV customer per month for use of a remote headend. This fee would cover paying for both a share of the electronics in the headend as well as the labor costs of technicians that operate the headend.

Sales and Marketing Expenses: The forecasts include a marketing budget. The assumption is made that there would be relatively high advertising costs in the first few years, but a continuous advertising cost forever. Most of our clients today that launch new networks use software tools that help them pre-sell before the network is built. Those tools significantly reduce marketing expenses because they often help to find the bulk of the needed customers early in the business launch process. The forecast also includes a marketing manager that would oversee the advertising process but who also would likely be the lead for selling to businesses.

If the city decides to move forward with this idea we strongly suggest you develop a preliminary marketing plan as part of that process. There would be several major issues that a marketing plan from Davis should consider. First would be to find the best way to pre-market to customers as the network is being built. The goal would be to have a significant number of customers pledged to use the network before it is operational. This differs from a sales plan, which is something developed after funding that looks at the specific tactical issues required to sign-up customers.

Another major issue in a University city is how to market to students. Students that live on campus or who live in billings with bulk billing arrangements are no issue—but students that live on their own are. We've found in working with other university cities that it's challenging to make new students aware of a city fiber network and many of them (or their moms) will already have made arrangements for broadband or other utilities before they arrive in the city.

Finally, a marketing plan is needed for selling to small businesses. They generally do not just show up to buy services but instead require a direct face-to-face sales effort.

Billing: A company has two choices for billing services. The company can subscribe to an external billing service or the company can buy software and do the billing internally. Even with internal billing many companies print and mail bills using an external vendor. These models assume the purchase of a billing system as part of a larger suite of software known as OSS/BSS. This software is used to take customer orders, to coordinate installations, and to keep track of inventory as well as to bill customers. The models also include the cost of auto-provisioning software, meaning that orders can be transmitted directly from a customer order to activate the voice switch, the cable TV services, and the data services. With this software a customer can call and ask for a new service and have it activated while they are still on the telephone.

The billing assumptions assume that customers will pay in multiple ways. Some will have the business auto-bill and debt their bank account. Others will leave a credit card on file for billing. Other customers are still going to want a paper bill. There is a different cost to the company for each of these different classes of customers.

<u>General & Administrative (G&A) Expenses</u>: The models include the number of overhead costs for operating the business. This includes such costs as:

- General liability insurance
- Legal expenses
- An annual accounting audit
- Travel expenses
- Office supplies
- Fees for the bond trustee
- Regulatory compliance
- External consultants
- And, finally, a catchall account called other G&A—there are always expenses that are hard to put into a category.

<u>Taxes</u>: The models assume that since the business is municipal that you would be exempt for most normal business taxes like income taxes, property taxes, etc. Even in the model where there is an external operator we assume that this is a vendor relationship with an operating agreement, but that the revenues would belong to the city.

There are a number of taxes that would accrue to the business due to being in the retail triple play business. This would include things like the franchise tax on cable services, various taxes on telephone services, fees to fund 911, fees assessed by the federal Universal Service Fund, etc. The assumption in the model is that all of these taxes would be passed on to customers and that the amounts collected would be sent to the tax authorities. Because of this these taxes are not shown in the forecasts because the tax expenses flow directly from customers to the tax authorities without affecting the company books.

Capital Assumptions

Capital is the industry term for the assets required to operate the business. The capital expenditures predicted in these models reflect the results of the engineering studies done by Finley Engineering and included as Section II of the report. The launch of a broadband network requires a significant investment in the fiber network and electronics and this is by far the biggest cost of getting into the business.

Capital includes several broad categories of equipment including fiber cable, electronics for FTTH, and the electronics needed to provide the triple play services. In addition to capital needed for the network, there are expenditures predicted for assets like furniture, buildings, computers, vehicles, tools, inventory, and capitalized software. The amount of investment required is going to vary by the type of technology used as well as by the number of customers covered by a given business plan.

One of the major capital costs of building a fiber network is the cost of installing each customer. This work consists of three components—the fiber drop to get from the street, the fiber electronics that translate the light on the fiber into usable bandwidth, and any installation or rewiring needed inside the home.

The goal is to be conservative with the capital estimates. The estimates include a construction contingency to cover potential cost overruns. It is important to remember that these estimates are high level. The goal of these estimates was to provide estimated costs that are detailed enough to see if it makes sense to move forward and consider a fiber project. However, before raising the money to build this project it would be prudent to do additional engineering to better pin down the cost of the network.

Specific Assets: Following are the assets that are in service by the end of the fourth year. That date was chosen because it represents a fully constructed network with subscribers. These are the assets that are funded by debt. Assets added after the fourth year would be funded by revenues.

Perhaps the primary question we are always asked is, "what is the cost to build the network?" As can be seen by these numbers, the cost of the network varies by the number of customers, and also by the number of employees needed to serve various levels of customers.

	40% Penetration	50% Penetration	60% Penetration
Vehicles	$ 231,800	$ 231,800	$ 271,724
Tools	$ 80,000	$ 80,000	$ 80,000
Buildings	$ 2,181,440	$ 2,181,440	$ 2,181,440
Furniture	$ 25,500	$ 27,000	$ 30,000
Computers	$ 52,083	$ 55,265	$ 61,631
Voice Gateways	$ 207,780	$ 245,940	$ 294,660
Data Servers	$ 102,500	$ 102,500	$ 105,500
Cable TV	$ 980,900	$ 1,053,926	$ 1,213,940
FTTH Electronics	$ 10,770,476	$ 11,946,563	$ 12,731,344
ONTs	$ 5,561,360	$ 6,650,091	$ 7,753,370
Fiber Drops	$ 8,882,591	$ 10,584,956	$ 12,664,177
Fiber Network	$ 65,864,087	$ 65,846,087	$ 65,864,087
Fiber Contingency	$ 6,566,409	$ 6,566,409	$ 6,566,409
Elect. Contingency	$ 376,274	$ 406,775	$ 445,116
Inventory	$ 350,000	$ 350,000	$ 350,000
Capitalized Software	$ 353,640	$ 395,670	$ 433,052
Total	$102,514,839	$106,742,422	$111,043,448

A description of the buildings (huts), the fiber network, and the core electronics is included in Section II of this report starting on page 32. Here is a brief description of the other assets included in the study.

Vehicles. Needed for the installers, the operations manager, and the general manager.

Tools. These are capitalized tools like test equipment used to monitor network performance and to diagnose network problems.

Furniture. Needed for employees.

Computers. For employees and including basic software.

Voice Gateways. These are devices needed to provide Voice over IP. These can range from tiny devices placed at each VoIP phone, like is done by Vonage, or one larger device that would provide VoIP service to all phones connected to the existing telephone wiring.

Data Routers. These are a few basic servers used to support ISP service. These would not be needed if all ISP functions are outsourced. There are large servers and routes included in the core electronics costs that are used to support the fiber network.

Cable TV. This includes two costs. First, there will be some electronics needed to insert local programming onto the network. That might include things like a channel to support city council meetings and other local government. There might be University channels inserted onto the network. There could be other local TV channels not covered by the cable headend owner. The biggest cost in this category is the settop coxes used for each cable TV customer.

ONTs. These are the devices at each fiber customer that receives a light signal from the fiber network and converts it into Ethernet.

Inventory. This includes spare electronics as well as spare fiber needed to make quick repairs.

WiFi Routers. We elected to not include WiFi routers in our analysis. ISPs differ widely in their treatment of WiFi. For example, Comcast automatically assumes that a customer wants their WiFi router and it’s built into the Comcast cable modem. It’s there even if a customer elects not to use it. Other ISPs make it optional for customers to use their own routers.

At CCG we recommend that our client not include WiFi routers directly in their terminal equipment. The indoor ONTs that are included in these studies do not include a WiFi router, but ONTs can be purchased with integrated WiFi capabilities at a higher cost than we’ve assumed.

It has been our experience that automatically including the WiFi router in the ONT is a bad business decision. First, many tech-savvy customers won't use a WiFi router from the ISP because there are far better WiFi routers available on the market. To provide unused WiFi routers to such customers is an expenditure that never gets recovered. More importantly, we've seen that WiFi technology is evolving rapidly. There is a great likelihood that the WiFi router in an ONT will become obsolete before the ONT electronics. If that happens then an ISP finds themselves replacing ONTs just to upgrade the WiFi—another unneeded expenditure.

We instead recommend that ISPs offer separate WiFi routers for lease. Since WiFi routers have one of the shortest useful lives of any telecom electronics, our experience is that the rental fees on WiFi routers don't do much more than recover the cost of the units. Therefore, we have elected not to include the WiFi router hardware or the rental fees since we believe they largely offset each other.

Capitalized Software. The models also assume capitalized software. The IRS requires that any software that is above a certain dollar amount and which has benefit to the business for more than one year be capitalized. There are a few kinds of software assumed in these studies that meet these requirements and which are shown as assets and not immediately expensed. These would include:

- An OSS/BSS operating system: This is the software used to run the company and includes such services as taking customer orders, billing, taking customer trouble calls, dispatching repair technicians, keeping track of inventory, etc.
- Cable TV software: A lot of the functions at the cable TV headend are done by software. This includes software to encrypt the signal to customers, middleware (includes things like the channel guide and operates the settop box and remote controls), and video on demand software that lets customers pause, rewind, and watch programming as if it was recorded on a DVR. While these costs are incurred by the cable headend owner the studies assume these costs will be passed on to the business.

City Purchasing Practices. One issue that always has to be considered when municipalities build a fiber network is the potential impact of city purchasing practices on the cost of a fiber network. We've seen instances when such purchasing practices added significant extra cost to a network.

For example, the municipal RFP process can add a lot of time to the purchasing timeline. When financing with bonds it's extremely important to get the construction underway as quickly as possible. Fiber networks lose money initially, by definition, and it's vital to get customer revenues generated as quickly as possible to help pay for the network. The cost of delaying revenues can become gigantic and it can be deadly to have a slow purchasing process.

We've also seen government purchasing processes that ended up compromising the quality of the network. Purchasing rules may require that each major component of the network be bid separately, and that might mean that the overall set of vendors selected might not be the team that will produce the best combined solution.

The most important factor is an interesting one. Government RFPs generally assume that vendors will bid with their best prices and that the government will get a good price for the components of the network. However, in real life practice we've often seen the opposite. Most telecom vendors are not experienced in working with municipalities since the majority of their customers are ISPs. We've seen this lead to telecom vendors responding with 'list' prices in RFPs. Telecom vendors also often offer list prices to ISPs, which is then followed by a negotiation for lower prices. Yet most RFP rules don't allow for negotiation after the acceptance of the RFP and we've seen municipal fiber providers paying significantly higher prices for electronics and components than similarly sized commercial ISPs.

There are ways around these issues in some states. For example, we've seen cities that bid the entire price of building the network to a contractor, thereby making the contractor responsible for buying the network components. However, many states would not allow this process.

We mention this issue because there is a risk that the assets could cost more than supposed by this analysis if the fiber construction process is run through routine municipal purchasing practices that could cause delays or lead to cost overruns.

MDU Asset Costs

The Finley Engineering analysis in Section II.A (pages 37-39) looks at some typical costs for wiring MDUs. The financial analysis made the assumption that the MDUs that get connected to the network would largely follow those suggested costs. There are always going to be some MDUs that are far costlier to wire than the costs suggested by Finley, and the report contains a more detailed discussion of MDU wiring issues in Section IV.B (pages 99-103).

But even in accepting the Finley suggested costs we had to make some assumptions. There will be some number of MDUs in the city that are already wired with Category 5 or 6 wiring that would allow for connection to the fiber network with little additional cost. Finley also provided a cost estimates for two different ways to bring broadband to MDUs—using G.Fast or directly wiring with new fiber. The nuances of the practical issues with using those two options is also discussed in more detail in Section IV.B of the report.

The following assumptions were made about the methods used to bring fiber broadband to the various sizes of MDUs:

	5-10 Units	11-19 Units	20-29 Units	50+ Units
Already Wired	5%	5%	5%	10%
New Fiber Wiring	95%	95%	80%	80%

G.Fast	0%	0%	15%	10%

Debt Assumptions

One of the most important assumptions affecting all of the scenarios is the cost of financing the new business. There are several key factors that affect financing costs:

- Interest Rate: The higher the interest rate, the higher any annual debt payments, just like with a home mortgage. For the last decade or so bonds have had much lower interest rates than commercial loans. That is not always the case throughout a longer history, but it's generally the case. The city has a great AAA bond rating but has not floated a major new bond issue in many years. The assumed interest rate for these forecasts 3.00%. It would be possible for the city to be able to get even lower rates. However, it's also possible for interest rates to increase at any time. We've enjoyed low municipal bond rates for the last decade, but nobody expects low rates to hold forever.
- Loan Term: The loan term means how long the borrower has to repay the loan. The studies assumed a term for bonds of 25 years. There have been a few municipal fiber bond issues financed for 30 years, which would result in more interest expense during the life of the bond but lower annual debt payments.
- Financing Construction: With bonds it is typical to borrow all of the money up front in a lump sum, meaning that interest is accumulating immediately. Commercial loans more often use what is called construction financing, meaning that the project borrows money each month as needed during construction, which greatly reduces the interest cost for the first few years.
- Capitalized Interest: Because bonds require the money to be borrowed up front, it's typical for a fiber project to have to borrow the funds needed to make the first 3–4 years of interest payments on the bonds, until the project generates enough cash to cover those payments. Commercial loans more typically excuse interest payments for the first few years (which is made up by applying a higher interest rate in the future). The studies assume that the first three years of interest payments are borrowed in the bonds.
- Bond Surety: Bonds often include some sort of surety, meaning some amount of money to cushion the bondholders against losses. This might include borrowing something called a Debt Service Reserve Fund, which is an amount of money that is borrowed and held in escrow during the life of the bond. This money would be used to pay principle and interest payments in case the project doesn't make enough to cover the needed payments. Bonds might also require bond insurance, which is an insurance policy, funded up front with the bond to cover future defaults. The forecasts assume that revenue bonds would require a Debt Service Reserve Fund.

Financing Assumptions: The financing assumptions for this scenario are as follows. Note that the amount of financing required varies by the assumed number of customers (and assets):

	40% Penetration	50% Penetration	60% Penetration
Interest Rate	3.00%	3.00%	3.00%
Term	25 Years	25 Years	25 Years
Assets Financed	$102.5 M	$106.7 M	$111.0 M

Bond Fees	$ 1.8 M	$ 1.9 M	$ 1.9 M
Working Capital	$ 6.5 M	$ 6.8 M	$ 7.1 M
Capitalized Interest	$ 11.8 M	$ 12.2 M	$ 12.7 M
Debt Service Reserve Fund	$ 7.9 M	$ 8.3 M	$ 8.6 M
Total Bond	$130.6 M	$136.0 M	$141.4 M

This scenario is typical for bond funding and the cost of bonds often exceed the cost of the funded assets by 25% to 35%. Following is an explanation of the components of the bond cost:

Assets Funded. These are the assets built during the first 4 years of the project.

Bond Fees. These are fees paid to raise the bond fund. They include numerous legal fees. The primary cost are fees charged by bond sellers to market and sell the bonds.

Working Capital. Federal bond law requires that bond proceeds must primarily be used to pay for the capitalized cost of a project. However, the rules allow for a bond to finance up to 5% of the cost of the bond issue to cover other costs. In this case the working capital would be used to cover operating expenses during the first few years before revenues are high enough to cover costs.

Capitalized Interest. As described earlier, this represents the first 3 years of interest payments that are borrowed up front to make bond payments.

Debt Service Reserve Fund. This is the surety described above and this amount is held in escrow during the life of the bond issue to be used in the case that the project is unable to cover bond costs. These funds would be released to the general funds of the city or to the fiber project when the bonds are fully retired.

Type of Bond. There are two primary types of bonds used to finance fiber projects – general obligation bonds and revenue bonds. These bonds are discussed in greater detail in section III.F. of the report. Revenue bonds are basically secured by the revenues of the project (in this case the revenues from the fiber network). General obligation bonds are secured by tax revenues.

But there is a nuance that is important when looking at funding a fiber network. One of the most common kinds of financing is a revenue bond that is backed by the full faith and credit of the city. That means that the revenues from fiber project are expected to cover the bond payments, but if there is ever a shortfall the city must use tax revenues to make up the shortfall.

The only real difference in cost between a pure revenue bond and one that is guaranteed by the city in case of failure is a lower interest rate for the safer bond. The difference in interest varies according to the credit rating of the city as well as the vagaries of the overall bond market. As we write this report there was only a tiny difference in the interest rate of a project backed by tax revenues versus a pure general obligation bond – because bondholders view those as nearly equivalent.

The financial models all assume a revenue bond that is backed by tax revenue. It has become difficult to secure a pure revenue bond for fiber networks since there have been a few failures nationwide of municipal fiber projects.

Funding and financing issues are discussed in more detail in Section III.F (pages 84-93).

'Reasonable Case' Scenario

Throughout all of the financial analysis the assumptions made are conservative. This is the approach that we always take with feasibility studies for several reasons. First, if a study looks feasible with conservative assumptions then we know that it can probably be improved in actual implementation. Second, it's important to not underestimate the cost of building the network. Since most municipal projects are funded with bonds, it's essential that the bonding process raise enough money to complete the project. It's often exceedingly difficult to find additional funding in the case of a cash shortfall. Finally, the people that sell bonds expect the underlying business plans to be conservative. It's not untypical for them to insist that you borrow enough money to handle the worst possible, yet reasonable business case. The bond sellers do not want to go back to bond buyers and explain that the initial bond was not of adequate size.

For these various reasons the financial analysis is conservative, particularly when looking at the cost of the needed assets. It's still reasonable to want to see how the business will perform if some of the most conservative assumptions are relaxed. This kind of analysis gives you a picture of where the business might head with good management. But again, we strongly warn that you want to plan for the worst, yet hope for the best. It's likely that any financing will be more in line with the base scenarios in the study.

We created a 'reasonable case' scenario that changed the following assumptions:

- We eliminated the construction contingency on the fiber network and the electronics. The base analysis includes a 10% contingency on the cost of the network and a 5% contingency on the cost of electronics. As we've said elsewhere in this report, we would recommend additional engineering before financing a project of this magnitude, and this new assumption reflects better engineering estimates of the cost that happen to be near to what we have forecast.
- We lowered the cost of fiber drops. The study assumes that the fiber drops will be installed by the primary construction contractor. But we have found that large construction companies charge too much for fiber drops and that they can generally be obtained elsewhere at a lower cost. It's also possible to save money on drops by using employees rather than contractors. This removes the 'profit' from the drops. This assumption assumes that the city could find a lower-cost alternative to fiber drop installation.
- We used a 50% customer penetration. This seams realistically achievable to us. The city might do better than this, but until you've had surveys to assess interest in the network we still don't want to raise this number too high. We also have a word of caution here in

that high interest on a survey doesn't always translate to high penetration rates for the future business. For example, we've seen fiber businesses that were unable to sell as much as expected due to a poor marketing plan, or due to making visible mistakes in the beginning of the business such as having numerous network outages.

- We used a slightly lower interest rate of 2.7% compared to 3% in the original studies. Davis has exemplary ratings and in the best of cases could qualify for a low rate in today's bond market. There is no way to predict where bond rates might be in a few years and in our sensitivity analysis we quantified the impact of seeing higher interest rates than expected.
- We kept the same operating expenses as the base case. These assumptions are not conservative and represent our best guess.
- We also looked at the impact of raising broadband rates in the future. The base studies assume no rate increases. We did three versions of the base study:
    - The first version still has no rate increases.
    - The second version keeps rates the same for the first three years and then has annual rate increases of 50 cents.
    - The third version holds rates steady for ten years and then has annual rate increases of 50 cents.
- Finally, we were able to reduce the amount of needed tax revenues from some other source to match the impact of the change in these assumptions.

These changes drop the required assets by year 4 by roughly $9.5 million. Below is a comparison of the assets required for the base study with a 50% customer penetration rates and the assets that instead use the reasonable case assumptions.

	Base Study Assets @ 50%	Reasonable Case Assets
Vehicles	$ 231,800	$ 231,800
Tools	$ 80,000	$ 80,000
Buildings	$ 2,181,440	$ 2,181,440
Furniture	$ 27,000	$ 27,000
Computers	$ 55,265	$ 55,265
Voice Gateways	$ 245,940	$ 245,940
Data Servers	$ 102,500	$ 102,500
Cable TV	$ 1,053,926	$ 1,053,926
FTTH Electronics	$ 11,946,563	$ 11,946,563
ONTs	$ 6,650,091	$ 6,650,091
Fiber Drops	$ 10,584,956	$ 7,679,156
Fiber Network	$ 65,864,087	$ 65,846,087
Fiber Contingency	$ 6,566,409	$ 0
Elect. Contingency	$ 406,775	$ 0
Inventory	$ 350,000	$ 350,000
Capitalized Software	$ 395,670	$ 395,670
Total	$106,742,422	$ 97,270,213

B. Open Access

This scenario would open up the market to multiple ISPs, which would provide retail products to customers. Under this scenario the city's only source of revenue is from providing wholesale connections to ISPs to use the network. In an open-access network the city would build and own the fiber network and would then sell access to the network to multiple ISPs or other service providers. There is no one single way to do an open-access arrangement and the city and the ISPs would need to negotiate the specific arrangements. For a more detailed description of the open-access operating model see Section IV.E (pages 124-127).

In most open-access networks in the US, the network owner operates the fiber network and some portion of the electronics and the ISPs are responsible for everything customer related. This is not the only possible model, but it reflects the fact that many ISPs are undercapitalized and unable to contribute to capital costs. When open-access networks have required the ISPS to fund more of the customer costs, such as the ONTs or fiber drops, the penetration rates on the network have been extremely low. These studies assume that the city builds the fiber network including the fiber drop to the customers and the FTTH electronics at the customer location (see diagram on page 136).

The most important change of assumptions between a retail model and open access is the speed of customer sales and connection to the network. The base retail model in this study has the business operated by one ISP partner that is directly in charge of the sales process to customers. Since it's vital to drive new revenues quickly in order to make bond payments in a retail operation, there is always a big push for early sales. In fact, we would expect there to be a big presales effort so that a lot of the customers are on-board before construction is complete.

Probably the biggest surprise to cities that are offering open access is that sales go much slower than anticipated. There are many reasons why the ISPs in an open access environment don't feel the same sense of urgency to sell. Many of the smaller ISPs are undercapitalized and understaffed and don't have the resources to connect many customers in a short period of time. Many ISPs on an open access network specialize in a niche of customers, be that a given demographic or a certain part of the market. But regardless of the reasons, it seems to take far longer to get to a reasonable customer penetration rate on an open access network.

<u>Open-Access Revenue</u>: The primary revenue for the city in an open-access environment is the fees that are charged to the ISPs for the right to use the network. Most of the open-access networks in the US charge the ISPs per loop, meaning they bill a flat monthly rate that buys the ISP a lit fiber connection at a given customer location. There have been a few open-access networks that have instead charged by the services being delivered to the customer. However, in today's world when almost every product on the fiber network can be delivered as an IP data stream, it's hard to monitor and charge properly by the service.

There has been a lot of debate in how to set the rate for ISPs in an open-access model. If the rate is too high then it pushes the ISPs to cherry-pick. For example, a number of open-access networks today charge flat fees of between $28 and $33 per month to the ISPs. When charged that rate the ISPs will not offer a standalone broadband product in the hoped-for retail range of $40 - $45. They instead will either charge more for standalone broadband or else only sell to customers that will purchase a bundle of products. This cherry picking is well documented on existing open-access networks and results in these open-access networks getting lower customer penetration rates than retail fiber networks. Having fewer customers is not the only negative consequence of the cherry picking since it means that low-income residents essentially get shut out from using the network.

We've suggested a set of wholesale rates in the forecasts that can mitigate the cherry picking. The rates are set so that the amount paid for a wholesale connection varies according to the broadband products being sold. The suggested rates are:

Residential 100 Mbps Loop	$ 20
Residential gigabit Loop	$ 50
Business 100 Mbps Loop	$ 45
Business gigabit Loop	$100

In composite, these rates bring in roughly the same amount of revenue as having a $30 rate across-the-board. Nevertheless, they ought to help mitigate the cherry picking and provide more broadband opportunities for lower income households.

In the open-access network the business would also see the wholesale connections to carriers and large businesses at the same rates shown above.

For the MDU market, the open-access environment makes it harder to sell into MDUs on a per-customer basis. For example, in a retail environment the city might only elect to build to an MDU after getting enough customers committed there. That is harder to coordinate with the ISPs. However, the open-access environment may instead lead to some increase in sales of wholesale connections to whole buildings.

Following are the other specific assumptions used in this scenario.

<u>Employees</u>: It takes fewer employees if the city's only role is to operate the network. We have assumed in these models that these functions would also be outsourced to some third party so that the city is not operating the network with city employees. The employees needed by year 4 are as follows:

	Employees
General Manager	1
Inside Technicians	2
Engineer	1
Installers	3
Billing/ISP Interface	1
Total	7

The only employees needed are those that directly take care of the fiber network as well as those that interface with the ISPs. There is no need for employees to provide the triple play or to interface with end-user customers.

Expenses: There are far fewer city expenses required in an open-access network. All expenses associated with the triple play services disappear. All expenses required to directly interface with retail customers disappear. The need for an Internet Backbone disappears. These expenses all accrue to the operating ISPs. The required expenses are:

Vehicles and other expenses to support employees
Rent for office and equipment space
Power and other utilities needed to operate the network
Maintenance contracts on the electronics
A reduced amount of advertising to create awareness of the fiber network
Backoffice expenses like accounting, legal, etc., but at a lower level than a retail model

Specific Assets: Following are the assets that are in service by the end of the fifth year at different levels of customer penetration. Note that most bonds require that the funds be spent within the five-year period. In an open-access network that means the bonds would not be able to cover customers added after the fifth year and those would need to be funded from revenues. In this scenario the assumption has been made the ISPs are responsible for assets inside the premise such as settop boxes or voice gateways. They also would be responsible for any wiring at the premise inside of the ONT. The ISPs would also have to pick up a lot of the cost of connecting inside MDUs. These open access network costs are lower than the capital costs of a retail network as shown above. The difference is the labor costs that pass to the ISPs rather than the city.

City Assets	40% Penetration	50% Penetration	60% Penetration
Vehicles	$ 154,850	$ 154,850	$ 154,850
Tools	$ 80,000	$ 80,000	$ 80,000
Buildings	$ 2,181,440	$ 2,181,440	$ 2,181,440
Furniture	$ 10,500	$ 10,500	$ 10,500
Computers	$ 21,360	$ 21,360	$ 21,360
FTTH Electronics	$ 9,014,535	$ 9,040,918	$ 9,071,334
ONTs	$ 1,945,070	$ 2,394,940	$ 2,847,231
Fiber Drops	$ 4,996,696	$ 6,172,131	$ 7,338,193
Fiber Network	$ 72,430,496	$ 72,430,496	$ 72,430,956
Inventory	$ 250,000	$ 250,000	$ 250,000
Total	$ 91,284,947	$ 92,936,634	$ 94,585,404

The most striking thing about these numbers is that it costs nearly as much to build an open-access network as a retail network. These asset costs are about 90% of the cost of the retail network shown earlier. The total difference between the two is even smaller since these estimates assume that it will take 7–8 years to connect customers to the network in the open-access environment, thus delaying the cost of many of the fiber drops and ONTs until after the end of the bond-financing period.

Financing Assumptions: The financing assumptions for the open-access scenario are as follows. Note that the amount of financing required varies by the assumed number of customers (and assets):

	40% Penetration	50% Penetration	60% Penetration
Interest Rate	3.00%	3.00%	3.00%
Term	25 Years	25 Years	25 Years
Assets Financed	$ 91.3 M	$ 92.9 M	$ 94.6 M
Bond Fees	$ 1.6 M	$ 1.7 M	$ 1.7 M
Working Capital	$ 5.8 M	$ 5.9 M	$ 6.0 M
Capitalized Interest	$ 10.5 M	$ 10.7 M	$ 10.8 M
Debt Service Reserve Fund	$ 7.1 M	$ 7.2 M	$ 7.3 M
Total Bond	$116.3 M	$118.4 M	$120.5 M

C. Public/Private Partnership

In a public/private partnership (PPP) the city would find a partner that is willing to fund some portion of the cost of serving customers. There are almost endless variations on this concept, but we chose the most common relationship where the city would provide the fiber networks and electronics and the partner would cover all costs inside the customer locations plus any costs for providing the triple play services. The partner would also assume all costs of operating the business. For a more detailed description of PPPs see Section IV.E. (pages 127-130).

Major PPP Assumptions. The constructed network is identical to the network in the retail scenario above. The commercial partner would seek to get customers quickly as was assumed in that scenario.

It was assumed that the ISP in this scenario would cover the cost of some of the assets. That includes assets needed to support employees (such as vehicles, computers, billing software, etc.) as well as costs for the customer electronics at the premise (the ONT) as well as any costs inside the customer premise such as settop boxes.

The scenario assumes that the commercial partner would operate the business in a manner identical to the earlier retail model. We have chosen a scenario where the revenues for a private partner would be the same as in the earlier scenarios where the city was the operator. The models also assume the expenses would be nearly the same. There might be some economy of scale in the provision of the triple play services, but those savings would not be significant enough to change the basic business plan—and there might not be any real efficiencies unless the operating partner was a large company. But it would be possible for a private partner to charge higher prices than the city since they don’t have the same motivation to help to close the digital divide. We know from experience that higher prices means fewer customers and so a model with higher prices would not have the same results as shown in this particular scenario.

There would be significant issues with funding a PPP. The bondholders would insist that the commercial partner pay enough to the city each year to make the bond payments. Since any commercial partner is unlikely to guarantee bond payments then it is not likely that a PPP could be funded from revenue bonds.

That means that the bonds would have to be general obligation bonds, meaning the city's tax revenues would be on the line for any shortfall of bond payments. There are also significant issues involved with getting tax-free bonds if much of the benefit of the business accrues to the commercial partner. The analysis assumed the same interest rates on the bonds, but there is a significant chance that the rates would be higher if there was not some way to fund this with tax-free bonds.

D. Digital Divide Scenarios

The Broadband Advisory Task Force (BATF) asked for scenarios that look at building fiber to more of the community in order to meet social goals like solving the digital divide.

We considered two options. The first added a digital divide broadband product—a $10 broadband product that would be provided to homes that qualify somehow for reduced-price broadband. The second scenario was more aggressive and considered offering lower-price broadband to the entire community including a minimal-speed broadband product to everybody.

<u>Digital Divide Scenario 1</u>

This scenario assumed a $10 broadband product for homes that qualify to buy subsidized broadband. The scenario doesn't consider what that speed might be since that would be a political decision. There are a number of different criteria that could be used to determine eligibility for the reduced-price broadband. For example, homes that qualify for the school lunch program or perhaps for food stamps might be eligible.

The financial model assumes that about 22% of the community would be eligible for subsidized broadband—an estimate that would have to examined based upon whatever qualifying metric is used for qualifying for such a program.

We examined two financial scenarios. The first is funded entirely by bond debt, which allows a comparison of the scenario to the base study described above. A second scenario looked at roughly funding this with half bond financing and half tax financing.

There most significant change to the financial projections for this scenario is that the amount of capital needed by year 4 increases to $115.2 M since more homes are connected to the fiber network.

Both of these scenarios do not necessarily change the broadband penetration rates in MDUs. There, the property owners still must give permission to enter their buildings, and most are still going to want to either build the triple play products into the rent or else participate in some sort of revenue share with the network provider.

<u>Digital Divide Scenario 2</u>

The second scenario was more aggressive and looks at the impact of lowering broadband prices across the board. The scenario considered the impact of lowering the price of a gigabit broadband product to $50, offering a 100 Mbps product for $20 and offering some minimal level of broadband, perhaps 5 Mbps for free.

This plan is similar to what has been discussed in San Francisco recently. A City Councilman there proposed a scenario that that would charge a monthly $25 ‘utility fee’ to everybody in the city that would be used to support the bonds needed to build a fiber network. They then proposed to provide free broadband at a low speed to all homes and reduced-price broadband at higher speeds.

The primary impact to the financial models was to increase capital in the early years to $121.6 million.

Note that both of these scenarios consider changing only a few variables. If the city is interested in this option you would want to study it further and consider how varying both the broadband prices and the number of homes that would opt into each scenario would affect the bottom line answer.

Appendix VI: Summary of Financial Results[3]

	Assets	Take Rate	Tax Funding	Equity	Debt	Total Financing	Year 25 Cash	Net Inc Positive	Cover Debt
One ISP Operator									
1. BASE - 50% Penetration	$106.7 M	50%			$136.0 M	$136.0 M	-$53.9 M	Year 17	Never
2. 60% Penetration	$111.0 M	60%			$141.4 M	$141.4 M	-$34.1 M	Year 13	Never
3. 40% Penetration	$102.5 M	40%			$130.6 M	$130.6 M	-$81.4 M	Never	Never
4. With GO Bonds	$106.7 M	50%			$126.2 M	$126.2 M	-$53.4 M	Year 25	Never
5. With Higher Interest Rate	$106.7 M	50%			$142.6 M	$142.6 M	-$80.1 M	Year 23	Never
6. With $5 Higher Data Prices	$106.7 M	50%			$136.0 M	$136.0 M	-$39.9 M	Year 13	Never
7. With Fewer Big MDUs	$103.8 M	50%			$132.3 M	$132.3 M	-$73.9 M	Never	Never
8. With No Cable TV	$105.5 M	50%			$134.4 M	$134.4 M	-$57.2 M	Never	Never
9. With PON Technology	$104.6 M	50%			$133.3 M	$133.3 M	-$49.5 M	Year 17	Never
10. With Breakeven Tax Financing	$106.7 M	50%	$37.0M		$86.0 M	$123.0 M	$4.4 M	Year 13	Year 25
11. 40% W/ Breakeven Tax Financing	$102.5 M	40%	$53.0 M		$61.8 M	$114.8 M	$2.9 M	Never	Year 25
12. 60% W/ Breakeven Tax Financing	$111.0 M	60%	$28.0 M		$102.5 M	$130.5 M	$13.0 M	Year 13	Year 24
Reasonable Case									
13. Base Reasonable Case	$97.3 M	50%	$24.0 M		$89.1 M	$113.1 M	$11.0 M	Year 13	Year 24
14. Reasonable – Delayed Increases	$97.3 M	50%	$24.0 M		$89.1 M	$113.1 M	$18.9 M	Year 13	Year 23
15. Reasonable – Annual Increases	$97.3 M	50%	$24.0 M		$89.1 M	$113.1 M	$25.6 M	Year 13	Year 22
100% Overbuild									
16. With Digital Divide Product	$115.2 M	72%			$146.7 M	$146.7 M	-$60.6 M	Year 23	Never
17. With 100% Tax Financing	$121.6 M	90%	$118.0 M			$118.0 M	$58.0 M	Never	N/A
Open Access									
18. Base - 50% Penetration	$92.9 M	50%			$118.4 M	$118.4 M	-$114.1 M	Never	Never
19. 40% Penetration	$91.3 M	40%			$116.3 M	$116.3 M	-$125.8 M	Never	Never
20. 60% Penetration	$94.6 M	60%			$120.5 M	$120.5 M	-$102.3 M	Never	Never
21. With Breakeven Tax Financing	$92.9 M	50%	$80.0 M		$25.0 M	$105.0 M	$7.9 M	Never	Year 25
Public Private Partnership									
22. <u>With Bond Funding</u>									
City Performance	$102.3 M	50%			$114.2 M	$114.2 M	-$3.4 M	Year 13	Year 26
Partner Performance	$4.6 M	50%		$2.3 M	$9.2 M	$11.5 M	-$23.2 M	Never	Never
23. <u>With Some Tax Financing</u>									
City Performance	$102.3 M	50%	$25.0 M		$89.6 M	$89.6 M	$0.8 M	Year 13	Year 26
Partner Performance	$4.6 M	50%		$1.2 M	$4.8 M	$6.0 M	$8.8 M	Year 5	Year 9

[3] Basic description of each scenario below.

Summary of the Assumptions used for the Above Scenarios

The scenario numbers below match the numbers of the scenarios in the above table.

One ISP Operator Scenarios

1. Base – Scenario at 50% Penetration.

This scenario assumes that one entity would operate the network. This scenario includes the numerous assumptions detailed in Appendix V, Section A, starting at page 143.

2. 60% Penetration

This is Scenario 1, but with an assumed 60% of customers buying service from the network. Adding more customers also adds assets to cover the cost of the fiber drops and the electronics needed to serve the additional customers.

3. 40% Penetration

This is Scenario 1, but with an assumed 40% of customers buying service from the network. Fewer customers means fewer fiber drops and the electronics.

4. With GO Bonds

This is Scenario 1 but uses general obligation bonds instead of revenue bonds. Since general obligation bonds are guaranteed by tax revenues the bond issue would likely be smaller and not require surety such as a Debt Service Reserve Fund. A general obligation bond might also have a lower interest rate, although at the time of writing this report that difference was tiny.

5. With Higher Interest Rate

This is Scenario 1 assuming an interest rate on the revenue bond that is 1% higher. A higher interest rate means a larger bond issue since the bonds capitalize (borrow ahead of time) the interest payments for the first three years.

6. With $5 Higher Prices

This is Scenario 1 that increases the retail price of all broadband products by $5 per month.

7. With Fewer Big MDUs

This is Scenario 1 that assumes that few larger MDUs (apartment buildings and complexes) choose some other ISP provider other than the city fiber network. For apartments with 20 – 49 units it assumes that the MDUs not connected to the network increases from 30% to 60%. For MDUs with 50 units or more the ones not connected to the network increases from 40% to 70%.

8. With No Cable TV

This is Scenario 1 that assumes there is no cable TV product, but instead just a double play of telephone and broadband.

9. With PON Technology

This is Scenario 1 that uses PON electronics instead of active ethernet technology. The PON technology is currently a little less expensive due mostly to having fewer lasers in the network.

10. With Breakeven Tax Financing

This is Scenario 1 that then calculates the amount of tax financing (financing with some other source than bonds, such as a sales tax) required to reach cash breakeven. Cash breakeven means the project always has sufficient cash to operate.

11. 40% Penetration with Breakeven Tax Financing

This is Scenario 3 that then calculates the amount of tax financing (financing with some other source than bonds, such as a sales tax) required to reach cash breakeven. Cash breakeven means the project always has sufficient cash to operate.

12. 60% Penetration with Breakeven Tax Financing

This is Scenario 2 that then calculates the amount of tax financing (financing with some other source than bonds, such as a sales tax) required to reach cash breakeven. Cash breakeven means the project always has sufficient cash to operate.

Reasonable Case Scenario

The reasonable case scenarios answer the question – what do the results look like with 'best guess' assumptions instead of conservative assumptions.

13. Base Reasonable Case

This scenario uses the assumptions described on page 166. This includes using less conservative assumptions such as eliminating the construction contingencies.

14. Reasonable Case with Delayed Rate Increases

This starts with Scenario 13 and then raises broadband rates by 50% per year beginning after year 10.

15. Reasonable Case with Annual Rate Increases
This starts with Scenario 13 and then raises broadband rates by 50% per year beginning after year

100% Overbuild Scenarios

These scenarios look at a fiber network that is built to every resident and business in the city. The scenario still assumes that fiber doesn't go to all apartments (MDUs) since apartment owners can decline fiber (which they might do if they already have fiber from somebody else). The assumptions for these scenarios are described starting on page 172.

<u>16. With Digital Divide Product</u>

This scenario includes a digital divide broadband product priced at $10 per month so that most homes could afford broadband. It assumed that 22% of the homes in the market would qualify for this product.

<u>17. With 100% Tax Financing</u>

This scenario uses tax financing to not only fund the network, but to reduce broadband prices in the city. For instance, it assumes a gigabit broadband product priced at $50 per month and a 100 Mbps broadband product priced at $20 per month.

Open Access Scenarios

These scenarios look at the option of allowing multiple ISPs onto the network. In this case, the retail revenues go to the ISPs and the city would collect a fee from each ISP for using the network.

<u>18. Base - 50% Penetration</u>

The base open access network scenario starts with Scenario 1 and changes the way that the city would collect revenues. In Scenario 1 all retail revenues went to the city. In the open access scenario the retail revenues go to the various ISPs and the only source of revenue for the city is from collecting 'access' fees from ISPs for connecting to the network. These assumptions are found starting on page 168.

<u>19. 40% Penetration</u>

This is Scenario 18 but with a 40% customer penetration.

<u>20. 60% Penetration</u>

This is Scenario 18 but with a 60% customer penetration.

<u>21. 50% With Breakeven Tax Financing</u>

This is Scenario 18 but with a calculation of the amount of tax financing (financing with some other source than bonds, such as a sales tax) required to reach cash breakeven. Cash breakeven means the project always has sufficient cash to operate.

Public Private Partnership Scenarios

These scenarios assume that an ISP partner would cover some of the costs of the assets needed to service customers. In these scenarios it was assumed that the ISP would cover the cost of assets needed to support employees (trucks, computers, furniture, etc.) as well as the electronics and anything inside the customer premise such as settop boxes. The city would still fund the other assets. These assumptions can be found starting on page 172.

<u>22. With Bond Funding</u>

This scenario use 100% bond funding for the assets funded by the city.

<u>23. With Some Tax Funding</u>

This scenario assumes $25 million calculates of tax financing (financing with some other source than bonds, such as a sales tax).