Boulder City Council
STUDY SESSION

TUESDAY
JULY 12
5:30-9 PM

Science Tuesday
5:30-6 PM
John Walker, Rocky Mountain Institute

Update on Community Broadband Initiative
6-9 PM

Council Chambers
Municipal Building
1777 Broadway

Submit Written Comments to City Council, ATTN: Lynnette Beck, City Clerk, 1777 Broadway, P.O. Box 791, Boulder, CO 80306 or Fax to 303-441-4478 or E-mail: council@bouldercolorado.gov

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CITY OF BOULDER
STUDY SESSION

TO: Mayor and Members of City Council

FROM: Jane S. Brautigam, City Manger
Tom Carr, City Attorney
Don Ingle, Director, Information Technology
Carl Castillo, Policy Advisor

DATE: July 12, 2016

SUBJECT: Update on Community Broadband Initiative

PURPOSE:

This study session will provide Council with background regarding and seek direction regarding the city's efforts to make true high speed broadband available to Boulder residents and businesses. The city's consultant has conducted a detailed feasibility analysis. A copy of the feasibility report is attached to the memorandum as Exhibit 1. In addition, the consultant project lead Joanne Hovis will present at the study session and be available to respond to council's questions.

INTRODUCTION:

Council scheduled this study session to address community broadband. Staff is seeking council input regarding next steps in the process of bringing competitive high speed internet to Boulder. As the result of a recent request for information, the city has the opportunity to work with one of three companies to leverage private investment in a way that would allow every resident and business in Boulder access to high speed internet over a fiber-optic network. Staff requests that council direct the city manager to negotiate with the three RFI respondents to implement a state of the art fiber network in Boulder as soon as possible. If staff begins such negotiations immediately it is possible to begin high speed service as early as 2018. If council would prefer a city-funded option the earliest possible date for voter approval would be November 2017. In that case, service could begin no earlier than 2019 or 2020. Staff recommends entering into immediate negotiations with the RFI respondents.

BACKGROUND:

At the November 2014 election, nearly 84% of those voting supported a measure exempting the city from a state law that purports to prohibit cities from providing broadband services. This was the first step in the city's "Connect Boulder" community broadband initiative. Since then city has introduced free community Wi-Fi in the civic area and convened a working group assist in guiding citywide broadband implementation. The city owns or has the right to use approximately 100 miles of fiber optic cable, which includes surplus capacity suitable for broadband deployment. The plan is to leverage this resource to the fullest extent possible in order to provide better internet service to the community.

Internet speed is measured in bits per second. A transfer rate of one kilobit per second can transfer 1,000 bits of data in a second. There are 8 bits in a byte. Generally, one byte equals one character of text. When you add this up, 1,000 bits per second is pretty slow.

A transfer rate of one megabit per second can transfer 1,000 kilobits or 1 million bits per second. At a rate of one megabit per second a user can download a song in the most popular mp3 format in about 30 seconds. The average internet speed in Boulder is about 10 megabits per second. Comcast offers 100 megabits per second speeds. For most customers, Century Link's top speed is 40 megabits per second.

The newest goal for community broadband is one gigabit per second. A system capable of one gigabit per second can transfer 1,000 megabits per second, 1 million kilobits per second or 1 billion bits per second. At this rate a user can download a high definition movie in about ten seconds.

Gigabit speeds are great for watching Netflix, but perhaps more important for economic development are upload speeds. This is the rate at which users can push data out to the internet. Fast upload speeds are crucial for most technology companies. According to one website, the average upload speed in Boulder is six megabits per second. Longmont is offering one gigabit per second speeds "synchronously", meaning the upload and download speeds are not only fast but also equal. Most commercial internet providers offer upload speeds that are significantly slower than their download speeds. To be economically competitive, Boulder businesses need to be able to match the upload speeds available to their Longmont competitors.

Currently, the bulk of the city's residents can choose either cable or telephone internet service given the limited options available. Cable internet service is provided over coaxial cable that also provides cable television, it uses a standard called Data Over

Cable Service Interface Specification (DOCSIS). Telephone companies use the copper telephone wire to provide internet service using what is known as Direct Subscriber Line (DSL). Both have speed limitations, although the ceiling for cable is probably higher than that for telephone. A third option is fiber optic cable. Fiber optic cable is believed to have a faster upside than either DOCSIS or DSL and is the infrastructure of choice to provide high-speed service for decades to come. Internet service pricing and speed availability are a function of demand and competition. Currently, Boulder has high demand but competition between only two companies. In other communities, when a third company enters the market with significantly better service, cable and telephone companies have responded by upgrading their systems to provide faster speeds. Thus, introducing a new provider could provide both a direct and indirect improvements to internet service in Boulder.

Request for Information

With input from the Broadband Working Group, the city issued an RFP and selected CTC Technology and Energy out of Maryland to assist the city in preparing a comprehensive broadband feasibility study. Part of CTC's scope was to work with the city to release a Request for Information (RFI) to gauge interest in broadband public-private partnerships. Issued last January, the RFI stated that the city was seeking a partner to achieve the following goals identified last year by the city's Broadband Working Group:

- Ubiquitous access to gigabit per second level broadband infrastructure: The partnership will provide the infrastructure to enable every Boulder home, business, visitor, and public or private institution the opportunity to access affordable high-speed broadband connections to the Internet and other networks.
- Open access: The partnership will demonstrate, support, and build a non-discriminatory, open-access infrastructure that should, to the maximum extent possible, be open to all users, service providers, content providers, and application providers, and be usable via all standard commercial devices.[1]
- A competitive local broadband marketplace: The partnership will facilitate a local broadband marketplace that is as competitive as reasonably possible.
- Unfettered access: The network will deliver competitive unfettered data offering that does not impose caps or usage limits on one use of data over another (i.e., does not limit streaming). All application providers (data, voice, video, cloud

[1] Open access is more challenging if the private partner pays for the construction. In such a case, the company is generally not willing to allow competitors to use the network.

services) are equally able to provide their services, and the consumer's access to advanced data opens up the marketplace.

The city received ten responses of which three were viewed as most qualified.[2] All three have indicated an interest in either constructing, owning and operating the network at the company's expense, or operating a network that the city would build and own. Staff interviewed these three companies and learned that each is backed by significant liquid financial resources and is capable of building a fiber optic broadband network in Boulder, although one company expressed reservations about some customers who might be too expensive to serve without some additional subsidy. Each company promised to provide service to all customers in Boulder. Each company included lower speed and cost alternatives to the higher speed and price services. Such offerings are important to bridging the digital divide faced by residents with very limited incomes. This is a particularly important issue for the Boulder Valley School District, which has been working with city staff on this initiative.

Alternatives for Fiber Optic Build-out.

There are at least four options for the city to achieve a ubiquitous fiber build out: 1) city ownership and operation, 2) city ownership with private operation; 3) city partnership with a private company and 4) private ownership and operation. These options are described in detail in Appendix C to the CTC Broadband Feasibility Report.

1) City Owned and Operated

Staff did not explore the first option in which the city would become not only the owner of the fiber, but also a competing internet service provider. This is the model deployed by Longmont. Council and the community expressed no interest in the city becoming an internet service provider. Thus, staff did not analyze this option.

2) City Owned and Privately Operated or 3) City Partnership with a Private Company

All things being equal, city ownership of the fiber network with private operation or a public private partnership is the option most likely to meet all of the city's goals. Either option would require the city to provide sufficient funding to construct all or part

[2] Google Fiber did not respond to the RFI. Google generally does not respond to RFIs. Nevertheless, staff is working to keep the lines of communication open with Google in the event that the company later expresses an interest in working with the city on a fiber optic build-out.

of the network. Any debt would need to be approved by the voters.[3] Ultimately, the debt would be repaid from lease payments for use of the network once it began operating. Some source of funding would be necessary to pay debt service between the date of issuance and the first day of service, which is likely to be two to three years. Thus, to implement a city-owned network, council would either need to use current general fund revenues or seek voter approval of a new tax to pay the initial debt service. As noted in CTC's feasibility report, a new city-owned fiber network passing every home and business in the community and using city fiber assets where possible would cost an estimated $70 to $90 million to construct. The earliest a debt measure could be placed before the voters would be November 2017.[4]

There are many other demands on the city's capital. The following is a partial list of potential multi-million dollar projects that could require city capital bonds supported by sales tax revenues in the near future:

- Fire station relocation
- Hospital site development
- Pollard site development
- Civic area
- University Hill Hotel Public Private Partnership
- Energy Future
- Build Valmont South Community Park

Thus, the question is whether implementing city-owned fiber network should have a higher priority than any of the projects listed above. Of course, the other thing to consider is that there is private funding available for the fiber network and not for any of the other projects listed above.

4) Privately Owned and Operated

The fourth option is a privately owned and operated network. The biggest downside to this is that the city would have little or no control over the network. The owner's charges would be based on the market, although the city would seek price

[3] The Taxpayers Bill of Rights (TABOR) requires voter approval of any multi-year fiscal obligation. The city acquired the Boulder Community Health facility through the use of Certificate of Participation (COPs), which are a form of lease/purchase and not subject to voter approval. To use COPs, the city pledges existing assets as security. The city does not have assets, not currently being used as security, valued sufficiently highly to secure sufficient funding to construct a fiber network. Thus, the only option for building a fiber network would be voter-approved debt.

[4] There is not sufficient time before the November 2016 election to do the analysis necessary to support a ballot measure. TABOR requires that voter approval of debt or tax measures can only occur at a November election.

guarantees as part of the initial contract. Also, none of the companies proposed a robust open access environment. It is understandable that a company investing between $50 million and $100 million, would not want to open its infrastructure to competitors. In addition, the significant infusion of private capital into this market is a relatively new development. The city would be one of the first to attempt to negotiate a mutually beneficial construction and operating agreement with a private broadband firm based on the goals that have been identified. There is very promising, concrete interest from potential partners in this model, but no case history that guarantees success in negotiating terms that meet all the city's objectives.

The most significant benefit from private development is that the network will be built more quickly than if the city does it and the city will bear no financial risk associated with the project. The city's participation would be limited to leasing the existing fiber network, expediting construction through priority permit processing and allowing access to the city's GIS system for utility location. These benefits will give the city some leverage even over a privately built and operated system.

Those participating in a Broadband Working Group meeting earlier this month reviewed options 2, 3 and 4 and agreed that all have merit. While the group did not reach a firm consensus on a preferred option, there was broad recognition that the community desires timely action and that the private build option offers opportunities that may not be available in the future.

Questions for Council

1. What are Council's policy objectives?

2. Does Council support the staff's recommendation of pursuing a privately owned and operated fiber optic network?

Attachment – Boulder Broadband Feasibility Study

Exhibit 1 – Broadband Feasibility Study by CTC Technology and Energy

ctc technology & energy

engineering & business consulting

Broadband Feasibility Study

Prepared for the City of Boulder

June 2016

Columbia Telecommunications Corporation

10613 Concord Street • Kensington, MD 20895 • Tel: 301-933-1488 • Fax: 301-933-3340 • www.ctcnet.us

Contents

1 Executive Summary 1
1.1 Project Background 1
1.2 Methodology 2
1.3 The City's Core Objectives Are Ubiquity, Competition, and Digital Inclusion 3
1.3.1 Ubiquitous FTTP Deployment Will Create Competition 3
1.3.2 New Broadband Competition Will Create Benefits for Digital Inclusion and Affordability 4
1.3.3 Meeting the Need for Better Services to Small and Medium Businesses in Boulder Will Promote Economic Vitality and Innovation 5
1.3.4 FTTP May Also Have a Positive Effect on the Environment 6
1.4 The City Is in an Enviable Position for Developing a Mutually Beneficial Partnership with a Private Entity 8
1.4.1 The City's Objectives Would Be Served By the Model in Which the City Owns the Dark Fiber 9
1.4.2 The City Can Accomplish Many of the Same Objectives at Lower Risk through a Private Investment Model 10
1.4.3 The Private Sector Expressed Deep Interest in Partnering with Boulder, Both Under the Private Investment Model and Under a Shared Risk Model 10
1.5 The Boulder Market Has Unmet Demand and Significant Frustration with Existing Providers 11
1.6 Building Ubiquitous FTTP in Boulder Would Cost $70 to $90 Million 12
1.7 Boulder Would Require Lease Payments of at Least $17 per Passing per Month to Cover its Costs 14
2 Assessment of Local Broadband Market 15
2.1 Enterprise Market 15
2.1.1 Dark Fiber Services 15
2.1.2 Lit Services 16
2.2 Residential and Small Business Services 21
2.2.1 Cable 22
2.2.2 DSL 23

2.2.3 Satellite 24
2.2.4 Wireless 24
3 Cost Estimates for FTTP Construction 26
3.1.1 FTTP Cost Estimate 26
3.1.2 Cost Estimate Breakdown 29
3.2 Field Survey 29
3.3 FTTP Network Design 33
3.3.1 Network Design 36
3.3.2 Network Core and Hub Sites 38
3.3.3 Distribution and Access Network Design 39
3.4 FTTP Cost Estimate 43
3.4.1 OSP Cost Estimation Methodology 44
3.4.2 OSP 45
3.4.3 Central Network Electronics Costs 46
3.4.4 Customer Premises Equipment and Service Drop Installation (Per Subscriber Costs) 48
3.5 Operating Cost Considerations 48
3.5.1 Technical Operational Expenditures 49
3.5.2 Technical Staffing Requirements 51
4 FTTP Financial Analysis 53
4.1 Cost Implications of FTTP Technical Model 54
4.2 Financing Costs and Operating Expenses 56
4.3 Operating and Maintenance Expenses 59
4.4 Revenue 60
4.5 Sensitivity Scenarios 60
4.5.1 Adding a One-Time, $10 Million Payment from the City's Partner 61
4.5.2 Increasing the City's Interest Rate 61
4.5.3 Increasing the City's Bond Term to 30 Years 62
4.5.4 Reducing Operating Expenses by 25 Percent 63
4.5.5 Constructing Network Completely Underground 63

5 Understanding Open Access and Competition 65
5.1 Facilities-Based Competition 65
5.2 Competition at the Dark Fiber Level 66
5.3 Competition at the "Lit" Services Level 68
5.4 Over-the-Top Content Offers Service-Level Competition and a Variation on Open Access 69
5.5 Evolving Over-the-Top Providers 70
6 The RFI Process and Respondents 74
6.1 Evaluating Responses to Develop a "Short List" of Potential Partners for Further Consideration 74
6.2 Partnership Models Proposed by Respondents 76
6.3 Scoring Mechanisms to Determine Which Respondents to Evaluate Further 78
6.4 Division of Shared Financial Responsibilities 78
6.5 In-Person Meetings with RFI Respondents 79
6.6 Elimination of Respondents That Propose Model 2 80
6.6.1 Colorado Fiber Community 81
6.6.2 Macquarie Infrastructure Development 81
6.6.3 Symmetrical Networks 82
6.7 RFI Respondents' Adherence to City Objectives 83
6.7.1 Allo Communications 83
6.7.2 Axia FibreNet 84
6.7.3 Ting Internet 84
6.8 Conclusion 85
Appendix A – Request for Information (RFI) for FTTP Network 87
Appendix B – Common Community Objectives 150
Appendix C – Financial and Strategic Considerations for Partnership Negotiations 167
Appendix D – Glossary of Terms 205

Figures

Figure 1: Demarcation Between City and Partner Network Elements 13
Figure 2: Total Estimated Cost versus Take Rate 27
Figure 3: Demarcation Between City and Partner Network Elements 28
Figure 4: Map of Field Survey Areas 30
Figure 5: Typical Alleyway with Rear Fed Utilities 31
Figure 6: Utility Pole Requiring Make Ready 32
Figure 7: Make Ready Required on a Utility Pole 32
Figure 8: High-Level FTTP Architecture 35
Figure 9: FTTP Service Areas 37
Figure 10: Sample FTTP Access Layer Design 38
Figure 11: Fiber Distribution Cabinet 41
Figure 12: Demarcation Between City and Partner Network Elements 54
Figure 13: Facilities-based Infrastructure Competition 66
Figure 14: Competition Over a Dark Fiber Network 67
Figure 15: Competition Over a Lit Network 68
Figure 16: Over-the-top Competition 70

Tables

Table 1: Breakdown of Estimated Dark FTTP Cost (Low End of Range) 13
Table 2: Ethernet Transport Pricing in Denver (Monthly Recurring Costs) 21
Table 3: DIA Pricing in Denver (Monthly Recurring Costs) 21
Table 4: Overview of Residential and Small Business Data Services in Boulder 21
Table 5: Comcast Residential Internet—Internet Only 22
Table 6: Comcast Small Business Internet—Internet Only 23
Table 7: CenturyLink Residential Internet 23
Table 8: Rise Broadband Residential Internet Services 25
Table 9: Rise Broadband Small Business Internet Services 25
Table 10: Breakdown of Estimated Total Cost with Electronics at 35 Percent Take Rate 27
Table 11: Breakdown of Estimated Dark FTTP Cost 28
Table 12: Field Survey Findings 31
Table 13: Breakdown of Estimated Total Cost (Fiber & Electronics – 25 Percent Take Rate) 43
Table 14: Estimated OSP Costs for FTTP 45
Table 15: Estimated Central Network Electronics Costs 46
Table 16: Per GPON Subscriber Cost Estimates 48
Table 17: Base Case Financial Analysis 53
Table 18: Breakdown of Estimated Dark FTTP Cost (aerial and underground construction) 54

Table 19: OSP Cost Estimate Summary (Underground Construction) 55
Table 20: Income Statement 57
Table 21: Cash Flow Statement 58
Table 22: Operating Expenses 60
Table 23: Base Case Financial Analysis 61
Table 24: A $10 Million Upfront Payment Reduces the City's Borrowing by $13 Million 61
Table 25: Increasing the City's Interest Rate by 2 Percentage Points Increases Required Borrowing by $4.5 Million 62
Table 26: Reducing the City's Interest Rate by 2 Percentage Points Reduces Required Borrowing by $4 Million 62
Table 27: Increasing the City's Bond Term to 30 Years Decreases the Per-Passing Fee 63
Table 28: Decreasing the City's Operating Expenses by 25 Percent Only Slightly Reduces the Per Passing Fee 63
Table 29: All Underground Construction Significantly Increases Per-Passing Fee 64
Table 30: Comparison of Models Based on City Goals 77
Table 31: Proposed Business Models Within Existing Partnership Models 78

1 Executive Summary

Localities throughout the U.S. are eager to find creative ways to meet their communities' broadband needs. More than ever, cities are exploring how to deploy new broadband networks, expand existing fiber infrastructure, or partner with private entities to offer fiber-to-the-premises (FTTP) in their communities. FTTP represents the Holy Grail of communications technology—long-lasting fiber optic lines all the way to the home and business with unlimited ability to meet growing needs for connectivity, now and for many decades to come.

Over a decade ago, the City of Boulder partnered with the U.S. Department of Commerce Boulder Labs, the National Center for Atmospheric Research, and the University of Colorado at Boulder to develop a shared fiber optic network to connect public service institutions in the City.[1] The Boulder Research and Administration Network (BRAN) consortium completed its network in 2000. While BRAN is not sufficient to support citywide FTTP, it speaks to the local understanding of a need for robust fiber connectivity to maintain a competitive edge in the global economy.

The City is committed to enabling greater connectivity for the community and to deploying a citywide FTTP network to serve all Boulder residents and businesses; it is currently exploring potential partnership with the private sector to achieve this.

1.1 Project Background

The City is clear about its desire for better access to broadband; in 2014, citizens voted overwhelmingly to make the City exempt from legislative barriers on telecommunications, which paved the way for the City to pursue an FTTP deployment.[2] The City responded by creating the "Connect Boulder" initiative to work toward meeting the community's broadband needs.

As one outcome of the Connect Boulder program, in early 2016, CTC Technology & Energy (CTC) and the City worked together to release a request for information (RFI) to gauge private-sector interest in partnering with the City to realize its broadband goals.[3] The City and CTC have identified, from among the RFI respondents, several private companies that may be able to meet the City's broadband goals Discussions between the City and potential partners are ongoing.

This report:

- Summarizes the City's goals based on input from staff, stakeholders, and the City's broadband working group;

[1] "BRAN Fiber Optic Network," *City of Boulder,* accessed February 10, 2016, https://bouldercolorado.gov/information-technology/bran-fiber-optic-network.
[2] "2C Ballot Information," *City of Boulder,* accessed April 4 2016, https://bouldercolorado.gov/connect-boulder/2c-ballot-information.
[3] See Section 1.3 for the current state of the RFI, and Appendix A for the full RFI document.

- Offers a conceptual fiber design and projected cost estimates for an FTTP deployment;
- Describes the emerging area of broadband public-private partnerships and the opportunities and risks presented by a range of partnership models;
- Discusses the current status of the City's negotiations with potential partners; and
- Outlines anticipated financial projections for deploying an FTTP network.

1.2 Methodology

This report was researched and prepared in winter and spring 2016 by CTC, in conjunction with ongoing efforts to review responses to the City's RFI process and evaluate potential partnerships for the City. Over the course of this engagement, CTC and City staff held a series of meetings, including:

- Focus groups with Boulder businesses and entrepreneurs to learn about the needs, requirements, and frustrations businesses may have with respect to broadband services and pricing;
- Public meetings with members of the public to discuss the initiative and solicit local input and ideas;
- Discussions with community leaders from the University of Colorado; the federal agencies located in Boulder; leaders and stakeholders of the BRAN partnership; and other community members with deep interest in this initiative to learn about their needs and to gather feedback on what the City's role should be in deploying an FTTP network; and
- Meetings with select RFI respondents to explore potential partnership relationships.

These onsite meetings sought to engage residents, businesses, providers, and other stakeholder groups to develop a sense of these users' broadband needs and perceptions. While these groups were presented with some specific questions, they were also encouraged to have a free-flowing discussion about their perceived broadband needs and the role they believe the City should take in addressing any gaps they felt existed in the market.

In addition to these meetings, we performed the following general tasks:

- Assessed the City's key physical infrastructure;
- Evaluated the City's current and future demand for broadband not only in focus groups but also with an online survey that received almost 500 responses
- Researched the region's available connectivity services and costs;
- Prepared an RFI and supported the City in the logistical and review process;
- Developed preliminary pro forma financial statements for the City based on initial service pricing and take-rate assumptions; and
- Facilitated regular meetings to apprise City leadership of the project's status.

1.3 The City's Core Objectives Are Ubiquity, Competition, and Digital Inclusion

The core objectives of this initiative were developed by the working group formed by the City as part of the Connect Boulder initiative and then further refined during CTC and City staff's meetings with stakeholders over the course of the past nine months. Generally, these objectives are (1) ubiquitous service that enables all within Boulder, regardless of location, to purchase services over a fiber network; (2) new competition over a fiber platform that would benefit consumers through the inevitable innovations, decreases in cost of service and investment driven by competition; and (3) digital inclusion, to create mechanisms and opportunities to participate among those members of the community who have traditionally been least able to access or afford broadband service.

In our view, the benefits of ubiquity, competition, and digital inclusion are likely to arise from this initiative, as are additional benefits. Some of these are summarized below.

1.3.1 Ubiquitous FTTP Deployment Will Create Competition

When a new, high-speed Internet service provider (ISP) enters a market, consumers tend to experience an increase in available services and a decrease in the cost of some services. As the new entrant begins to offer services, incumbent providers typically respond by upgrading their infrastructure to enable higher tiers of service and decreasing the price that customers pay. The impact is especially pronounced when the new entrant, or a public sector partner, builds a new FTTP network, capable of delivering speeds beyond what most incumbent cable and telecommunication networks currently provide.

For instance, in most of the markets where Google has announced plans to launch Google Fiber service, consumers benefit from Google's additional service offerings, as well as from upgraded service and significant price reductions from incumbent telecom and cable carriers. A recent *Consumerist* report notes that in markets where Google has announced plans to build fiber, AT&T offers customers 1 Gigabit per second (Gbps) service starting at $70 per month. In markets without competition from Google, AT&T charges customers $80 per month for 300 Mbps service.[4]

The threat of a new entrant is often enough to spur incumbents to make new investment or lower prices. Where competition emerges, the competitive reaction intensifies and incumbent companies lower prices and improve services. Indeed, in the various markets where Google Fiber has announced that it will—or may—build new fiber networks, the incumbent phone and cable companies have responded by upgrading their own facilities, increasing speeds, and reducing pricing. This reaction frequently emerges in cities that build municipal networks also. For

[4] Chris Morran, "ATT Touts Lower Prices for Gigabit Internet," *Consumerist*, last modified September 15, 2015, http://consumerist.com/2015/09/30/att-touts-lower-prices-for-gigabit-internet-still-charges-40-more-if-google-fiber-isnt-around/.

example, in Chattanooga, Tennessee, Comcast fought hard to prevent the public electric utility from offering Internet service. Unable to block the new entrant, Comcast has been forced to compete. The cable company last year announced that Chattanooga would be one of the first cities to receive its 2 Gbps FTTP service.[5]

1.3.2 New Broadband Competition Will Create Benefits for Digital Inclusion and Affordability

Residents who do not use broadband are typically confronted with one or more of the following issues:

1. Lack of access to service
2. Inability to afford service
3. Lack of knowledge of how to use computers, devices, or broadband

With those causes in mind, new broadband competition can have a significant positive impact on efforts to close the digital divide. The City's initiative to bring a competitive FTTP provider to Boulder addresses the second, and often most pressing concern—affordability—by introducing robust competition into the market.

As described above, broadband competition will serve to lower some prices. We believe that a new provider (whether a public or private entity) will offer some low-cost products. Even if the new provider does not offer low-cost products, incumbents are likely to lower their pricing on some products in response to the new competition. We have seen this in other markets, and have no reason to doubt that the same scenario will play out in Boulder.

To be clear, this does not mean that the high-end symmetrical Gigabit products will necessarily be available at low prices, or affordable to every resident. It may be that only lower bandwidth products are available at low prices. For example, in some markets we have seen the incumbent telephone companies compete for price-sensitive customers by offering low-price, low-bandwidth services.

But a more robust market environment will lead to competitive pricing that benefits low-income consumers in ways that simply do not happen in monopoly and duopoly environments. Further, some of the private companies that are interested in serving Boulder have indicated that they would offer lower-cost digital inclusion products, and would actively participate in the FCC's Lifeline program (which offers broadband subsidies to low-income Americans).

[5] Jon Brodkin, "Comcast brings fiber to city that it sued 7 years ago to stop fiber roll out," *ArsTechnica,* last modified April 30, 2015, http://arstechnica.com/business/2015/04/comcast-brings-fiber-to-city-that-it-sued-7-years-ago-to-stop-fiber-rollout/.

We expect this FTTP initiative, regardless of the partner that the City selects or the partnership approach that the City takes, to result in real benefits for low-income residents of Boulder. Further, we note that in any partnership arrangement, the City would have the option to subsidize service for low-income residents.

1.3.3 Meeting the Need for Better Services to Small and Medium Businesses in Boulder Will Promote Economic Vitality and Innovation

Based on the many focus groups and conversations we had with business owners in Boulder and the City's own staff, we believe that there is a significant gap with respect to very high-end competitive broadband services for small and medium-sized businesses. Larger business and institutions appear relatively well served by the incumbents and the competitive providers, like Zayo, that are already present in the market—but as is the case in many markets, small and medium-sized businesses outside the major fiber corridors struggle to get affordable high-end services.

And there is a gap, too, when it comes to home-based businesses and teleworkers. Given the demographics of Boulder, many teleworkers are very sophisticated telecommunications users—and many of them have expressed real frustration with the reliability and capacity of the consumer-based broadband connections they have from the phone and cable companies that currently offer service in Boulder.

These gaps represent both a real need in the community, and a significant business opportunity for private sector retail service providers. A growing body of evidence demonstrates that high-speed fiber connections facilitate an innovation ecosystem and enable small businesses and start-ups to thrive.

Blazing fast Internet connections provide entrepreneurs, freelancers and small-business owners with a variety of new tools that allow them to compete as never before. A growing portion of the US workforce can do much of their work from wherever they find a robust Internet connection. While a basic broadband connection is sufficient for certain tasks, gigabit speeds enable richer collaboration tools, such as vivid telepresence.[6] As bandwidth-hungry collaboration tools continue to improve, the physical location of people becomes less important.[7] Small business owners and entrepreneurs with access to abundant bandwidth can draw on talent from across the globe, forming short-lived teams that complete specific tasks without ever needing to meet in person. Although contractors and freelancers are generally free to roam as they please, they

[6] http://www.pewinternet.org/2014/10/09/killer-apps-in-the-gigabit-age/

[7] According to the New Jersey Institute of Technology, 45 percent of U.S. employees already work from home at least part of the time. http://betanews.com/2015/09/11/the-rise-of-telecommuting-45-percent-of-us-employees-work-from-home/

will gravitate to areas with abundant bandwidth that can provide a quality connection to their clients.

Higher speed connections have the potential to improve the flow of goods and services in every sector of the economy. Many entrepreneurs with a desire to create new services based on high capacity connections have flocked to the first few Gig Cities to build and test their products.[8] Although a robust two-way connection has the potential to improve everything from how we exercise[9] to how we react to weather emergencies,[10] there are a number of emerging fields that are entirely dependent on extremely high speed connections. Virtual and augmented reality and precise 3D modeling require data flows far beyond the average home or small business connection speed today. The new businesses that emerge in these sectors will undoubtedly be based in localities that have abundant, affordable bandwidth.

Big bandwidth will be particularly important for the entrepreneurs that seek to create value through the analysis of large data sets. As sensors proliferate and the cost of memory plummets, more data is being collected than ever before in history. In the past, only large companies would be able to afford the computing power necessary to make sense of such huge data sets, but now any savvy statistician with a laptop and a gigabit internet connection can run an analysis in minutes. Big data stands to improve productivity and efficiency in every sector of the economy,[11] but the companies and individuals that will conduct the analysis will be located in areas with abundant bandwidth.

Innovation is possible everywhere, but individuals living in a place with affordable high speed connections have a natural advantage coming up with a new idea or when trying to turn a prototype into a product. Abundant bandwidth gives people the freedom to tinker and figure out how symmetrical high-speed connections can improve our daily lives. As William Gibson once said, “The future is already here, it’s just not evenly distributed.” People living in the first few cities with super high speed broadband have the chance to create the future for everyone else.

1.3.4 FTTP May Also Have a Positive Effect on the Environment

Better broadband enables more sustainable ways of meeting our needs. In a 2007 economic analysis of the environmental benefits of broadband services, The American Consumer estimated

[8] http://www.nlc.org/Documents/Find%20City%20Solutions/City-Solutions-and-Applied-Research/Innovation%20Districts%20Report.pdf
http://siliconprairienews.com/2014/04/three-years-after-announcement-kansas-city-is-still-figuring-out-fiber/
[9] https://www.nsf.gov/mobile/discoveries/disc_summ.jsp?cntn_id=134550&org=NSF
[10] https://www.us-ignite.org/globalcityteams/actioncluster/zJiQHYzzoXrZJthAHwcN5F/
[11] http://www.mckinsey.com/business-functions/business-technology/our-insights/big-data-the-next-frontier-for-innovation

that widespread adoption and use of broadband-based applications could lead to an "incremental reduction of more than 1 billion tons of greenhouse gas emissions over ten years."[12]

Daily commutes and work-related long-distance travel burn huge amounts of fossil fuels each day. Telecommuting drastically reduces the ecological cost of doing business. As home broadband speeds improve, many employees are able to regularly skip the commute and be equally productive at home or a nearby coffee shop or co-working space. This allows companies to downsize their offices, reducing energy use and emissions associated with construction. Already, 40 percent of IBM employees do not need to go into the office each day.[13]

The benefits of telecommuting extend far beyond ecological impact. Employees save money on gas and time spent in traffic. In a 2009 Cisco survey,[14] telecommuters reported experiencing higher rates of productivity, better work-life flexibility and overall improved satisfaction with work. When Cisco started using telecommuting internally in 2007, it kept 47,320 tons of greenhouse gasses out of the atmosphere and saved its employees $10.3 million in fuel cost.

On an average home broadband connection, a virtual meeting is hardly a replacement for a face-to-face interaction. Video conferencing is a step up from conference calls, but over a DSL or cable connection, video calls often lag and randomly disconnect. A symmetrical gigabit connection will make video chatting feel more like sitting across the table from someone, and could even allow conversation partners to appear as holograms or other rich forms of telepresence.[15] Richer online collaboration tools will reduce the need for daily commutes and work related long-distance travel.

Blazing fast broadband can also reduce the need for other forms of travel. Instead of traveling to and from a hospital for a quick check-up, doctors will be able to monitor their patients remotely and rely on video conferencing for non-critical check-ins. If a patient needs to see a specialist that does not live in the same city, rich telepresence could allow the patient to skip travelling back and forth. Surgeons may even be able to operate on patients thousands of miles away provided both parties have access to extremely fast and reliable data transport services.[16] As bandwidth becomes more abundant, there is less need to travel to a physical location to receive specific goods and services, reducing the energy load and carbon emissions associated with meeting our needs.

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[12] http://www.theamericanconsumer.org/2007/10/broadband-services-economic-and-environmental-benefits/
[13] http://www.fastcompany.com/3039241/how-the-workforce-is-evolving-and-what-leaders-can-do-to-keep-up
[14] http://www.fastcompany.com/1300971/cisco-says-telecommuting-saves-money-and-world
[15] http://www.pewinternet.org/2014/10/09/killer-apps-in-the-gigabit-age/
[16] http://www.computerworld.com/article/2927471/healthcare-it/robot-performs-test-surgery-1200-miles-away-from-doctor.html

1.4 The City Is in an Enviable Position for Developing a Mutually Beneficial Partnership with a Private Entity

Although the community has a desire for better access to broadband, it was clear from our focus groups and stakeholder meetings (see Section 1.5) that there is little interest in seeing the City directly enter the market as a retail service provider. City staff and leadership have also indicated that the City is currently uninterested in a fully-municipal business model. Offering retail service is complex, and in light of the partnership options available to the City for this particular type of service, there is little reason it should have to take this level of risk.

Even absent the municipal model, the City faces a wealth of choices. It appears that it can, given emerging capital investment interest, enable private deployment of FTTP. Alternatively, or as a fallback, it has the option of developing a fiber network of its own and maintaining ownership and control of some or all of the new fiber assets while assigning operational responsibilities, including the capital investment for network and consumer electronics, to a private partner. This enables both parties to perform functions that highlight their strengths.

In summary, and as is discussed in detail in Appendix C, our analysis is that there exist three models for community broadband as of the time of this writing:

- **Model 1 – Private risk, public facilitation**: The model focuses not on a public sector investment, but on modest measures the public sector can take to enable or encourage greater private sector investment.
- **Model 2 – Private execution, public risk:** This model, which involves a substantial amount of public investment, is a variation on the traditional municipal ownership model for broadband infrastructure—but with private rather than public sector execution.
- **Model 3 – Shared investment and risk (City fiber and private operations):** In this model, localities and private partners find creative ways to share the capital, operating, and maintenance costs of a broadband network.

The City is uniquely poised to take advantage of either Model 1 or Model 3; depending on its goals, either of these models may be a comfortable fit for the City and a private partner. While Model 1 could potentially meet the City's goals almost exclusively through private investment and without City ownership, it would not give much, if any, control to the City over the new fiber assets. At this point, the City does not require such ownership in order to meet most of its broadband goals. Under Model 3, that retaining all or some level of ownership over new dark fiber could make best use of the City's strengths, while allowing a private partner to provide what they can uniquely bring to the table (e.g., customer service experience, economies of scale in a retail service setting).

1.4.1 The City's Objectives Would Be Served By the Model in Which the City Owns the Dark Fiber

In Model 3—a dark fiber model—the City would construct and own the fiber network and the private partner would "light" the fiber with electronics and directly serve the end user. This is the model currently underway in the City of Westminster, Maryland with its private partner, Ting Internet,[17] and in Huntsville, Alabama with its private partner, Google Fiber.[18]

While the City does not wish to compete with private industry in the retail services market, a dark fiber ownership model, at least in theory, allows the City to engage multiple private providers to offer service over its network. The challenge with this model is that not all markets are large and diverse enough to support multiple ISPs competing at the same time. Although most cities likely cannot support multiple ISPs competing for the same market share or customer base, a dark fiber model might enable specialized ISPs to focus on serving specific customers. For example, Google Fiber has historically served only residential customers in its traditional approach where it builds, owns, and maintains the fiber infrastructure. If the City opted to retain ownership of the dark fiber network, it could potentially lease fiber to various providers that are interested in serving specific portions of the market.

There is a greater level of risk to the City under this model because it requires a substantial capital investment to build (or expand) and maintain the fiber network., but it also gives the City the greatest degree of control because the City owns the network. In the event that the partnership fails for any reason, the City owns its assets and can take over control of the network directly or by engaging a different partner. This model would enable the City to make use of its existing fiber assets, and retain a great degree of control. And the City can have some peace of mind knowing that the private partner is making a substantial investment in network equipment (and potentially in building the "drop" cables or wireless connections from the network at the curb into the home or business) in this model.

We offer a couple of key caveats with respect to this model: first, while the potential for robust competition among many service providers on the City's fiber platform is very attractive from a policy standpoint, it is unlikely to emerge in the short to medium term. The economics of broadband will still make it challenging for more than one ISP to compete for the same customers in a market – even one as attractive as Boulder – with a finite set of customers and in which the phone and cable companies already compete (albeit over a less capable network).

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[17] Wiley Hayes, "Westminster, Md. Partners with Private Sector to Broaden Fiber-Optic Network," *GovTech*, last modified October 26, 2015, http://www.govtech.com/dc/articles/Westminster-Md-Partners-with-Private-Sector-to-Broaden-Fiber-Optic-Network.html.

[18] Frederic Lardinois, "Google Fiber Is Coming To Huntsville, Alabama," *Tech Crunch*, last modified February 22, 2016, http://techcrunch.com/2016/02/22/google-fiber-is-coming-to-huntsville-alabama/.

Our second caveat is that, while this model gives the City long term control over the fiber (such as the ability to lease to additional entities as the market develops and to replace a non-performing lessee), the City still is not likely to have control over most aspects of its ISP/lessees business models, including pricing, marketing, quality of customer service, and so on. Indeed, the City would have limited control or influence over even the best of ISP/lessees in the event the company were sold or its business model dramatically changed. As a result, the City's fiber investment would give it the ability over time to react to structural changes in the market, including to lease to additional entities if the market attracted them, but not day-to-day control over the customer experience. Frankly, that level of control can be achieved only through the full municipal model, and it comes with greater risk.

1.4.2 The City Can Accomplish Many of the Same Objectives at Lower Risk through a Private Investment Model

As an alternative to a shared-risk model, the City appears at the moment to be in the enviable position of having several credible private service providers expressing interest in investing their own funds to build fiber optics all the way to the home or business throughout the City. This model, if selected by the City, removes the requirements for the City to finance the cost of building out the network—moving that obligation to the private partner, with the City serving as facilitator and enabler through the permitting and franchising processes, rather than as an investor in the network.

This model thus significantly reduces the City's financial risk, but it also significantly reduces the City's long-term control over the infrastructure and how it is operated. For example, if the investment is purely private, it would be difficult for the City to require long-term commitments with regard to open access, types of services, ubiquity, pricing, and so on—though the competitive market may serve to address concerns such as how costly services could be.

1.4.3 The Private Sector Expressed Deep Interest in Partnering with Boulder, Both Under the Private Investment Model and Under a Shared Risk Model

Our analysis is that Boulder is a desirable market for a new broadband entrant. Based on our focus groups and stakeholder discussions, and the City's own online survey, it is clear that there is considerable consumer dissatisfaction with the incumbents—and real opportunity for a third competitor in the residential and small and medium-sized business markets.

We also appear to be in a perhaps unique moment when the City's options are better and more plentiful than we have ever seen over our two decades in telecommunications consulting. The RFI process demonstrated that multiple companies are interested in working with the City, either in a shared risk partnership or in a pure private investment model:

- Three companies are offering to build FTTP in Boulder exclusively with private funds, likely on a fully ubiquitous level, seeking only support and facilitation from the City rather than a financial investment. We believe that all three are well-capitalized and credible.
- Of these three, two also indicated a strong interest in partnering with the City on a shared risk model (Model 3) in which the City would build and own some or all of the fiber network and the private company would pay the City for access to the fiber to deliver services.

These are both excellent options and we find that the City is in a better position than we could have anticipated before this process began, in part because of the sheer attractiveness of Boulder as a market and in part because of the new private investor interest in fiber-to-the-premises.

The best fit for the City comes down to whether the City wants to take on the capital costs, financial risk, and effort over time in order to have long-term control over the infrastructure.

The shared risk model certainly maximizes the City's ability to control and influence the network over time, while mitigating the risk by sharing it with a private partner in a win-win scenario. It does, however, entail a significant upfront capital investment that we estimate could be in the range of $70 to 90 million.

If the City is willing to cede most of the long-term control over the new infrastructure, then it is in the enviable position of having a private investment option, which most cities do not currently have—and the City would not have had just a year or two ago before the current wave of FTTP investment began.

We note, too, that many companies have also expressed interest in long-term public–private partnerships (a public risk, private execution approach, as described below); given the amount of risk that would entail to the City and the long-term costs, City staff and CTC determined those options were less attractive to the City than the shared risk or private investment models.

1.5 The Boulder Market Has Unmet Demand and Significant Frustration with Existing Providers

To understand the need and demand for broadband services in the community, CTC representatives and City staff met with a dozen or so separate groups in late 2015. These meetings included residential consumers, community leaders, businesses of all sizes, and representatives of incumbent communications providers.

In general, most of the participants in the group discussions are able to purchase some broadband services but struggle with service quality, reliability, customer service, and capacity. Residential users typically have access to cable modem and digital subscriber line (DSL) service. As in many markets, consumers perceive that these services are overpriced for the quality of service. DSL, in particular, is unreliable and expensive. The residents in the group discussions

indicated that they would prefer better consistency and reliability for their service, as well as far higher speeds and capacity.

Large businesses and enterprise users were well-served by existing services. Small and medium-sized businesses, on the other hand, experience significant gaps and unreliable services. This is especially true in business areas where cable modem technology is not necessarily available because cable infrastructure has not been built to these areas. For those businesses, DSL is sometimes the only option—and given its lack of reliability, it is particularly ill-suited to support businesses, which require consistent service reliability.

Based on our discussions, the biggest availability gap relative to the business profile is for a service mid-way between cable and DSL (on the low end) and Metro Ethernet and other higher-end services.

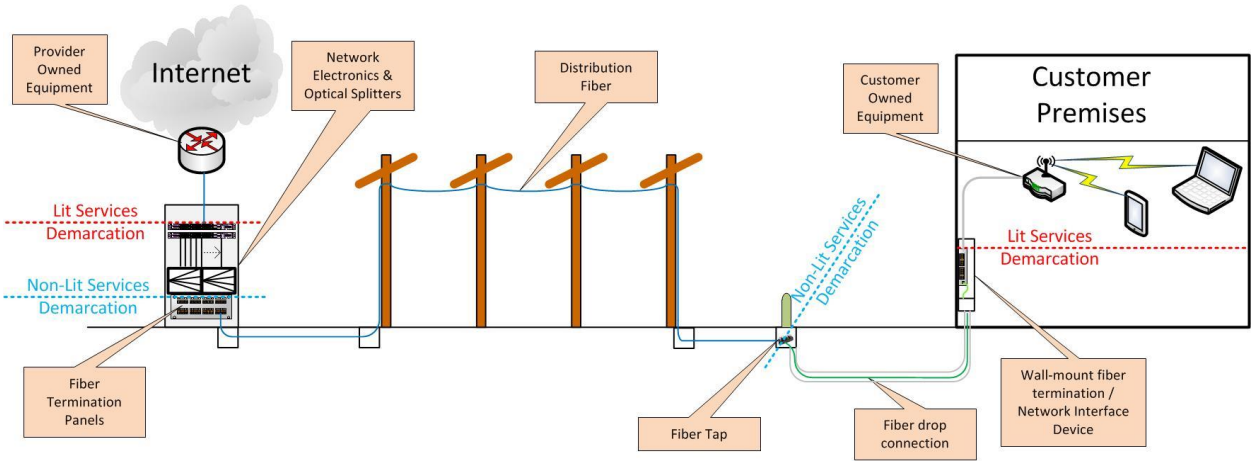
The stakeholders with whom we spoke generally feel that the City is not well-suited to enter the broadband market as a retail service provider. But the same stakeholders expressed strong support for the City playing an active role to facilitate private investment or to build fiber infrastructure that would enable private sector innovation and competition.

The existing broadband market is described in more detail in Section 2 below.

1.6 Building Ubiquitous FTTP in Boulder Would Cost $70 to $90 Million

As part of this project, CTC engineers undertook a high level fiber network design and cost estimate for purposes of understanding the scope of the effort required to build FTTP in Boulder and to inform the financial and partnership analysis. The cost estimate is based on a ubiquitous fiber deployment. The lower estimate assumes a mix of 68 percent aerial and 32 percent underground construction. In the event that more underground construction is required or that aerial construction proves particularly challenging, the higher end of the range is likely. The cost estimate also assumes that the City constructs and owns the dark FTTP infrastructure up to a demarcation point at the optical tap near each residence and business, and leases the dark fiber backbone and distribution fiber to a private partner. As we noted, this means the private partner would be responsible for all network electronics, fiber drops to subscribers, and CPEs—as well as network sales, marketing, and operations. (The precise demarcation point that makes sense for the City and its partner can be negotiable, and will have to be determined through discussions between the City and its potential partner.)

Figure 1: Demarcation Between City and Partner Network Elements



Based on these and other assumptions (detailed in Section 3 below), we estimate that a Citywide dark FTTP network deployment will cost more than $71 million, assuming a mix of aerial and underground construction, inclusive of OSP construction labor, materials, engineering, permitting, and pole attachment licensing. This estimate does not include and electronics, subscriber equipment, or drops.

Table 1: Breakdown of Estimated Dark FTTP Cost (Low End of Range)

Cost Component	Total Estimated Cost
OSP Engineering	$7.9 million
Quality Control/Quality Assurance	2.9 million
General OSP Construction Cost	53.3 million
Special Crossings	0
Backbone and Distribution Plant Splicing	2.2 million
Backbone Hub, Termination, and Testing	4.9 million
FTTP Lateral Installations	0
Total Estimated Cost:	$71.2 million

The City or its partner(s) may aim to place all newly constructed fiber underground to avoid weather-related concerns (e.g., ice storms and other weather incidents that could cause outages due to downed aerial lines), and challenges with obtaining pole attachments. Because all-underground construction is a possibility, we estimated costs to place all fiber underground. We estimate that it will cost approximately $90 to construct an all-underground dark FTTP network, an incremental cost of approximately $18 million in capital costs.

The engineering analysis and cost estimate are described in detail in Section 3 below.

1.7 Boulder Would Require Lease Payments of at Least $17 per Passing per Month to Cover its Costs

Using the engineering cost estimate as one key set of inputs, CTC's analysts built a financial model to understand the implications of the shared risk partnership in which the City would construct, own, and operate the fiber assets, and in which the cost to own, operate, maintain, and replenish network electronics and customer premises equipment (CPE), and to install the drop cable, is the obligation of the lessee of the City's fiber.

The financial model suggests that the City would need to recover from its private partner $17.10 per address (home or business) passed per month for 20 years in order to cover its debt service and other operating costs.[19] The financial analysis is described in detail in Section 4 below.

[19] The model keeps the $17.10 per passing fee constant, although the City and its partner should negotiate periodic increases that apply to the O&M portion of the fee. The flat model does not incorporate operating cost increases (including salaries) because it assumes those costs will be offset by increases in operator lease payments. We anticipate the City will apply an inflation factor, typically based on a Consumer Price Index (CPI), to the portion of the per-subscriber fee covering projected operating expenses during negotiations with a private partner.

2 Assessment of Local Broadband Market

We assessed the current market for enterprise and residential/small business services in Boulder.

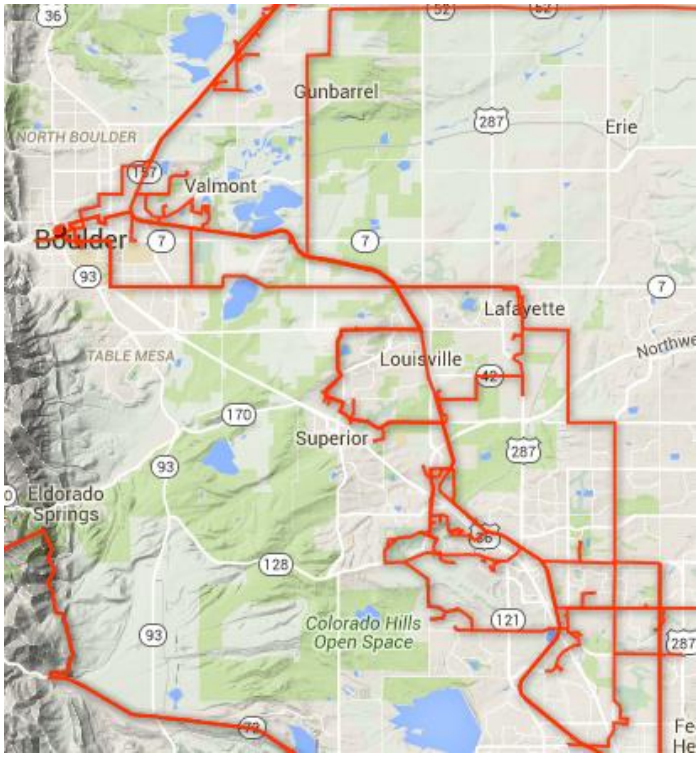
2.1 Enterprise Market

This section provides an overview of dark fiber and lit services available to enterprise customers within the City of Boulder. During the course of our research, we identified 11 service providers in the Boulder area that offer a range of services, from dark fiber connectivity to data transport services, with speeds that range from 1 Mbps to 100 Gbps. Individual providers tailor these services to customers' requirements (speed, class of service, etc.). Greater proximity to the provider's existing network infrastructure results in lower service pricing. Providers prefer to offer transport services between locations on their network ("on-net") and provision Multiprotocol Label Switching (MPLS) based services for connecting locations that are off-net.

2.1.1 Dark Fiber Services

Two service providers in the City lease dark fiber: Level 3 and Zayo. Level 3 has multiple dark fiber routes in Boulder, as depicted in Figure 1. Dark fiber pricing varies individually, based on distance from the provider's fiber ring. A difference in a few tenths of a mile can lead to significant differences in the price of dark fiber connectivity, due to additional construction costs.

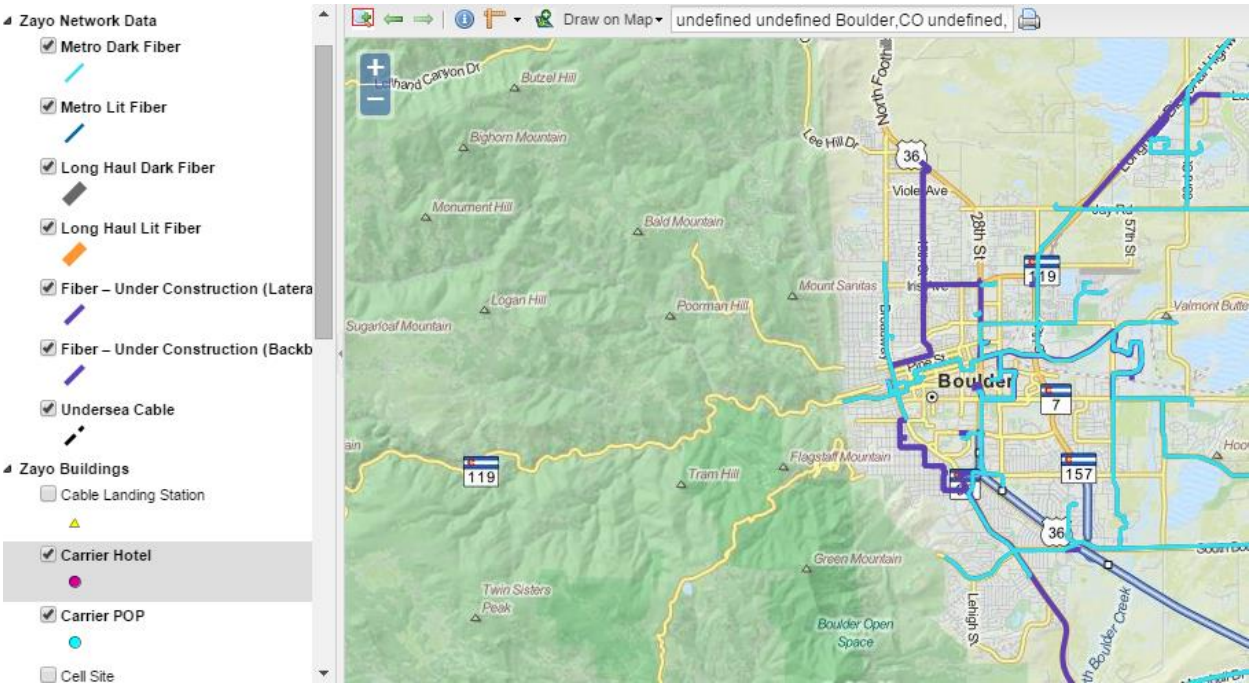
Figure 1: Level 3 Dark Fiber Routes[20]



[20] http://maps.level3.com/default/, accessed February 2016.

Zayo provides dark fiber connectivity over its national network of metro and intercity fiber. The company offers monthly leases and Indefeasible Rights of Use (IRU) agreements. Pricing varies significantly depending on whether the customer's building is on-net or not; if the location is off-net, construction and splicing costs would apply.[21] As an example, we identified pricing for a dark fiber lease between two on-net locations in Denver that are one mile apart; for that lease, Zayo charges $7,570 per month for a one-year term and $3,163 for a five-year term. Additional non-recurring charges, which we have typically seen to be approximately $5,000, are also present as part of the pricing.

Figure 2: Zayo Fiber Map[22]



2.1.2 Lit Services

Almost all existing service providers offer enterprise-grade, Ethernet-based services. Bandwidths range from 1 Mbps to 100 Gbps. Ethernet service can be classified into three types: Ethernet Private Line (EPL or E-Line), Ethernet Virtual Private Line (EVPL), and ELAN. These may be known by different names among providers.

EPL is a dedicated, point-to-point, high-bandwidth Layer 2 private line between two customer locations. EVPL service is similar to EPL but is not dedicated between two locations. Instead, it provides the ability to multiplex multiple services from different customer locations onto one point on the provider's network (multiple virtual connections) to another point on the network.

[21] http://zayofibersolutions.com/why-dark-fiber, accessed February 2016.
[22] http://www.zayo.com/network/interactive-map, accessed February 2016.

ELAN is a multipoint-to-multipoint connectivity service that enables customers to connect physically distributed locations across a Metropolitan Area Network (MAN) as if they were on the same Local Area Network (LAN).

Internet services over Ethernet are typically classified under two categories: Dedicated Internet Access (DIA) and MPLS IP Virtual Private Networks (IP-VPN). Providers prefer to offer MPLS-based IP-VPN services when the service locations are off-net, thus avoiding construction and installation costs. MPLS-based networks provide high performance for real-time applications such as voice and video and are typically priced higher.

The carriers that provide these services in the Boulder area are Birch, CenturyLink, Comcast, Integra Telecom, Level 3, Mammoth Networks, MHO Networks, Verizon, Windstream Communications, XO Communications, and Zayo. Prices depend on the bandwidth, location, and network configuration; whether the service is protected or unprotected; and whether the service has a switched or mesh structure.

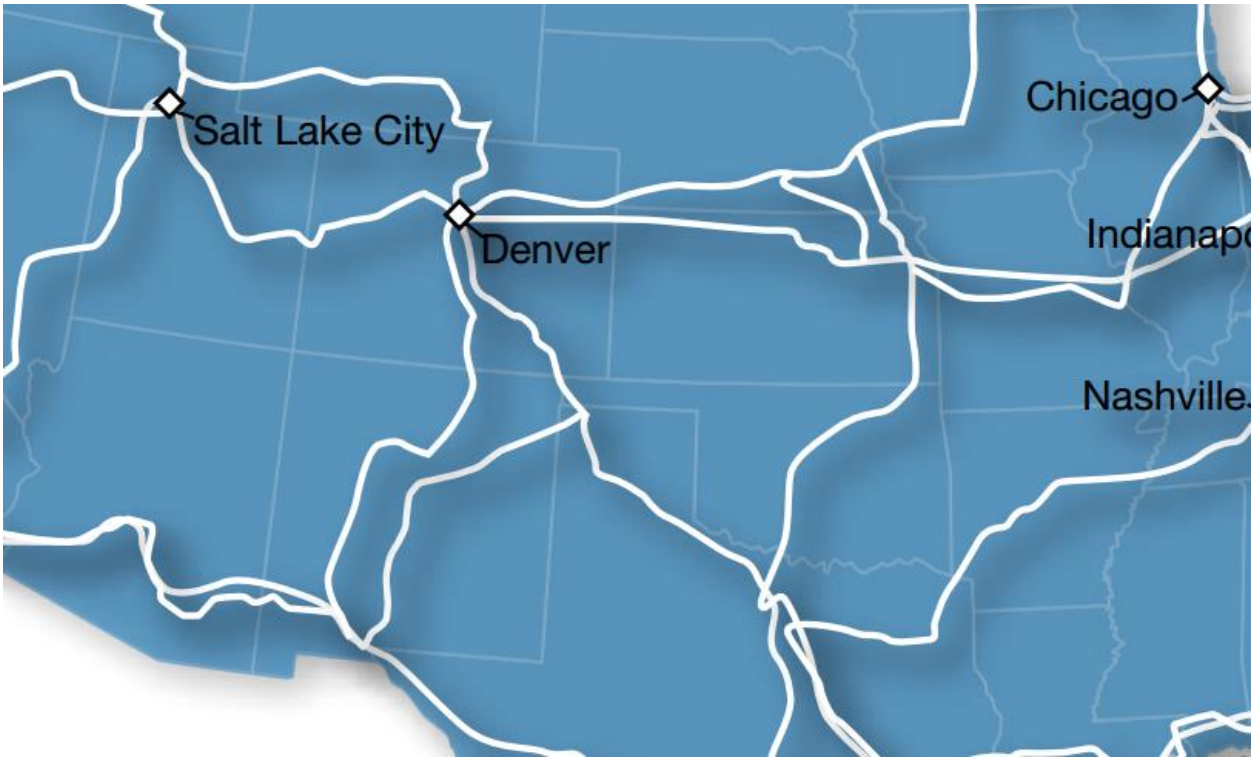
Birch offers Ethernet and DIA services in the region. They have fiber routes in the City but they currently do not have any lit fiber buildings in Boulder. They can offer up to 1 Gbps symmetric service with a 120-day build lead time.[23]

CenturyLink provides point-to-point inter-city and intra-city configurations for full-duplex data transmission. The company offers speeds of 100 Mbps to 10 Gbps. Preliminary pricing for a 1 Gbps Ethernet port and loop in Boulder for a three-year term is $7,922 per month.[24]

Comcast provides EPL services, which enable customers to connect their customer premises equipment (CPE) using a lower-cost Ethernet interface, as well as using any Virtual Local Area Networks (VLAN) or Ethernet control protocol across the service without coordination with Comcast. EPL service is offered with 10 Mbps, 100 Mbps, 1 Gbps, or 10 Gbps Ethernet User-to-Network Interfaces (UNI) and is available in speed increments from 1 Mbps to 10 Gbps.[25] Comcast's fiber optic network is depicted in Figure 3.[26]

[23] http://www.birch.com/solution/size/enterprise, accessed February 2016.
[24] http://www.centurylink.com/business/products/products-and-services/data-networking/private.html, accessed February 2016
[25] http://business.comcast.com/ethernet/products/ethernet-private-line-technical-specifications, accessed February 2016.
[26] http://business.comcast.com/about-us/our-network, accessed February 2016.

Figure 3: Comcast Fiber Routes



Level 3's Metro Ethernet dedicated service is available in bandwidth options of 3 Mbps to 1 Gbps and its EVPL offers speeds ranging from 3 Mbps to 10 Gbps.[27] It is an end-to-end, Layer 2, switched Ethernet service delivered via a Multi-protocol Label Switched (MPLS) backbone. Internet services are available in a range of 14 speeds up to 10 Gbps.[28]

Integra Telecom offers Ethernet services from 1.5 Mbps to 10 Gbps. Point-to-point E-Line and multipoint-to-multipoint ELAN configurations are available.[29]

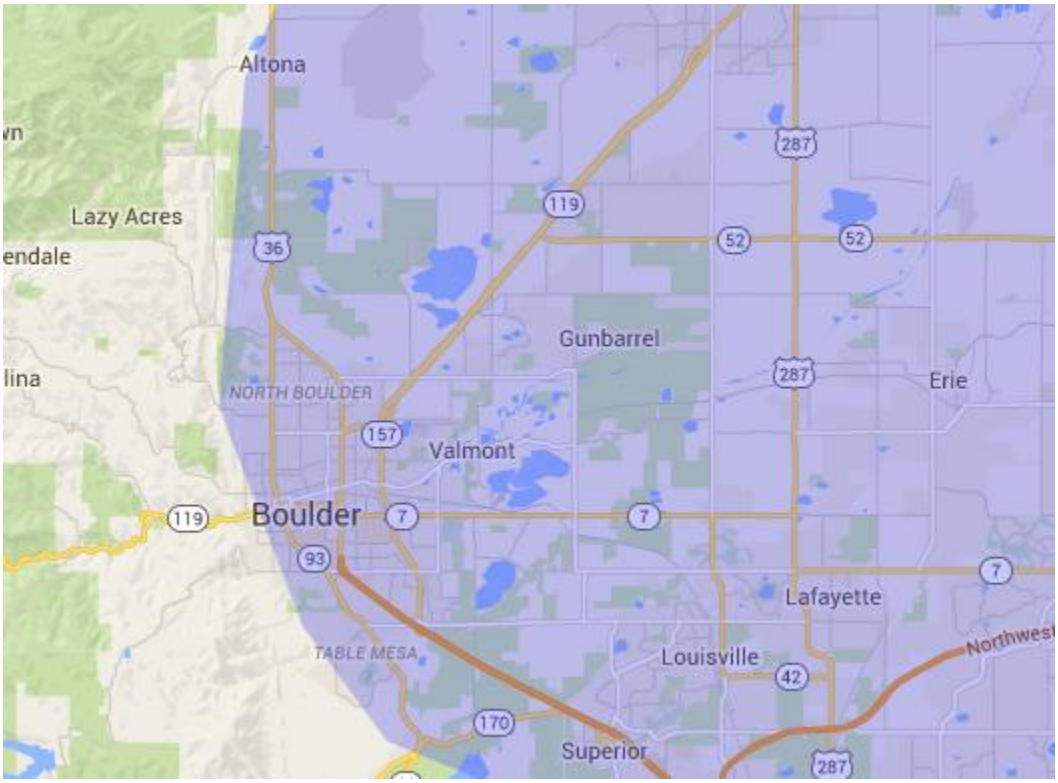
Mammoth Networks provides Ethernet connectivity, Layer 2 aggregation primarily to wholesale customers such as ILECs, CLECs, national carriers, public utility districts (PUD), electrical utilities, regional fiber providers, and voice-over-IP and Internet telephony providers.[30]

MHO Networks provides DIA and Ethernet services in Boulder as shown in Figure 4. It primarily serves small to medium-size businesses but also offer services to carriers and enterprises. DIA

[27] http://www.level3.com/en/products-and-services/data-and-internet/vpn-virtual-private-network/evpl/, accessed February 2016.
[28] http://www.level3.com/~/media/files/factsheets/en_ethernet_fs_ethernetmatrix.pdf, accessed February 2016.
[29] http://www.integratelecom.com/enterprise/products/pages/carrier-ethernet-services.aspx, accessed February 2016.
[30] http://www.mammothnetworks.com/industry.php, accessed February 2016.

speeds from 10 Mbps up to 4 Gbps are available. MHO's Metro Ethernet Service provides connectivity within the Metro area with speeds from 10 Mbps to 1 Gbps.[31]

Figure 4: MHO Business Services Coverage Map

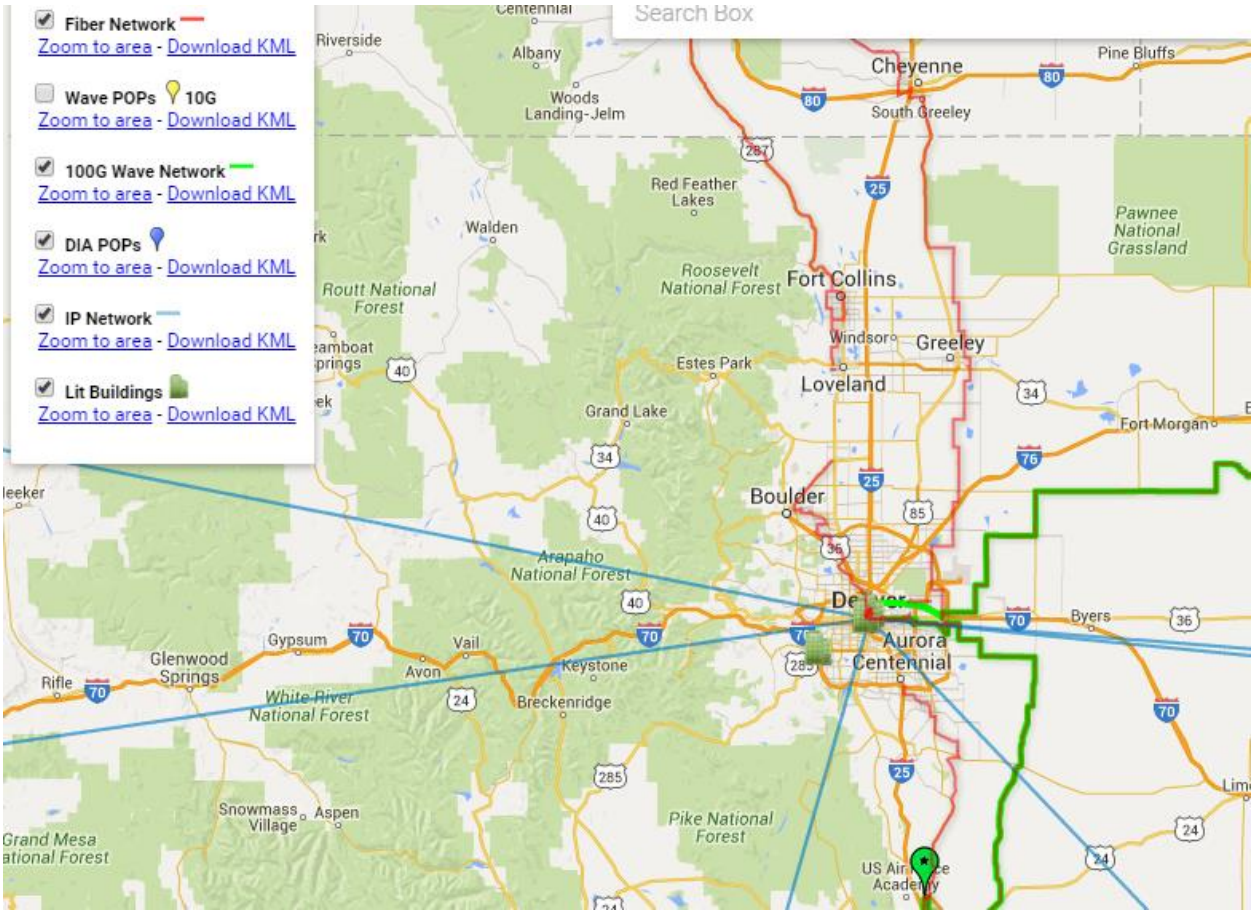


Verizon offers Ethernet services under three different product categories—ELAN, EPL, and EVPL. The ELAN is a multipoint-to-multipoint bridging service at native LAN speeds. It is configured by connecting customer User-to-Network Interfaces (UNIs) to one multipoint-to-multipoint Ethernet Virtual Connection or Virtual LAN (VLAN), and provides two Class of Service options—standard and real time. The EPL is a managed, point-to-point transport service for Ethernet frames. It is provisioned as Ethernet over SONET (EoS) at speeds of 10 Mbps to 10 Gbps. The EVPL is an all-fiber optic network service that connects subscriber locations at native LAN speeds; EVPL uses point-to-point Ethernet virtual connections (EVC) to define site-to-site connections. It can be configured to support multiple EVCs to enable a hub-and-spoke configuration and supports bandwidths from 1 Mbps to 10 Gbps.[32]

[31] http://www.mho.com/services, accessed February 2016.
[32] http://www.verizonenterprise.com/products/networking/ethernet/, accessed February 2016.

Windstream Communications has a nationwide presence serving major metropolitan areas, including Boulder, where it offers DIA services with speeds up to 1 Gbps.[33] [34] Windstream has fiber routes traversing Boulder, as depicted in Figure 4.[35]

Figure 4: Windstream Network Map[36]



XO Communications offers carrier Ethernet and DIA services at multiple bandwidth options, from 3 Mbps to 100 Gbps, over its Tier 1 IP network.[37] [38]

Zayo delivers Ethernet in three service types, with bandwidth ranging from 100 Mbps to 10 Gbps and options like quality of service (QoS) guarantees and route protection based on customer needs. The different types of services offered are: E-Line, which provides point-to-point and

[33] http://carrier.windstreambusiness.com/wordpress/wp-content/uploads/2014/10/Carrier-Ethernet-Ordering-Guide-10.8.14.pdf, accessed February 2016.
[34] http://www.windstreambusiness.com/shop/products/ca/Boulder, accessed February 2016.
[35] http://carrier.windstreambusiness.com/, accessed February 2016.
[36] http://carrier.windstreambusiness.com/interactive-map/, accessed February 2016.
[37] http://www.xo.com/carrier/transport/ethernet/, accessed February 2016.
[38] http://www.xo.com/network-services/internet-access/ip-transit/100G/, accessed February 2016.

point-to-multipoint configurations with reserved bandwidth availability; ELAN, with multipoint configurations having a guaranteed service level; and Ethernet Private Dedicated Network (E-PDN) with a completely private, managed network operated by Zayo, with dedicated fiber and equipment.[39] Sample pricing for 1 Gbps and 10 Gbps point-to-point Ethernet lines between two on-net locations in Denver is provided in the table below.

Table 2: Ethernet Transport Pricing in Denver (Monthly Recurring Costs)

Term	1 Gbps	10 Gbps
12 Months	$2,850	$6,714
60 Months	$2,080	$4,901

Pricing for 1 Gbps and 10 Gbps DIA service at an on-net location in Denver is provided in the table below.

Table 3: DIA Pricing in Denver (Monthly Recurring Costs)

Term	1 Gbps	10 Gbps
12 Months	$6,693	$31,843
60 Months	$4,016	$19,105

2.2 Residential and Small Business Services

Residential and small business customers in the Boulder area have access to a range of services, though individual service options depend on location. Table 4 lists the service providers and minimum price for each type of service that is available in at least some part of the City.

Table 4: Overview of Residential and Small Business Data Services in Boulder

Service Type	Provider	Monthly Price
Cable	Comcast	$29.99
DSL	CenturyLink	$29.95
	Birch	$39.95
	MegaPath	$45
Satellite	HughesNet	$49.99
3G/4G/Wireless Internet Service Provider	Verizon	$60

[39] http://www.zayo.com/ethernet, accessed February 2016.

Service Type	Provider	Monthly Price
	T-Mobile	$20
	Cricket	$40
	AT&T	$50
	Sprint	$35
	Rise Broadband	$42.95

2.2.1 Cable

Comcast offers Internet service from 3 Mbps to 150 Mbps (download) starting at $29.99 per month in some locations in the City as illustrated in Table 5. Promotional rates are available for the first year, after which the rates increase. Discounted prices are available if bundled with another service like voice or TV.[40] On the small business side, multiple options are available from 16 Mbps to 150 Mbps (download) as illustrated in Table 5.[41] Bundling with voice introduces a monthly savings of $30 to $40.

Table 5: Comcast Residential Internet—Internet Only

Package	Internet Speed (download)	Monthly Price (Regular)	Monthly Price (Promo)
Performance Starter	Up to 10 Mbps	$49.95	$29.99
Performance 25	Up to 25 Mbps	$61.95	$39.99
Performance	Up to 75 Mbps	$66.95	$44.99
Blast!	Blast! Internet—up to 150 Mbps	$91.95	$49.99
Extreme	Up to 250 Mbps	$149.95	–

[40] http://www.comcast.com/internet-service.html ,accessed February 2016.
[41] http://business.comcast.com/internet/business-internet/plans-pricing, accessed February 2016.

Table 6: Comcast Small Business Internet—Internet Only

Package	Internet Speed	Monthly Price
Starter	16 Mbps download/3 Mbps upload	$69.95
Deluxe 50	50 Mbps download/ 10 Mbps upload	$109.95
Deluxe 75	75 Mbps download/15 Mbps upload	$149.95
Deluxe 100	100 Mbps download/20 Mbps upload	$199.95
Deluxe 150	150 Mbps download/20 Mbps upload	$249.95
Deluxe 250	250 Mbps download/25 Mbps upload	$349.95

2.2.2 DSL

CenturyLink offers DSL service for residential customers in Boulder starting at $29.95 per month for standalone 7 Mbps (download) service for the first 12-months for new customers. Thereafter pricing increases, per Table 7 below:

Table 7: CenturyLink Residential Internet

Download Speed (Mbps)	Monthly Price
Up to 7	$49.00
Up to 12	$54.00
Up to 20	$64.00
Up to 40	$74.00

Birch provides DSL-based business services in the region starting at $39.59 per month for 3 Mbps download speeds and 512 Kbps upload speeds. It offers speeds up to 24 Mbps.[42]

MegaPath is an Internet service provider that offers speeds of up to 20 Mbps download and 1 Mbps upload for business customers in certain parts of Boulder.[43] The lowest plan offered is for

[42] http://www.birch.com/products/birchnetwork/birchnet-broadband, accessed February 2016.
[43] http://www.megapath.com/services/, accessed February 2016.

1.5 Mbps download speeds at $45 per month. MegaPath offers business Ethernet services in the Boulder area with advertised symmetrical speeds up to 45 Mbps. Higher speeds are available on a case-by-case basis.[44]

2.2.3 Satellite

Satellite Internet access is available in the area as well. HughesNet has four packages available, of which two packages are for Internet services to small businesses. The Business 50 package provides speeds of up to 5 Mbps download and 1 Mbps upload for $69.99 per month, with a 5 GB per month anytime allowance and 10 GB "bonus bytes" from 2 a.m. to 10 a.m., for a total monthly data allowance of 15 GB. This package requires a two-year agreement and only supports up to five users. The Business 100 package provides the same download and upload speeds of the Business 50 package, but offers a higher data allowance threshold of 10 GB per month anytime and 15 GB "bonus bytes" from 2 a.m. to 10 a.m., for a monthly data allowance of 25 GB. This package also requires a two-year agreement and is best for five to just over 10 users.

2.2.4 Wireless

Verizon offers two 4G LTE data packages with multiple choices for data allowances and pricing, depending on the desired mobility and equipment chosen. The HomeFusion Broadband Package (LTE-Installed) is a data-only 4G LTE service with Wi-Fi connectivity and wired Ethernet for up to four devices. Available download speeds are 5 Mbps to 12 Mbps and upload speeds are 2 Mbps to 5 Mbps. Monthly prices range from $60 for a 10 GB data allowance to $120 for a 30 GB data cap. Overages are charged at $10 per additional GB. A two-year contract is required, with a $350 early termination fee. Verizon offers a $10 monthly deduction for every month completed in the contract. The Ellipsis JetPack provides a mobile solution, with download speeds of 5 Mbps to 12 Mbps and upload speeds of 2 Mbps to 5 Mbps. Prices for the 12 options of data allowances range from $30 per month for a 4 GB data allowance to $335 per month for 50 GB of data, in addition to a monthly line access charge of $20.The device is $0.99 with a two-year contract. There is a $35 activation fee.[45]

Sprint offers 4G LTE wireless data in Boulder. The two data packages offered for tablets are 100 MB per month data allowance for $10 per month and 1 GB per month data allowance for $15 per month. Beyond the data limit, the plan switches to low-speed data. A two-year contract is required, as well as an activation fee of $20 and equipment charges for different types of devices.

AT&T also provides 4G LTE wireless data service in the area, and offers three packages: a 250 MB per month download allowance for $14.99 per month, a 3 GB per month download allowance for $30 per month and a 5 GB per month download allowance for $50 per month. There is an

[44] http://www.megapath.com/data/ethernet/, accessed February 2016.
[45] http://www.verizonwireless.com/support/wireless-internet-data-only/, accessed January 2016.

overage fee of $10 per 1 GB. There are also equipment charges, with or without a contract, and an activation fee up to $45.[46]

Cricket Wireless offers 4G LTE wireless service in Boulder with a download speed of up to 8 Mbps with three options for data allowance packages, starting at $40 per month for 2.5 GB of data. There are also options for data allowances of 5 GB ($50) and 10 GB ($60). Data used beyond allowances are at reduced speeds. There is a $15 activation fee, but no contract or early termination fees.

Of the cellular wireless providers in the area, the least expensive wireless data option offered is from T-Mobile, for $20 per month with a limit of 2 GB per month. T-Mobile offers additional capabilities and increasing data limits at incremental costs in a total of five packages, up to $80 per month for up to 18 GB of data. Depending on current promotions, the $35 activation fee is sometimes waived. [47]

Rise Broadband is a wireless Internet service provider (WISP) that provides services in Boulder for speeds up to 20 Mbps for residential customers. The range of standard speeds and pricing available are indicated in Table 8. Rise also offers small business services (
Table 9).[48]

Table 8: Rise Broadband Residential Internet Services

Package	Internet Speed(Download)	Monthly Price
Breakout	20 Mbps	$62.95
Preferred	10 Mbps	$52.95
Economy	5 Mbps	$42.95

Table 9: Rise Broadband Small Business Internet Services

Package	Internet Speed(Download/Upload)	Monthly Price
Small Home Office	5 Mbps/2 Mbps	$59.95
Small Business	10 Mbps/2 Mbps	$89.95
Small Business Plus	15 Mbps/3 Mbps	$109.95

[46] https://www.att.com/shop/wireless/plans/planconfigurator.html, accessed January 2016.
[47] http://www.t-mobile.com/cell-phone-plans/mobile-internet.html, accessed January 2016.
[48] http://risebroadband.com/business/, accessed February 2016.

3 Cost Estimates for FTTP Construction

At the City's request, CTC prepared a high-level network design and cost estimate for deploying a gigabit FTTP network. The CTC cost estimate provides data relevant to assessing the financial viability of network deployment, and to developing a business model for a potential City construction effort (including the full range of models for public–private partnerships). This estimate will also enable financial modeling to determine the approximate revenue levels necessary for the City to service any debt incurred in building the network.

The CTC design and cost estimate are underpinned by data and insight gathered by CTC engineers through a number of related steps of discussions with City stakeholders and an extensive desk survey of candidate fiber routes.

The descriptions in this document are highly technical and make use of a number of acronyms. We have included a glossary as Appendix D.

3.1.1 FTTP Cost Estimate

Based on these inputs and other guidance from the City, we developed a conceptual, high-level FTTP design that reflects the City's goals and is open to a variety of architecture options. The cost estimate presented uses a combination of aerial and overhead construction. From this design we present two cost examples. The first is the cost to deploy an FTTP infrastructure, all electronics, consumer drops, and customer premises equipment (CPE). This estimate shows the total capital costs (by the City or the City and partners) to build a FTTP network to support a ubiquitous Gbps data service. The second estimate is the cost to deploy the FTTP outside plant (OSP). This is the total capital cost for the City to build a dark FTTP network for lease to a private partner.

3.1.1.1 FTTP Cost Estimate (Fiber and Electronics)

This citywide FTTP network deployment will cost more than $102 million, inclusive of outside plant (OSP) construction labor, materials, engineering, permitting, pole attachment licensing, network electronics, drop installation, customer premises equipment (CPE), and testing.[49] The cost per passing is $1,400 on average.

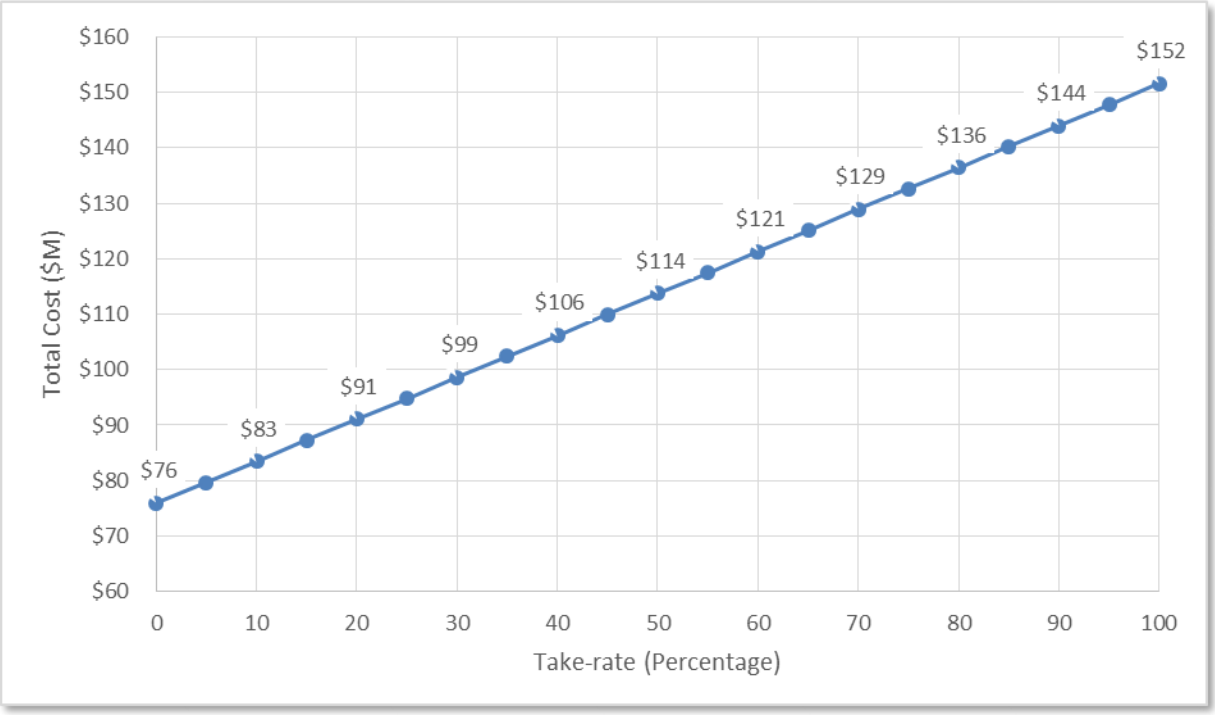
[49] The estimated total cost breakdown assumes a percentage of residents and businesses that subscribe to the service, otherwise known as the penetration rate or the "take rate," of 35 percent.

Table 10: Breakdown of Estimated Total Cost with Electronics at 35 Percent Take Rate

Cost Component	Total Estimated Cost
OSP	$71 million
Central Network Electronics	7 million
FTTP Service Drop and Lateral Installations	12 million
CPE	12 million
Total Estimated Cost:	$102 million

Figure 2 shows the total estimated cost by varying the expected take rate.

Figure 2: Total Estimated Cost versus Take Rate



The cost is roughly linear by take rate as the cost of adding additional subscribers is a fixed cost.

Actual costs may vary due to unknown factors, including: 1) costs of private easements, 2) utility pole replacement and make ready costs, 3) variations in labor and material costs, 4) subsurface hard rock, and 5) the City's operational and business model (including the percentage of residents and businesses who subscribe to the service, otherwise known as the penetration rate or the "take rate"). We have incorporated suitable assumptions to address these items based on our experiences in similar markets.

The total estimated technical operating cost for this model are outlined in Section 3.5 (not including non-technical operating costs such as marketing, legal services, and financing costs). The total cost of operations will also vary with the business model chosen and the level of existing resources that can be leveraged by the City and any potential business partners.

3.1.1.2 Dark FTTP Cost Estimate (No Electronics, Drops, or CPE)

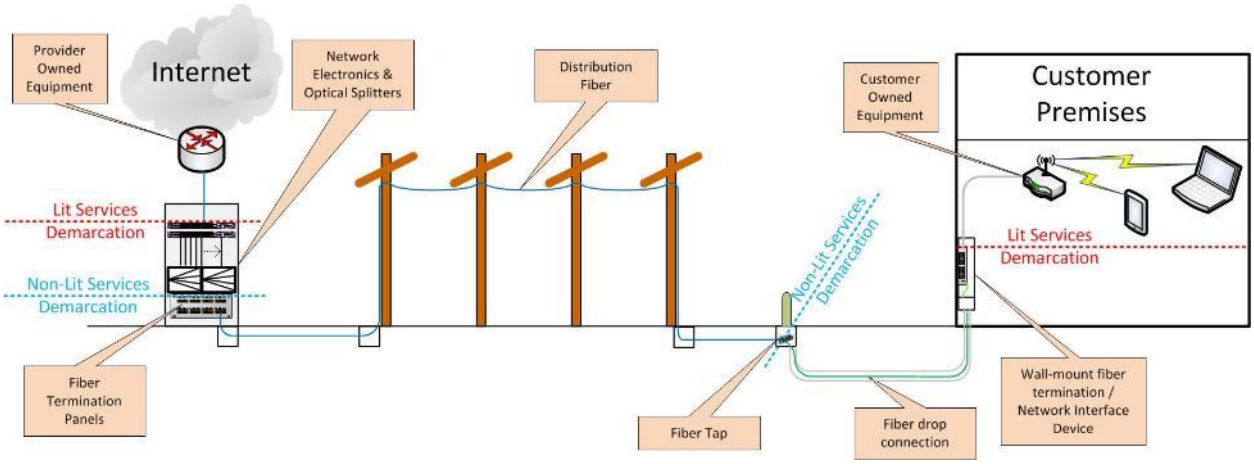
This citywide dark FTTP network deployment will cost more than $71 million, inclusive of outside plant (OSP) construction labor, materials, engineering, permitting, and pole attachment licensing. This estimate does not include any electronics, subscriber equipment, or drops.

Table 11: Breakdown of Estimated Dark FTTP Cost

Cost Component	Total Estimated Cost
OSP Engineering	$7.9 million
Quality Control/Quality Assurance	2.9 million
General OSP Construction Cost	53.3 million
Special Crossings	0
Backbone and Distribution Plant Splicing	2.2 million
Backbone Hub, Termination, and Testing	4.9 million
FTTP Lateral Installations	0
Total Estimated Cost:	$71.2 million

This estimate assumes that the City constructs and owns the FTTP infrastructure up to a demarcation point at the optical tap near each residence and business, and leases the dark fiber backbone and distribution fiber to a private partner. The private partner would be responsible for all network electronics, fiber drops to subscribers, and customer premises equipment (CPE)—as well as network sales, marketing, and operations.

Figure 3: Demarcation Between City and Partner Network Elements



3.1.2 Cost Estimate Breakdown

The cost components for OSP construction include the following tasks:

- ***Engineering*** – includes system level architecture planning, preliminary designs and field walk-outs to determine candidate fiber routing; development of detailed engineering prints and preparation of permit applications; and post-construction "as-built" revisions to engineering design materials.
- ***Quality Control / Quality Assurance*** – includes expert quality assurance field review of final construction for acceptance.
- ***General Outside Plant Construction*** – consists of all labor and materials related to "typical" underground or aerial outside plant construction, including conduit placement, utility pole make-ready construction, aerial strand installation, fiber installation, and surface restoration; includes all work area protection and traffic control measures inherent to all roadway construction activities.
- ***Special Crossings*** – consists of specialized engineering, permitting, and incremental construction (material and labor) costs associated with crossings of railroads, bridges, and interstate / controlled access highways.
- ***Backbone and Distribution Plant Splicing*** – includes all labor related to fiber splicing of outdoor fiber optic cables.
- ***Backbone Hub, Termination, and Testing*** – consists of the material and labor costs of placing hub shelters and enclosures, terminating backbone fiber cables within the hubs, and testing backbone cables.
- ***FTTP Service Drop and Lateral Installations –*** consists of all costs related to fiber service drop installation, including outside plant construction on private property, building penetration, and inside plant construction to a typical backbone network service "demarcation" point; also includes all materials and labor related to the termination of fiber cables at the demarcation point. A take-rate of 35 percent was assumed for standard fiber service drops.

3.2 Field Survey

A CTC outside plant (OSP) engineer performed a preliminary survey of Boulder via Google Earth Street View to develop estimates of per mile cost for aerial in the power space and communications space, and per mile costs for underground (where poles are not available). The engineer reviewed available green space, necessary make-ready on poles, pole replacement—all of which have been factored in to our design and cost estimate.

Figure 4 illustrates the areas reviewed during the field survey, while Table 12 summarizes each. Both the map and the table refer to the three types of population densities we used in our cost estimation model—high, medium, and low. (See Section 3.4 for more details.)

Figure 4: Map of Field Survey Areas

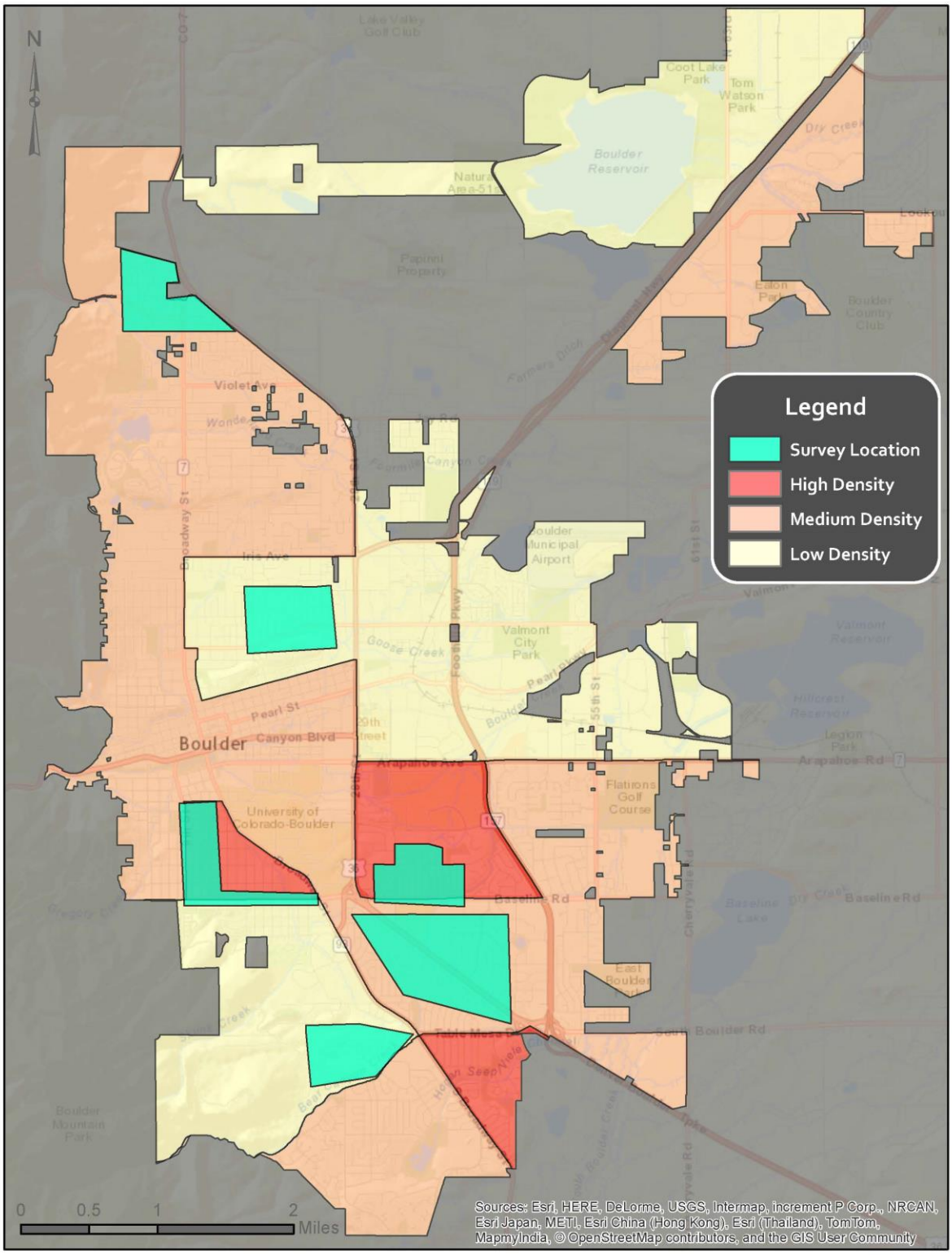


Table 12: Field Survey Findings

	High Density	Medium Density	Low Density
Aerial Construction	77%	67%	65%
Poles per Mile	46.6	45.6	45.8
Moves per Pole	3.5	2.5	2
Poles Requiring Make Ready	35%	25%	20%
Poles Requiring Replacement	7%	4%	3%
Intermediate Rock	35%	35%	35%
Hard Rock	0%	0%	0%

CTC's OSP engineer noted that the quality of the poles and pole attachments in Boulder varied, as they do in many cities—but that overall, many poles would be capable of supporting an additional communications attachment with moderate make ready.

The following example photos document the existing utility conditions observed by CTC's OSP engineer. Figure 5 shows a typical rear fed utility in an alleyway. The need for tree trimming in the communications space can be seen.

Figure 5: Typical Alleyway with Rear Fed Utilities

Figure 6 shows a typical utility pole requiring make ready and tree trimming to add a new attachment in the communications space.

Figure 6: Utility Pole Requiring Make Ready

Figure 7 shows a utility pole that will likely require make ready and tree trimming to add a new attachment in the communications space.

Figure 7: Make Ready Required on a Utility Pole

3.3 FTTP Network Design

OSP (layer 1, also referred to as the physical layer) is both the most expensive part of the network and the longest lasting. The architecture of the physical plant determines the network's scalability for future uses and how the plant will need to be operated and maintained; the architecture is also the main determinant of the total cost of the deployment.

Figure 8 (below) shows a logical representation of the high-level FTTP network architecture we recommend. This design is open to a variety of architecture options. The drawing illustrates the primary functional components in the FTTP network, their relative position to one another, and the flexibility of the architecture to support multiple subscriber models and classes of service.

The recommended architecture is a hierarchical data network that provides critical scalability and flexibility, both in terms of initial network deployment and its ability to accommodate the increased demands of future applications and technologies. The characteristics of this hierarchical FTTP data network are:

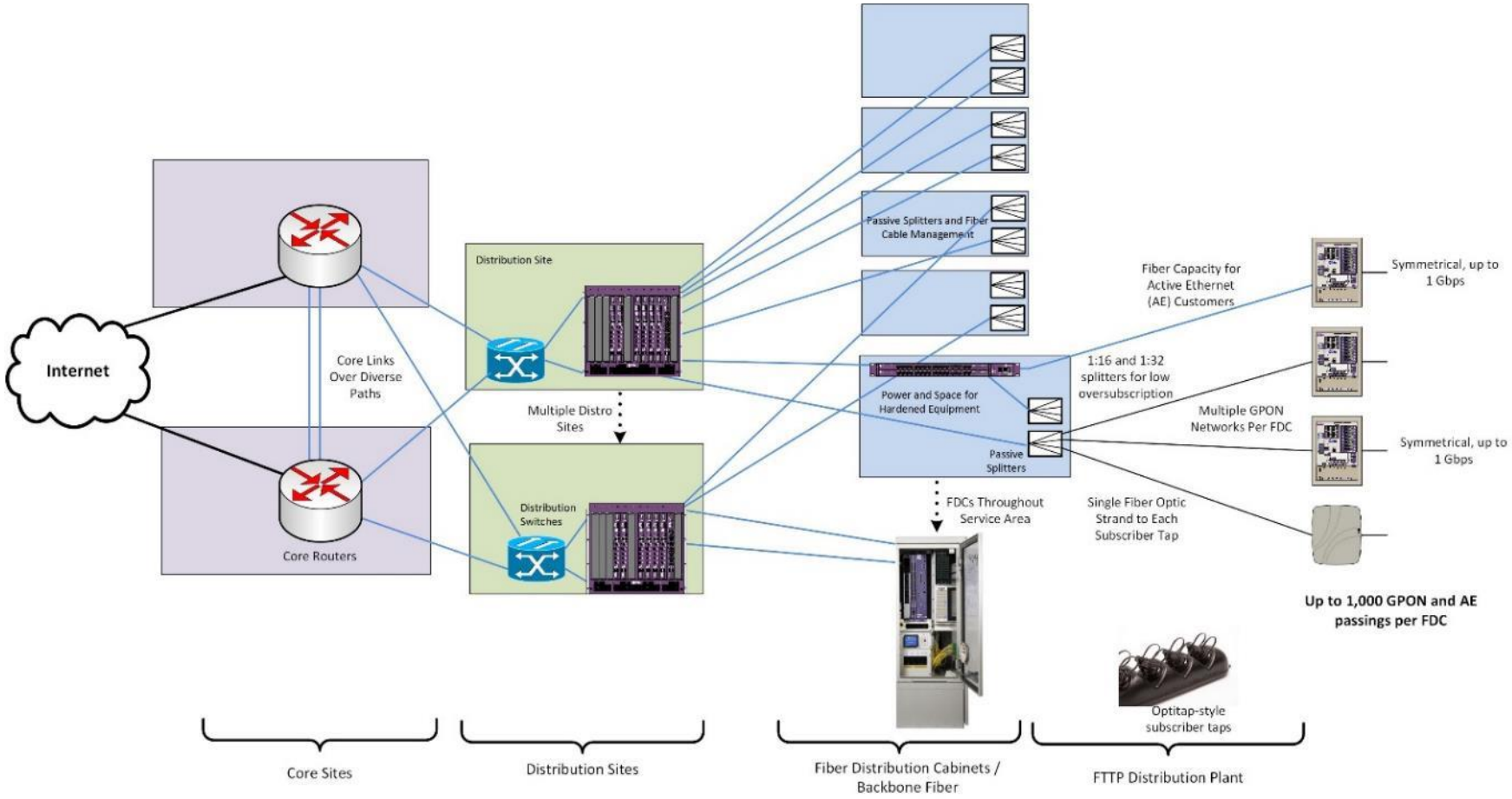
- Capacity – ability to provide efficient transport for subscriber data, even at peak levels
- Availability – high levels of redundancy, reliability, and resiliency; ability to quickly detect faults and re-route traffic
- Diversity – physical path diversity to minimize operational impact resulting from fiber or equipment failure
- Efficiency – no traffic bottlenecks; efficient use of resources
- Scalability – ability to grow in terms of physical service area and increased data capacity, and to integrate newer technologies
- Manageability – simplified provisioning and management of subscribers and services
- Flexibility – ability to provide different levels and classes of service to different customer environments; can support an open access network or a single-provider network; can provide separation between service providers on the physical layer (separate fibers) or logical layer (separate VLAN or VPN)
- Security – controlled physical access to all equipment and facilities, plus network access control to devices

This architecture offers scalability to meet long-term needs. It is consistent with best practices for an open access network model that might potentially be required to support multiple network operators, or at least multiple retail service providers requiring dedicated connections to certain

customers. This design would support a combination of Gigabit Passive Optical Network (GPON) and direct Active Ethernet services (with the addition of electronics at the fiber distribution cabinets), which would enable the network to scale by migrating to direct connections to each customer, or reducing splitter ratios, on an as-needed basis.

The design assumes placement of manufacturer-terminated fiber tap enclosures within the right-of-way or easements, providing watertight fiber connectors for customer service drop cables and eliminating the need for service installers to perform splices in the field. This is an industry-standard approach to reducing both customer activation times and the potential for damage to distribution cables and splices. The model also assumes the termination of standard lateral fiber connections within larger multi-tenant business locations and multi-dwelling units (MDU).

Figure 8: High-Level FTTP Architecture



3.3.1 Network Design

The network design and cost estimates assume the City will:

- Identify and procure space at two core facilities to house network electronics and provide backhaul to the Internet;
- Utilize existing City locations for two distribution hub facilities with adequate environmental and backup power systems to house network electronics;
- Utilize the existing City fiber optics to connect core sites to distribution hubs
- Construct additional fiber or use existing City fiber where available to connect the distribution hubs to fiber distribution cabinets (FDC);
- Construct fiber optics from the FDCs to each residence and business (i.e., from termination panels in the FDC to tap locations in the right-of-way or on City easements); and
- Construct fiber laterals into large, multi-tenant business facilities and MDUs.

Utilizing City fiber decreases the network cost associated with constructing a backbone and identifying locations to house electronics that are attached to the City's fiber network. The utilization of City fiber resources will also allow the City to conduct FTTP pilot programs or begin deployment in neighborhoods where demand is greatest.

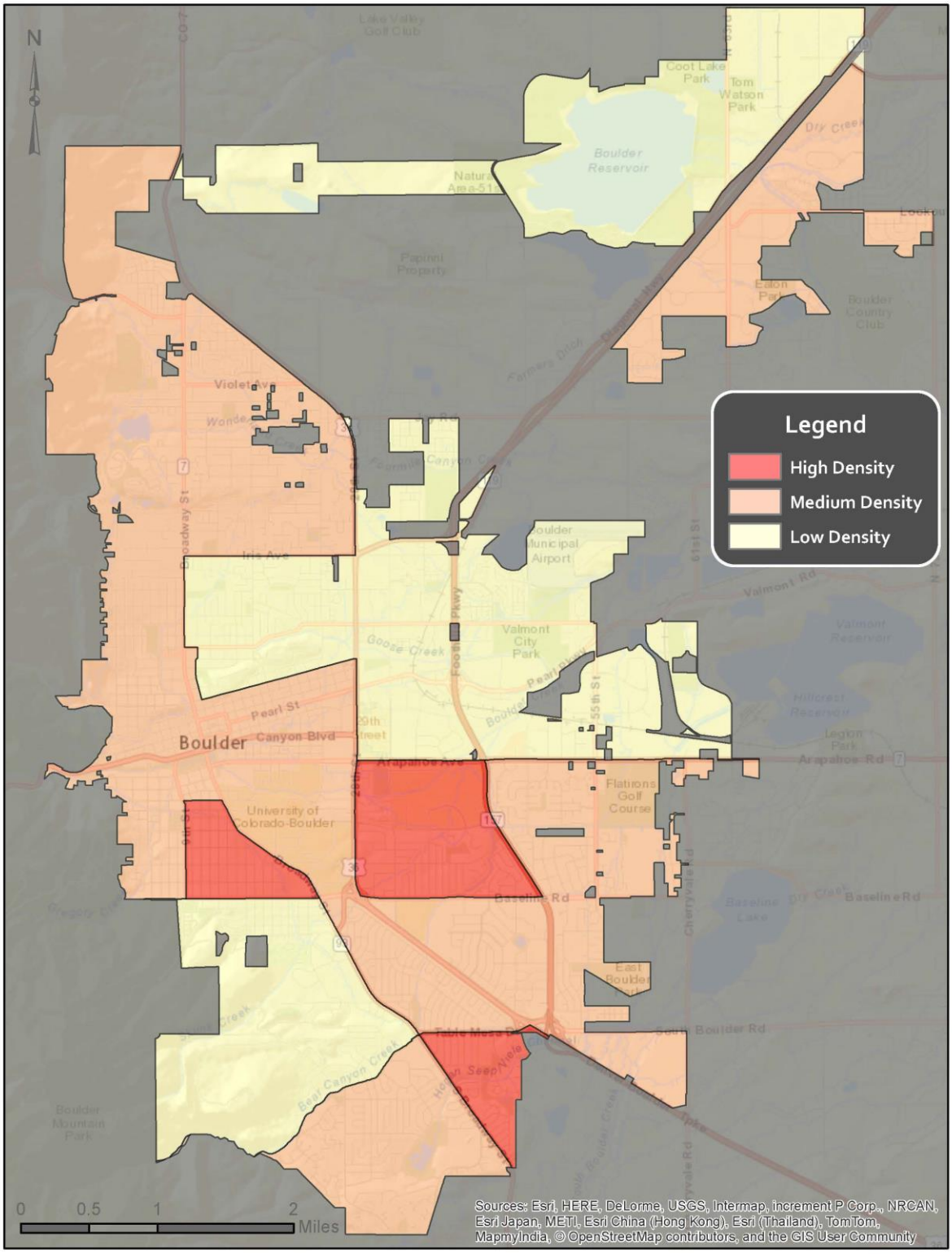
The FTTP network and service areas were defined based on the following criteria:

- Targeting 512 passings per FDC;
- Service areas are defined by passing density and existing utilities and are broken into the categories of High, Medium, and Low densities;
- Multiple FDCs serve each service area;
- FDCs suitable to support hardened network electronics, providing backup power and an active heat exchange;[50] and
- Avoiding the need for distribution plant to cross major roadways and railways.

Coupled with an appropriate network electronics configuration, this design serves to greatly increase the reliability of fiber services provided to the customers compared to that of more traditional cable and telephone networks. The backbone design minimizes the average length of non-diverse distribution plant between the network electronics and each customer, thereby reducing the probability of service outages caused by a fiber break.

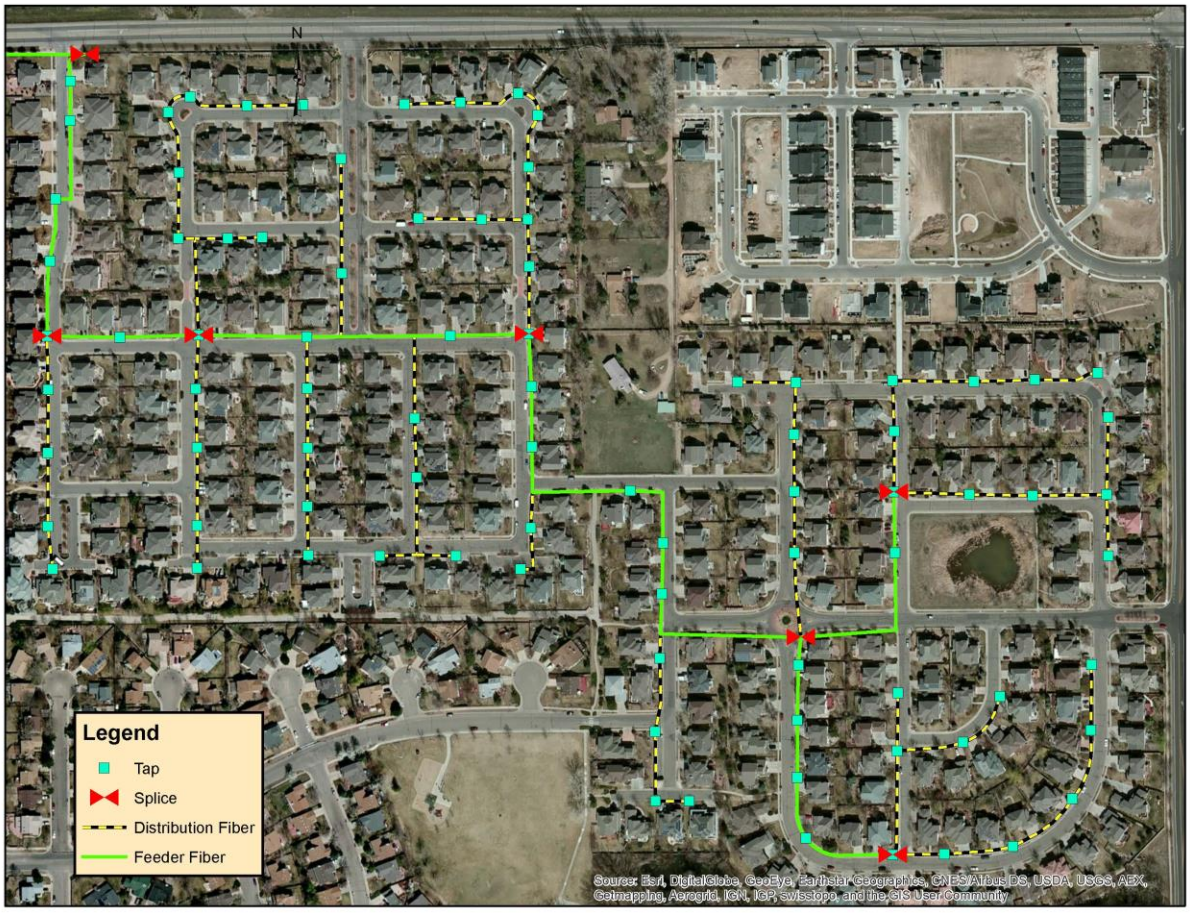
[50] These hardened FDCs reflect an assumption that the City's operational and business model will require the installation of provider electronics in the FDCs that are capable of supporting open access among multiple providers. We note that the overall FTTP cost estimate would decrease if the hardened FDCs were replaced with passive fiber distribution cabinets (which would house only optical splitters) and the providers' electronics were housed only at hub locations.

Figure 9: FTTP Service Areas



The access layer of the network, encompassing the fiber plant from the FDCs to the customers, dedicates a single fiber strand from the FDC to each passing (potential customer address). This traditional FTTP design allows either network electronics or optical splitters in the FDCs. See Figure 10 below for a sample design.

Figure 10: Sample FTTP Access Layer Design



This architecture offers scalability to meet long-term needs, and is consistent with best practices for an open access network model that might potentially be required to support multiple network operators, or at least multiple retail service providers requiring dedicated connections to certain customers.

3.3.2 Network Core and Hub Sites

The core sites are the bridges that link the FTTP network to the public Internet and deliver all services to end users. The proposed network design includes two core locations, based on the network's projected capacity requirements and the need for geographical redundancy (i.e., if one core site were to fail, the second core site would continue to operate the network).

The location of core network facilities also provides physical path diversity for subscribers and all upstream service and content providers. For our design and cost estimates, we assume that the Boulder core sites will be housed in secure locations with diverse connectivity to the Internet and the City's existing fiber optic network.

The core locations in this plan will house providers' Operational Support Systems (OSS) such as provisioning platforms, fault and performance management systems, remote access, and other operational support systems for FTTP operations. The core locations are also where any business partner or content / service providers will gain access to the subscriber network with their own point-of-presence. This may be via remote connection, but collocation is recommended.

The core locations are typically run in a High Availability (HA) configuration, with fully meshed and redundant uplinks to the public Internet and/or all other content and service providers. It is imperative that core network locations are physically secure and allow unencumbered access 24x7x365 to authorized engineering and operational staff.

The operational environment of the network core and hub locations is similar to that of a data center. This includes clean power sources, UPS batteries, and diesel power generation for survival through sustained commercial outages. The facility must provide strong physical security, limited/controlled access, and environmental controls for humidity and temperature. Fire suppression is highly recommended.

Equipment is to be mounted securely in racks and cabinets, in compliance with national, state, and local codes. Equipment power requirements and specification may include -48 volt DC and/or 120/240 volts AC. All equipment is to be connected to conditioned / protected clean power with uninterrupted cutover to battery and generator.

For the cost estimate, we assumed that the core and distribution hubs are located within existing City facilities connected to the fiber optic network.

3.3.3 Distribution and Access Network Design

The distribution network is the layer between the hubs and the fiber distribution cabinets (FDCs, which provide the access links to the taps). The distribution network aggregates traffic from the FDCs to the core. Fiber cuts and equipment failures have progressively greater operational impact as they happen closer to the network core, so it is critical to build in redundancies and physical path diversities in the distribution network, and to seamlessly re-route traffic when necessary.

The distribution and access network design proposed in this report is flexible and scalable enough to support two different architectures:

1. Housing both the distribution and access network electronics at the hubs, and using only passive devices (optical splitters and patches) at the FDCs; or
2. Housing the distribution network electronics at the hubs and pushing the access network electronics further into the network by housing them at the FDCs.

By housing all electronics at the hubs, the network will not require power at the FDCs. Choosing a network design that only supports this architecture may reduce costs by allowing smaller, passive FDCs in the field. However, this architecture will limit the redundancy capability from the FDCs to the hubs.

By pushing the network electronics further into the field, the network gains added redundancy by allowing the access electronics to connect to both hub sites. In the event one hub has an outage the subscribers connected to the FDC would still have network access. Choosing a network design that only supports this architecture may reduce costs by reducing the size of the hubs.

Selecting a design that supports both of these models would allow the City to accommodate many different service operators and their network designs. This design would also allow service providers to start with a small deployment (i.e., placing electronics only at the hub sites) and grow by pushing electronics closer to their subscribers.

3.3.3.1 Access Network Technologies

FDCs can sit on a curb, be mounted on a pole, or reside in a building. Our model recommends installing sufficient FDCs to support higher than anticipated levels of subscriber penetration. This approach will accommodate future subscriber growth with minimal re-engineering. Passive optical splitters are modular and can be added to an existing FDC as required to support subscriber growth, or to accommodate unanticipated changes to the fiber distribution network with potential future technologies.

Figure 11: Fiber Distribution Cabinet

Our FTTP design also includes the placement of indoor FDCs and splitters to support MDUs. This would require obtaining the right to access the equipment for repairs and installation in whatever timeframe is required by the service agreements with the customers. Lack of access would potentially limit the ability to perform repairs after normal business hours, which could be problematic for both commercial and residential services.

In this model we assume the use of GPON electronics for the majority of subscribers and Active Ethernet for a small percentage of subscribers (typically business customers) that request a premium service or require greater bandwidth. GPON is the most commonly provisioned FTTP service—used, for example, by Verizon (in its FiOS systems), Google Fiber, and Chattanooga EPB.

Furthermore, providers of gigabit services typically provide these services on GPON platforms. Even though the GPON platform is limited to 1.2 Gbps upstream and 2.4 Gbps downstream for the subscribers connected to a single PON, operators have found that the variations in actual subscriber usage generally means that all subscribers can obtain 1 Gbps on demand (without provisioned rate-limiting), even if the capacity is aggregated at the PON. Furthermore, many GPON manufacturers have a development roadmap to 10 Gbps and faster speeds as user demand increases.

GPON supports high-speed broadband data, and is easily leveraged by triple-play carriers for voice, video, and data services. The GPON OLT uses single-fiber (bi-directional) SFP modules to support multiple (most commonly less than 32) subscribers.

GPON uses passive optical splitting, which is performed inside fiber distribution cabinets (FDC), to connect fiber from the OLTs to the customer premises. The FDCs house multiple optical splitters, each of which splits the fiber link to the OLT between 16 to 32 customers (in the case of GPON service).

Active Ethernet (AE) provides a symmetrical (up/down) service that is commonly referred to as Symmetrical Gigabit Ethernet. AE can be provisioned to run at sub-gigabit speeds, and like GPON easily supports legacy voice, voice over IP, and video. AE is typically deployed for customers who require specific service level agreements that are easier to manage and maintain on a dedicated service.

For subscribers receiving Active Ethernet service, a single dedicated fiber goes directly to the subscriber premises with no splitting. Because AE requires dedicated fiber (home run) from the OLT to the CPE, and because each subscriber uses a dedicated SFP on the OLT, there is significant cost differential in provisioning an AE subscriber versus a GPON subscriber.

Our fiber plant is designed to provide Active Ethernet service or PON service to all passings. The network operator selects electronics based on the mix of services it plans to offer and can modify or upgrade electronics to change the mix of services.

3.3.3.2 Expanding the Access Network Bandwidth

GPON is currently the most commonly provisioned FTTP technology, due to inherent economies when compared with technologies delivered over home-run fiber[51] such as Active Ethernet. The cost differential between constructing an entire network using GPON and Active Ethernet is 40 percent to 50 percent.[52] GPON is used to provide services up to 1 Gbps per subscriber and is part of an evolution path to higher-speed technologies that use higher-speed optics and wave-division multiplexing.

This model provides many options for scaling capacity, which can be done separately or in parallel:

1. Reducing the number of premises in a PON segment by modifying the splitter assignment and adding optics. For example, by reducing the split from 16:1 to 4:1, the per-user capacity in the access portion of the network is quadrupled.

[51] Home run fiber is a fiber optic architecture where individual fiber strands are extended from the distribution sites to the premises. Home run fiber does not use any intermediary aggregation points in the field.
[52] "Enhanced Communications in San Francisco: Phase II Feasibility Study," CTC report, October 2009, at p. 205.

2. Adding higher speed PON protocols can be accomplished by adding electronics at the FDC or hub locations. Since these use different frequencies than the GPON electronics, none of the other CPE would need to be replaced.

3. Adding WDM-PON electronics as they become widely available. This will enable each user to have the same capacity as an entire PON. Again, these use different frequencies than GPON and are not expected to require replacement of legacy CPE equipment.

4. Option 1 could be taken to the maximum, and PON replaced by a 1:1 connection to electronics—an Active Ethernet configuration.

These upgrades would all require complementary upgrades in the backbone and distribution Ethernet electronics, as well as in the upstream Internet connections and peering—but they would not require increased fiber construction.

3.3.3.3 Customer Premises Equipment (CPE) and Subscriber Services

In the final segment of the FTTP network, fiber runs from the FDC to customers' homes, apartments, and office buildings, where it terminates at the subscriber tap—a fiber optic housing located in the right-of-way closest to the premises. The service installer uses a pre-connectorized drop cable to connect the tap to the subscriber premises without the need for fiber optic splicing.

The drop cable extends from the subscriber tap (either on the pole or underground) to the building, enters the building, and connects to customer premises equipment (CPE).

3.4 FTTP Cost Estimate

This section provides a summary of cost estimates for construction of a citywide FTTP network to all City residents and businesses. This deployment will cost more than $102 million, inclusive of outside plant (OSP) construction labor, materials, engineering, permitting, pole attachment licensing, network electronics, drop installation, customer premises equipment (CPE), and testing.

Table 13: Breakdown of Estimated Total Cost (Fiber & Electronics – 25 Percent Take Rate)

Cost Component	Total Estimated Cost
OSP	$71 million
Central Network Electronics	7 million
FTTP Service Drop and Lateral Installations	12 million
CPE	12 million
Total Estimated Cost:	$102 million

3.4.1 OSP Cost Estimation Methodology

As with any utility, the design and associated costs for construction vary with the unique physical layout of the service area—no two streets are likely to have the exact same configuration of fiber optic cables, communications conduit, underground vaults, and utility pole attachments. Costs are further varied by soil conditions, such as the prevalence of subsurface hard rock; the condition of utility poles and feasibility of "aerial" construction involving the attachment of fiber infrastructure to utility poles; and crossings of bridges, railways, and highways.

To estimate costs for a citywide network, we extrapolated the costs for strategically selected sample designs on the basis of street mileage and passings. Specifically, we developed sample FTTP designs to generate costs per passing for four types of population densities and existing utilities—high, medium aerial, medium underground, and low. [53]

Our observations determined that for the medium underground and low-density areas, utilities are primarily underground, but the low-density areas require more construction of fiber to reach a smaller number of homes in an area.

Downtown business districts in high-density urban areas tend to have underground utilities; utilities are predominantly aerial in urban residential areas (although the poles there tend to require more make ready). Medium and low-density areas tend to have the greatest variation in the percentages of aerial versus underground construction. Generally, the newest subdivisions and developments tend to be entirely underground, whereas older neighborhoods have a mixture of aerial and underground construction. Many areas also tend to have rear easements for utilities, which can increase the cost of construction due to restricted access to the utility poles.

The assumptions, sample designs, and cost estimates were used to extrapolate a cost per passing for the OSP. This number was then multiplied by the number of passings in each area based on the City's GIS data. The actual cost to construct FTTP to every premises in the City could differ from the estimate due to changes in the assumptions underlying the model. For example, if access to the utility poles is not granted or make-ready and pole replacement costs are too high, the network would have to be constructed underground—which could significantly increase the cost of construction. Alternatively, if the City were able to partner with a local telecommunications provider and overlash to existing pole attachments, the cost of the build could be significantly lower. Further and more extensive analysis would be required to develop a more accurate cost estimate across the entire City.

[53] The sample design was 24 percent of the total City street mileage.

3.4.2 OSP

In terms of OSP, the estimated cost to construct the proposed FTTP network is $71 million, or $1,400 per passing.[54] As discussed above, our model assumes a mixture of aerial and underground fiber construction, depending on the construction of existing utilities in the area as well as the state of any utility poles and existing infrastructure Table 14 provides a breakdown of the estimated OSP costs by type of area. (Note that the costs have been rounded.)

Table 14: Estimated OSP Costs for FTTP

Area	Distribution Plant Mileage	Total Cost	Passings	Cost per Passing	Cost Per Plant Mile
Backbone	80	$5.8 million	-	NA	$71,000
High Density	51	$9.3 million	7,200	$1,290	$200,000
Medium Density	267	$40.0 million	31,000	$1,290	$169,000
Low Density	123	$16.1 million	12,800	$1,260	$149,000

Costs for aerial and underground placement were estimated using available unit cost data for materials and estimates on the labor costs for placing, pulling, and boring fiber based on construction in comparable markets.

The material costs were generally known with the exception of unknown economies of scale and inflation rates, and barring any sort of phenomenon restricting material availability and costs. The labor costs associated with the placement of fiber were estimated based on similar construction projects.

Aerial construction entails the attachment of fiber infrastructure to existing utility poles, which could offer significant savings compared to all-underground construction, but increases uncertainty around cost and timeline. The utility pole owners can impose costs related to pole remediation and “make-ready” construction that can make aerial construction cost-prohibitive in comparison to underground construction.

[54] The passing count includes individual single-unit buildings and units in small multi-dwelling and multi-business buildings as single passings. It treats larger buildings as single passings.

While generally allowing for greater control over timelines and more predictable costs, underground construction is subject to uncertainty related to congestion of utilities in the public rights-of-way and the prevalence of subsurface hard rock—neither of which can be fully mitigated without physical excavation and/or testing. While anomalies and unique challenges will arise regardless of the design or construction methodology, the relatively large scale of this project is likely to provide ample opportunity for variations in construction difficulty to yield relatively predictable results on average.

We assume underground construction will consist primarily of horizontal, directional drilling to minimize right-of-way impact and to provide greater flexibility to navigate around other utilities. The design model assumes a single two-inch, High-Density Polyethylene (HDPE) flexible conduit over underground distribution paths, and dual two-inch conduits over underground backbone paths to provide scalability for future network growth.

3.4.3 Central Network Electronics Costs

Central network electronics will cost an estimated $7 million, or $140 per passing, based on an assumed take-rate of 35 percent.[55] (These costs may increase or decrease depending on take rate and the costs may be phased in as subscribers are added to the network.) The central network electronics consists of the electronics to connect subscribers to the FTTP network at the core, hubs, and cabinets. Table 15 below lists the estimated costs for each segment.

Table 15: Estimated Central Network Electronics Costs

Network Segment	Subtotal	Passings	Cost per Passing
Core and Distribution Electronics	$4 million	51,000	$80
FTTP Access Electronics	$3 million	51,000	$60
Central Network Electronics Total	**$7 million**	**51,000**	**$140**

3.4.3.1 Core Electronics

The core electronics connect the hub sites and connect the network to the Internet. The core electronics consist of high performance routers, which handle all of the routing on both the FTTP network and to the Internet. The core routers should have modular chassis to provide high availability in terms of redundant components and the ability to "hot swap"[56] line cards and

[55] The take rate affects the electronics and drop costs, but also may affect other parts of the network, as the city may make different design choices based on the expected take rate. A 35 percent take rate is typical of environments where a new provider joins the telephone and cable provider in a city. In CTC's financial analysis, we will examine how the feasibility of the project depends on a range of take rates.

[56] A "hot swappable" line card can be removed and reinserted without the entire device being powered down or rebooted. The control cards in the router should maintain all configurations and push them to a replaced line card without the need for reconfirmation.

modular in the event of an outage. Modular routers also provide the ability to expand the routers as demand for additional bandwidth increases.

The cost estimate design envisions redundant rings between the core sites running networking protocols such as hot standby routing protocol (HSRP) to ensure redundancy in the event of a core failure. Additional rings can be added as network bandwidth on the network increases. The core sites would also tie to both hubs using 10 Gbps links. The links to the hubs can also be increased with additional 10 Gbps and 40 Gbps line cards and optics as demand grows on the network. The core networks will also have 40 Gbps to Internet service providers that connect the FTTP network to the Internet.

The cost of the core routing equipment for the two core sites is $2 million. These costs do not include the service provider's Operational Support Systems (OSS) such as provisioning platforms, fault and performance management systems, remote access, and other operational support systems for FTTP operations. The services providers and/or their content providers may already have these systems in place.

3.4.3.2 Distribution Electronics

The distribution network electronics at the two hub sites aggregate the traffic from the FDCs and send it to the core sites to access the Internet. The core sites consist of high performance aggregation switches, which consolidate the traffic from the many access electronics and send it to the core for route processing. The distribution switches typically are large modular switch chassis that can accommodate many line cards for aggregation. The switches should also be modular to provide redundancy in the same manner as the core switches.

The cost estimate assumes that the aggregation switches connect to the access network electronics with 10 Gbps links to each distribution switch. The aggregation switches would then connect to the core switches over single or multiple 10 Gbps links as needed to meet the demand of the FTTP users in each service area.

The cost of the distribution switching equipment for distribution hubs is $2 million. These costs do not include any of the service provider's OSS or other management equipment.

3.4.3.3 Access Electronics

The access network electronics at the FDCs connect the subscribers' CPEs to the FTTP network. We recommend deploying access network electronics that can support both GPON and Active Ethernet subscribers to provide flexibility within the FDC service area. We also recommend deploying modular access network electronics for reliability and the ability to add line cards as more subscribers join in the service area. Modularity also helps reduce initial capital costs while the network is under construction or during the roll out of the network.

The cost of the access network electronics for the network is $3 million. These costs are based on a take rate of 35 percent and include optical splitters at the FDCs for that take-rate.

3.4.4 Customer Premises Equipment and Service Drop Installation (Per Subscriber Costs)

Customer premises equipment (CPE) are the subscriber's interface to the FTTP network. For this cost estimate, we selected CPEs that provide only Ethernet data services (however, there are a wide variety of CPEs offering other data, voice, and video services). Using the estimated take rate of 35 percent, we estimated the CPE for residential and business customers will be $12 million.

Each activated subscriber would also require an FTTP service drop and lateral installation which would cost roughly $650 on average per customer or $12 million. The combined total for CPE and FTTP service drop and lateral would be roughly $24 million.

The drop installation cost is the biggest variable in the total cost of adding a subscriber. A short aerial drop can cost as little as $250 to install, whereas a long underground drop installation can cost upward of $2,000. (We estimate an average of $650 per drop installation for the City's deployment.)

The other per subscriber expenses include the cost of the optical network terminal (ONT) at the premises, a portion of the optical line termination (OLT) costs at the hub, the labor to install and configure the electronics, and the incidental materials needed to perform the installation. The numbers provided in the table below are averages and will vary depending on the type of premises and the internal wiring available at each premises.

Table 16: Per GPON Subscriber Cost Estimates

Construction and Electronics Required to Activate a Subscriber	Estimated Average Cost
Drop Installation and Materials	$650
GPON Subscriber Electronics (ONT and OLT)[57]	390
Electronics Installation	200
Installation Materials	100
Total	**$1,340**

3.5 Operating Cost Considerations

This section outlines some of the key technical operating expenditures that a citywide FTTP network would incur. Costs for technical operations of the FTTP network include staffing

[57] AE subscribers will require more expensive subscriber electronics at an estimate of $730 per subscriber.

(technicians, program manager), OSP maintenance, electronics maintenance, and customer support.

The costs discussed in this section are not meant to be inclusive of all operating costs such as marketing, legal, and financial costs. Further, the magnitude of total cost of operations will vary with the business model chosen, balance of added new staff versus using contractors, the level of existing resources that can be leveraged by the City, and any potential business partners.

In the Financial Analysis, we outline the estimated costs for the dark FTTP lease model. This model does not require electronic costs, vendor maintenance fees, or other costs associated beyond maintaining a dark fiber network.

3.5.1 Technical Operational Expenditures

If the City was to offer a retail data service, we estimate that the City would likely initially purchase 8 Gbps of Internet capacity. This is an estimated number for the beginning of the network deployment and can be expected to grow as video streaming and other cloud applications grow in importance. Depending upon the contract terms for Internet bandwidth we would estimate costs in the $0.50 per Mbps per month to $1.00 per Mbps per month range in Boulder. We recommend that the Internet access be purchased from multiple Internet providers and be load balanced to ensure continuity during an outage.

The operating costs also include maintenance contracts on the core network electronics. These contracts ensure that the City has access to software support and replacement of critical network electronics that would be cost-prohibitive to store as spares. Where cost-effective, such as the distribution aggregation switches and the FTTP electronics, we recommend storing spares to reduce the total costs of maintenance contracts. We estimate hardware maintenance contracts and sparing at 15 percent of the total electronics cost.

In addition, we recommend planning for an annual payment into a depreciation operating reserve account based on the equipment replacement cost to help limit risk. This reserve fund should never go negative; the balance that accrues in this account will fund the capital needs for ongoing capital replenishments.

3.5.1.1 Fiber Maintenance Costs

The City would need to augment its current fiber staff or contractors with the necessary expertise and equipment available to maintain the fiber optic cable in a citywide FTTP network. Typical

maintenance costs can exceed 1 percent of the total fiber OSP construction cost per year and includes a mix of City staff and contracted services.

Fiber optic cable is resilient compared to copper telephone lines and cable TV coaxial cable. The fiber itself does not corrode, and fiber cable installed over 20 years ago is still in good condition. However, fiber can be vulnerable to accidental cuts by other construction, traffic accidents, and severe weather. In other networks of this size, we have seen approximately 80 outages per 1,000 miles of plant per year.

The fiber optic redundancy from the hubs to the FDCs in the backbone network will facilitate restoring network outages while repair of the fiber optic plant is taking place.

Depending on the operational and business models established between the City and service providers, the City might be responsible for adds, moves, and changes associated with the network as well as standard plant maintenance. These items may include:

- Adding and/or changing patching and optical splitter configurations at FDCs and hubs;
- Extending optical taps and laterals to new buildings or developments;
- Extending access to the FTTP network to other service providers;
- Relocating fiber paths due to changes such as the widening of roadways;
- Participating in the moving of utilities due to pole replacement projects; and
- Tree trimming along the aerial fiber optic path.

The City would need to obtain contracts with fiber optic contractors that have the necessary expertise and equipment available to maintain a citywide FTTP network. These contracts should specify the service level agreements the City needs from the fiber optic contractors in order to ensure that the City can meet the service level agreements it has with the network service providers. The City should also ensure that it has access to multiple fiber optic contractors in the event that one contractor is unable to meet the City's needs. The fiber optic contractors should be available 24x7 and have a process in place for activating emergency service requests.

3.5.1.2 Fiber Locating

The City will be responsible for locating and marking all underground conduit for excavation projects according to Colorado's one-call statutes. Locating involves receiving and reviewing excavation tickets to determine whether the area of excavation may impact the City's underground FTTP infrastructure. If the system is impacted, the City must mark its utilities in the manner and within the allotted timeframe provided by the statute.

Locating is either done in-house or by contractors who specialize in utility locating. The City may be able to leverage its existing utility locating personnel, processes, or contractors to reduce the cost of utility locating for the FTTP network.

3.5.1.3 Pole Attachment Fees

The City will need to pay utility pole owners an annual fee per pole to attach its fiber optic cables to the poles. Pole attachment fees can be thought of a rent for using the pole. Pole attachment fees are set by the pole owner and would be outlined in the City's pole attachment agreement with the owner, which will be negotiated with the pole owners.

3.5.2 Technical Staffing Requirements

Additional staffing will be required to perform the maintenance and operation responsibilities of a Citywide FTTP network. The staffing levels and the responsibility for that staffing will vary greatly with the various potential business models. The following sections outline the technical groups that will be required maintain and operate the network.

3.5.2.1 Outside Plant

The outside plant group will be responsible for the maintenance, operations, and expansion of the City's telecommunications infrastructure including conduit, fiber, pole attachments, and splice enclosures. During construction, the outside plant group will be responsible for tracking and overseeing the construction of new infrastructure. Once the network is constructed, the outside plant group will oversee any future adds, moves, or changes to the network.

The outside plant group may use contractors to perform activities such as construction, repair, and locating. Management of contractors will be a responsibility of an outside plant manager with outside plant technicians assisting with project oversight and quality assurance and quality control. The outside plant manager will also assist with engineering and design of any adds, moves, and changes that occur on the network.

The outside plant group will have responsibility for general field operations. This group will include outside plant technicians to perform locates, and contracted support to provide repair services. Tasks will include management of the One Call process, fiber locates, response and troubleshooting of Layer 1 troubleshooting, and fleet management. Additionally, it is critical that while many of OSP jobs may be outsourced, that the outside plant group be equipped with the proper locate and testing equipment.

Our estimate includes one OSP manager and up to two OSP technicians to operate the network, depending on what roles are contracted and what capabilities already exist within the City for locates.

3.5.2.2 Network Engineering

The network engineering group develops and maintains the network architecture, responds to high-level troubleshooting requests, manages network electronics and makes sure the network delivers to the end user a reliable service.

The network engineering group is responsible for making architecture decisions that will determine how the network is capable of delivering services to users. The network engineering group will also be responsible for change management and architectural review to ensure that network continuity is ensured after changes.

The network engineering group will also be responsible for vendor selections when new hardware, technologies, or contractor support is needed to support the network. The network engineering team will perform regular maintenance of the network as well as provision, deploy, test, and accept any electronics to support new sites or services.

Network technicians will be responsible for troubleshooting issues with network electronics and responding to customer complaints.

To operate network electronics (if required by the business model) we estimate a staffing requirement of one network manager, two network engineers, and two network technicians that could be a combination of in-house personnel and contracted support.

3.5.2.3 Network Operations Center and Customer Service

The network will require individuals to perform monitoring and oversight of the network electronics. The group will be responsible for handling technical calls from users, actively monitoring the health of the network, and escalating issues to the proper operations groups. The group is also required to develop and monitor network performance parameters to ensure that the network is meeting its obligations to its users as defined in the network service level agreements (SLAs).

Often network operations require a 24/7 customer service helpdesk and tools for network monitoring, alerting, and provisioning.

4 FTTP Financial Analysis

The financial analysis for all scenarios presented here represent a minimum requirement for the City of Boulder to break even each year, excluding any potential revenue from other dark fiber lease opportunities that may be available to the City.

The base case scenario assumes that the City's private partner will pay a fee of $17.10 per passing per month, with no upfront or balloon payments. Based on an assumption that the City will deploy a ubiquitous FTTP network, the financial model applies the fee to all residential and business premises in the City. The current model keeps that $17.10 per passing fee constant, although the City and its partner could negotiate periodic increases.

The financial analysis for the base case scenario is as follows:

Table 17: Base Case Financial Analysis

Income Statement	1	5	10	15	20
Total Revenues	$ 52,330	$ 9,941,940	$ 10,465,200	$ 10,465,200	$ 10,465,200
Total Cash Expenses	(608,040)	(1,471,990)	(1,471,990)	(1,471,990)	(1,471,990)
Depreciation	(1,105,940)	(3,600,200)	(3,600,200)	(3,600,200)	(3,600,200)
Interest Expense	(1,650,000)	(5,298,440)	(4,230,110)	(2,800,430)	(887,210)
Taxes	-	-	-	-	-
Net Income	$ (3,311,650)	$ (428,690)	$ 1,162,900	$ 2,592,580	$ 4,505,800
Cash Flow Statement	1	5	10	15	20
Unrestricted Cash Balance	$ 436,490	$ 208,750	$ 2,690,600	$ 5,173,410	$ 7,656,780
Depreciation Reserve	-	118,800	124,800	130,390	135,980
Interest Reserve	1,650,000	-	-	-	-
Debt Service Reserve	1,375,000	4,725,000	4,725,000	4,725,000	4,725,000
Total Cash Balance	$ 3,461,490	$ 5,052,550	$ 7,540,400	$ 10,028,800	$ 12,517,760

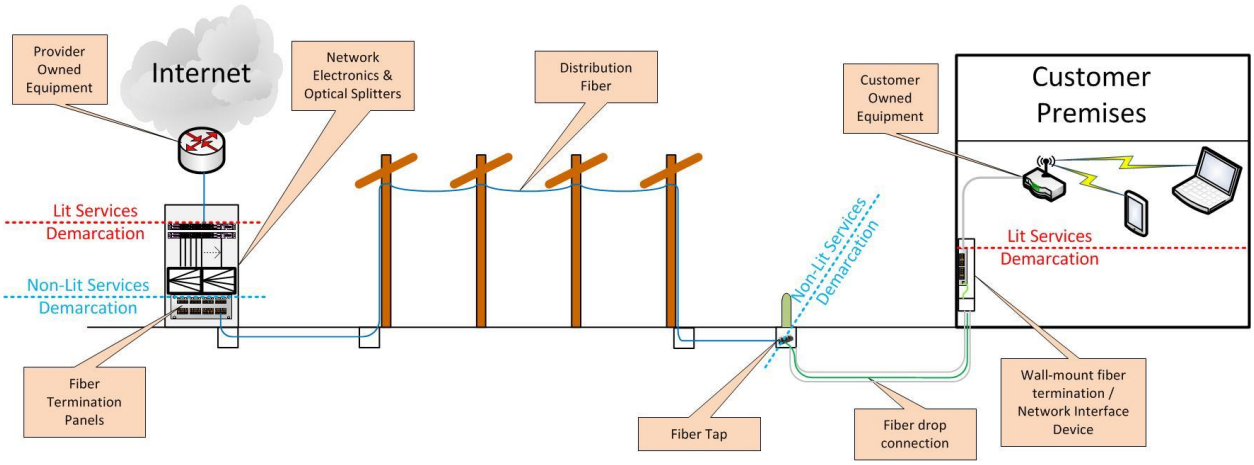
Please note that we used a "flat-model" in the analysis. In a "flat-model," inflation and operating cost increases (including salaries) are not used in the analysis because it is assumed that operating cost increases will be offset by increases in operator lease payments over time (and likely passed on to subscribers in the form of increased prices). We anticipate that the City will apply an inflation factor, typically based on a Consumer Price Index (CPI), to the portion of the per subscriber fee covering projected operating expenses during negotiations with a private partner. Please note that it is not appropriate to apply a CPI to the entire passing fee because the majority of the fee is to support the principal and interest on the debt service. This is discussed further in Section 4.4.

This document presents an overview of the financial model; we have provided the City with a complete financial model in Excel format. Because the Excel spreadsheets can be manipulated to show the impact of changing assumptions (much as we have done in the scenarios in Section 4.5 below), it will be an important tool for the City to use as it negotiates with a private partner.

4.1 Cost Implications of FTTP Technical Model

The financial analysis in this section assumes that the City constructs and owns the fiber-to-the-premises (FTTP) infrastructure up to a demarcation point at the optical tap near each residence and business, and leases the dark fiber backbone and distribution fiber to a private partner. The private partner would be responsible for all network electronics, fiber drops to subscribers, and customer premises equipment (CPE)—as well as network sales, marketing, and operations.

Figure 12: Demarcation Between City and Partner Network Elements



Using a mix of 68 percent aerial and 32 percent underground construction the citywide dark FTTP network deployment will cost more than $71 million, inclusive of outside plant (OSP) construction labor, materials, engineering, permitting, and pole attachment licensing. This estimate does not include and electronics, subscriber equipment, or drops.

Table 18: Breakdown of Estimated Dark FTTP Cost (aerial and underground construction)

Cost Component	Total Estimated Cost
OSP Engineering	$7.9 million
Quality Control/Quality Assurance	2.9 million
General OSP Construction Cost	53.3 million
Special Crossings	-
Backbone and Distribution Plant Splicing	2.2 million
Backbone Hub, Termination, and Testing	4.9 million
FTTP Lateral Installations	-
Total Estimated Cost:	$71.2 million

The City or its partner(s) may aim to place all newly constructed fiber underground to avoid weather-related concerns (e.g., ice storms and other weather incidents that could cause outages due to downed aerial lines), and challenges with obtaining pole attachments. Because all-underground construction is a possibility, we estimated costs to place all fiber underground. We estimate that it will cost more than $89 million to construct an all-underground dark FTTP network.

Table 19: OSP Cost Estimate Summary (Underground Construction)

Item	Cost
OSP Engineering	$7.9 million
Quality Control/Quality Assurance	2.9 million
General OSP Construction Cost	71.4 million
Special Crossings	-
Backbone and Distribution Plant Splicing	2,2 million
Backbone Hub, Termination, and Testing	4.9 million
FTTP Lateral Installations	-
Total Estimated OSP Cost	**$89.3 million**

The above estimates assume that the City constructs and owns the FTTP infrastructure up to a demarcation point at the optical tap near each residence and business, and leases the dark fiber backbone and distribution fiber to a private partner. The private partner would be responsible for all network electronics, fiber drops to subscribers, and customer premises equipment (CPE)—as well as network sales, marketing, and operations.

The ownership of the drops is an assumption that could be changed through negotiation with a private partner—as, indeed, could many of the assumptions underpinning this analysis. We have chosen this key parameter for the base case scenario because we believe this approach presents a reasonable balance of costs, control, and risk for the City. (City ownership of the drops, for example, would increase the City's control, but also significantly increase the City's costs.)

In a related vein, we note that some network operators suggest that the network's optical splitters should be a part of the Layer 1 or dark fiber assets. We caution against this approach. The network operator (i.e., the City's partner) should maintain the splitters because, as operator of the electronics, it must determine and control the GPON network split ratio to meet the network's performance standards. This may involve moving power users to GPON ports with lower split ratios, or moving users to different splitters to manage the capacity of the GPON ports. The City should not be involved in this level of network management. Also, the City should not have to inventory various sized splitters or swap them as the network operator makes changes. Even if the City were to decide to purchase some of the optical splitters for the network, we believe it should be the network operator's responsibility to manage and maintain the splitters.

4.2 Financing Costs and Operating Expenses

For the base financial analysis, we used the OSP costs for a combination aerial and underground construction. In the scenarios we show the impact of the increased costs for an all-underground deployment.

This financial analysis assumes that the City will cover all of its capital requirements with general obligation (GO) bonds. Based on discussions with staff we assume that the City's bond rate would be 6 percent.

To accomplish this objective, we expect that the City would take three 20-year bonds—one each in years one, two, and three—for a total of $94.5 million in financing. (The difference between the financed amount and the total capital costs—$71.2 million—represents the amount needed to maintain positive cash flow in the early years of network deployment.) The resulting principal and interest (P&I) payments would be the major factor in determining the City's long-term financial requirements; P&I accounts for about 85 percent of the City's annual costs in our base case model after the construction period.

We project that the bond issuance costs would be equal to 1.0 percent of the principal borrowed. For the bond, a debt service reserve account is maintained at 5.0 percent of the total issuance amount. An interest reserve account would be maintained for the first two years. Principal repayment on the bonds would start in year two.

The model assumes a straight-line depreciation of assets, and that the OSP and materials would have a 20-year life span. Because we assume the City's partner would be responsible for network electronics and CPE, we have not included depreciation or replacement costs for that equipment (although we note that, typically, network equipment would be replaced after 10 years, while CPE and last-mile infrastructure would be depreciated over five years). The model plans for a depreciation reserve account starting in year three to fund future replacements and upgrades.

Table 20 shows the income statement for years one, five, 10, 15, and 20.

Table 20: Income Statement

	Year 1	Year 5	Year 10	Year 15	Year 20
Income Statement					
a. Revenues					
Per Passing	$ 52,330	$ 9,941,940	$ 10,465,200	$ 10,465,200	$ 10,465,200
Total	$ 52,330	$ 9,941,940	$ 10,465,200	$ 10,465,200	$ 10,465,200
c. Operating Costs					
Operation Costs	$ 457,537	$ 981,990	$ 981,990	$ 981,990	$ 981,990
Labor Costs	150,500	490,000	490,000	490,000	490,000
Total	$ 608,037	$ 1,471,990	$ 1,471,990	$ 1,471,990	$ 1,471,990
d. EBITDA	$ (555,707)	$ 8,469,950	$ 8,993,210	$ 8,993,210	$ 8,993,210
e. Depreciation	1,105,940	3,600,200	3,600,200	3,600,200	3,600,200
f. Operating Income (EBITDA less Depreciation)	$ (1,661,647)	$ 4,869,750	$ 5,393,010	$ 5,393,010	$ 5,393,010
g. Non-Operating Income					
Interest Income	$ -	$ 12,120	$ 12,120	$ 12,140	$ 12,150
Interest Expense (10 Year Bond)	-	-	-	-	-
Interest Expense (20 Year Bond)	(1,650,000)	(4,242,230)	(4,242,230)	(2,812,570)	(899,360)
Interest Expense (Loan)	-	-	-	-	-
Total	$ (1,650,000)	$ (4,230,110)	$ (4,230,110)	$ (2,800,430)	$ (887,210)
h. Net Income (before taxes)	$ (3,311,650)	$ (428,690)	$ 1,162,900	$ 2,592,580	$ 4,505,800
i. Facility Taxes	$ -	$ -	$ -	$ -	$ -
j. Net Income	$ (3,311,650)	$ (428,690)	$ 1,162,900	$ 2,592,580	$ 4,505,800

Table 21 shows the cash flow statement for years one, five, 10, 15, and 20. The unrestricted cash balance is approximately $437,000 in year one and $2.7 million in year 10. By year 15, the unrestricted cash balance is approximately $5.2 million, and it is $7.7 million by year 20.

Table 21: Cash Flow Statement

	Year 1	Year 5	Year 10	Year 15	Year 20
Cash Flow Statement					
a. Net Income	$ (3,311,650)	$ (428,690)	$ 1,162,900	$ 2,592,580	$ 4,505,800
b. Cash Outflows					
Debt Service Reserve	$ (1,375,000)	$ -	$ -	$ -	$ -
Interest Reserve	(3,300,000)	-	-	-	-
Depreciation Reserve	-	(39,600)	(39,600)	(39,600)	(39,600)
Financing	(275,000)	-	-	-	-
Capital Expenditures	(21,557,800)	-	-	-	(2,000)
Total	$ (26,507,800)	$ (39,600)	$ (39,600)	$ (39,600)	$ (41,600)
c. Cash Inflows					
Interest Reserve	$ 1,650,000	$ -	$ -	$ -	$ -
Depreciation Reserve	-	-	-	-	2,000
Grants (infrastructure)	-	-	-	-	-
10-Year Bond/Loan Proceeds	-	-	-	-	-
20-Year Bond Proceeds	27,500,000	-	-	-	-
Loan Proceeds	-	-	-	-	-
Total	$ 29,150,000	$ -	$ -	$ -	$ 2,000
d. Total Cash Outflows and Inflows	$ 2,642,200	$ (39,600)	$ (39,600)	$ (39,600)	$ (39,600)
e. Non-Cash Expenses - Depreciation	$ 1,105,940	$ 3,600,200	$ 3,600,200	$ 3,600,200	$ 3,600,200
f. Adjustments					
Proceeds from Additional Cash Flows (10 Year Bond)	$ -	$ -	$ -	$ -	$ -
Proceeds from Additional Cash Flows (20 Year Bond)	$ (27,500,000)	$ -	$ -	$ -	$ -
Proceeds from Additional Cash Flows (Loan)	$ -	$ -	$ -	$ -	$ -
g. Adjusted Available Net Revenue	$ (27,063,510)	$ 3,131,910	$ 4,723,500	$ 6,153,180	$ 8,066,400
h. Principal Payments on Debt					
10 Year Bond Principal	$ -	$ -	$ -	$ -	$ -
20 Year Bond Principal	-	3,158,620	4,226,940	5,656,600	7,569,810
Loan Principal	-	-	-	-	-
Total	$ -	$ 3,158,620	$ 4,226,940	$ 5,656,600	$ 7,569,810
j. Cash Balance					
Unrestricted Cash Balance	$ 436,490	$ 208,750	$ 2,690,600	$ 5,173,410	$ 7,656,780
Depreciation Reserve	-	118,800	124,800	130,390	135,980
Interest Reserve	1,650,000	-	-	-	-
Debt Service Reserve	1,375,000	4,725,000	4,725,000	4,725,000	4,725,000
Total Cash Balance	$ 3,461,490	$ 5,052,550	$ 7,540,400	$ 10,028,800	$ 12,517,760

Significant network expenses—known as "capital additions"—are incurred in the first few years during the construction phase of the network. These represent the equipment and labor expenses associated with building a fiber network. (Again, because the City's responsibility will be limited to OSP, we have not included any costs for core network equipment, drops, or CPE.) This analysis projects that capital additions in year one will total approximately $21.4 million. These costs will total approximately $35.6 million in year two, and $14.2 million in year three. This totals just over $71.2 million in capital additions for years one through three.

4.3 Operating and Maintenance Expenses

The cost to deploy an FTTP network goes far beyond fiber implementation. Network deployment requires sales and marketing, network maintenance and technical operations, and other functions. In this model, we assume that the City's partner will be responsible for lighting the fiber and selling services, so the City's financial requirements are limited to expenses related to OSP infrastructure and network administration.

These expanded responsibilities will require the addition of new staff. We assume the City will add a total of three and one-half full-time-equivalent (FTE) positions within the first three years, and will then maintain that level of staffing. Our assumptions include one FTE for OSP management, one-half FTE for HR/administrative support, and two FTEs for fiber plant maintenance and operations. Salaries and benefits are based on estimated market wages, and benefits are estimated at 40 percent of base salary.

Locates and ticket processing will be significant ongoing operational expenses for the City. Based on our experience in other cities, we estimate that a contract for locates will cost $37,500 in year one, increase to $75,000 in year two, and increase to $150,100 from year three on. (If the City decides to perform this work in house, the contract expense would be eliminated—but staffing expenses would increase.)

Additional key operating and maintenance assumptions include the following:

- Pole attachment fees are $30 per year per pole.
- Insurance is estimated to be $50,000 in year one and $75,000 from year two on.
- Office expenses are estimated to be $2,400 annually.
- Contingency expenses are estimated at $10,000 in year one and $25,000 in subsequent years.
- Legal fees are estimated to be $100,000 in year one, $50,000 in year two, and $25,000 from year three on.
- Consulting fees are estimated at $100,000 in year one and $20,000 from year two on.

Fiber network maintenance costs are calculated at 0.5 percent of the total construction cost, per year. This is estimated based on a typical rate of occurrence in an urban environment, and the cost of individual repairs. This is in addition to staffing costs to maintain the fiber.

Table 22 lists the City's projected operating expenses for years one, five, 10, 15, and 20.

Table 22: Operating Expenses

	Year 1	Year 5	Year 10	Year 15	Year 20
Operating Expenses					
Insurance	$ 50,000	$ 75,000	$ 75,000	$ 75,000	$ 75,000
Office Expenses	2,400	2,400	2,400	2,400	2,400
Locates & Ticket Processing	37,500	150,100	150,100	150,100	150,100
Contingency	10,000	25,000	25,000	25,000	25,000
Fiber & Network Maintenance	106,850	356,180	356,180	356,180	356,180
Legal and Lobby Fees	100,000	25,000	25,000	25,000	25,000
Consulting	100,000	20,000	20,000	20,000	20,000
Education and Training	3,010	9,800	9,800	9,800	9,800
Pole Attachment Expense	47,777	318,510	318,510	318,510	318,510
Sub-Total	$ 457,537	$ 981,990	$ 981,990	$ 981,990	$ 981,990
Labor Expenses	$ 150,500	$ 490,000	$ 490,000	$ 490,000	$ 490,000
Sub-Total	$ 150,500	$ 490,000	$ 490,000	$ 490,000	$ 490,000
Total Expenses	$ 608,037	$ 1,471,990	$ 1,471,990	$ 1,471,990	$ 1,471,990
Principal and Interest	$ -	$ (39,600)	$ (39,600)	$ (39,600)	$ (39,600)
Facility Taxes	-	-	-	-	-
Sub-Total	$ -	$ (39,600)	$ (39,600)	$ (39,600)	$ (39,600)
Total Expenses, P&I, and Taxes	$ 608,037	$ 1,432,390	$ 1,432,390	$ 1,432,390	$ 1,432,390

4.4 Revenue

The base case scenario assumes that the City's private partner will pay a fee of $17.10 per passing per month, with no upfront or balloon payments. Based on an assumption that the City will deploy a ubiquitous FTTP network, the financial model applies the fee to all residential and business premises in the City. The current model keeps that $17.10 per passing fee constant, although the City and its partner could negotiate periodic increases.

Operating and maintenance expenses account for approximately 14.8 percent of the City's total annual costs. (P&I payment on debt is the remaining amount.) At a minimum, then, 14.8 percent of the per-passing fee should be increased by a CPI each year.

In the scenarios below, we show how changing certain assumptions related to financing will affect that fee. (We note, too, that the fee will be just one element of the City's negotiations with a private partner.)

4.5 Sensitivity Scenarios

This section demonstrates the sensitivity of the financial projections to changes in various assumptions. For comparison, we repeat the base case scenario—with a per-passing fee of $17.10 per month—here:

Table 23: Base Case Financial Analysis

Income Statement	1	5	10	15	20
Total Revenues	$ 52,330	$ 9,941,940	$ 10,465,200	$ 10,465,200	$ 10,465,200
Total Cash Expenses	(608,040)	(1,471,990)	(1,471,990)	(1,471,990)	(1,471,990)
Depreciation	(1,105,940)	(3,600,200)	(3,600,200)	(3,600,200)	(3,600,200)
Interest Expense	(1,650,000)	(5,298,440)	(4,230,110)	(2,800,430)	(887,210)
Taxes	-	-	-	-	-
Net Income	$ (3,311,650)	$ (428,690)	$ 1,162,900	$ 2,592,580	$ 4,505,800
Cash Flow Statement	1	5	10	15	20
Unrestricted Cash Balance	$ 436,490	$ 208,750	$ 2,690,600	$ 5,173,410	$ 7,656,780
Depreciation Reserve	-	118,800	124,800	130,390	135,980
Interest Reserve	1,650,000	-	-	-	-
Debt Service Reserve	1,375,000	4,725,000	4,725,000	4,725,000	4,725,000
Total Cash Balance	$ 3,461,490	$ 5,052,550	$ 7,540,400	$ 10,028,800	$ 12,517,760

4.5.1 Adding a One-Time, $10 Million Payment from the City's Partner

In this section, we demonstrate the impact of a one-time payment from the City's partner on the financial model. A $10 million upfront payment from the private partner would enable the City to reduce its bond requirement by $13 million—which, in turn would lower the required per-passing fee to $15.10.

Table 24: A $10 Million Upfront Payment Reduces the City's Borrowing by $13 Million

Income Statement	1	5	10	15	20
Total Revenues	$ 10,046,210	$ 8,779,140	$ 9,241,200	$ 9,241,200	$ 9,241,200
Total Cash Expenses	(608,040)	(1,471,990)	(1,471,990)	(1,471,990)	(1,471,990)
Depreciation	(1,105,940)	(3,600,200)	(3,600,200)	(3,600,200)	(3,600,200)
Interest Expense	(1,380,000)	(4,575,710)	(3,656,430)	(2,426,230)	(779,950)
Taxes	-	-	-	-	-
Net Income	$ 6,952,230	$ (868,760)	$ 512,580	$ 1,742,780	$ 3,389,060
Cash Flow Statement	1	5	10	15	20
Unrestricted Cash Balance	$ 6,740,370	$ 215,690	$ 2,394,770	$ 4,574,800	$ 6,755,380
Depreciation Reserve	-	118,800	124,800	130,390	135,980
Interest Reserve	1,380,000	-	-	-	-
Debt Service Reserve	1,150,000	4,075,000	4,075,000	4,075,000	4,075,000
Total Cash Balance	$ 9,270,370	$ 4,409,490	$ 6,594,570	$ 8,780,190	$ 10,966,360

4.5.2 Increasing the City's Interest Rate

Because the City would be building and maintaining the OSP, but not lighting the fiber or selling retail services, the City's capital investment and financing are the key sensitivities in the model. As we noted above, about 85.2 percent of the City's annual cash outflow will cover P&I; only 14.8 percent of cash outflow will be for network operations and maintenance. If the City's interest rate were to increase by two percentage points, to 8 percent, the City would need to increase its borrowing by $4.5 million to cover the increased interest payments in early years, as well as to

keep cash flow positive. The increased borrowing would, in turn, increase the required per-passing payment from $17.10 to $20.10 (a roughly 18 percent increase in that fee).

Table 25: Increasing the City's Interest Rate by 2 Percentage Points Increases Required Borrowing by $4.5 Million

Income Statement	1	5	10	15	20
Total Revenues	$ 104,790	$ 19,909,010	$ 20,956,860	$ 20,956,860	$ 20,956,860
Total Cash Expenses	(814,560)	(2,288,200)	(2,288,200)	(2,288,200)	(2,288,200)
Depreciation	(2,190,320)	(7,215,000)	(7,215,000)	(7,215,000)	(7,215,000)
Interest Expense	(3,542,500)	(11,549,920)	(9,300,060)	(6,217,570)	(1,994,320)
Taxes	-	-	-	-	-
Net Income	$ (6,442,590)	$ (1,144,110)	$ 2,153,600	$ 5,236,090	$ 9,459,340
Cash Flow Statement	1	5	10	15	20
Unrestricted Cash Balance	$ 189,830	$ (12,370)	$ 4,950,950	$ 9,915,540	$ 14,881,120
Depreciation Reserve	-	140,700	182,200	223,430	264,660
Interest Reserve	3,542,500	-	-	-	-
Debt Service Reserve	2,725,000	9,475,000	9,475,000	9,475,000	9,475,000
Total Cash Balance	$ 6,457,330	$ 9,603,330	$ 14,608,150	$ 19,613,970	$ 24,620,780

In contrast to the scenario above, if the City were able to decrease its interest rate by two percentage points, to 4 percent, it would be able to reduce its borrowing by $4 million and reduce the required per-passing cost to $14.40.

Table 26: Reducing the City's Interest Rate by 2 Percentage Points Reduces Required Borrowing by $4 Million

Income Statement	1	5	10	15	20
Total Revenues	$ 44,060	$ 8,372,160	$ 8,812,800	$ 8,812,800	$ 8,812,800
Total Cash Expenses	(608,040)	(1,471,990)	(1,471,990)	(1,471,990)	(1,471,990)
Depreciation	(1,105,940)	(3,600,200)	(3,600,200)	(3,600,200)	(3,600,200)
Interest Expense	(1,040,000)	(3,333,190)	(2,564,970)	(1,630,320)	(493,200)
Taxes	-	-	-	-	-
Net Income	$ (2,709,920)	$ (33,220)	$ 1,175,640	$ 2,110,290	$ 3,247,410
Cash Flow Statement	1	5	10	15	20
Unrestricted Cash Balance	$ 238,220	$ 140,700	$ 2,251,200	$ 4,362,660	$ 6,474,680
Depreciation Reserve	-	118,800	124,800	130,390	135,980
Interest Reserve	1,040,000	-	-	-	-
Debt Service Reserve	1,300,000	4,525,000	4,525,000	4,525,000	4,525,000
Total Cash Balance	$ 2,578,220	$ 4,784,500	$ 6,901,000	$ 9,018,050	$ 11,135,660

4.5.3 Increasing the City's Bond Term to 30 Years

To illustrate the sensitivity of the City's financial model to bonding and borrowing terms, we increased the City's bond term from 20 years to 30 years. The per-passing fee required to maintain cash flow decreases from $17.10 to $14.25. However, the longer bond term increases the city's risk and increases the City's interest rate. Further, a longer bond term would require a

longer contract with the private partner; given both the pace of change in the broadband industry, and the average lifespan of telecommunications companies.

Table 27: Increasing the City's Bond Term to 30 Years Decreases the Per-Passing Fee

Income Statement	1	5	10	15	20
Total Revenues	$ 43,610	$ 8,284,950	$ 8,721,000	$ 8,721,000	$ 8,721,000
Total Cash Expenses	(608,040)	(1,471,990)	(1,471,990)	(1,471,990)	(1,471,990)
Depreciation	(1,105,940)	(3,600,200)	(3,600,200)	(3,600,200)	(3,600,200)
Interest Expense	(1,620,000)	(5,390,630)	(4,909,670)	(4,266,030)	(3,404,720)
Taxes	-	-	-	-	-
Net Income	$ (3,290,370)	$ (2,177,870)	$ (1,260,860)	$ (617,220)	$ 244,090
Cash Flow Statement	1	5	10	15	20
Unrestricted Cash Balance	$ 17,770	$ 216,250	$ 2,199,310	$ 4,183,330	$ 6,167,900
Depreciation Reserve	-	118,800	124,800	130,390	135,980
Interest Reserve	1,620,000	-	-	-	-
Debt Service Reserve	1,350,000	4,637,500	4,637,500	4,637,500	4,637,500
Total Cash Balance	$ 2,987,770	$ 4,972,550	$ 6,961,610	$ 8,951,220	$ 10,941,380

4.5.4 Reducing Operating Expenses by 25 Percent

Because the City will be borrowing to cover not just all of its capital requirements, but also a portion of its operating costs in the early years, decreasing the City's expenses would have a corresponding effect on the required per-passing fee. However, the impact is not linear. Decreasing operating expenses by 25 percent would only decrease the per-passing cost by 80 cents, to $16.30.

Table 28: Decreasing the City's Operating Expenses by 25 Percent Only Slightly Reduces the Per Passing Fee

Income Statement	1	5	10	15	20
Total Revenues	$ 49,880	$ 9,476,820	$ 9,975,600	$ 9,975,600	$ 9,975,600
Total Cash Expenses	(456,030)	(1,103,990)	(1,103,990)	(1,103,990)	(1,103,990)
Depreciation	(1,105,940)	(3,600,200)	(3,600,200)	(3,600,200)	(3,600,200)
Interest Expense	(1,620,000)	(5,228,700)	(4,174,610)	(2,764,020)	(876,300)
Taxes	-	-	-	-	-
Net Income	$ (3,132,090)	$ (456,070)	$ 1,096,800	$ 2,507,390	$ 4,395,110
Cash Flow Statement	1	5	10	15	20
Unrestricted Cash Balance	$ 176,050	$ 24,670	$ 2,457,890	$ 4,892,070	$ 7,326,800
Depreciation Reserve	-	118,800	124,800	130,390	135,980
Interest Reserve	1,620,000	-	-	-	-
Debt Service Reserve	1,350,000	4,662,500	4,662,500	4,662,500	4,662,500
Total Cash Balance	$ 3,146,050	$ 4,805,970	$ 7,245,190	$ 9,684,960	$ 12,125,280

4.5.5 Constructing Network Completely Underground

In the scenario below, we have assumed that the City's FTTP infrastructure would be constructed underground (as opposed to the base case and other scenarios, in which we assume a split of roughly 32 percent underground, 68 percent aerial). An all-underground network would increase

construction costs and the ongoing costs for fiber locates and ticketing, while eliminating the pole maintenance costs. In this scenario, the required financing would increase to $117.5 million and the per-passing fee would increase by about 22 percent, to $20.80.

Table 29: All Underground Construction Significantly Increases Per-Passing Fee

Income Statement	1	5	10	15	20
Total Revenues	$ 63,650	$ 12,093,120	$ 12,729,600	$ 12,729,600	$ 12,729,600
Total Cash Expenses	(667,000)	(1,562,450)	(1,562,450)	(1,562,450)	(1,562,450)
Depreciation	(1,377,340)	(4,504,850)	(4,504,850)	(4,504,850)	(4,504,850)
Interest Expense	(2,040,000)	(6,588,710)	(5,260,500)	(3,483,100)	(1,104,560)
Taxes	-	-	-	-	-
Net Income	$ (4,020,690)	$ (562,890)	$ 1,401,800	$ 3,179,200	$ 5,557,740
Cash Flow Statement	1	5	10	15	20
Unrestricted Cash Balance	$ 290,950	$ 98,850	$ 3,131,540	$ 6,165,520	$ 9,200,380
Depreciation Reserve	-	135,150	168,400	201,250	234,100
Interest Reserve	2,040,000	-	-	-	-
Debt Service Reserve	1,700,000	5,875,000	5,875,000	5,875,000	5,875,000
Total Cash Balance	$ 4,030,950	$ 6,109,000	$ 9,174,940	$ 12,241,770	$ 15,309,480

5 Understanding Open Access and Competition

A desire for increased competition in the marketplace is often at the root of the goals that drive a public entity to seek ways to expand access to ultra-high speed broadband connectivity. This can potentially be achieved through "open access," which has traditionally meant one infrastructure that is available to multiple providers to offer service. Open access networks are meant to enable numerous providers to deliver service over the network—thus fostering competition—and to give consumers greater choice and flexibility in picking a provider.

Open access is most easily achieved if a community builds and owns a network itself, because it is then in a position to set terms for private lessees of its fiber that could include open access. But some forms of open access may be possible even under the pure private investment model. Indeed, two of the potential partners with which we spoke (Allo and Axia) are open to variations on an open access approach. (See Section 3.) So there is the potential, even with private investment, that Boulder might achieve open access.

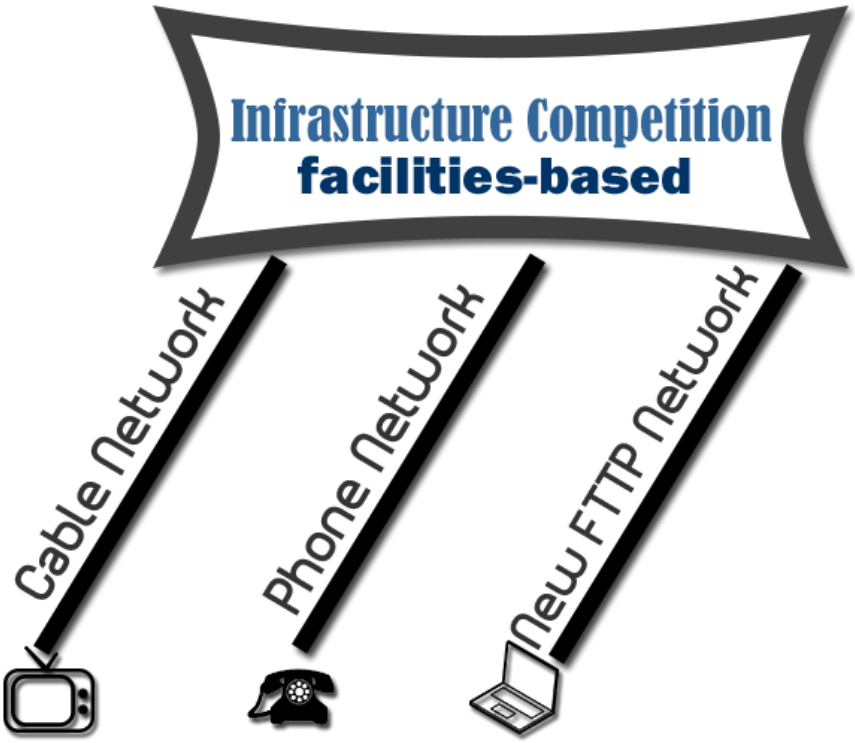
It's essential to note that creating the *potential* for open access does not mean that actual competition will emerge over that platform, particularly over the short to medium term, given the economics of broadband competition—but the potential exists.

There may be other ways for the City to achieve its open access goals, too. That is, the City may find that it can concede on providing infrastructure-based open access if it can ensure that the community's goals with respect to *competition* are met. Indeed, the primary goal of developing an open access network is to level the provider playing field to reduce monopolistic and oligopolistic practices by incumbents, and to give consumers greater choice in service providers. Pursuit of a traditional open access model may not be necessary for to achieve better competition. Rather, competition over the data pipe (known as Over the Top competition) and over multiple network infrastructures (known as facilities-based competition) can serve to enable real competition, thus reducing the need to provide access to physical infrastructure in order to promote and support competition.

5.1 Facilities-Based Competition

While it is frequently derided by open access advocates and is not economically efficient, we suggest that the City not discount the benefits of achieving competition through facilities-based competition. In this scenario, competition is achieved when multiple separate entities develop their own separate networks and physical pathways to reach the customer. Most private providers are usually not interested in granting access to their expensive infrastructure for companies that will then compete with them over it, so each of these networks is likely to host only one Internet Service Provider—the network owner.

Figure 13: Facilities-based Infrastructure Competition



This approach is not efficient because it requires a large capital expenditure by each network owner and, frankly, robust competition over separate facilities has not emerged for the most part in the United States, unless one considers the modest duopoly-competition between phone and cable companies to constitute "competition."

But the past five years have brought new competitive networks and new competitors into the broadband market, led by a range of municipalities and by Google Fiber. For cities that have had the benefit of a third provider in the market (whether public or private), facilities-based competition has begun to work, particularly as the incumbents have started to react to competition by investing, upgrading, and improving services and prices.

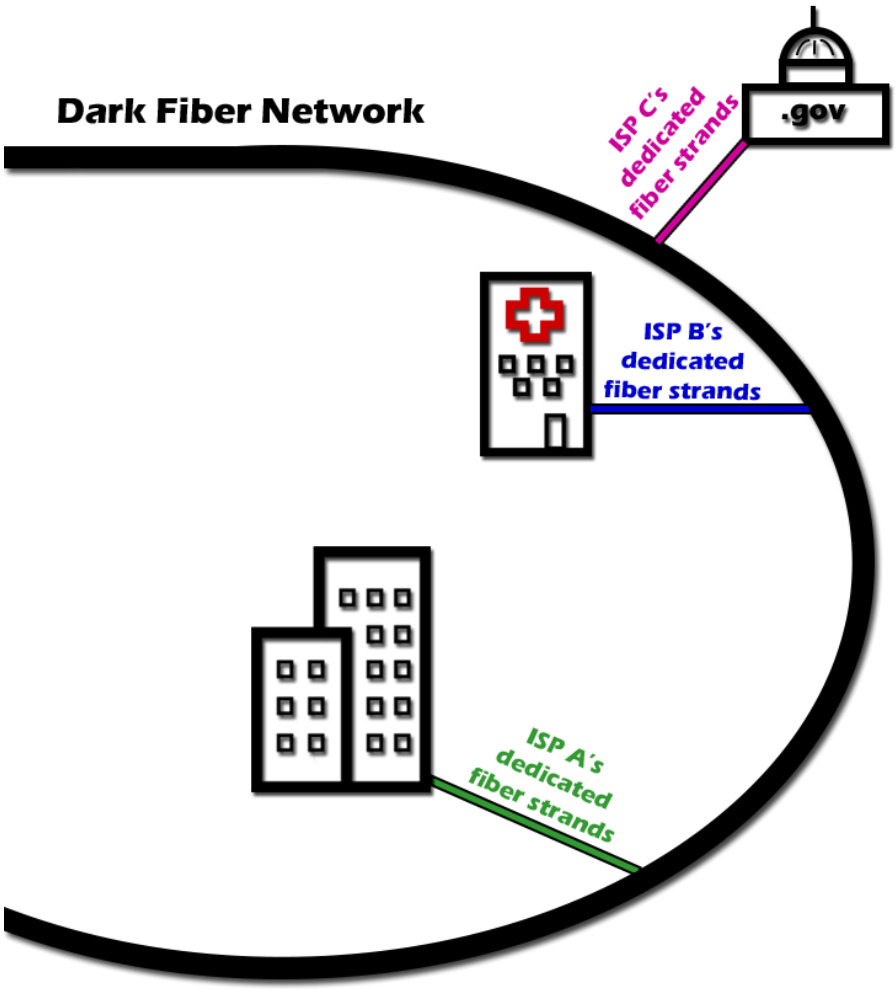
As a result, we believe that Boulder is likely to see the substantial benefits of competition from the development of a FTTP network to compete with Comcast and CenturyLink, even if open access over that network does not emerge.

5.2 Competition at the Dark Fiber Level

Dark fiber open access enables private providers to offer services without having to construct their own infrastructure. Instead, ISPs can enter into dark fiber lease or indefeasible right of use (IRU) agreements with the network owner, and the ISPs can then offer retail data, video, and voice services over the network.

In a dark fiber model, there is one fiber network infrastructure, and one or more ISPs pay the network owner for access to dedicated fiber strands that the ISPs can use at their discretion (see Figure 14).

Figure 14: Competition Over a Dark Fiber Network



This model requires each ISP to "light" the dark fiber by investing in network electronics to provide service over the network. While the cost to install electronics is a lower upfront capital investment than paying to deploy and maintain fiber, electronics costs are still a significant expense for an ISP. This is especially true given that the equipment the ISP owns must be replaced, multiple times over the lifetime of the dark fiber. Equipment may be refreshed every five, seven, or 10 years—and possibly more frequently, depending on advances in technology.

And the ISPs will face many other significant costs to compete in the market, even with access to ubiquitous dark fiber. For example, none of the traditional costs for billing, collections, marketing, and sales are removed by dark fiber access. Nor are costs for customer service. Further, this

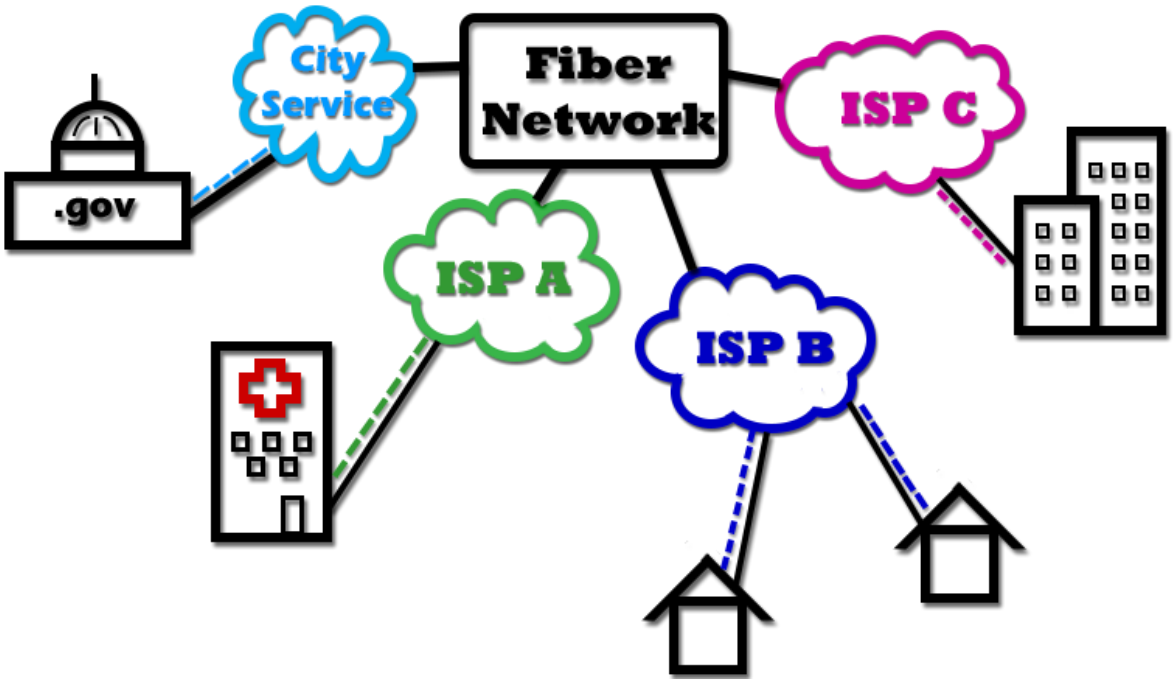
model may also require the ISP to pay some portion of the cost to install a fiber drop from the dark fiber network at the curb to the home or business of a potential customer it wishes to serve.

As a result, the ISP still has considerable costs to enter the market, thus making multiple-ISP competition at the dark fiber layer more challenging, particularly given that the market has a finite size and that each additional competitor is competing for the same set of customers currently served by the existing providers. For these reasons, we are not optimistic about the potential for multiple-ISP competition over dark fiber, at least in the short to medium-term. In the long run, the market is likely to change dramatically, however, and dark fiber open access could enable all kinds of new innovators to offer competitive services.

5.3 Competition at the "Lit" Services Level

Another option to enable competition is to allow ISPs to compete over a "lit" fiber network—this lowers the barriers to market entry by removing the cost of fiber, electronics, and maintenance, thus allowing more ISPs to compete in the marketplace. In this scenario, the network owner lights the fiber and ISPs compete at the virtual network layer instead of at the physical layer (see Figure 15).

Figure 15: Competition Over a Lit Network



In this model, consumers could hypothetically choose which service provider they want to engage by simply clicking a button on a Web interface from the comfort of their homes. The idea is that many ISPs will be able to compete to be a consumer's chosen service provider, and the ISPs can

enter the market without having to make large investments in fiber infrastructure or network electronics.

The underpinnings of the traditional open access model are a desire for competition and consumer choice. A lit services model can support both.

That said, it's important to note that even if the barriers to entry are reduced through this model, there is no guarantee that many new competitors will emerge in the near-term. Indeed, it may not make sense for smaller ISPs to operate in a market where there are several other competitors and where customer acquisition and retention costs are correspondingly high.

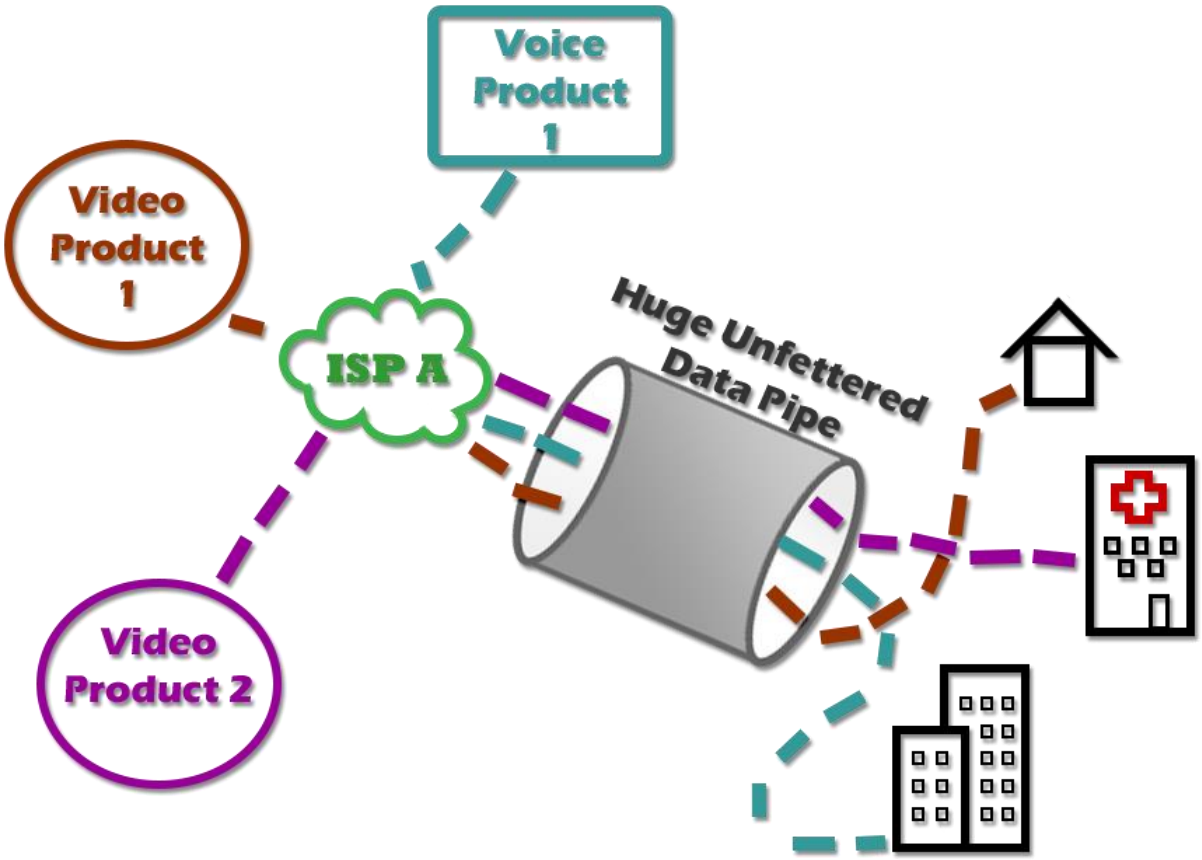
5.4 Over-the-Top Content Offers Service-Level Competition and a Variation on Open Access

Another way to potentially achieve the City's open access goals is to enable multiple over-the-top (OTT) providers to offer various services over a high-capacity data network. OTT content (typically video and voice) is delivered over the Internet by a third-party application or service that utilizes a robust, (ideally unfettered) data connection.

OTT content delivery is particularly effective over ultra-high-speed fiber optic broadband networks that are provisioned for affordable data service at 1 Gbps speeds and beyond, operated by service providers that do not put constraints on consumers' access to data. Such high-capacity networks can support a variety of OTT applications to meet consumers' needs. Consumers are likely to pursue alternatives to conventional video and voice services as additional and increasingly varied content becomes available OTT, and as access to high-speed data connections becomes more prominent and affordable.

A large, unfettered data connection can thus serve to meet the competition goals typically associated with open access networks.

Figure 16: Over-the-top Competition



As OTT programming and applications become increasingly prevalent, the need for traditional open access, which relies on access to infrastructure—and all the operational details and costs associated with it—is reduced. The City may find that it can achieve its open access goals of promoting competition and consumer choice through alternative means. If the City builds a ubiquitous network, and then partners with a private entity to manage operations and provide an unfettered data service, this introduces a new competitor into the market and drives competition at the applications layer.

5.5 Evolving Over-the-Top Providers

The concept of OTT or "value added" services took hold in the voice market first, as consumers sought alternatives to traditional landline service without being locked into long cell phone contracts—Voice over Internet Protocol (VoIP) providers offered a middle ground. VoIP providers like Vonage emerged in the early 2000s and continued to increase in popularity along with consumers' desire for greater choice. Prior to becoming the videoconferencing-focused service

it is today, Skype started with voice service that allowed consumers to make inexpensive or free calls domestically and internationally with their computer, a data connection, and a headset.[58]

Different OTT services have begun to emerge and evolve rapidly in the video market as consumers increasingly ditch cable service in favor of streaming video,[59] and providers clamor to compete with each other in response.[60] There are numerous established services and applications that will likely continue to promote change in the cable industry and drive an increase in consumers' desire for greater choice and control over how they access content. Standalone media-streaming boxes like Apple TV and Roku have enabled consumers to stream content with applications such as YouTube, Netflix, and Hulu without a cable subscription since 2008.[61,62] These "cord-cutters" cancel their cable subscriptions in favor of accessing their favorite content via applications and services streamed over the Internet—OTT content.

Since the debut of Apple TV and Roku, similar devices like the Amazon Fire TV stick and Google Chromecast have entered the market, allowing consumers greater choice. Further, consumers can now purchase smart TVs, which come with preinstalled platforms that support streaming applications and require no additional hardware. With only an Internet connection, consumers can stream movies, music, news, TV shows, movies, and even play games.

Some streaming video services strive to emulate cable television—without the hefty price tag, long contracts, and notoriously subpar customer service that traditional cable providers are known for.[63] Other services specialize in one type of content, like only offering documentaries or movies. The OTT video market has exploded in recent years as consumers continue to seek alternatives to traditional video services, and content providers nimbly adapt to consumer demand. Providers like Amazon, Hulu, and Netflix have continued to tailor their approach through efforts like creating original content to supplement traditional content offerings.[64] Such content easily rivals traditional television programming; some OTT provider original series have

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[58] Doug Aamoth, "A Brief History of Skype," *Time*, last modified May 10, 2011, http://techland.time.com/2011/05/10/a-brief-history-of-skype/2/.

[5959] http://www.consumerreports.org/cro/tvservices/more-people-are-cutting-the-pay-tv-cord, accessed April 2016.

[60] http://techcrunch.com/2016/05/02/hulu-to-compete-with-sling-tv-via-new-cable-tv-like-service/, accessed May 2016.

[61] http://www.apple.com/pr/library/2008/01/15Apple-Introduces-New-Apple-TV-Software-Lowers-Price-to-229.html, accessed January 2016.

[62] http://rokumodels.com/roku-models/first-generation-roku/, accessed January 2016.

[63] http://www.fool.com/investing/general/2015/06/03/comcast-time-warner-cable-still-rank-worst-in-cust.aspx, accessed January 2016.

[64] http://www.huffingtonpost.com/2014/01/18/netflix-hulu-amazon-prime-originals_n_4591418.html, accessed January 2016.

been nominated or won Critics' Choice, Emmy, Golden Globe, People's Choice, Screen Actors Guild, and other awards. Even tech giant Apple may begin producing original content.[65]

In 2015 alone, several companies began offering standalone streaming or providing access to content through new streaming services. HBO and Showtime both began offering access to their content through directly streaming via subscription service in 2015.[66,67] In addition to an ability to easily access sports programming, a desire for premium programming like HBO and Showtime has been a stubborn barrier to customers who want to eliminate their cable subscriptions (and to competitors that want to disrupt the market). Often, consumers would happily give up enormous cable bills in favor of more streamlined, inexpensive services—but they do not take the leap because they want specific programming that is only available with a cable subscription. It is significant when content powerhouses like HBO and Showtime take such an industry-disrupting leap.

Also in 2015, Verizon FiOS announced an "a la carte" offering called Custom TV, which allows consumers to choose from bundled packages that more appropriately reflect their programming desires and include less unwanted channels.[68] While this is not a true OTT application, it demonstrates a recognition within the incumbent market that consumers are dissatisfied with traditional content delivery and are seeking alternate choices.

As we noted, sports programming is a major barrier for many consumers who wish to cancel their cable subscription. Dish Network launched an OTT service in early 2015 called Sling TV that offers sports programming on channels such as ESPN, as well as other programming and popular TV channels. The service, called Sling TV, is streamed over the Internet.[69] Like other streaming services, Sling TV does not require additional hardware to access OTT content, including sports programming. Sling TV currently is priced at $20 per month with no time commitments, but it has experienced hiccups as its offerings are subject to limitations and restrictions that are reminiscent of traditional cable.[70] Traditional cable content providers' attempts at OTT service have seen varying degrees of success, but it is significant in the industry for these providers to even acknowledge the need for these services.

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[65] http://gizmodo.com/the-apple-original-content-rumor-is-back-1727863339, accessed January 2016.
[66] http://www.pcworld.com/article/2894534/hbo-announces-hbo-now-standalone-streaming-service-with-discounted-apple-tv.html, accessed January 2016.
[67] http://money.cnn.com/2015/07/07/media/showtime-streaming/, accessed January 2016.
[68] http://arstechnica.com/business/2015/04/verizons-new-custom-tv-is-small-step-toward-a-la-carte-pricing/, accessed January 2016.
[69] http://www.nytimes.com/2015/01/06/business/media/dish-network-announces-web-based-pay-tv-offering.html, accessed January 2016.
[70] http://www.pcworld.com/article/2909572/sling-tv-channel-guide-all-the-programming-and-all-the-restrictions-all-in-one-chart.html, accessed February 2016.

Companies that hope to compete in the video market will likely find that they must adjust their business models, marketing strategies, and understanding of consumer demands and desires. Perhaps one of the most significant illustrations of this is that, for the first time ever, Comcast's broadband subscribers outnumbered its cable subscribers in 2015—an unprecedented and major shift in the industry.[71] The City can essentially "court" OTT providers and promote these applications by requiring a public–private partnership's data-only offering to provide unfettered access. The City has already laid out unfettered access to data as a base requirement for any partnership agreement it enters. This can help the City achieve its goals of consumer choice and competition in the market without the need for traditional infrastructure-based open access.

[71] Emily Steel, "Internet Customers Surpass Cable Subscribers at Comcast," *The New York Times,* last modified May 4, 2015, http://www.nytimes.com/2015/05/05/business/media/comcasts-earnings-rise-10-driven-by-high-speed-internet.html?_r=0.

6 The RFI Process and Respondents

The City's RFI explicitly stated certain goals the City seeks through a partnership, and methodically requested detailed information from each respondent on how they would help the City achieve those by delivering:

- **Ubiquitous access to Gigabit broadband infrastructure:** The partnership will provide the infrastructure to enable every Boulder home, business, public or private institution the opportunity to access affordable high-speed broadband connections to the Internet and other networks
- **Open access:** The partnership will demonstrate, support, and build a non-discriminatory, open-access infrastructure that should, to the maximum extent possible, be open to all users, service providers, content providers, and application providers, and be usable via all standard commercial devices
- **A competitive local broadband marketplace:** The partnership will facilitate a local broadband marketplace that is as competitive as reasonably possible
- **Unfettered access:** The FTTP network will deliver a competitive unfettered data offering that does not impose caps on one use of data over another (i.e., does not limit streaming), and that enables all application providers (data, voice, video, cloud services) to provide services on equal footing

There were 12 total responses to the City's RFI, of which two were deemed noncompliant with the basic RFI response requirements. One of the remaining responses was from Boulder-based long-haul fiber provider Zayo Group, which does not deploy FTTP networks, but as a local partner to the City offered to be collaborative as the City moves forward with FTTP deployment.

Setting aside that response, the remaining nine responses were carefully vetted by CTC and City staff and stakeholders through a multi-step evaluation process.

6.1 Evaluating Responses to Develop a "Short List" of Potential Partners for Further Consideration

Each response was judged based on its compliance with the RFI requirements and how well the proposed partnership model would fit with the City's stated objectives. We summarized each response for the City, and developed additional mechanisms to guide the review process.

First, we created a scorecard tool that employed a simple pass/fail approach on basic elements of responses to establish the validity of each response. In addition to the pass/fail criteria, respondents were rated on a points system on adherence to stated response requirements:

- Business model meets City's goals and objectives
- Balance of risk and risk management

- Market experience and proposed services
- Technical experience
- Financing and funding
- Community experience
- Schedule
- Model experience
- Sustainability
- References

This tool assisted in quickly weeding out any noncompliant responses to avoid wasted effort on reviewing responses that do not meet the City's minimum guidelines for partnership. This tool also guided the in-person review process, during which City staff members met with CTC to review responses. The scorecard is a points-based review designed to help quantify some of the respondents' strengths and weaknesses, and drive the discussion between the City and CTC.

CTC also conducted a separate analysis to outline our understanding of each response to ensure that the larger group basically agreed on what each respondent's business model proposed. This analysis was a brief narrative of our understanding of each business model and a complementary response comparison chart. The response comparison chart sought to distill from the large responses the base model each respondent was offering, the potential financial structure of the proposed partnership, whether the respondent met the City's goals, and whether to consider pursuing a potential partnership discussion with the respondent.

The response comparison chart:

- Outlined each respondent's base model;
- Evaluated whether each response met City goals;
- Noted whether the respondent has completed a similar project in the U.S.;
- Analyzed the funding and financing aspects of the proposed partnership; and
- Recommended whether to advance each respondent to the next round of review.

Eventually, the City selected seven respondents for further evaluation, which included in-person meetings with City staff and CTC representatives (see Section 6.5). One of these potential partners did not respond to requests for further discussion and evaluation—thus, seven potential partners were added to the City's short list for further consideration. The following respondents participated in phone or in-person meetings to allow City and CTC representatives to further

evaluate whether a public–private partnership would be a comfortable match for a long-term relationship:

- Allo Communications (Allo)
- Axia FibreNet (Axia)
- Colorado Fiber Community (CFC)
- Macquarie Infrastructure Deployment (Macquarie)
- Si-Fi Networks (Si-Fi)
- Symmetrical Networks (Symmetrical)
- Ting Internet (Ting)

After additional review of each respondent's proposed business model, the City settled on three potential partners that would likely best meet the City's goals. They are:

- Allo Communications
- Axia FibreNet
- Ting Internet

In the following sections, we discuss the process that led to the City's choice to further explore a relationship with Allo, Axia, and Ting.

6.2 Partnership Models Proposed by Respondents

As we note in Appendix C, there are three basic types of partnerships emerging today:

- **Model 1 – Private risk, public facilitation**: The model focuses not on a public sector investment, but on modest measures the public sector can take to enable or encourage greater private sector investment.

- **Model 2 – Public risk, private execution:** This model, which involves a substantial amount of public investment, is a variation on the traditional municipal ownership model for broadband infrastructure—but with private rather than public sector execution.

- **Model 3 – Shared risk and investment:** In this model, localities and private partners find creative ways to share the capital, operating, and maintenance costs of a broadband network.

Debt service guarantees are also important to consider when evaluating potential public–private partnerships. A debt service guarantee is a backstop in case the network does not yield enough revenue to sustain itself.

Each of the emerging partnership models has merits and disadvantages, depending on what a locality finds most important and meaningful for its community. Based on our understanding of these approaches, Table 30 shows how each of the models fits with the City's goals.

Table 30: Comparison of Models Based on City Goals

Objective	Model 1	Model 2	Model 3
Ubiquity	Possibly	Yes	Yes
City Debt Service Guarantee	No	Yes (indirect)	Yes
City Control	No	Partial	Yes
Financial Risk to City	Negligible	Yes	Yes

In Model 1, there is no need for a debt service guarantee because the private partner is making its own investment with no City financial risk; the tradeoff is that the City has little control. The financial risk to the City in this model is negligible; there may be some cost associated with taking steps to facilitate private investment, such as discounted permit fees. But in this model the City does not directly seek financing, nor is it required to guarantee the financing that the private partner provides. A ubiquitous buildout may be possible in this model, depending on what the City is able to offer a partner to incite it to deploy citywide FTTP. The three finalist partners that are willing to significantly invest with City facilitation have indicated a willingness to consider a ubiquitous buildout—how and if this can be achieved will vary, and will be worked out in the details of negotiation.

In Model 2, the locality is often required to make a guaranteed payment (often referred to as a "anchor payment") to the private partner to cover the company's debt service, operating costs, and margin. In this model, there are other mechanisms (e.g., a utility fee applied to all property owners' tax bills) that theoretically provide revenue equal to the locality's guarantee, and minimize its risk—and enable revenue sharing between the City and its partner. Still, even if there is a mechanism for long-term revenues within the project to potentially offset public cost, the risk frequently will be on the public sector side if those revenues do not materialize. This model is attractive to some communities given the turnkey private financing, deployment, operations, and revenue-sharing solution it can offer. But the City has promising partners that seem willing and able to successfully carry out Model 1 or Model 3, which we believe are lower risk for the City. In light of this, the City opted to move forward only with potential partners whose business models fit in the Model 1 or Model 3 category (see Section 6.6).

In Model 3, the City finances the network and is directly responsible for debt service payments. But if there is an equitable balance of shared risk and reward between the City and its partner, guaranteed payments that flow between the two entities may be a necessary built-in part of the

agreement between the partners. The City takes significant financial risk in this model, but also has the greatest degree of control, and owns the fiber network.

Each of the RFI responses submitted a business plan that fit into one of these categories:

Table 31: Proposed Business Models Within Existing Partnership Models

Model 1 – Private Risk, Public Facilitation	Model 2 – Public Risk, Private Execution	Model 3 – Shared Risk and Investment
• Allo • Axia • Ting	• CFC • Macquarie • Symmetrical • Si-Fi	• Ting

6.3 Scoring Mechanisms to Determine Which Respondents to Evaluate Further

RFI respondents were evaluated based on a specific set of criteria within the RFI document and appendices (see this report's Appendix A), as well as additional criteria. These evaluations were conducted by City staff and CTC.

The initial review used a pass or fail approach to evaluate respondents on certain procedural criteria, such as whether the respondent followed all RFI instructions and submitted substantially complete copies of all required appendices and documentation. The scorecard also considered whether respondents' business models:

- Met the City's stated goals and objectives;
- Adequately balanced risk and risk management;
- Indicated sufficient technical expertise;
- Demonstrated market experience with model and services they proposed;
- Required substantial financial backing from the City;
- Adhered to the City's proposed timeline for deployment;
- Indicated that the respondent has successfully carried out this business model elsewhere in the U.S.;
- Demonstrated community experience, such as a history of supporting local economic and community development;
- Proposed to have a local company presence in Boulder;
- Appeared to be sustainable long term; and
- Provided references consistent with the City's request in the RFI.

6.4 Division of Shared Financial Responsibilities

In addition to evaluating respondents based on these criteria, the evaluation process considered in detail whether and to what degree the City would be required to provide financing. The

financial breakdown between a partner and the City is one of the most important components of a successful partnership, and the City and CTC sought to clearly understand what respondent proposed.

Some partnership models directly require the City to seek financing or otherwise fund the construction or other portions of the FTTP deployment. Model 3, specifically, directly requires a locality to invest in network infrastructure. In this model, the City would finance the construction of the fiber network, and the private partner would provide all the electronics to "light" the network. The cost to procure and manage network electronics is also a substantial investment, but one that is realized over a longer period of time than network construction, which requires a large upfront capital expenditure. In this model, the City owns the fiber asset. [72]

As we noted in Section 6.2, other proposed models also require substantial City risk and investment, but are less clear about the City's direct role, and the City does not own the infrastructure. In this model, the City is required to "guarantee" the debt through a backstop to ensure that the private partner can cover the debt service payments. Further, in this model the City does not have to bond, but the partnership financing will most likely be considered by auditors, state authorities, and the bond markets as counting against the public sector entity's borrowing capacity. Appendix C further details the nuances of current partnership models, including financial implications.

6.5 In-Person Meetings with RFI Respondents

A public–private partnership is a very long-term relationship between the City and its partner(s). While a relationship may appear attractive on paper, it is equally important to determine from further discussions with potential partners whether the relationship feels like a good fit. A successful public–private partnership depends on each party fulfilling its contractual obligations, and on positive interpersonal relationships between representatives from each entity.

Further, in-person meetings to determine whether a partnership makes sense are not wholly subjective. In many cases, a locality may require additional clarification on partnership parameters that are difficult to articulate in writing. For example, while a respondent may appear unwilling or unable to deploy an open access network, further discussions might reveal that the partner can provide some variation of open access, but is unable to do so at the infrastructure layer of the network. Although the RFI process was designed to capture as much information as possible to inform the City's next steps, in-person discussions go a long way toward clarifying a partner's position on certain items.

[72] Fiber drop cables may belong to the City, or the private partner may make that investment. The point of demarcation between where the City's and the partner's responsibility for ownership of infrastructure would be determined throughout the course of partnership negotiations.

Additionally, the technical, financial, and contractual parameters of a partnership are only one component of the relationship. It is difficult to quantify what exactly makes a relationship between two entities "good" outside a measurable framework, but it very important for a locality to take this step prior to executing a long-term contractual agreement.

The City and CTC met with representatives from Allo, Axia, CFC, Macquarie, Symmetrical, and Ting. These in-person meetings were held in Austin, Texas during the annual Broadband Communities Summit, an FTTP conference that is typically attended by industry experts, private and public providers, and public-sector representatives that are interested in deploying fiber networks.[73]

The City and CTC met before and after each meeting to discuss strategy, and to debrief about what was garnered from each in-person discussion with the respondents. The meetings were not a formal scoring process, but were an opportunity for City representatives to engage respondents on items of interest, and for each side to ask questions about the potential partnership. Each respondent the City met with was given the same opportunity to meet and allotted the same amount of time for discussion.

6.6 Elimination of Respondents That Propose Model 2

Our review ultimately indicated that Model 2 (where the City makes a substantial investment and takes significant risk but does not have as much control as in Model 3) is not a best fit for the City. In that model, the City would back financing obtained by a private partner—the same way a credit-worthy person might co-sign for a loan on a large purchase to secure the debt for a less credit-worthy individual. Consider a parent who co-signs on a loan for a vehicle for a young adult new to the workforce. While the latter is primarily responsible for payments, the former must cover any shortfall. We further discuss guaranteed payments in Appendix C.

In such a model, the City would be responsible for payments to the private partner if there were any shortages[74]—for example, if the take rate is not as high as anticipated, and revenues fall short of covering the debt service payments. If revenues cover debt service and there are funds leftover, the private partner would share these with the City. This model relies heavily on the private partner's willingness and ability to successfully market the retail product in Boulder, and obtain a sufficient take rate, which is the percentage of subscribers who purchase broadband service from the FTTP enterprise.

Such a financial risk with no municipal ownership of the network is not currently a viable option for the City. This model is sometimes attractive for communities that want to avoid the challenges

[73] "Summit," *Broadband Communities,* accessed May 3, 2016, http://www.bbcmag.com/2016s/.

[74] Some respondents require the City to guarantee an anchor payment, then offer a revenue share potential after certain "profitability" benchmarks are obtained.

of securing public financing, and where there is little interest from private companies to invest. But Boulder is a desirable community for private investment, and the City could seek to directly pay for the network if that meant also owning the asset. Further, given the additional RFI responses with alternative business models, we believe that the City is positioned to enter a partnership with a more equitable balance of risk and reward.

Note that we spoke with or met with representatives from CFC, Macquarie, Si-Fi, and Symmetrical to gather additional information on their responses and to ensure that we were clear about their proposed division of financial responsibilities.

6.6.1 Colorado Fiber Community

CFC is based in Sandy, Utah, and "is a coalition of companies that was formed in 2014 with the express intent of supporting public and public–private partnership broadband development efforts throughout the United States."[75] The coalition comprises several types of partners, and would rely on each of these companies to provide expertise in areas such as engineering and operations experience to successfully carry out the partnership. This is not necessarily a "bad" approach, but there are challenges unique to coordinating multiple partners on a project.

It was not immediately clear in the initial CFC response who would own the fiber network in a partnership. Based on our understanding after review and discussions with CFC, the "coalition" would own the network, though the City will be responsible for securing the financing, consistent with Model 2. While CFC does seem willing to meet the City's other goals and objectives, such a significant financial risk is not attractive to the City at this point.

6.6.2 Macquarie Infrastructure Development

Macquarie is based in Australia, though the representative we met with works from a U.S.-based satellite office in New York. The Macquarie model differs slightly from the CFC approach, but the end result for the City is basically the same: significant financial risk through providing a debt service guarantee.

This model relies on the City to make an availability payment, and suggests the City can either employ a "utility fee" or a "user fee" as a mechanism to enable this. The downside of a user fee-based model is that it relies on the partnership's ability to attract and retain users, and any shortfall is the City's responsibility. If marketing is not sufficiently robust, it can be challenging to meet these goals. Further, a user fee-based approach is inherently variable, and this gives the City little peace of mind that it will be able to consistently fund the availability payment.

[75] Based on the response CFC submitted.

The "utility fee" model is essentially a property tax model. That is, a fee is assessed on each parcel in the City to ensure that the availability payment is fully funded.[76] Such an approach is likely not politically palatable, and may be unpopular in the community. The one potential "benefit" to such an approach is that ubiquitous access is prioritized, meaning all premises are passed.

Through this model, Macquarie would contract with several ISPs, which would be obligated to offer a "free" 5 Megabits per second (Mbps) service to all residents and businesses. This model relies on "upselling," or convincing subscribers to buy a higher level of data service and/or voice and video service. The idea is that if subscribers experience the service firsthand, they are more likely to seek a higher level of service.

The potential downfall of this model is that 5 Mbps may be sufficient to meet many subscribers' needs, and the potential projected profit margins may not be enough to cover the costs that are passed to ISPs. Boulder may be a more feasible market than most to make an upsell approach work, but it is not guaranteed and this puts a major burden on ISPs, which are required to cover the cost of providing the base level service at no charge to the consumer. Further, if an ISP does manage to upsell, it is then required to give a portion of those revenues to the partnership.

Macquarie has not successfully carried out its proposed model with an FTTP network anywhere in the U.S. The company's current project with the Commonwealth of Kentucky is a middle-mile network, and not a good indicator of success or failure with an FTTP network.

6.6.3 Symmetrical Networks

Symmetrical Networks is based in Lake Oswego, Oregon, where it is in the process of attempting to deploy a fiber network through a relationship with the municipality; voters will ultimately decide in November 2016 whether the City should move forward with the partnership.[77]

Like CFC and Macquarie, the Symmetrical model relies on a financial backstop mechanism from the City. In the proposed Symmetrical business model, it will arrange to own, operate, and maintain the network for 30 years. The City is required to guarantee a minimum payment to Symmetrical, though the ISP payments to the City are expected to offset these payments, thus making the City "cash flow neutral."

Symmetrical also uses a Consumer Price Index (CPI) escalation on its payment structure (see Appendix C), which is problematic for the City. Unlike other potential partners that use market-based finance rates to determine guaranteed payments, Symmetrical uses a discounted finance

[76] There are potential legal ramifications to assessing what amounts to a property tax that should be reviewed by the City's legal counsel. CTC cannot provide legal advice.

[77] Anthony Macuk, "Lake Oswego voters will be asked to decide fiber network's fate in November," *Portland Tribune*, last modified March 16, 2016, http://portlandtribune.com/pt/9-news/298084-175530-lake-oswego-voters-will-be-asked-to-decide-fiber-networks-fate-in-november.

rate. This structure would ostensibly work toward ensuring the City was "cash flow neutral." This would require a heavily discounted rate, which does not seem feasible under the proposed business model in Boulder.

Unlike CFC and Macquarie, the Symmetrical response does not support open access in the traditional sense. Its response cites CTC's analysis that open access can be achieved through alternative means and does not require infrastructure-based open access (consistent with our analysis in Section 2 of this report). We do not believe that Symmetrical's inability to deploy a traditionally open access network is a reason to not consider it for partnership; as we have noted, there are alternative ways to meet the City's open access goals. However, in light of the division of financial risk and responsibilities, the City opted not to consider Symmetrical for further evaluation.

6.7 RFI Respondents' Adherence to City Objectives

We analyzed all of the RFI responses through a lens of the City's stated objectives, to determine whether each respondent could successfully help the City meet its goals. During the early stages of review, some potential partners adhered to the City's goals, but proposed a breakdown of financial responsibilities that would put significant risk and burden on the City. While this may be necessary in some markets, there were enough alternative business models proposed in Boulder that we were able to narrow down to the three finalists and determine how they fit with the City's objectives.

6.7.1 Allo Communications

Allo Communications is based in Lincoln, Nebraska, where it currently serves more than 350,000 customers. Allo operates FTTP networks in Nebraska, where it competes with cable and telephone providers to offer voice, video, and data service. The markets Allo currently serves are much smaller than Boulder, though it is currently building in Lincoln, Nebraska. Allo is particularly interested in deploying in University communities.

In its core proposed model, Allo would own and operate the network, and would seek support from the City in the form of expedited permitting and other avenues to make building and operating the network easier. Essentially, Allo proposed a 100 percent private risk and investment with City endorsement, or Model 1 (see Section 6.2).

Allo was recently acquired by Nelnet,[78] a private equity firm that began as a student loan servicing company.[79] In light of this, Allo has significant access to capital to invest in the way it appears to

[78] "About Allo Communications | Serving Western Nebraska," *Allo Communications*, accessed May 3, 2016, http://allocommunications.com/about/.
[79] "About Nelnet—Who We Are and What We Do," *Nelnet,* accessed April 18, 2016, https://www.nelnet.com/About-Nelnet/.

be interested in. While Allo is willing to consider a ubiquitous buildout in Boulder, it will not directly lease its fiber to competitors in the traditional open access model.

6.7.2 Axia FibreNet

Based in Calgary, Axia Broadband claims to operate FTTP networks in Asia, Europe, and the U.S. The only U.S.-based example is its partnership with Massachusetts Broadband Institute (MBI), where Axia manages and operates the network, known as MassBroadband 123. Axia manages the relationship with several ISPs to offer service to Community Anchor Institutions (CAIs) throughout the state of Massachusetts.

The nearly $90 million MassBroadband 123 project was possible through a combination of Broadband Technology Opportunities Program (BTOP) and public matching funds. That is, Axia did not make a private investment in the MassBroadband 123 project. Further, the network is primarily backbone and middle mile infrastructure, and is not an illustration of Axia's track record in the U.S. offering FTTP retail services.

Axia's proposed business model is private risk and investment with modest public facilitation, or Model 1. The base model requires a 40 percent citywide "Expression of Interest," at which point it would strive for a 90 percent market share. Using this model, Axia would rely on the City to help market services to obtain the take rates it believes are necessary to make the model work.

Axia prioritizes open access, and is willing to promote unfettered access to data, which meets the City's goals on those items and addresses competition in the marketplace. The company is in the process of being acquired by a private investment firm, which will mean access to significant new capital. Although Axia does not have a history of direct significant investment in FTTP, this acquisition could change that.

6.7.3 Ting Internet

Ting Internet, based in Toronto and a division of Tucows Internet, got its start offering mobile service, and announced in December 2014 that it would begin offering fiber-based Internet services in Charlottesville in a private investment model. Shortly after that announcement, the City of Westminster, Maryland announced a public–private partnership with Ting Fiber to deploy a citywide fiber network to offer services to Westminster residents. Ting is also following the private investment model in Holly Springs, North Carolina. Tucows is a publicly-traded company with sufficient access to capital.

In its RFI response, Ting proposed to act as both the network operator and the retail service provider, while the City would retain ownership of the fiber assets. In this "Model 3" scenario, as in Ting's approach in Westminster, Maryland, Ting would invest in all network electronics and manage the relationship with retail customers.

In subsequent verbal responses CTC, Ting representatives indicated that the company would also be willing to commit its own funds (Model 1), but would not commit to ubiquity or open access in that event. (That position may be open to negotiation.)

Ting's approach as proposed in its RFI response requires the City to directly finance the fiber network, which the City would then own. This does not mean that Ting has no financial responsibility; it must obtain financing for network electronics, and is responsible for marketing and operations costs. Further, Ting is willing to help the City cover its bond payments through a customer "lit" fees mechanism, or a per-subscriber fee. Each party in this agreement is responsible for securing its own financing, though Ting does offer to help the City offset its costs for debt service. Ting pays a lease payment to the City for use of City-owned fiber, plus potentially offer backstops for debt services obligations the City will incur.

The Ting model is not a traditional open access model, as it would be the only provider to offer services over the network for the duration of an agreed-upon period of exclusivity. However, it would be willing to share the network with other providers in later years. This approach fosters competition in the marketplace by bringing in another provider, but does not achieve the open access goals the City articulated in its RFI.

The potential partnership model that Ting proposes in its suggested business model offers true shared risk and shared investment from the private entity, unlike any of the other RFI responses. It is also the only respondent that has provided FTTP service in the U.S.

6.8 Conclusion

Each of the three finalist RFI respondents could bring a meaningful partnership to Boulder, and we believe the City would benefit from partnering with any of these entities.

Assuming that negotiations go well and that the companies are willing to commit to many of the offers they have made verbally, the City is well-positioned to secure private investment in FTTP and to realize the enormous benefits of FTTP without the financial risk of owning the network.

On the other hand, if the City is willing and able to make a significant investment, we believe that shared risk approach offered by Ting (and potentially by Axia) would truly meet all the City's objectives, including long-term control of the asset. Retaining ownership of the fiber mitigates the risk of long-term changes in the market and falling behind with respect to innovation. Indeed, owning assets is a way for communities to retain some control of the network, and to have some say in when, where, and how it is built. The City can balance risk and reward if it maintains ownership and control of the assets and assigns operational responsibilities (including the capital investment for network and consumer electronics) to the partner. This enables both the City and

its partner perform functions that highlight the strengths of each, and avoids having to expend resources and energy attempting to carry out tasks for which they are ill-equipped.

While it did not respond to the City's RFI, Google Fiber is another important competitor to consider in the context of public–private partnership. It announced in February 2016 that it will lease fiber from Huntsville Utilities (HU) and the City of Huntsville to offer ubiquitous gigabit services throughout Huntsville, Alabama.[80] This partnership is similar to the Ting model in Westminster though the payment terms are different; Google Fiber will use the fiber network that HU is constructing to offer retail services.

[80] "Google Fiber Blog: working with Huntsville to connect more people," *Google Fiber*, last modified February 22, 2016, http://googlefiberblog.blogspot.com/2016/02/huntsville.html.

Appendix A – Request for Information (RFI) for FTTP Network

City of Boulder

Request for Information

RFI No. 06-2016

Partnership for Deployment of Citywide Fiber to the Premises (FTTP)

Issue Date: **January 25, 2016**

Due Date: **February 25, 2016, 4 p.m. (Mountain Time)**

CITY OF BOULDER, COLORADO

NOTICE OF CALL FOR RESPONSES - RFI NO. 06-2016

CONSULTING/PROFESSIONAL SERVICES

The City of Boulder, Colorado, is seeking responses for:

Partnership for Deployment of Citywide Fiber to the Premises (FTTP)

In accordance with the specifications of the RFI, sealed responses will be received in the office of the Purchasing Coordinator until 4 P.M. Mountain Time, Friday, February 25, 2016. Late responses will not be considered.

A copy of this Request for Information (RFI) may be obtained from the Rocky Mountain e-Purchasing System website at:

www.rockymountainbidsystem.com

Sealed responses shall be plainly marked "RFI No. 06-2016, Partnership for Deployment of Citywide Fiber to the Premises (FTTP), 4 P.M., Friday, February 25, 2016". Responses can be mailed to:

Pam Andrus
City of Boulder – Purchasing Division
P.O. Box 791
Boulder, Colorado 80306-0791

Hand delivered responses or those not delivered by the USPS must be delivered to the office of the Purchasing Coordinator, 1777 Broadway, Boulder, Colorado 80302.

Responses shall be prepared at the bidder's expense and becomes a city record and therefore a public record. Any trade secrets, privileged information or confidential commercial or financial information that the bidder believes would not be subject to disclosure pursuant to the Colorado Open Records Act should be marked "Confidential" prior to submittal pursuant to the terms of the Mutual Non-Disclosure Agreement attached as Appendix B.

The services upon which responses are submitted shall equal or exceed the specifications outlined in the RFI. Preference is hereby given to labor, materials, supplies or provisions produced, manufactured or grown in Colorado, quality and price being equal to articles or services offered by competitors outside the State of Colorado.

Contents

I. Introduction 1
II. City Vision 2
III. Background: The City of Boulder 4
IV. Project Need 9
V. Project Goals 9
VI. General Network Design and Construction Parameters 10
VII. Contributions and Assets 12
VIII. RFI Response Requirements 12
IX. Administrative Information and Requirements 15
X. Personal Presentations 17
Appendix A: Responsibility Matrix 18
Appendix B: Mutual Non-Disclosure Agreement 19
Appendix C: Non-Collusion Affidavit Certificate 23
Appendix D: Survey Results – Community Interest in Broadband 24

I. Introduction

The City of Boulder (the "city") issues this Request for Information (RFI) for the purpose of gauging the interest of for-profit and nonprofit entities in forming potential public–private partnerships (PPP) with the city to make Gigabit per second-class bandwidth available to all Boulder homes and businesses. This initiative, which envisions a citywide fiber-to-the-premises (FTTP) deployment, will **enhance the broadband connectivity of the city's residents, businesses, and anchor institutions** by expanding the range and quality of available broadband and data transport services.

The city has initiated this RFI to identify one or more potential private partners to enable or directly provide high-capacity broadband services over fiber to end users within the city. The city seeks input from potential providers regarding the terms and conditions under which they would participate in such a project. **We are interested in providers who will use a fiber infrastructure to provide ubiquitous Gigabit per second-class broadband access.**

We seek successful respondents who will consider a variety of business models that share technological and operational responsibilities and financial risk between the successful respondent(s) and the city in innovative ways.

The goal of this project is to provision 21st century communications services to residents, businesses, and visitors. Broadband can enable communities otherwise at a disadvantage to participate on a more equal footing in the emerging global economy. The Internet can enable many types of businesses to locate anywhere—as long as there is enough bandwidth at an affordable price. High-tech firms and other companies that rely on high connection speeds will go where they can flourish. Residential rental property owners understand that many of their potential tenants require broadband for entertainment and to stay connected to their work. Broadband-enabled communities generally have higher property values, improved job creation and retention, and better quality of life.

Responses to this RFI should state how the respondent's approach will further the city's goals of attracting businesses, residents, and visitors, and encouraging economic vitality.

Boulder is already an attractive and thriving city; through this FTTP initiative, we seek to make Boulder an even more desirable place for visitors, businesses, and residents—who will see the quality-of-life benefits of broadband, both directly through home connections and through enhanced services provided by the business community.

We encourage respondents to share their expertise, which may be used to shape the direction and form of the network. Respondents may work together to respond to this RFI. The city is open to creative solutions that will maximize the efficiency of the investment while providing reliable and high-quality services to meet the needs of its citizens.

We welcome the responses of all respondents, including incumbent service providers, as well as competitive providers, nonprofit organizations, public cooperatives, and entities that are not traditional Internet service providers (ISPs) but are interested in offering service under innovative

business models. Nontraditional providers may respond as part of a partnership with an ISP, or may provide separate responses outlining their approaches.

The city will review and rank responses based on the successful respondents' experience, how well the responses address the city's objectives, how the proposed solutions balance and share risks and rewards, and other factors. Following the evaluation, the city may initiate negotiations with one or more respondents by providing more detailed information on available city assets and asking the selected respondent(s) to refine their responses. The city may also issue to selected respondents to this RFI a more detailed Request for Proposal (RFP) relating to the city-initiated project; may issue an open RFP relating to the city-initiated project; cancel or delay plans to obtain an FTTP network in the city; or choose another direction that is deemed in the community's best interest.

Responding to the RFI is not a guarantee of a contract award. Further, there is no guarantee an RFP will be developed as a result of this RFI. The city reserves the right to withdraw the RFI and/or any subsequent RFP, or decline to award a contract.

All respondents must complete all requirements specified in Section IX, complete the attached responsibility matrix (Appendix A), provide an executed non-disclosure agreement (Appendix B), and provide an executed non-collusion affidavit certificate (Attachment C). All responses must follow the format specified in the RFI instructions.

II. City Vision

Our vision is to provide a world-class community telecommunications infrastructure to Boulder for the 21st century and beyond, facilitated by newly available access to the public's local telecommunications assets. Boulder's citizens voted in 2014 to authorize the city to provide high-speed Internet services, thereby granting the city "autonomy for investing in community broadband services formerly limited by Colorado Senate Bill 152."[1] The vote passed by nearly 84 percent, and allows the city to leverage our assets to work with a successful respondent(s) to deliver service. Respondents are encouraged to review the city's comprehensive website for its broadband efforts at https://bouldercolorado.gov/connect-boulder.

We acknowledge that broadband is a critical service for quality of life, on par with roads, water, sewer, and electricity. Every home, business, nonprofit organization, government entity, and place of education should have the opportunity to connect affordably, easily, and securely. Boulder's broadband service will be shaped by the community's values.

We intend to empower our citizens and local businesses to be network economy producers, not just consumers of network information and data services. Further, we intend to provide our stakeholders with the broadband capacity, affordability, and local, regional, and national connectivity they need to compete successfully in the global marketplace.

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[1] "2C Ballot Information," *City of Boulder Colorado*, https://bouldercolorado.gov/connect-boulder/2c-ballot-information.

To reach these goals, we are seeking to work with the successful respondent(s) to deliver:

- **Ubiquitous access to Gigabit per second-class broadband infrastructure:** The partnership will provide the infrastructure to enable every Boulder home, business, visitor, and public or private institution the opportunity to access affordable high-speed broadband connections to the Internet and other networks
- **Open access:** The partnership will demonstrate, support, and build a non-discriminatory, open-access infrastructure that should, to the maximum extent possible, be open to all users, service providers, content providers, and application providers, and be usable via all standard commercial devices
- **A competitive local broadband marketplace:** The partnership will facilitate a local broadband marketplace that is as competitive as reasonably possible
- **Unfettered access:** The FTTP network will deliver competitive unfettered data offering that does not impose caps or usage limits on one use of data over another (i.e., does not limit streaming). All application providers (data, voice, video, cloud services) are equally able to provide their services, and the consumer's access to advanced data opens up the marketplace.

One of our key priorities is that *all* members of the community have access to broadband service. The network should be built everywhere with no redlining or "cherry picking"—building to the most traditionally affluent areas of a community where there is a higher likelihood of obtaining subscribers willing to pay for service, and thus seeing a return on capital investment. Citizens in low-income neighborhoods and housing developments are particularly vulnerable, and broadband is important to level the playing field. As the world becomes increasingly connected, broadband access is key to education, job training, and even access to one's own medical records.

We understand that ubiquitous access may seem implausible for some providers, and we are prepared to work with the successful respondent(s) to make this an attainable goal. Respondents that believe this goal to be a barrier to their ability to successfully partner with the city should clearly articulate their reasoning, and describe how they may provide a "good-enough" contingency plan for ubiquitous access. We stress that ubiquitous access is an important component of our vision, but the city is willing to consider creative alternatives to traditional ubiquity.

We envision significant progress toward an operational network in one to two years, with commitments from providers, community stakeholders, and regional partners, and a shared common vision to make Gigabit per second-class bandwidth available to all residents, workers, and visitors in Boulder.

The community interest in obtaining a Gbps service that meets the above goals was highlighted in a recent survey. Please see for Appendix D for additional details.

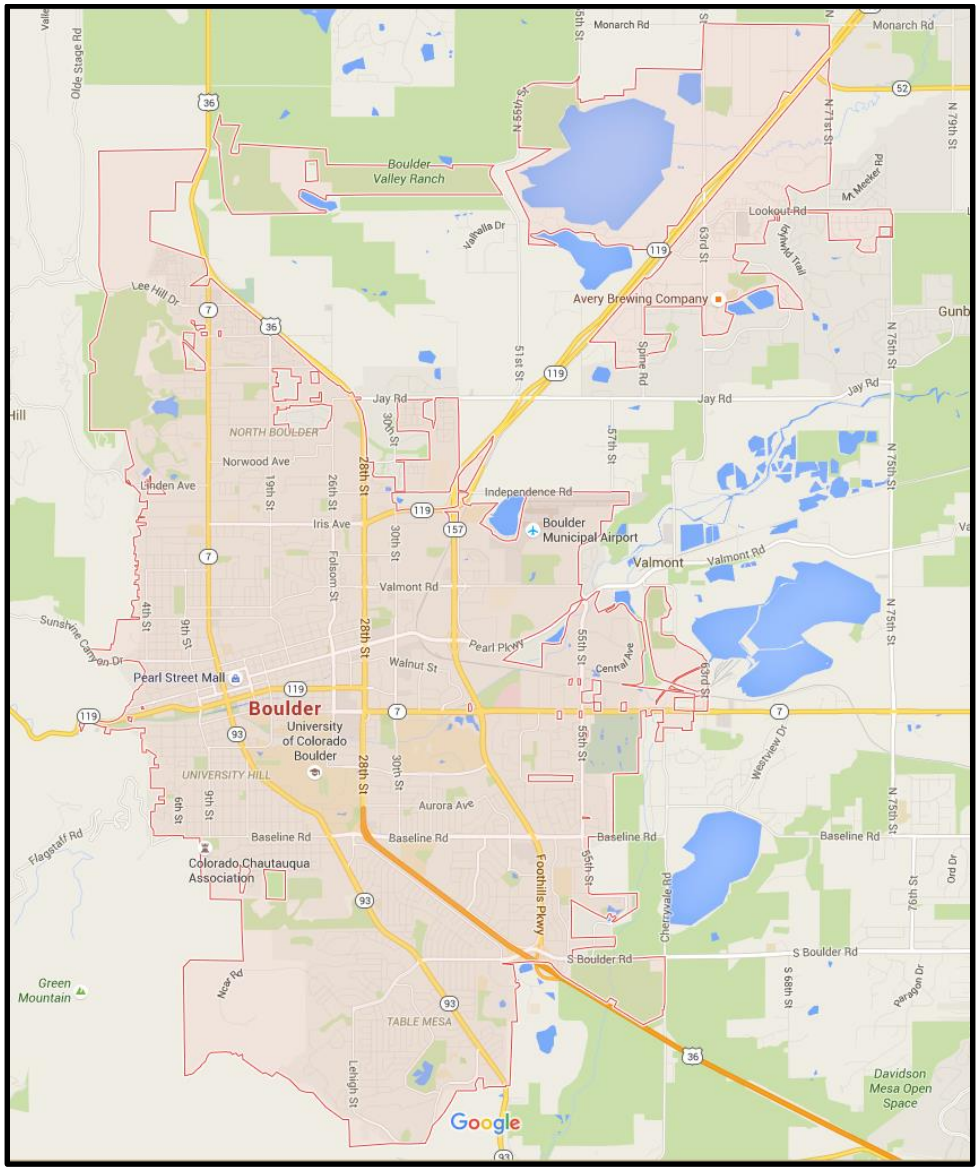
III. Background: The City of Boulder

Boulder is a thriving city at the base of the foothills of the Rocky Mountains. Located 25 miles northwest of Denver, it is the eleventh most populous city in Colorado, with a population of approximately 105,000 residing in roughly 43,500 housing units as of 2014.

The city is home to about 16,800 businesses,[2] supporting a diverse economy and a vibrant start-up community. With industries ranging from natural and organic products, clean-tech, biotech, and high-tech, to aerospace and federal laboratories, Boulder is a center of innovation and entrepreneurship. Owing in part to these diverse employers, Boulder's population spikes during the workday by more than 40 percent (43,900).[3]

[2] *United States Census Bureau*, "State & County QuickFacts: Boulder (city), Colorado," 2014 estimate, http://quickfacts.census.gov/qfd/states/08/0807850.html.
[3] *City-data.com*, "Boulder, Colorado," http://www.city-data.com/city/Boulder-Colorado.html#b#ixzz3rstPoY00.

Figure 1: Boulder and Surrounding Area



The city's largest employer is the Boulder Valley School District. Other leading employers include multinational technology and consulting corporation IBM; global health care product manufacturer Covidien; the international operator of one of the world's largest Internet backbones, Level 3; Ball Aerospace; Oracle; Walmart; Whole Foods; and Amgen.[4] Thanks to the contribution of these leading employers and others, the Boulder Metropolitan Statistical Area boasted a gross metropolitan product of $18.3 billion in 2010, making it the 110th largest

[4] Wallace, Alicia, "Top 50 employers in Boulder and Broomfield counties: IBM back on top," *Daily Camera*, July 26, 2010, http://www.dailycamera.com/ci_15589565.

metropolitan economy in the United States.[5] Boulder's thriving economy prompted *Forbes* magazine to identify the city as the best place in the United States to start a business in 2015.[6]

This moniker is well earned. In 2013, *Inc.* magazine declared, "Boulder is an entrepreneurial powerhouse like no other."[7] In another recent study, the city was found to have supported six times more high-tech start-ups per capita than the national average.[8] The city is among the top 20 most productive metropolitan areas in the nation,[9] with unemployment (3.5 percent) substantially lower than the national average (5.5 percent).[10]

The City of Boulder is frequently heralded as one of the most desirable places to live and work in the U.S., and it has been the recipient of a number of awards recognizing its community assets and quality of life. Notably, Boulder was identified as:

- One of the seven best cities in which to launch a startup in 2016[11]
- One of the best college towns in which to live (2015)[12]
- One of the 100 best places to live overall[13]
- Among the top 10 cities in the U.S. for small business friendliness[14]
- Among the best housing markets for growth and stability[15]

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[5] *Greyhill Advisors*, "Gross Metropolitan Product," 2010, http://greyhill.com/gross-metropolitan-product.
[6] Dill, Kathryn, "The Best Places for Starting a Business In 2015," *Forbes*, April 30, 2015, http://www.forbes.com/sites/kathryndill/2015/04/30/the-best-places-for-starting-a-business-in-2015/?utm_campaign=ForbesTech&utm_source=TWITTER&utm_medium=social&utm_channel=Technology&linkId=13888201.
[7] Helm, Burt, "How Boulder Became America's Startup Capital," *Inc.*, December 2013, http://www.inc.com/magazine/201312/boulder-colorado-fast-growing-business.html.
[8] Lindenstein, Joshua, "Boulder ranks 2nd, Fort Collins 6th on Most Innovative Tech Hubs list," *Boulderopolis*, http://boulderopolis.com/boulder-ranks-2nd-fort-collins-6th-on-most-innovative-tech-hubs-list/.
[9] Ibid.
[10] *United States Department of Labor, Bureau of Labor Statistics*, "Economy at a Glance: Boulder, CO," http://www.bls.gov/eag/eag.co_boulder_msa.htm#eag_co_boulder_msa1.f.2, with "Economy at a Glance: United States" (reporting May 2015 data), http://www.bls.gov/eag/eag.us.htm.
[11] Alton, Larry, "The 7 Best Cities to Launch a Startup in 2016," *Small Business Trends*, Nov. 15, 2015, http://smallbiztrends.com/2015/11/best-cities-to-launch-a-startup-2016.html.
[12] Wallace, Nick, "The Best College Towns to Live In," *SmartAsset*, October 19, 2015, https://smartasset.com/mortgage/best-college-towns-2015.
[13] Carmichael, Matt, "Why Boulder, Colo., Is a Top 100 Best Place to Live 2015," *Livability*, Sept. 15, 2014, http://www.livability.com/co/boulder/real-estate/why-boulder-colo-top-100-best-place-live-2015.
[14] Winkell, Vince, "Boulder ranks high in small business survey," *Longmont, Colorado Times-Call*, Aug. 18, 2015 (citing Thumbtack, Inc. survey), http://www.timescall.com/business/ci_28655753/boulder-ranks-high-small-business-survey.
[15] Garrison, Trey, "These are the 10 best housing markets for growth and stability," *HousingWire*, July 8, 2015 (citing SmartAsset data), http://www.housingwire.com/articles/print/34445-these-are-the-10-best-housing-markets-for-growth-and-stability.

Potential residents and business owners recognize Boulder's attributes—and the city's population is steadily increasing, with the city's growth (7.8 percent) more than double that of the U.S. as a whole (3.3 percent) from April 1, 2010 to July 1, 2014.[16] Moreover, Boulder's population is younger than the national average, owing in part to the large number of university students. The median age of Boulder residents was 28.7 years in 2010,[17] compared to 37.7 years nationwide.[18]

As the city continues to expand, its numerous local technical and scientific industries will likely also grow. Robust, citywide connectivity will support growth in new and bourgeoning high-tech industries. The expertise to advance these and other industries already exists in Boulder, and the city's goal is to nurture an environment conducive to further economic expansion.

The city has a number of communications service providers in the area, including Comcast, CenturyLink, MegaPath, Zayo (headquartered in Boulder), and Level 3. Per discussions with local businesses and residents, it appears that the local appetite and need for greater and more uniformly available broadband services both now and in the future cannot be met with current and projected service levels.

The educational needs of Boulder residents—from K–12 through higher education—are also a factor in the city's broadband goals. The Boulder Valley School District (BVSD) encompasses 56 schools, approximately 30,000 students, and more than 4,000 employees. BVSD supports a growing reliance on connectivity. The use of technology in the classroom and beyond is steadily increasing in the region. BVSD is implementing a one-to-one technology initiative, and ultimately plans to provide iPads to the youngest students and Chromebooks to all students from third grade through high school. The initiative was launched last fall with a pilot program at Centaurus High School, in which freshmen were issued their own Chromebooks for school and home use.[19] Over the past five years, BVSD has added roughly 10,000 Chromebooks and that number is expected to grow as the one-to-one program is fully implemented.[20]

Boulder is also home to several higher education institutions, including the University of Colorado Boulder, with 30,000 undergraduate students, 7,000 graduate students, and 10,000 staff and faculty members. Naropa University, a private university in Boulder, has approximately 400

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[16] *United States Census Bureau*, "QuickFacts Beta: United States: Boulder City, Colorado," http://www.census.gov/quickfacts/table/PST045214/00,0807850.
[17] *City-data.com*, "Boulder, Colorado," http://www.city-data.com/city/Boulder-Colorado.html#b.
[18] *Statista*, "Median age of the resident population of the United States from 1960 to 2014," http://www.statista.com/statistics/241494/median-age-of-the-us-population/.
[19] Bounds, Amy, "Local school districts using one-to-one technology to bring world to students," *Daily Camera: Boulder County News*, August 16, 2014, http://www.dailycamera.com/boulder-county-news/ci_26343916/local-school-districts-using-one-one-technology-bring.
[20] Bounds, Amy, "Boulder Valley adding bandwidth to accommodate tech usage at schools," *Daily Camera: Boulder County News,* July 8, 2015, http://www.dailycamera.com/boulder-county-schools/ci_28455505/boulder-valley-adding-bandwidth-accommodate-tech-usage-at.

undergraduate and more than 600 graduate students. World-class telecommunications infrastructure is needed to support these populations.

Boulder is also noted for its wealth and educational attainment, as reflected in the table below.

Table 1: Wealth Indicators, U.S. versus Boulder (2010–2014) [21, 22]

	United States	Boulder
Bachelor's Degree or Higher, Percent of Persons Age 25+	29.3%	71.5%
Median Value of Owner-Occupied Housing Units	$175,700	$499,200
Per Capita Annual Income (2014 dollars)	$28,555	$38,401
Median Household Income	$53,482	$92,951

[21] *United States Census Bureau*, "QuickFacts Beta: United States: Boulder City, Colorado," http://www.census.gov/quickfacts/table/PST045214/00,0807850 (visited Dec. 3, 2015).
[22] *"Demographic and Economic Data,"* Boulder Economic Council," http://boulderecon omiccouncil.org/boulder-economy/demographic-economic-data/ (visited January 18, 2016).

IV. Project Need

The City of Boulder, Colorado seeks a successful respondent(s) to operate fast, affordable broadband Internet and data services over publicly and/or privately constructed fiber optics to meet the city's broadband goals. City officials have prioritized pursuing the deployment of an FTTP network that will connect to every home and business and will:

1) Serve the growing demands in the private sector for affordable, reliable, and sophisticated broadband technology; and
2) Support a thriving business environment.

The city will consider a range of construction, operation, and ownership models for the FTTP network. The city and the selected successful respondent(s) will collaboratively determine the most mutually beneficial partnership structure, which may include cost-sharing, infrastructure leasing, and profit-sharing arrangements. The city is prepared to consider various business models, which could include, but are not limited to, the following scenarios:

- Private construction, operation, and maintenance of privately owned fiber optic infrastructure
- Public construction and private operation and maintenance of fiber optic infrastructure, and private operation of services over the public infrastructure
- Private provisioning of services over public infrastructure

The city will also consider any combination of these models as well as alternative suggestions proposed by respondents.

V. Project Goals

Respondents to this RFI should indicate whether and how their responses serve the city's goals:

1. Provide the infrastructure to every Boulder home, business, public facility, and private institution to enable residents, workers, and visitors the opportunity to access affordable, high-speed broadband connections to the Internet and other networks
2. Respond to the needs of Boulder's broadband user groups, including:
    a. Health care providers and patients
    b. The research and development community
    c. K–12 and higher-education institutions
    d. Large and small businesses
3. Offer non-discriminatory, open access to all users, service providers, content providers, and application providers connected to the citywide fiber network. Serving only limited areas of the city or specific types of customers is less desirable. Further, the network should be usable via all standards-based commercial devices.

4. Offer unique services and speeds not currently provided in the city (e.g., gigabit per second (Gbps) speeds, symmetrical services, services that continue operating when commercial power fails, service level agreements, and direct connectivity between locations on the network).

5. Consider innovative models, including, but not limited to:

    a. Leasing city-built and -owned dark fiber to provide services

    b. Partnering with the city to construct and operate an FTTP network

    c. Contracting with the city to manage and provide services on a fiber network built, owned, and operated by the city

6. Consider ways for the city and the successful respondent(s) to share financial and operational risks

7. Respond to the needs of the businesses connected to the fiber network

8. Provide cost-effective services for price-sensitive customers and flexible pricing plans to help narrow the digital divide and ensure access to all city residents

9. Facilitate a local broadband marketplace that is as competitive as reasonably possible

10. Provide stakeholders with the broadband capacity, affordability, and local, regional, and national connectivity they need to compete successfully in the global marketplace

For the network to have the intended economic and quality-of-life impacts, we consider both cost and availability of service to be important. We encourage responses that address both to maximize adoption of service.

All respondents must fully complete Appendix A, Appendix B (including two signed copies of the Mutual Non-Disclosure Agreement) Appendix C (including two signed copies of the Non-Collusion Affidavit Certificate) and fully comply with the instructions in Section VIII.

VI. General Network Design and Construction Parameters

Though the city is willing to consider all responses for partnerships, we prefer that the successful respondent(s) perform network construction and installation and that required city resources be minimal. Given that we expect the successful respondent(s)—and potentially subcontractors—to perform construction and installation, the city will dedicate resources to support its successful respondent(s) through plan review, coordination, and inspection services to assure an expedited approach to construction and installation in the public right-of-way and will work with the successful respondent(s) to facilitate work.

The city is seeking a successful respondent(s) willing to deliver game-changing services using a best-in-class technical approach, as defined below. Respondents are expected to base their design on a fully fiber-based architecture providing long-term scalability and reliability. It is important for broadband service to extend to new residents and businesses as Boulder continues

to grow in population, and network design and implementation should take these growth factors into consideration.

The following baseline technical attributes are preferred:

- Fully fiber-based connectivity to residential and business customers alike
- Fiber strand capacity capable of providing direct homerun connections to businesses and residential "power" users
- Fiber strand capacity and physical architecture (e.g., handhole placement, backbone routes, etc.) anticipating full deployment to all homes and businesses
- Fiber strand capacity to each customer that is sufficient to provide redundancy and support for future unknown applications, especially current and potential intensive city applications (e.g., smart grid)
- Low latency to reduce the number of hops to the Internet backbone
- Backbone topology capable of supporting connections over diverse paths from one or more central hub locations to fiber distribution cabinets distributed throughout the city to facilitate high-availability service offerings
- Fiber distribution plant placed in underground conduit (as opposed to direct burial cable) to more readily facilitate repairs and capacity upgrades
- Aerial fiber distribution plant constructed on utility poles where beneficial[23]
- Active components placed in environmentally hardened shelters and/or cabinets equipped with backup power generation and/or batteries, as appropriate, capable of sustaining services in the event of extended power outages
- Fiber path diversity to public facilities in order to maintain continuous service even if one path is broken
- Underground communications conduit pathways that can be utilized by the city for future scalability
- Fiber routes that are aligned with existing city conduit and coincide with planned city utility, roadway, and related capital improvement projects to reduce cost and minimize disruption where possible

[23] Xcel energy owns and operates the electric infrastructure in Boulder—the existing plant is 65 percent underground and 35 percent aerial.

VII. Contributions and Assets

While only at an early stage of defining its specific role in promoting enhanced broadband access for its businesses and residents, the city understands the critical role that broadband connectivity plays in its continued prosperity and quality of life for its residents. At this stage, the city itself does not wish to provide services to end users, but will work with the successful respondent(s) to help facilitate broadband deployment.

The city will work with the successful respondent(s) to facilitate the smoothest possible access in construction and installation of the network. Once we have selected the successful respondent(s), the city is prepared to promptly move forward with the partnership. An important component of any fiber build is franchising and permitting. As part of the partnership, the city will assign a point of contact (POC) for each successful respondent and/or its contractor(s), and commits to provide services to help prevent or lessen conflicts in the successful respondent's construction schedule.

For selected respondent(s) and under a non-disclosure agreement (Appendix B), the city will provide access to its GIS resources and, where available, access to existing conduit infrastructure. Map layers include but are not limited to traffic, sewer, water, and storm-drainage facilities. Conduit size and available capacity vary. The city has over 100 miles of existing fiber. Respondents may leverage this existing middle-mile fiber to provide an FTTP network for city residents and businesses.

Respondents should also identify any existing assets they may have in the Boulder area and how they intend to leverage those for this project. The successful respondent(s) may be asked to pay franchise fees to the city and pole attachment fees to the appropriate utility. Respondents should consider whether they propose to offset the fees with in-kind contributions, including conduit and dark fiber.

VIII. RFI Response Requirements

The City of Boulder requests the following information—in concise and clear detail—from respondents. **All responses must adhere to the following response requirements and page requirements.** All responses must follow the exact order below and use the appropriate response headers. Start a new page for each response header. All responses must adhere to 1" margins and use 12-point Times New Roman font. Failure to follow these instructions may result in rejection of the response.

We do expect that each response is likely to take some exceptions to the project goals and requirements listed above (Sections V and VI).

1. **Cover Letter:** Please include company name, address of corporate headquarters, address of nearest local office, contact name for response, and that person's contact information (address, phone, cell, email, other). Keep response to one (1) page.

2. **Business Model Summary:** Summarize the business model you intend to use for the partnership. This should be a concise explanation of the key components of your business model, including but not limited to the division of network and operations responsibility and ownership. Keep response to two (2) pages.

3. **Affirmation:** Affirm that you are interested in this partnership and address the core project goals and requirements listed above (Sections V and VI). If you cannot meet any of those requirements, indicate the requirements to which you take exception, and provide an explanation of the exceptions. Keep response to no more than two (2) pages.

4. **Experience:** Provide a statement of experience discussing your firm's past performance, capabilities, and qualifications. Identify other networks your firm has designed, built, maintained, or operated; include the levels of broadband speed, availability, and adoption among different categories of end users and unique capabilities or attributes. Discuss partnerships with other service providers, government, or nonprofit entities you have undertaken, particularly any involving dark fiber leasing. Describe the nature of the projects and your firm's role. For entities currently providing communication services in or near Boulder, describe your current service footprint in the city, including a description of the type of infrastructure and services you currently offer and the technology platform(s) used. Explain how your firm is a suitable respondent for this project. Keep response to no more than three (3) pages.

5. **Technical and Operations:** At a high level, summarize the technological and operational approach you would use for this project.

    a. How would you use technology to meet the city's goals? Keep response to one (1) page.
    b. What approach would you use to interconnect with the Internet and other public networks? Keep response to one (1) page.
    c. How would you perform network management? Keep response to one (1) page.
    d. Under what scenarios would you require route diversity or other special features in the city fiber? At what sort of facility (or facilities) would you place network electronics? Keep response to one (1) page.
    e. Provide a proposed network diagram. Keep response to one (1) page.

6. **Business Structure:** Summarize the business approach you would use for the project. How would your business plan help to meet the city's goals? What are the key assumptions? What are your main areas of risk, and how can the city help reduce the risks? What are the city's main areas of risk, and how can you help reduce the risks? Keep response to no more than three (3) pages. Also complete Appendix A to clarify areas of responsibility.

7. **Open Access:** If you currently operate communications facilities, indicate whether they are operated on an open-access basis. Describe whether and, if so, how you would support open access to infrastructure in the city. Keep response to one (1) page.

8. **Unfettered Access:** Describe what technical and practical solutions you will provide to prioritize unfettered data access. Keep response to one (1) page.

9. **Competitive Marketplace:** Explain how your business structure and partnership plan will create a competitive local broadband marketplace, consistent with the city's vision and goals for the partnership. Keep response to one (1) page.

10. **Schedule:** Describe your proposed schedule for implementing service. Offer a timeline with key milestones. Would you be able to begin service before the entire network is constructed? Are there areas of the city you would recommend be constructed first? Keep response to two (2) pages (one page for response, one page for schedule).

11. **Ubiquitous Access:** Explain how your business plan and schedule for network construction and service implementation will support the city's vision of ubiquitous access to Gigabit per second-class broadband infrastructure. Keep response to one (1) page.

12. **Maintenance:** If you are proposing to perform fiber network maintenance, describe your ability to perform maintenance on an ongoing and as-needed basis. If you are not performing maintenance, who is? Keep response to one (1) page.

13. **Privacy:** Describe your ability to provide secure network service or infrastructure that complies with public safety and other security and privacy regulations and requirements. Also, please describe how you will protect the privacy of network users—an extremely important issue for providers today. Keep response to a maximum of two (2) pages.

14. **Financing and Funding:** List any requirements the city must meet for you to partner with the city on this project.

    a. What, if any, financial requirements do you have of the city in order to enter into a partnership?
    b. How do you propose to finance the network build-out?
        i. If you intend to borrow funds, how will those monies be secured, and by whom? (Financing is any borrowing required.)
    c. How is the project funded? (Funding is the cash flow that includes investment funds, subscriber revenues, taxes, or other sources that are used to cover operation, maintenance, debt service, and other expenses.)

d. Please provide a one-page flow chart that shows the flow of funds between all parties in your response. Include all sources and uses of funds.

If you intend to provide financing directly or through a third-party partner, please indicate how these funds will be secured. While third-party financing options may not require the city to directly bond through a public approval process, this form of financing still impacts the city's borrowing capacity and its credit rating.

If your response does not address this question regarding financial requirements, we will assume that you are interested in the partnership but have no financial requirements whatsoever of the city. Please keep response to no more than three (3) pages, plus the one-page flowchart.

15. **Services:** Describe the service options you plan to offer over this network (for example, data only; voice and data; a triple play of voice, data, and cable television; etc.). What download/upload or symmetrical speeds would you offer and guarantee to end users? How will your residential and business offerings differ? What types of service level agreements (for lit services: availability, packet delivery, packet loss, latency, jitter, and other; for dark fiber: repair time, other) would you be prepared to offer? If you plan to use the city fiber, what types of service level agreements would you need? Keep response to two (2) pages.

16. **Pricing:** Provide your approach to pricing the proposed services. For managed services, please describe factors impacting non-recurring costs (estimated fiber path distances, equipment redundancy, etc.); recurring costs for varying capacity levels; and any key technical assumptions upon which prices are based. For dark fiber offerings, please describe desired pricing models. Keep response to two (2) pages.

17. **Local Participation and Economic Vitality:** Provide a statement of how your proposed participation would help the city's economic vitality goals. Describe your interests and plans to hire local contractors and providers in the City of Boulder, and how your participation would help local job creation. Describe your relationships with local businesses in the city, if any, as well as your interest and plans to engage them in this project. Keep response to no more than three (3) pages.

18. **References:** Provide a minimum of three (3) references, including contact information, from previous contracts or partnerships. Keep response to two (2) pages.

IX. Administrative Information and Requirements

1. **RFI Official Contact:** Upon release of this RFI, all vendor communications should be directed to the RFI Coordinator listed below. Unauthorized contact regarding this RFI with other city employees may result in disqualification. Any oral communications will be considered unofficial and non-binding on the city. Vendors should rely only on

written statements issued by the RFI Coordinator.

Name: RFI Coordinator
Don Ingle, Director of IT

Address: City of Boulder
Information Technology
3065 Center Green Drive, 2nd Floor
Boulder, Colorado 80301

Telephone: 303.441.4183

E-mail: ingled@bouldercolorado.gov

2. **Schedule:** The schedule for this project is as follows:

Note: The city reserves the right to adjust this schedule as necessary.

Milestone	Date
Release RFI to Vendors	January 25, 2016
Vendor Questions (if any) Due	February 10, 2016
Answers to RFI Questions Released	February 15, 2016
Responses Due	February 25, 2016

3. **Questions Regarding This RFI:** Vendors who request clarification of the RFI's requirements may submit written questions to the RFI Coordinator by 4 p.m. (Mountain Time) on February 10, 2016. An email attachment sent to ingled@bouldercolorado.gov is preferred. The compiled questions and answers will be included in an addendum that will be posted on the Rocky Mountain e-Purchasing System by 5 p.m. (Mountain Time) on February 15, 2016.

4. **Response Preparation:** Please prepare RFI response in PDF and Excel (Appendix A) format. All responses must adhere to instructions in Section VIII, including all formatting requirements.

5. **Response Submission:** The following provides specific instructions for submitting your sealed response.

Due Date:	***Sealed Responses must be received by the Purchasing Coordinator no later than February 25, 2016, at 4 p.m. (Mountain Time).*** Sealed responses shall be plainly marked

	"RFI No. 06-2016, Partnership for Deployment of Citywide Fiber to the Premises (FTTP)". Late responses will not be accepted nor will additional time be granted to a specific vendor. All responses and accompanying documentation will become the property of the city and will not be returned.
Number of Copies:	A total of two (2) paper copies and an electronic copy (CD or thumb drive) of the vendor's response, in its entirety, must be received as specified above. The city will **not** accept facsimiles.
Address for Submission:	Mailed Responses: Pam Andrus City of Boulder – Purchasing Division Attn: RFI No. 06-2016 P.O. Box 791 Boulder, Colorado 80306-0791 Hand delivered responses: Office of the Purchasing Coordinator Attn: RFI No. 06-2016 1777 Broadway Boulder, Colorado 80302

6. **Mutual Non-Disclosure Agreement:** Respondents much complete and attach two signed copies of the Mutual Non-Disclosure Agreement included as Appendix B.

7. **Non-Collusion Affidavit Certificate:** Respondents much complete and attach two signed copies of the Non-Collusion Affidavit Certificate included as Appendix C.

X. Personal Presentations

At its discretion, the city may request that vendors and other parties that provide a timely response to this RFI make an individual and personal presentation to better explain information or solutions identified in the RFI. These presentations, if requested by the city, shall be held at a time and place of mutual convenience.

Appendix A: Responsibility Matrix

Appendix A is included as a separate file.

Note that Appendix A ***must*** be submitted in its native Microsoft Excel format. Failure to follow submission instructions may result in rejection of the response.

Appendix B: Mutual Non-Disclosure Agreement

Please provide two signed copies of the following Mutual Non-Disclosure Agreement.

MUTUAL NON-DISCLOSURE AGREEMENT

THIS MUTUAL NON-DISCLOSURE AGREEMENT (this "Agreement"), effective as of the ____ day of _____ 2016, is between the City of Boulder, a Colorado home rule municipal corporation (the "City"), and _____ ("Vendor"). The City and Vendor may hereinafter be referred to individually as a "Party" or collectively as the "Parties."

WHEREAS, Vendor and the City are involved in telecommunications-related design projects (the "Purpose"); and

WHEREAS, in the course of negotiations or communications, each Party may disclose to and/or receive from the other Party certain information belonging to the disclosing Party or its affiliates (collectively, the "Discloser") that includes trade secrets, privileged information, or confidential commercial, financial, geological, or geophysical data, including insurance policies and social security numbers ("Confidential Information");

NOW, THEREFORE, in consideration of the foregoing and of the mutual covenants and promises set forth herein and for other good and valuable consideration, the receipt and sufficiency of which are hereby acknowledged, the Parties agree as follows:

1. Records maintained by the City are subject to public disclosure pursuant to the Colorado Open Records Act ("CORA"). Certain confidential business records are exempt. If Vendor provides to the City documents that include trade secrets, privileged information, or confidential commercial, financial, geological, or geophysical data, including insurance policies or social security numbers, Vendor shall segregate any documents including such information from other documents provided to the City and shall clearly identify such documents with a stamp, watermark or other clear mark identifying the documents as confidential pursuant to CORA.

2. The Party receiving Confidential Information (the "Recipient") (i) shall use such Confidential Information only for the Purpose; (ii) shall reproduce such Confidential Information only to the extent necessary for the Purpose; (iii) shall restrict disclosure of such Confidential Information to its, and its affiliates', employees and agents who need to know such Confidential Information to carry out the Purpose and who are not direct competitors of the Discloser (and require such employees and agents to undertake confidentiality and use obligations at least as restrictive as those Recipient assumes herein); (iv) shall not disclose such Confidential Information to any other Party without prior written approval of Discloser; and (v) shall protect such Confidential Information with at least the same degree of care as it normally exercises to protect its own proprietary information of a similar nature, which shall be no less than reasonable care. If Recipient discloses Confidential Information to an employee, affiliate, or other person in accordance with the terms of this Agreement, any subsequent disclosure or use of such Confidential Information by such employee, affiliate, or other person shall be deemed a disclosure or use by Recipient and Recipient shall be responsible for such disclosure or use. The Recipient shall immediately notify the Discloser upon the discovery of any loss or unauthorized disclosure or use of the Confidential Information of the Discloser.

3. The restrictions on use and disclosure of Confidential Information shall not apply unless such Confidential Information, when in tangible, electronic or viewable form is marked confidential or proprietary by Discloser, or when disclosed only orally is both identified as confidential or proprietary at the time of disclosure and summarized in a writing so marked and provided to Recipient within thirty (30) days following the oral disclosure; except that any unmarked material and any verbally disclosed information that Recipient knows or reasonably should know to contain Confidential Information of the

Discloser, including but not limited to business or technical information not generally known to the public, such as patents, copyrights, trademarks and trade secrets, as well as all written or oral pricing and contract proposals exchanged between the Parties shall be subject to the use and disclosure restrictions of this Agreement. Within the 30-day period referenced above, all Confidential Information communicated only orally shall be subject to the use and disclosure restrictions of this Agreement.

4. The restrictions on the use or disclosure of Confidential Information shall not apply to any information:
   a. Which is independently developed by the Recipient as evidenced by documentation in such Party's possession; or
   b. Which is lawfully received from another source free of restriction and without breach of this Agreement by the Recipient; or
   c. After it has become generally available to the public without breach of this Agreement by the Recipient; or
   d. Which at the time of disclosure to the Recipient was known to the Recipient free of restriction as evidenced by documentation in such Party's possession; or
   e. Which the Discloser agrees in writing is free of such restrictions.

5. All Confidential Information shall remain the exclusive property of the Discloser, and no license under any intellectual property right is either granted or implied by this Agreement or the conveying of Confidential Information to Recipient hereunder. Discloser makes no representations, warranties, assurances, guarantees or inducements of any kind, and, in particular, with respect to the non-infringement of any intellectual property rights, or other rights of third persons or of Discloser.

6. Neither this Agreement nor the disclosure or receipt of Confidential Information hereunder shall constitute or imply any promise or intention by either Party to enter into any transaction or business relationship, nor is it an inducement for either Party or its affiliated companies to spend funds or resources or purchase or provide products or services, nor is it any commitment by either Party or its affiliated companies with respect to the present or future marketing of any product or service. No such agreement will be binding unless and until stated in a separate writing signed by authorized representatives of both Parties.

7. Each Party agrees not to announce or disclose to any other person (other than persons described in Section 1(iii), above) the Confidential Information or the nature of any discussions concerning the Purpose without first securing the prior written approval of the other Party. All Confidential Information furnished hereunder shall be returned or destroyed upon written request or upon Recipient's determination that it no longer has a need for such Confidential Information, except that Recipient's legal counsel may retain one copy in counsel's files solely to provide a record of such Confidential Information for archival purposes.

8. The restrictions on use and disclosure of Confidential Information disclosed hereunder shall survive for a period of three (3) years from the date of last disclosure of any such Confidential Information (except in the case of software, for an indefinite period). Either Party may terminate this Agreement upon thirty (30) days advance written notice to the other.

9. All notices or communications required or permitted as a part of this Agreement shall be in writing (unless another verifiable medium is expressly authorized) and shall be deemed delivered when:
   A. actually received,
   B. upon receipt by sender of a certified mail, return receipt signed by an employee or agent of the Party,
   C. upon receipt by sender of proof of email receipt, or
   D. if not actually received, ten (10) days after deposit with the United States Postal Service authorized mail center with proper postage (certified mail, return receipt requested) affixed and addressed to the respective other party at the address set forth in this Agreement or such other address as the Party may have designated by notice or Agreement amendment to the other Party.

The consequences of failure to receive a notice due to improper notification by the intended Recipient of a new address will be borne by the intended Recipient. The addresses of the Parties to this Agreement are as follows:

<Vendor Name>	City of Boulder
<Vendor Address Line 1>	1777 Broadway
<Vendor Address Line 2>	Boulder, CO 80302
Attention: Project Manager	Attention: Project Manager

10. This Agreement shall not be construed to limit either Party's right to independently develop or acquire products or services without use of the other Party's Confidential Information.

11. The restrictions on disclosure of Confidential Information under this Agreement shall not preclude Recipient, on the advice of counsel, from complying with applicable law, regulation, other governmental requirement or other demand under lawful process, including a discovery request in a civil litigation, if Recipient first gives Discloser notice of the required disclosure and cooperates with Discloser, at Discloser's expense, in seeking reasonable protective arrangements. In no event shall Recipient be required to take any action which, on the advice of Recipient's counsel, could result in the imposition of any sanctions or other penalties by a court or government body.

12. Neither Party has any obligation to disclose Confidential Information to the other. Either Party may, at any time: (i) cease giving Confidential Information to the other Party without any liability, or (ii) request in writing return of Confidential Information previously disclosed.

13. Recipient acknowledges that Confidential Information provided under this Agreement may be subject to U.S. export laws or regulations. Recipient shall not use, distribute, transfer or transmit Confidential Information (even if incorporated into products, software or other information) except in compliance with such laws and regulations. If requested, Recipient shall sign written assurances and other export-related documents as may be required to comply with such laws or regulations.

14. Each Party agrees that all of its obligations undertaken herein as Recipient shall survive and continue after any termination of this Agreement, subject to Section 8 above.

15. No amendment or modification of this Agreement shall be valid or binding on the Parties unless made in writing and signed by duly authorized representatives of each Party.

16. Subject to the limitations set forth in this Agreement, this Agreement will inure to the benefit of and be binding upon the Parties. This Agreement may not be assigned by one Party without the other Party's prior written consent.

17. If any provision of this Agreement shall be held by a court of competent jurisdiction to be illegal, invalid or unenforceable, the remaining provisions shall remain in full force and effect to the greatest extent permitted by law.

18. No forbearance, failure or delay in exercising any right, power or privilege is waiver thereof, nor does any single or partial exercise thereof preclude any other or future exercise thereof, or the exercise of any other right, power or privilege. This Agreement is binding upon and inures to the benefit of the Parties and their heirs, executors, legal and personal representatives, successors and assigns, as the case may be.

19. This Agreement shall be governed by the laws of the State of Colorado, U.S.A., without regard to its conflicts of law principles. Each Party acknowledges and agrees that a breach by it or one of its affiliates, employees or representatives of any of the covenants set forth in this Agreement will cause irreparable injury to the other Party and its business for which damages, even if available, will not constitute an adequate remedy. Accordingly, each Party, for itself and its affiliates, employees and representatives, agrees that the other Party, in addition to any other remedy available at law or in equity, shall be entitled

to the issuance of injunctive relief (including, without limitation, specific performance) by a court of competent jurisdiction in order to enforce the covenants and agreements contained herein.

20. Any judicial proceeding brought by or against any of the Parties on any dispute arising out of this Agreement or any matter related hereto shall be brought exclusively in the state district court sitting in Boulder County, Colorado, and by execution and delivery of this Agreement, each of the Parties accepts for itself the exclusive jurisdiction and venue of the aforesaid court as trial courts. Each Party expressly waives any objection (including, without limitation, objections based on *forum non conveniens*) which any Party may have now or hereafter to the laying of venue or to the jurisdiction of any such suit, action, or proceeding, and irrevocably submits generally and unconditionally to the jurisdiction of any such court in any such suit, action, or proceeding. Each Party agrees that its attorneys shall accept service of process.

21. This Agreement constitutes the entire understanding between the Parties as to the treatment of Confidential Information disclosed for the Purpose and merges all prior discussion between them relating thereto. Each Party has read this Agreement, understands it and agrees to be bound by its terms and conditions. This Agreement may be executed in counterparts, each of which shall be deemed an original, but all of which taken together shall constitute one single agreement between the Parties. Signatures exchanged by facsimile or other electronic means are effective for all purposes hereunder to the same extent as original signatures.

IN WITNESS WHEREOF, the Parties have executed this Agreement as of the date first set forth above.

_____	**City of Boulder, Colorado**
By: _____	By: _____
_____ (Typed or printed name)	_____ (Typed or printed name)
_____ (Title)	_____ (Title)

Appendix C: Non-Collusion Affidavit Certificate

Please provide two signed copies of the following Non-Collusion Affidavit Certificate.

NON-COLLUSION AFFIDAVIT CERTIFICATE

STATE OF _____)

ss.

COUNTY OF _____)

The undersigned, being duly sworn, deposes and says that the person, firm, association, co-partnership or corporation herein named, has not, either directly or indirectly, entered into any agreement, participated in any collusion, or otherwise taken any action in restraint of free competitive bidding in the preparation and submission of a response to the City of Boulder for consideration in the award of a contract on the improvement described as follows:

Partnership for Deployment of Citywide Fiber to the Premises (FTTP)

_____

(Firm Name)

By: _____
(Authorized Signature)

Title _____

Sworn to before me this day of , .

Notary Public

CORPORATE SEAL:

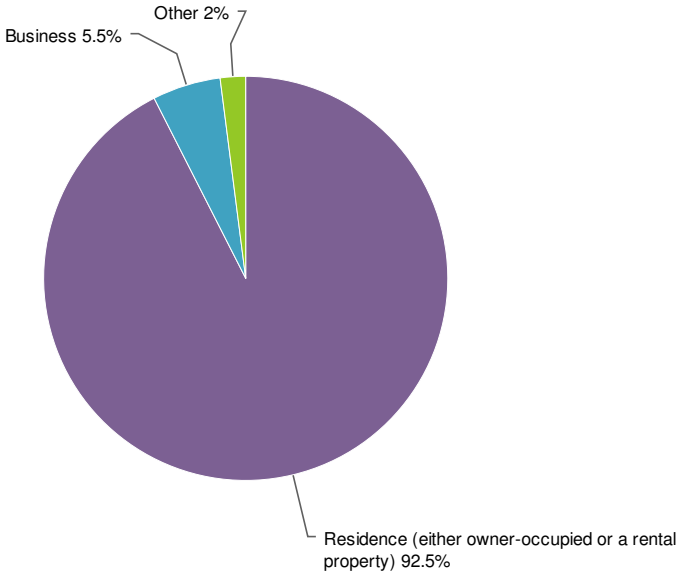
Appendix D: Survey Results – Community Interest in Broadband

Appendix D is included as a separate file.

Appendix D: Survey Results - Community Interest in Broadband

(From early-November through December 2015, the city conducted a widely-advertised web survey to gauge public interest in broadband service enhancements. The results are included below.)

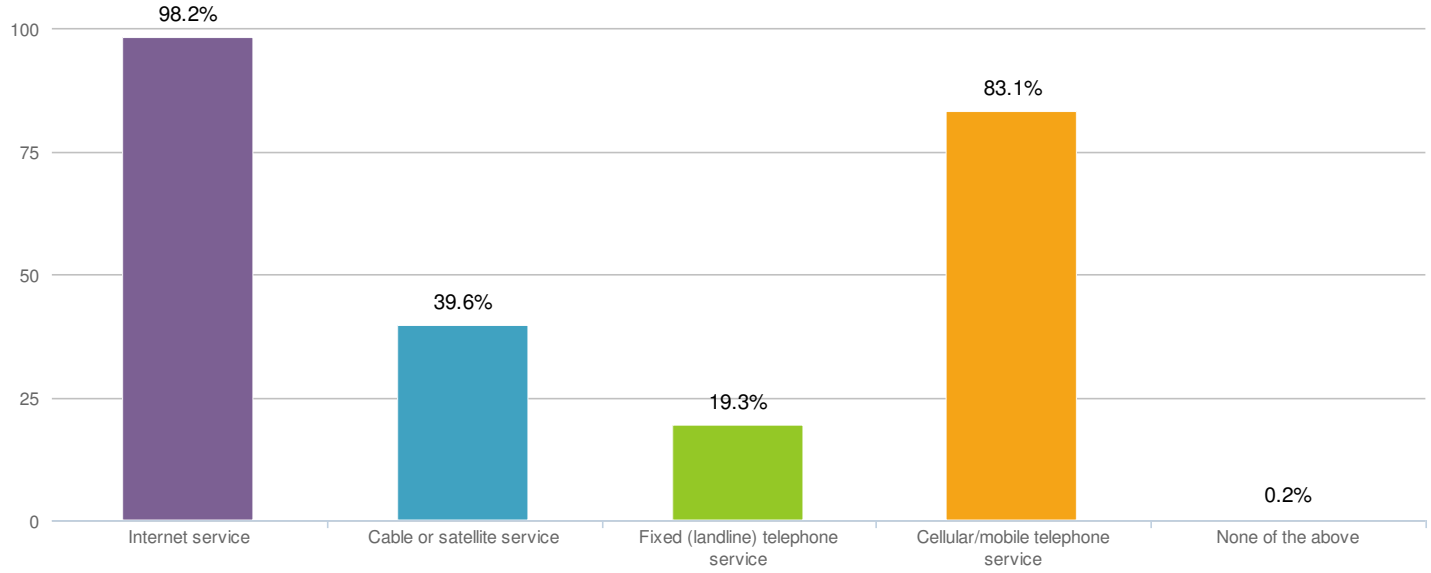
1. Are you answering this survey on behalf of your residence in Boulder, or for a business?



Value	Percent	Count
Residence (either owner-occupied or a rental property)	92.5%	457
Business	5.5%	27
Other	2.0%	10
	Total	494

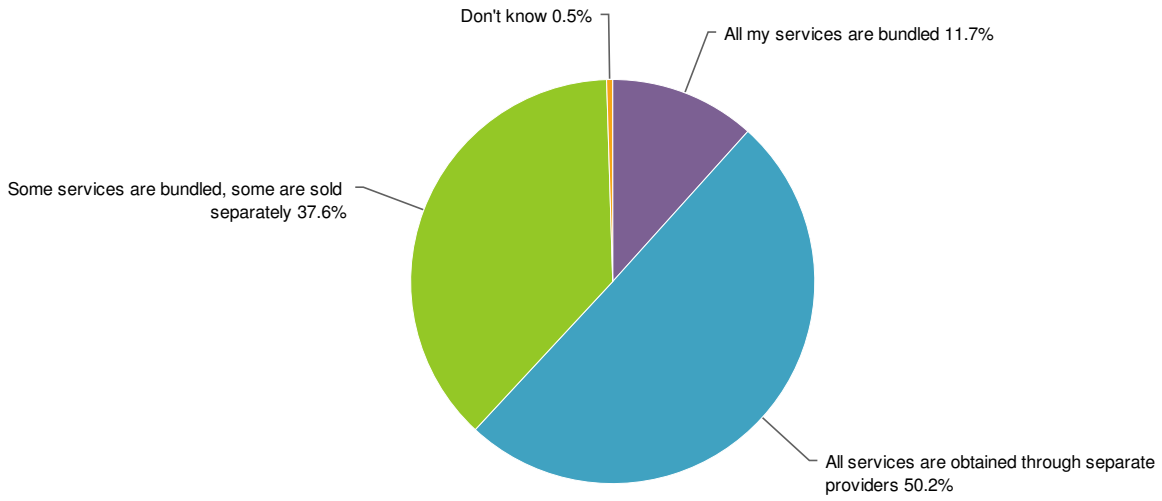
Responses "Other"	Count
Left Blank	488
Both - I work from home	1
Both! I work at home!	1
Both! I work from home.	1
Business from home	1
Mork asked me to help.	1
My business is run from my residence.	1
Non-profit	1
residence and business (home office)	1
soon to be resident	1
As an entrepreneur in Boulder, I am answering this for my residence as well as for a company I am helping start.	1

2. Which of the following services do you currently purchase for your home or business in Boulder? (Please select all that apply)



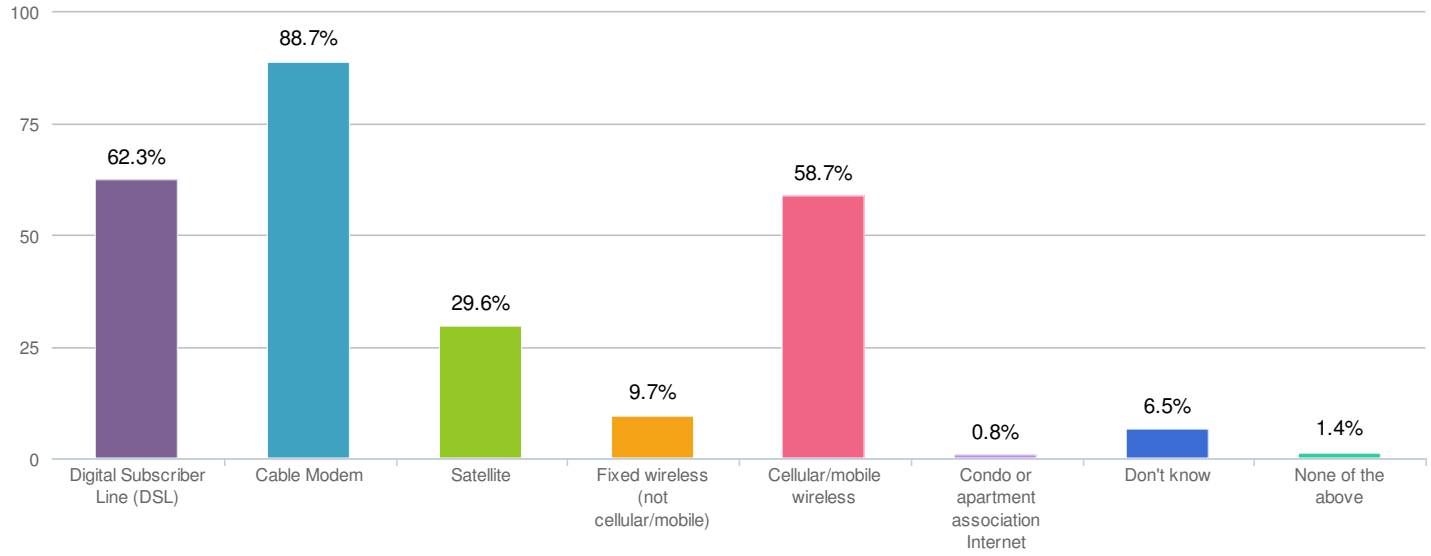
Value	Percent		Count
Internet service	98.2%		488
Cable or satellite service	39.6%		197
Fixed (landline) telephone service	19.3%		96
Cellular/mobile telephone service	83.1%		413
Don't know	0.0%		0
None of the above	0.2%		1
		Total	497

3. Are any of these services obtained from the same provider (bundled)?



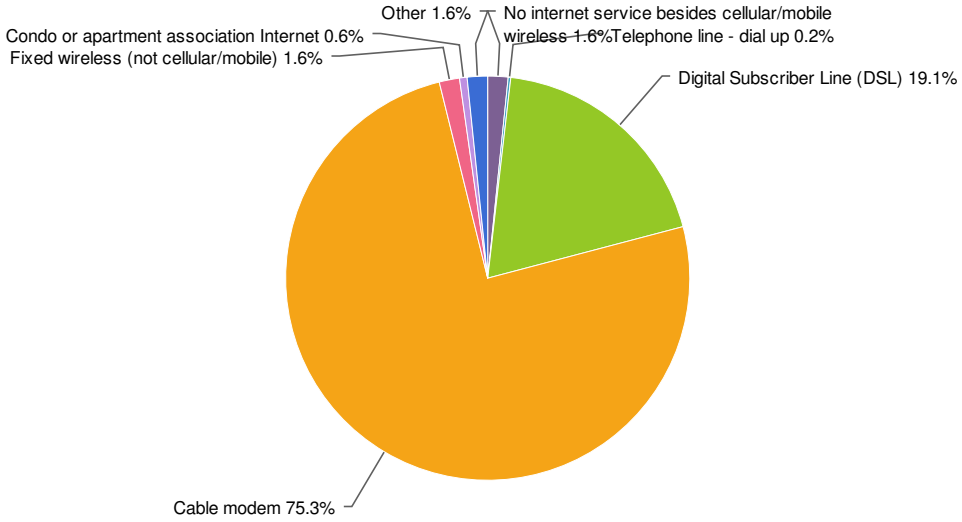
Value	Percent	Count
All my services are bundled	11.7%	49
All services are obtained through separate providers	50.2%	211
Some services are bundled, some are sold separately	37.6%	158
Don't know	0.5%	2
	Total	420

4. What kinds of non-dial-up Internet service are available for you to purchase at your home or business? (Please select all that apply)



Value	Percent	Count
Digital Subscriber Line (DSL)	62.3%	309
Cable Modem	88.7%	440
Satellite	29.6%	147
Fixed wireless (not cellular/mobile)	9.7%	48
Cellular/mobile wireless	58.7%	291
Condo or apartment association Internet	0.8%	4
Don't know	6.5%	32
None of the above	1.4%	7
	Total	496

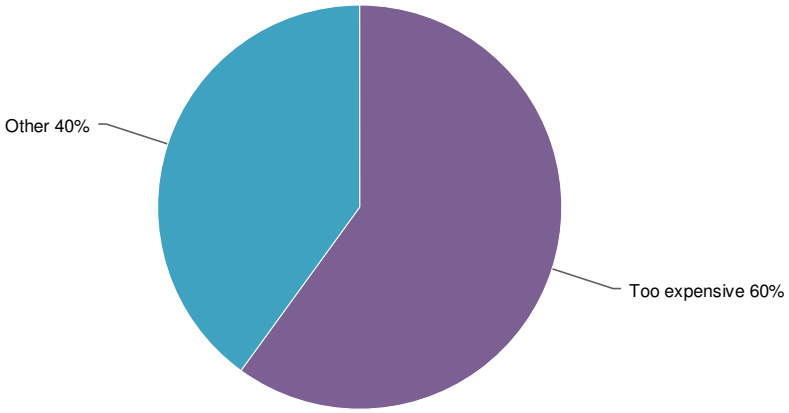
5. Other than cellular/mobile wireless, do you purchase Internet service at your home or business, and if so, what is your primary Internet service?



Value	Percent	Count
No internet service besides cellular/mobile wireless	1.6%	8
Telephone line - dial up	0.2%	1
Digital Subscriber Line (DSL)	19.1%	94
Cable modem	75.3%	371
Satellite	0.0%	0
Fixed wireless (not cellular/mobile)	1.6%	8
Condo or apartment association Internet	0.6%	3
Other	1.6%	8
	Total	493

Responses "Other"	Count
Left Blank	490
2	1
Comcast	1
DSL + Cable	1
Direct from spaceship.	1
Fiber	1
Zayo Fiber	1
share with neighbor who has cable access	1
I use both DSL and cable from 2 different providers. DSL is usually, but not always, faster in my neighborhood.	1

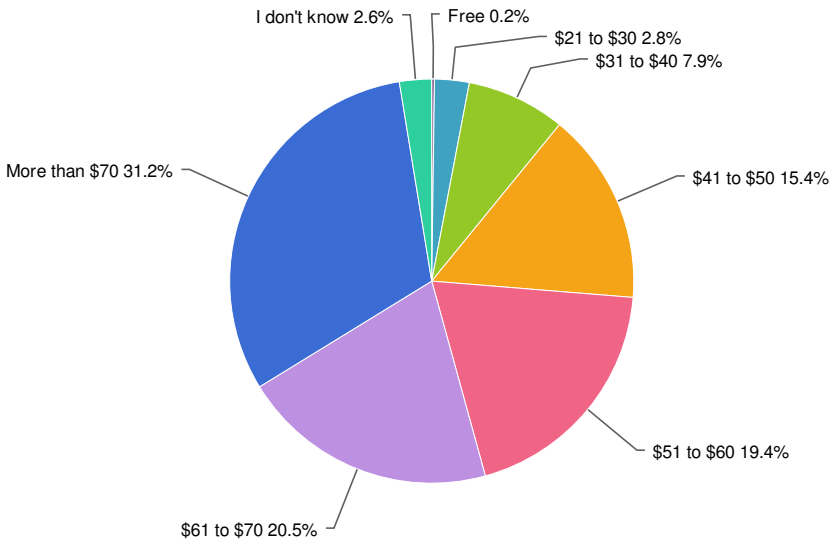
6. If you do not have Internet service (besides cellular), what is your main reason for not purchasing Internet service?



Value	Percent	Count
We have not Internet-enabled (computer/tablet) devices	0.0%	0
We have no need for the Internet	0.0%	0
We can get Internet access at another location	0.0%	0
Too expensive	60.0%	3
Cellular/mobile data service meets our needs	0.0%	0
Other	40.0%	2
	Total	5

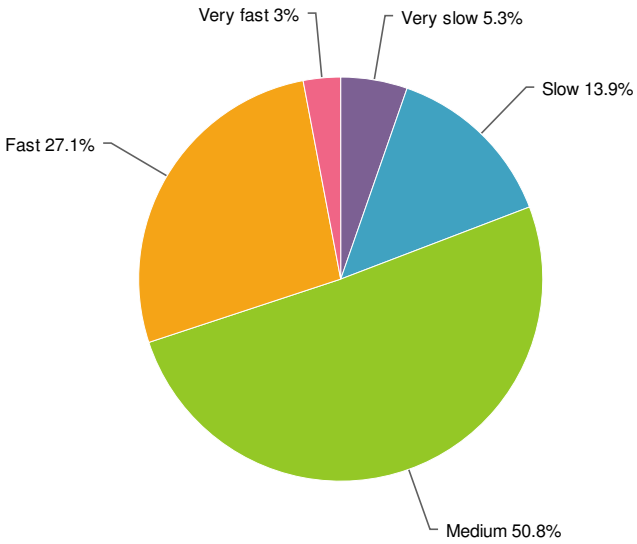
Responses "Other"	Count
Left Blank	496
Broken English from Boulder Colorado, I was into this survey before I saw that.	1
We have not internet-enabled devices. What? Did anyone proof read your answers? Really? This is a survey taken in Boulder Colorado, do you not have anyone that knows correct grammar? Really?	1

7. Approximately how much does your household or business pay PER MONTH for your Internet service (not including cellular/mobile wireless, cable TV, or land line phone service)?



Value	Percent		Count
Free	0.2%		1
$1 to $20	0.0%		0
$21 to $30	2.8%		13
$31 to $40	7.9%		37
$41 to $50	15.4%		72
$51 to $60	19.4%		91
$61 to $70	20.5%		96
More than $70	31.2%		146
I don't know	2.6%		12
		Total	468

8. How would you describe the speed of your Internet connection at your home or business (not your mobile/cellular connection)?



Value	Percent		Count
Very slow	5.3%		25
Slow	13.9%		65
Medium	50.8%		238
Fast	27.1%		127
Very fast	3.0%		14
		Total	469

9. How important or unimportant are the following aspects of Internet service at your home or business to you? Again, please do not include cellular/mobile service.

	1 - Not at all important	2	3	4	5 - Very important	Responses
A. Speed of connection	0 0.0%	0 0.0%	15 3.2%	95 20.2%	360 76.6%	470
B. Reliability of connection	0 0.0%	0 0.0%	4 0.9%	29 6.2%	438 93.2%	470
C. Price of services	1 0.2%	13 2.8%	84 17.8%	140 29.7%	235 49.9%	471
D. Clarity of bills	21 4.5%	69 14.7%	134 28.6%	123 26.2%	123 26.2%	469
E. Ability to contact provider	6 1.3%	53 11.3%	105 22.4%	170 36.2%	138 29.4%	469
F. Technical support service	12 2.6%	81 17.3%	115 24.6%	141 30.1%	120 25.6%	468
G. Overall customer service	4 0.9%	33 7.1%	100 21.4%	182 39.0%	150 32.1%	467
H. Ability to "bundle" with cable TV service	366 78.4%	48 10.3%	27 5.8%	16 3.4%	13 2.8%	467

10. How satisfied or dissatisfied are your with the following aspects of your current home or business Internet access or service?

	1- Very dissatisfied	2	3	4	5 - Very satisfied	Responses
A. Speed of connection	55 11.7%	99 21.1%	160 34.0%	122 26.0%	36 7.7%	470
B. Reliability of connection	68 14.5%	105 22.4%	127 27.1%	128 27.4%	41 8.8%	468
C. Price of services	178 38.0%	156 33.3%	90 19.2%	33 7.0%	14 3.0%	469
D. Clarity of bills	82 17.6%	91 19.6%	188 40.4%	85 18.3%	21 4.5%	465
E. Ability to contact provider	95 20.4%	110 23.7%	165 35.5%	77 16.6%	18 3.9%	465
F. Technical support service	116 24.9%	122 26.2%	160 34.3%	56 12.0%	14 3.0%	466
G. Overall customer service	152 32.6%	113 24.2%	142 30.5%	50 10.7%	11 2.4%	466
H. Ability to "bundle" with cable TV service	71 16.1%	34 7.7%	262 59.3%	49 11.1%	31 7.0%	442

11. Consider what price level would make you interested in switching to another Internet service provider. How willing or unwilling would be to switch to a service of 100 Megabits per second downstream and upstream (this would be 5 to 10 times faster than a cable modem) for the following monthly price?

	1 - Very unwilling	2	3	4	5 - Very willing	Responses
A. $55 a month	**8** 1.7%	**10** 2.2%	**19** 4.1%	**50** 10.8%	**378** 81.3%	465
B. $65 a month	**37** 8.0%	**33** 7.2%	**63** 13.7%	**100** 21.7%	**228** 49.6%	460
C. $75 a month	**97** 21.2%	**68** 14.8%	**96** 21.0%	**87** 19.0%	**111** 24.2%	458
D. $85 a month	**168** 36.7%	**97** 21.2%	**87** 19.0%	**68** 14.8%	**43** 9.4%	458
E. $95 a month	**254** 55.8%	**82** 18.0%	**63** 13.8%	**32** 7.0%	**27** 5.9%	455

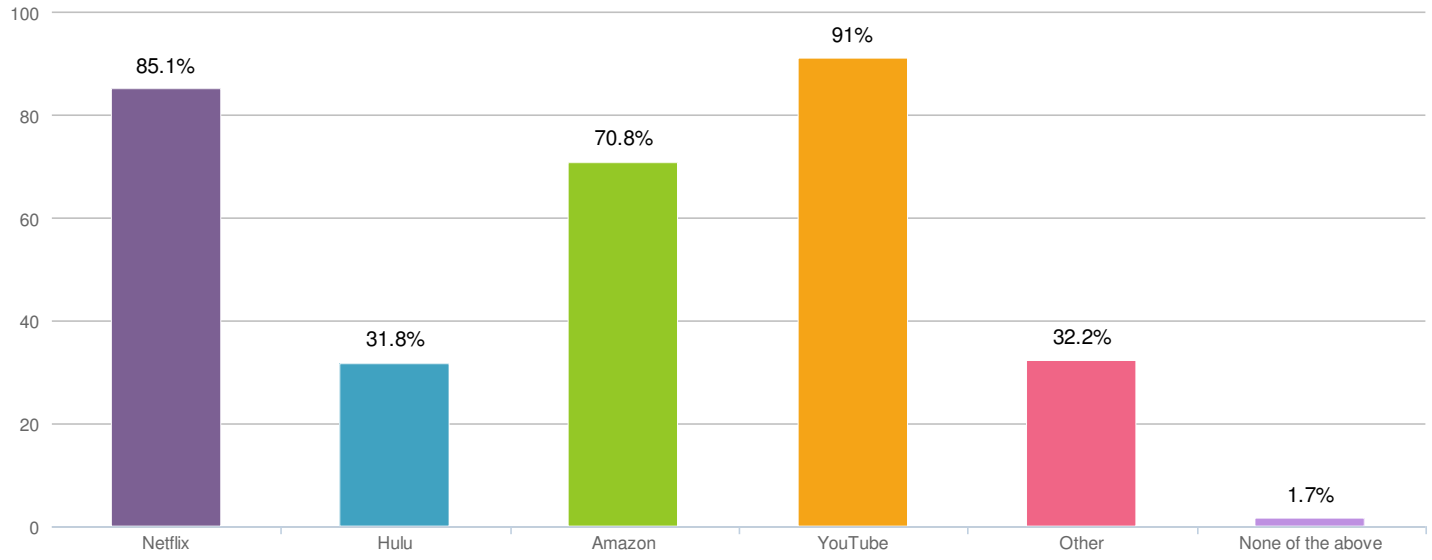
12. How willing or unwilling would you be to switch to a service of 1 Gigbits per second downstream or upstream (this would be 100 times faster than a cable modem) for the following monthly prices? (Please select your response for each price level)

	1 - Very unwilling	2	3	4	5 - Very willing	Responses
A. $55 a month	**10** 2.0%	**7** 1.4%	**10** 2.0%	**21** 4.3%	**442** 90.2%	490
B. $65 a month	**27** 5.5%	**12** 2.5%	**25** 5.1%	**59** 12.1%	**366** 75.0%	488
C. $75 a month	**61** 12.5%	**36** 7.4%	**61** 12.5%	**90** 18.5%	**240** 49.3%	487
D. $85 a month	**115** 23.8%	**64** 13.2%	**89** 18.4%	**67** 13.8%	**151** 31.2%	484
E. $95 a month	**183** 37.7%	**81** 16.7%	**62** 12.8%	**47** 9.7%	**114** 23.5%	485

13. How often do you use your Internet connection at your home or business (not including cellular/mobile for: (Please select a response for each activity)

	Never	Occasionally	Frequently	Responses
A. Listening to music (streaming)	**17** 3.6%	**109** 23.2%	**343** 73.1%	469
B. Watching movies, videos or TV	**8** 1.7%	**65** 13.9%	**396** 84.6%	468
C. Playing online games	**186** 40.0%	**104** 22.4%	**176** 37.8%	465
D. Connecting to a work computer	**67** 14.3%	**114** 24.4%	**287** 61.3%	468
E. Making video calls (Skype, etc.)	**63** 13.5%	**244** 52.1%	**163** 34.8%	468
F. Buying products online	**3** 0.6%	**126** 26.9%	**341** 72.7%	469
G. Running a home business	**225** 48.2%	**100** 21.4%	**145** 31.0%	467
H. Sending large files (online file back-ups, high-resolution graphics, photos, etc.)	**29** 6.2%	**196** 41.8%	**244** 52.0%	469
I. Receiving government info such as service locations or contact info	**133** 28.4%	**248** 53.0%	**87** 18.6%	468

14. What streaming services do you access via your Internet connection? (Please select all that apply)



Value	Percent		Count
Netflix	85.1%		399
Hulu	31.8%		149
		Total	469

Value	Percent	Count
Amazon	70.8%	332
YouTube	91.0%	427
Other	32.2%	151
None of the above	1.7%	8
	Total	469

Responses "Other"	Count
Left Blank	358
	1
ABC, HBO, A&E, HGTV, HGTV Canada, and other streams directly from the channel's site.	1
Acorn	1
Acorn and HBO via Roku	1
Apple Music, Vimeo	1
Apple Music, iTunes	1
Apple TV	3
Apple music, HBO Go	1
Apple rentals	1
Apple tv	2
Apple, others via Roku 3	1
Comcast/HBO online	1
Comedy central	1
Crunchyroll	1
Dozens more via computers,AppleTV, and Roku 3 devices.	1
ESPN	1
ESPN	1
ESPN3	1
Google	1
Google Play	1
Google chrome	1
Google music, pandora, etc	1
Google play	1
Google play	1

Responses "Other"	Count
HBO	6
HBO	2
HBO GO, showtime, google, apple	1
HBO Go	1
HBO Now	5
HBO Now, Sports	1
HBO go	1
HBO showtime	1
HBO, SlingTv, Spotify	1
HBO2GO, Slingbox streaming tv service	1
HBOGO	1
HBOGo	1
HBONOW	1
HBONow	1
Hbo now	1
Hbogo	1
Hbogo, cbs, etc	1
Internet public radio streams	1
JHboGo	1
Lots	1
Many	1
Many streaming services such as TWIT, Live stream, Vimeo, GFQnetwork,	1
NBA	1
Network TV & Major League Sports	1
Npr	1
Numerous others	1
Pandora	7
Pandora	1
Pandora, Google Play Music, Plex from home server	1
Pandora, Hangouts & other music Sites	1
Pandora/8tracks/Spotify	1

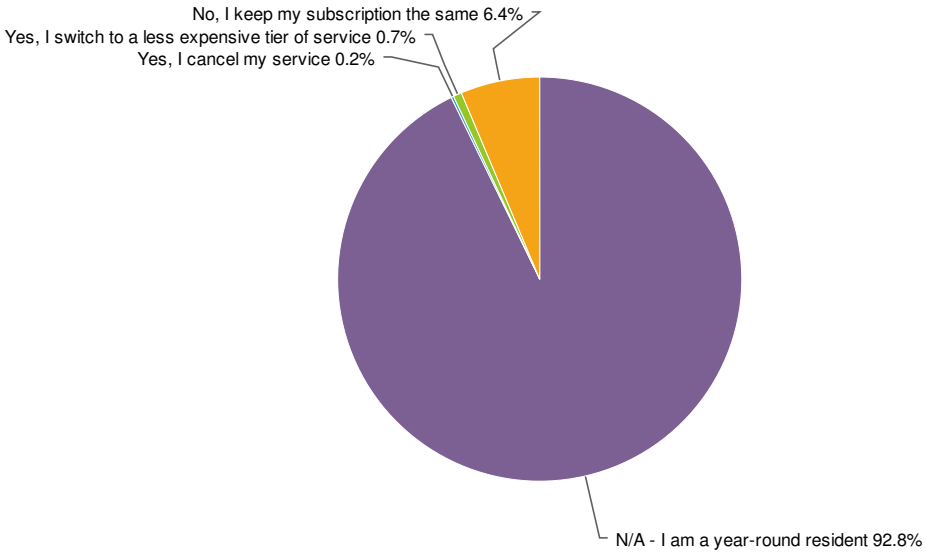
Responses "Other"	Count
Pivotal Tracker	1
Podcasts	1
Rdio	1
Redbull	1
Rhapsody	1
Sling	2
Sling tv	1
SoundCloud	1
Sporting streams (football, baseball, etc), TED talks	1
Sports	1
Spotify	4
Spotify and others	1
Spotify, Apple	1
Spotify, Comcast Streaming	1
Spotify, PBS video	1
Spotify, Pandora	2
Spotify, Vimeo	1
Steam	1
Twitch	4
Twitch, PSN	1
Twitch, Vimeo, Spotify, Pandora, and many, many others	1
Twitch.tv	4
VPN for work	1
Various	1
Vimeo	1
Vudu	3
Xfinity Go TV	1
Xfinity app, NBC app, ESPN app, March Madness app, NFL Mobile, Masters Golf app, PGA app	1
Xfinity, Eve Online, Hearthstone	1
Xfinity, other TV network apps	1
You Name It, We Use It	1

Responses "Other"	Count
ace stream	1
amazon echo / tune-in	1
apple	1
apple TV, HBO, itunes	1
appletv	1
crunchyroll	1
iTunes	3
iTunes, Rhapsody, HBO Now	1
music	1
reddit	1
so many	1
spotify	2
spotify, pandora, etc	1
the internet	1
twitch.tv	3
vimeo	1
xfinity, hbo	1

15. How important or unimportant are these features when selecting an Internet (not cellular/mobile) provider? (Please select a response for each feature)

	1 - Not at all important	2	3	4	5 - Very important	Responses
A. I can choose from multiple Internet providers	**29** 6.2%	**32** 6.9%	**119** 25.6%	**124** 26.7%	**164** 35.3%	465
B. I can buy service with very high speeds (10 to 100 times faster than DSL or cable speeds)	**1** 0.2%	**15** 3.2%	**45** 9.7%	**114** 24.5%	**291** 62.6%	465
C. I can pay for Internet service based on usage (amount of data)	**187** 40.4%	**91** 19.7%	**104** 22.5%	**55** 11.9%	**29** 6.3%	463
D. My service provider does not place "caps" on my total data use	**3** 0.6%	**3** 0.6%	**23** 4.9%	**74** 15.9%	**362** 77.8%	465
E. I can use my home Internet connection to support a home business	**88** 18.9%	**42** 9.0%	**75** 16.1%	**72** 15.5%	**192** 41.2%	466
F. I can use my home Internet connection to telework for a job	**48** 10.3%	**27** 5.8%	**49** 10.5%	**78** 16.8%	**267** 57.4%	465

16. If you are not a full-time resident of Boulder, does your property's Internet subscription change during the off-season?

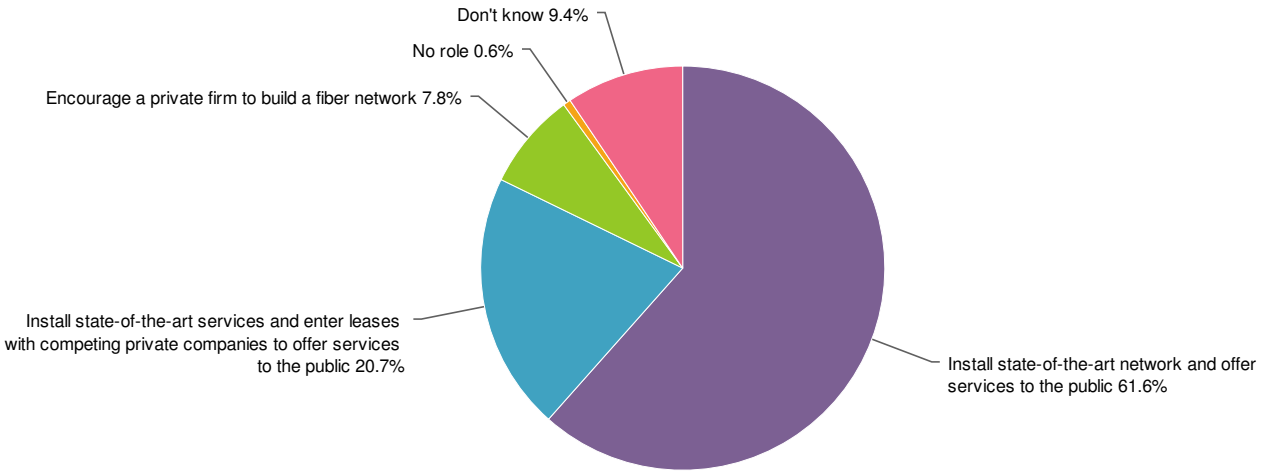


Value	Percent	Count
N/A - I am a year-round resident	92.8%	424
Yes, I cancel my service	0.2%	1
Yes, I switch to a less expensive tier of service	0.7%	3
No, I keep my subscription the same	6.4%	29
	Total	457

17. One proposed financing model for a world-class fiber optic network is to charge residences an initial hook-up fee to connect to the network, which enables data rates 100 times faster than cable modem service and allows many competing Internet, phone and cable television companies to offer consumer services. How willing or unwilling would you be to pay an upfront hook-up fee for this service if the one-time fee were: (Please select your response for each price point)

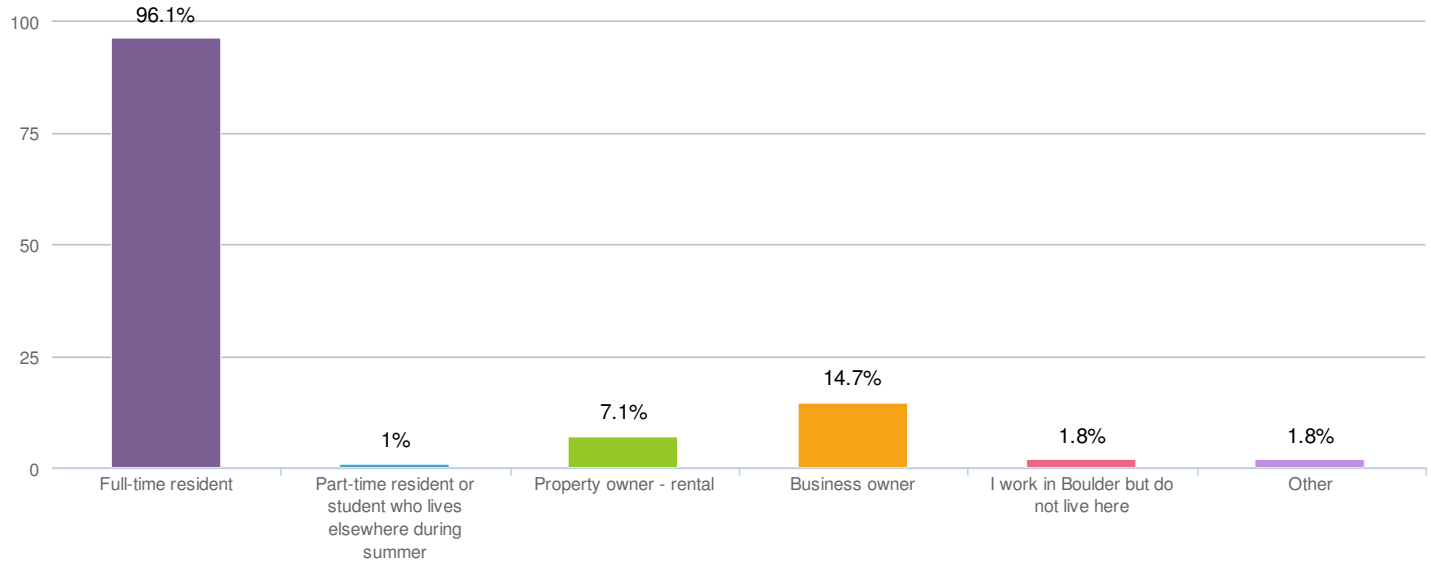
	1 - Very unwilling	2	3	4	5 - Very willing	Responses
A. $0 (zero)	**1** 0.2%	**0** 0.0%	**1** 0.2%	**1** 0.2%	**453** 99.3%	456
B. $100	**13** 2.8%	**15** 3.3%	**47** 10.2%	**72** 15.7%	**315** 68.5%	460
C. $250	**83** 18.1%	**50** 10.9%	**98** 21.4%	**88** 19.2%	**142** 30.9%	459
D. $500	**194** 42.4%	**91** 19.9%	**87** 19.0%	**44** 9.6%	**47** 10.3%	458
E. $750	**283** 61.8%	**94** 20.5%	**37** 8.1%	**29** 6.3%	**15** 3.3%	458
F. $1,000	**356** 78.1%	**56** 12.3%	**23** 5.0%	**10** 2.2%	**12** 2.6%	456

18. What do you think the main role for the City of Boulder government should be with respect to broadband access? (Please choose only one)



Value	Percent	Count
Install state-of-the-art network and offer services to the public	61.6%	301
Install state-of-the-art services and enter leases with competing private companies to offer services to the public	20.7%	101
Encourage a private firm to build a fiber network	7.8%	38
No role	0.6%	3
Don't know	9.4%	46
	Total	489

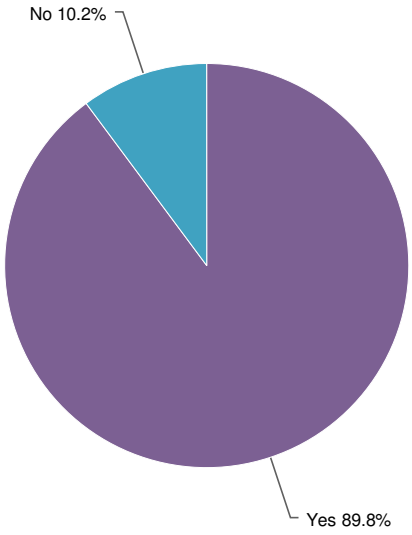
19. Which of the following describes your relationship to the City of Boulder? (Select all that apply)



Value	Percent	Count
Full-time resident	96.1%	471
Part-time resident or student who lives elsewhere during summer	1.0%	5
Property owner - rental	7.1%	35
Business owner	14.7%	72
I work in Boulder but do not live here	1.8%	9
Other	1.8%	9
	Total	490

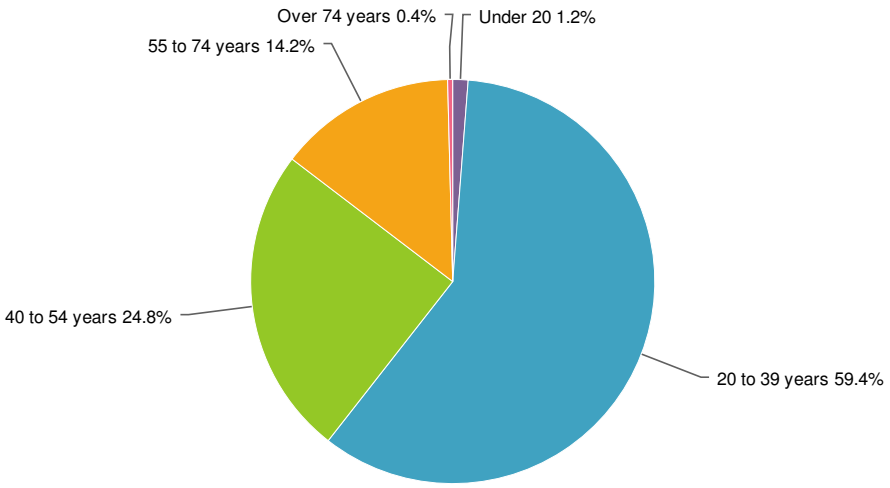
Responses "Other"	Count
Left Blank	490
Breathe its air. Thks.	1
Concerned Citizen	1
FT resident of unincorporated Boulder County (Gunbarrel)	1
I live a few feet outside the city limits	2
Work in Boulder	1
live in the county	1
My relationship with Boulder is complicated. We were seeing each other then were broke up for a while. We are still good friends, but not with benefits or anything like that.	1

20. Are you registered to vote in the City of Boulder?



Value	Percent		Count
Yes	89.8%		441
No	10.2%		50
		Total	491

21. To which age group do you belong?



Value	Percent	Count
Under 20	1.2%	6
20 to 39 years	59.4%	292
40 to 54 years	24.8%	122
55 to 74 years	14.2%	70
Over 74 years	0.4%	2
	Total	492

Statistics	
Sum	14,570.0
Average	30.1
StdDev	13.3
Max	55.0

22. Please share any other thoughts, concerns or issues with regard to Internet services you wish us to be aware of or consider.

Count	Response
1	A high speed internet structure from the city would be incredible.
1	Allow for competition among providers.
1	Any broadband should be extended to non-city county residents with Boulder utilities.
1	Bring me Google Fiber!
1	Comcast Sucks!
1	Comcast has a monopoly on what should be public utilities. Please give us a viable alternative.
1	Comcast is evil.
1	Comcast needs more competition
1	Comcast sucks
1	Do want. Please build!
1	Do what Longmont is doing. Comcast is pure concentrated EVIL.

Count	Response
1	East pearl business parks need better high speed internet access
1	Fast internet is great, but not if it's expensive.
1	Fast low cost internet is a huge opportunity for Boulder
1	Fiber to my home - yes
1	F*** comcast.
1	Get an English editor for your surveys.
1	Get it done.
1	Gigabit fiber would help Boulder become an even greater innovation hub. Let's get going!
1	Go for it!
1	Google Fiber
1	Huge bandwidth now, please. Help the businesses.
1	I hate Comcast so much. PLEASE. SAVE. ME.
1	I highly support municipal broadband. Comcast is awful.
1	I'm jealous of longmont's internet!!
1	If Longmint can offer fiber why can't Boulder? Long overdue.
1	If you are going to do this, do it right. Make internet a utility, with no caps.
1	Internet is a utility just like water/elec/gas. And should be treated like one
1	Love to see some competition in the marketplace. Tired of monopolies.
1	Municipal internet service like Longmont would be ideal.
1	Need more options, Muni should be one.
1	PLEASE make this happen
1	Please bring municipal broadband to Boulder
1	Please build out a residential/commercial fiber network across Boulder!
1	Please give me an alternative to Comcast!
1	Please give us options other than Comcast or very slow DSL.
1	Please look to Sweden as a role model for how to structure fiber in Boulder.
1	Please make this happen!
1	Please no data usage rates or caps! We need to join the future and get 1 gbps internet!
1	Please offer Internet service through the city!
1	Please, please, please build out a municipal high speed internet that competes with comcast.
1	Privacy is another concern when considering ISPs

Count	Response
1	Save us from Comcast.
1	Some of these questions are bogus
1	Sooner is better then later
1	THE SOONER I GET OUT FROM UNDER COMCAST, THE BETTER.
1	Thank you for considering this, another exciting opportunity for Boulder!
1	The ability to get a static IP address is very important to me, even if it costs extra.
1	The lack of competition is ridiculous.
1	The private sector is failing us in terms of speed/$, reliability, and data caps.
1	We NEED fiber to continue to be competitive as a state-of-the-art city to live
1	We need more competition, but not a network created or ran by the City of Boulder.
1	We should have universal wi-fi.
1	Wish this was a county-level conversation instead of a city-of-Boulder conversation
1	for home use reliable adequate speed is more important than top speeds
1	free gig internet , should be a planetary human right . its 2015 not 1992 .
1	i hate comcast
1	please please make this happen
1	I think Boulder should either offer high speed internet service or allow companies such as Google to put in Fiber and provide service to all of Boulder
2	Municipalization or, at the very least, having the city set prices and speed specs is a no brainer. I voted against the Xcel municipalization but I support the city taking over internet service 100 percent.
1	I trust my local government with services and infrastructure much more than I will every trust private enterprise. The internet is a newly recognized infrastructure requirement for successful communities and ought to be subsidized for residents and non-profits. Services, such as email, file exchange and chat ought to be provided, or at least offered, to residents who otherwise may not have access to those services. Additionally, offering free computers or very low cost (such as low end linux or chrome laptops) to low or no income residents will go a very long way to bridging the digital divide which hinders personal economic success for low and no income residents. I am willing to pay more for City provided services to enable low and no income residents to receive these benefits.
1	14.D depends on cap There is a trade-off in 16 with 11. It's hard to answer those two separately.
1	Please help us get out of the stranglehold that Comcast has on all of us. All we really want is to be treated fairly and not deceptively. I will gladly pay double what I pay comcast for just internet if it means that it's staying in the community and I'm not going to be lied to. I would not mind volunteering to help this initiative. Alex Oxford 678 993 4547 Boulder, CO
1	Hell Yes! Hook us up to some faster internet. The rest of the world is usually faster than the US and much cheaper.
1	If you want us to buy municipalized internet, you're going to have to compete with Comcast's prices, and for internet only anything above $70 and more than a small fiver installation fee I doubt this is going to work out. Good luck trying to charge more than $150 for fiber installation, people won't see it as worth it.

Count	Response
1	Please offer Comcast some competition. They are slowly rolling out data caps across the nation in an effort to prevent people from dropping cable.
1	I work in IT and I'm very excited. It's sad that we're playing catch up to Longmont and it's about time. I'm ready to drop Comcast!
1	If high speed infrastructure is available for the home, at a reasonable cost (vs. the 2 choices that we've had), then there's no reason not to try to get it up and running ... It fulfills Al Gore's vision in terms of increasing productivity and creativity ...
1	Would really like to have a viable alternative to comcast. Comcast is too expensive for the services delivered and they amount to a rent holding monopoly. If there is a government broadband system I'd like it to be under a network neutrality agreement: particularly with no filtering based on content. The government shouldn't be in the business of policing net content.
1	Your connection protocols need some work. I have an Android 5.1 smart phone. Every time I go to connect it is a race to see if i can connect fast enough. If I am unable to click the sign-on button in less than about 3 seconds it just disconnects and says avoided poor internet connection. I'm able to log on at Starbucks no problem, Denver library no problem, in fact, the only problem I've ever had logging on is on the boulder connect network. Kinda makes me want to move back to Denver if you want to know the truth. At least in Denver they realize you need more than 3 seconds to scroll down to the sign-on button.
1	The lack of competition in wired internet service is the problem. We have an oligopoly of CenturyLink and Comcast. I use CenturyLink, but their speeds are way too slow, particularly upload. They have old wires here which degrade during rainstorms. Comcast is fast enough for me, but the cost more and I don't like them. Despite that, I may soon switch to Comcast because of the speed. I would love to see more competition. If the private sector won't step up to compete, government should get in the act. I support Boulder's work in this arena and would be okay with a full city-owned network. Private is maybe better, but what I really care about is good speed at moderate price.
1	Gigabit with equal up/down bandwidths would be amazing. You would do Boulder and its businesses a huge favor. Compete directly with existing providers if needed... they make it so hard for anyone to enter the market due to existing regulations and access restrictions to existing infrastructure.
1	Unless Google is willing to work a deal with the city on providing Google Fiber to residents, you need look no farther than Longmont. Muni highspeed internet is the answer here. The private companies have shown they will drag their feet and provide a poor solution unless a muni or google fiber effort is available in the same location.
1	I manage multi-family buildings including 2 units, 4 units, and 12 units. I am interested in how community broadband could allow WiFi connectivity to my tenants.
1	I hate only having the option to choose between two large companies with government lobbies, poor customer service, and price fixing as my only choices for my ISP.
1	There absolutely needs to be more options than Comcast. Comcast is anti-competitive and needs to be shown that they need to innovate in order to compete. If I had another option from Comcast, I would switch in a heartbeat.
1	Right now I am stuck with Comcast. They are greedy and their internet service frequently breaks down. Customer service is non existent.
1	Please give us municipal fiber. I'm tired of using Comcast and having my rates increased periodically for worse service.

Count	Response
1	1. I don't like how this survey only offers $55 as the lowest option. Boulder needs to offer truly affordable broadband, e.g. $25–40/month for service that's at least on par with the $50/month unbundled Comcast/Xfinity residential service (currently ~7.5 Mbps down, 1.25 Mbps up, one dynamic IP address, with usage caps promised in the near future). Obviously this is far below symmetric gigabit service, but it would be an enticing option for many students and struggling families who could be spending the savings on health insurance. 2. The lowest price for true gigabit should be no more than $50/month, which is about the lowest price you can get unbundled Internet service for at useful speeds. 3. Boulder should try hard to ensure that its plans include empowering and keeping things affordable for people who want to run their own services (e.g. email & web) and stream outbound content from their own devices (e.g. live video). This can include hobbyists, privacy-minded individuals and organizations, and other organizations and schools—so don't just make good upload speeds and static IPs be a for-businesses-only, minimum $70/month thing like Comcast does. For example, static IPv4 addresses should be affordable, e.g. if you're on the $50/month residential plan but want a static IPv4 address, you have to either pay more *or* opt for a service reduction, such as usage caps or sub-gigabit bandwidth.
1	This does not require a municipal power utility to implement. Since you will be in court for the next 17 years over the muni I suggest that you mentally separate your thinking on each service.
1	I feel Like Comcast has a monopoly on any above average internet connections, and they offer the worst customer service i have ever received. As a company I thoroughly despise them for all the times they have lied to me about charges, and all the fees I receive, but yet I feel as though they are my only option. I would be ecstatic to never give them another dime, and I do believe that the longmont Model is a good one. If they can offer wireless for ~$50 per month, why can't boulder??
1	Boulder should offer Internet service to residents either directly or in partnership with a private company. Don't wait forever to do it! Longmont has proven that this can work. Let's build on their positive experience!
1	Although having Boulder County manage and install a network, having another company like Google come into play would also be advantageous. They already have experience with this, and have the financial ability to start and finish the project in a timely manner.
1	100% of my working life takes place on the internet. It is extremely important to have very fast and very reliable broadband internet.
1	Static IP addressing is required to support business activities (e.g. VPN access control and Internet services provided from residential locations)
1	I think service reliability may make or break this. People like to hate on comcast, but their service *is* pretty stable at this point.
1	Seeing as we are considered to be Silicon Mountain, it only makes sense that Boulder would also have a very reliable, fast internet service provided to its residents.
1	Competition is what makes a free market economy work, but there's little to no competition for ISPs. Comcast has no incentive to ever improve their service, and they even increase the cost of my service... without any improvements! When business fail to provide something that the community needs, it's time for the government to step in.
1	Please create a city internet network as it will help drive down the massive prices of comcast and other services. It would be amazing if it could be a 1GB per second service as well
1	I used Google fiber a fee times along with a few 1gig Internet connections, it's a wonderful service, especially with Google fiber and the support they offer. Very excited to hear that boulder is attempting to bring such a nice service to its residents.
1	Getting municipal fiber will make Boulder an even better place to start a business and to live. The two main incumbents will never offer us what we should have.
1	i assume 17b was supposed to read "Install state-of-the-art NETWORK and enter leases with competing private companies to offer services to the public"
1	I would switch to city internet in a heart beat if I could. We seriously need some competition for internet here
1	Internet access is a human right and should be a public utility. Billing should be based on usage.

Count	Response
1	Thank you for conducting this survey. The state of Internet across the US is ridiculous. Only localities with community broadband seem to be making a difference!
1	I would like to see Boulder move ahead promptly with something that greatly improves our current service at a reasonable price. I think this will be well received. And, it is important since we are such a high-tech city, and this should attract more such businesses (and other businesses). It is the future.
1	Most important component of a muni network should be that it is owned by the city and reliability should be prioritized. Speed is very important, but reliability and uptime is key
1	We as a city must do what we can to combat the monopoly companies like Comcast have over our internet service. We overpay for underperforming services. Installing a fiber network would solidify Boulder as a leading city in the tech world and redefine how we, as a city and as individuals, use the Internet.
1	The city is sitting on a wonderful asset that should be utilized. In conjunction with providing residents and businesses with a Gig connection, the city should make as many public spaces wifi enabled for the public. I travel a great deal and in other cities, as well as in other countries, most public spaces have free, fast internet access. This enables better communication and commerce for all.
1	The City of Boulder should provide ultra-high-speed internet as a utility -- but only if the project has a realistic timeline and budget, INCLUDING maintenance costs. This is much more do-able and will have much more visible results, than municipalizing electric services from Xcel.
1	I am a software engineer. Work at home. Reliable fast internet is very important. And is a business deduction for me. I am willing to pay a lot.
1	A public option for residents would be highly desirable. Even with some measure of competition (i.e., CenturyLink), Comcast simply gouges consumers. In the modern era, high-speed Internet access is a necessity of daily living (secondary to food, water, shelter, and healthcare, but arguably more necessary than many other government-provided or subsidized services) and it should be affordable for all citizens.
1	(1) The City should only get involved if private businesses are not interested to build a network. (2) Fiber optic at 1 Gigbits per second is becoming standard in newly installed networks (see Google Fiber). Hope you're not considering anything less than that!
1	Living in a high-density, lower-rent part of town means I experience more frequent interruptions of service.
1	The current state of internet in Boulder is very poor. Comcast is the only provider and screws customers at every turn. I really hope Boulder can figure out a way to bring another option like fiber to its residents. It would boost an already thriving tech sector and create jobs across industries. Also proving reliable speeds will help people educate themselves online and provide new opportunities to people that can't usually afford the expensive college classes. Fast reliable internet is essential in today's world. I am very excited to be able to use a internet service that actually listens to its customers and provides a service we desperately need. One point I'll bring up. There are a lot of renters in Boulder. If there is a one time hook up fee, the price needs to be low otherwise renters won't want to pay that every time they move.
1	Internet for all seems to me to be a more viable. reasonable goal than energy municipalization. I pay way too much for Comcast; their bundling and bsit & switch constantly changing prices forces me into services I don't want at unreasonable prices. I don't really want cable TV. I need and want internet service at a reasonable price. Let's get to it, Boulder!
1	Get on it (!) Spend some of our tax revenues on our skyhigh property values and give us something in return besides talk.
1	Just to clarify, I would be registered to vote, if I were a US citizen. I think it is really important to offer Boulder residents an alternative option to Comcast, which currently has a monopoly on high-speed internet in Boulder (DSL speeds available by CenturyLink aren't high enough) and takes advantage of that in many ways (high prices, forced bundles to get higher speeds, poor customer service). I would love to see an alternative that would increase choice and introduce competition in this market.

Count	Response
1	People don't want to, or don't think much about specifics with internet in my 18-24 age group. We just want cheap, reliable service. Multiple devices on one household network is main contributor to speed issues. Would like to pay for same service with neighbors we share walls with (in apartments, etc).
1	The lack of quality internet in this town is surprising given the large tech influence. Get with the program.
1	I've considered the regional ISP problem for a number of years. Unless we can adopt a model similar to the UK, the next best alternative is socializing the ISP industry. The only two providers available right now for our property are CenturyLink and Comcast. Although we currently use Comcast, we'd dump them in a second for a municipal provider.
1	I have no words to express how ecstatic I would be to have connectivity through someone other than Comcast or CenturyLink.
1	I'm not sure of the city role but I do think we've already invested in a huge amount of fiber infrastructure that should be used for fast internet. Boulder should be leading the charge for a fast internet infrastructure. There's no reason Comcast and Centurylink should control internet access here. There are already lots of teleworkers in Boulder and this would help. Telework reduces traffic and makes neighborhoods more active during the day.
1	It is quite frustrating to be forced to use service from CenturyLink, which often isn't fast enough, because the only alternative is Comcast, whose prices are terrible and whose business practices I abhor. I would love an alternative to drive competitive pricing, since for now Comcast is the only cable provider around, and DLS is quickly becoming too slow for things like Cloud computing (my upload speed is only 768kb/s).
1	I'm very dissatisfied with the current choices available in Boulder for Internet access. Comcast has a virtual monopoly and their pricing structure is completely hocus pocus (a free market dictates that consumers should know the price for a commodity). Comcast's "bundles" are inscrutable. I think the city should regulate the Internet, opening it up to private competing companies. Internet access is a necessity in today's world and it should not be left to a monopoly.
1	Xfinity/Comcast does not practice ethical business. 90% of the reason I support this is to NOT support comcast.
1	Viable competition is the only thing that encourages private ISPs to offer good service. CenturyLink and Comcast are at best a duopoly and largely offer medicore service
1	We currently have only one choice (Comcast) and it drops out frequently and the speeds vary wildly. Bringing fiber to Boulder residences (and as a competitive option to Comcast) would be a huge boon to residents.
1	I currently work remote and my job depends on the reliability and speed of my internet connection. I spend a lot of money for a higher quality and speed of internet through comcast, their product is a joke. I didn't think it could get any worse than Time Warner Cable in New York State, but Comcast continually under performs in every way. PLEASE BRING GOOGLE FIBER TO BOULDER. For a city that is becoming the new tech center, going with a better provider will only work to help businesses here.
1	Municipal broadband networks are a bad idea. Look what happened to the network in Celebration, Florida to see what I mean. Technology moves too quickly, and governments too slowly to keep up.
1	Please please PLEASE get comcast the hell out of Boulder, they charge so much and have such poor service.
1	Good survey - except I don't fully understand the issue to be able to vote on it. You should provide more info on what it would take/cost to bring in private broadband. I assume competition is good for lowering prices, but maybe service would be terrible? What I have now with Century Link works "well enough". I have not had any issues in 3 years. Although $65 a month is rather expensive, I think. But, I need internet access to run my business. I don't want to introduce issues that don't currently exist - OR pay more. Thanks!
1	The initial hook-up fee should be a one time thing linked to your voter registration or something. I shouldn't have to pay a new fee every time I move. Think of all the hassle and extra expense for students and small-business owners. If I leave the area and come back after more than a year, that's a different story.
1	Internet service should be regulated as a common carrier, as a distinct offering from content such as tv, movies, etc. I would welcome a city-provided internet service at a better price/bandwidth than Comcast or Century Link.

Count	Response
1	I hope the City will consider condemnation of all of Xcel's "dark fiber" as part of the municipalization effort and operate a non-profit municipal broadband utility. There is absolutely no reason the City should turn over this asset to allow some other profiteers to monopolize - we already have a couple of those to choose from. Running an ISP is not rocket science in this day and age, and with our local skill set - consumers would be in Utility Heaven if they could dump Xcel, Comcast and CenturyLink in one shot!
1	I think the city should stay out of the internet service provider business, and instead encourage competition among private companies and make it easier for them to provide quality services to business and residents. If the city wants to provide free public wi-fi, they should purchase it from a qualified provider vs becoming their own service organization.
1	Mindy has been missing for 25 years now and if she doesn't return soon I will be forced to leave, perhaps moving to NYC and parking above Central Park. Problem is the lack of cafes in Central Park and inability to use the internet there when so many are pricking me with their tooth picks. If Mindy returns I will contemplate sharing new technologies with Boulder like transmutation and the ability to walk through other matter besides simple gases and liquids. Thank you for your time in asking these questions.
1	1. Q14a makes no sense to me. "When selecting an Internet provider, how important is...having a choice of Internet providers?" 2. Don't care if it's city owned and operated, or privately owned and operated. Good luck with the latter, unless there are subsidies. Installing fiber to the curb ain't cheap. Presumably other cities that commit to low rates do this on their own because they don't have a profit motive, unlike private companies.
1	Internet access is arguably in the category of public good services that should follow a "socialized" model. If there were a ballot issue to fund citywide municipal access to everyone through taxes, I'd support that also. It should be ubiquitous and profoundly simple to use.
1	Since many aspects of daily life including work and even paying bills and filing government documents now require the use of the internet, I feel that internet access has now reached the point that it should be considered a public good and therefore treated as such.
1	Comcast has a functional monopoly on broadband service in my Boulder neighborhood. CenturyLink offers DLS service, but it is extremely slow (
1	My main concern with regards to internet is the threats of data caps (with exorbitant fees for extra usage) and throttling of web traffic based on content.
1	Giving people a service equal to Comcast will be enough to get them to switch because folks hate Comcast so much. If you bring in gigabit with no data caps at less than $75/month folks will like you rather than simply be happy you exist. If you can get gigabit for less than $50/month with decent customer service people will want to move here for the internet alone.
1	I want cover internet so bad... I hate being a slave to centurylink and Comcast. Let's build a city cover network or, even better, encourage Google to build one along with their new campus.
1	Boulder has the chance not only to scale the cutting edge of technology but to ensure that Boulder's future as a technology hub goes unscathed. It will not ascend to this goal, however, if what should be a public service (albeit not free) is monopolized once again by private interests like Comcast and Century Link, who only upgrade when their bottom line is threatened and who only provide the minimal level of customer service (which is to say, not a lot) to citizens, while catering mainly to business interests. With the City of Boulder building and successfully running a state of the art fiber network, we can become a model of how internet should be provided in the 21st century. We can inspire other small towns across Colorado and the nation to adopt a model similar to ours, and ensure that no citizen is left behind as the nation transitions to an economy largely based on technical pursuits. I implore the City of Boulder to be the innovative leader that this state, and indeed this country, needs. The council members who contribute to a public fiber network's implementation will not only have my continued political support, but will be enshrined in history as early pioneers of the transition to a more fair and open internet.
1	I am a resident of unincorporated Boulder County entirely within the City of Boulder (off Palo Parkway). We have city water and sewer. Much like the muni, the City needs to provide clarity on what services will be available (should be all of them!) If this requires annexation to the City then I'm all for it, but in the meantime the unnecessarily complex zoning is a hurdle to providing fiber to a geographical area that makes sense from a technical standpoint.

Count	Response
1	I'm concerned that Comcast (my current provider) is going to introduce data caps here as well, as they keep adding areas with data caps. If that happens I'll have to move to a slower provider without caps. I have strong hopes that Boulder can, and will provide a first class municipal network for its residents, just as other cities have done. I believe that the benefit for the community would be great, and that it would contribute to making Boulder an even better environment for its residents and businesses. Please see the following study: http://ftpcontent2.worldnow.com/wrcb/pdf/091515EPBFiberStudy.pdf
1	I would prefer that the government does not become it's own ISP, due to obvious privacy and conflict of interest issues. If the government provides the service, it could theoretically be leveraged to collect bulk data, prevent access (or restrict access) to sites the state does not approve, or to manipulate users by injecting content into unencrypted data (ie: advert replacement). That said, installing a fiber backbone (or allowing Google Fiber, etc) to build out a fiber network - definitely could be a good step (as long as no one service is allowed a government-granted monopoly on under/aboveground wire runs).
1	Now that our citizens have secured a right to opt out of the current cable monopoly, I am excited for us to do so ASAP. I do not care whether it is done directly by the city, by authority transferred to Google or other entities, or via a hybrid partnership. This is as important as reliable water and power in securing Boulder's future.
1	City of Boulder, only YOU can service the internet needs of this community properly. All the existing companies are huge national businesses who take very little care to address the needs of their customers. Since there is such a smaller amount of infrastructure to manage, I know a local broadband would vastly improve everyone's internet experience, especially in the area of customer support. I can tell you, we as citizens want this to happen. Please make it so!
1	The public doesn't have enough Internet choices. The telecom and cable companies really hold us hostage. Internet should be a Right for every Citizen of the United Stated. The City of Boulder should do everything in its power to provide high speed Internet to its residents. I'm very unhappy with Comcast and the lack of choice of Internet providers. We really do need to break the monopoly the telecoms have over us with respect to this vital technology. Also, the City of Boulder should do everything in its power to support Net-Neutrality. Thanks.
1	The city should never grant a monopoly contract to any television or internet provider. Providers should be required to share infrastructure and compete.
1	Century Link is expensive considering what you get. They are awful to deal with. Their services are lousy. Getting help can take 20-25 minutes on hold for customer service. I would pay a great deal upfront to have City Internet and be rid of these people. The City should establish their own internet service and at least offer it as an option to residents to change to City service. Please free us from Century Link and Comcast. They have a monopoly and treat their customers awful, plus they price-fix. Laura - UniHill neighborhood
1	I think Boulder needs this. Comcast is terrible, they have terrible service, their connection speeds are highly variable, and they randomly increase our prices every month unless I go to their office and tell them to stop. Longmont is getting optical fiber and we are losing tech folks because they prefer the Internet speeds that will be available in Longmont.
1	Data caps and speed limits will stunt growth and slow the internet economy we benefit massively from. We must have a service to compete and prevent the imposition of arbitrary caps to get more money out of people.
1	I've advocated to the City Manager that Boulder offer wireless service on a sliding scale, from free to low income families to a modest but sustainable price to everyone else. We are way past due!!!!
1	Fast reliable internet can attract even more startups. Widely available low cost internet is a social benefit for lower income and rural citizens
1	I think this will break up the monopoly-like status of service providers in the area. We have little choice in who we can get service through and the majority of services provided are terrible and exceedingly expensive for what is provided.
1	I've had great service and quality from Comcast's internet. However, there is no alternative for me to get similar or better speeds. I don't mind paying a fair price for the product. However, for a modern connection speed, Comcast requires bundling with their cable tv product, for which I have no use. As a result, the total bill for a decent but not high-end connection ends up over $120/month or higher, which is excessive.

Count	Response
1	My internet and cable service is included in my apartment rent so some of the questions were not applicable to me or not possible for me - we are not allowed to get a different service.
1	It's confusing that the city council supports municipalizing our electric utility but doesn't seem to favor municipal broadband. Let's just do it like Longmont!
1	Municipal broadband is the future. I would love it if we were able to kick Comcast to the curb. I'd pay a bit more for a local service!
1	I'm technically outside city of Boulder, but still have a Boulder Address. A higher speed service is definitely needed to meet current and future bandwidth demands.
1	Lack of competition for Internet service about 50 mbps symmetric is a major issue. It's also important that any service offers network amenities including static IP addresses, IPv6 support, no data caps, and liberal, net neutral Terms of Service allowing the operation of servers and services on the connection, sharing of connections, etc.
1	WHY would Boulder sit on fiber internet for so long without using it? And how is it that Longmont (our 'poor cousin') has it, and we don't? Can't Google help out :-D? Also, while we're at it, I hear Longmont has a free city bus line that runs up and down Main Street... sheesh! C'mon, Boulder!
1	Please get us fiber! Slow cable modems are starting to feel antiquated, a place like Boulder ought to have the best current technology.
1	I think it is important that the city understand that there is undoubtedly a strong desire for a fiber network to be available for purchase for residents of the city. Additionally, the network would undoubtedly be very popular considering the utter hatred and contempt for the primary service provider Comcast and their inability to apparently not constantly denigrate, screw over, and treast their customers like vapid idiots who couldn't possibly understand what they actually want or how cable internet service is actually provided.
1	I think Boulder should offer LOW SPEED broadband - perhaps 1 - 2 Mb/sec - to public residential customers for free or very low cost ($10 - $15 per month) and fast 1Gb service at some reasonable rate. I believe this is what Google offers in communities where it provides service.
1	I love the idea of creating competition for current ISP's in our area and potentially providing faster/more reliable internet service. However, I don't know the best way to go about this and am unsure of what role the government should play.
1	I am so tired of the monopoly that Comcast and CenturyLink have on Internet services in Boulder, with high prices, low speeds, and lack of 100% service reliability. I want faster, more reliable, and more reasonably affordable internet options. Bring it on, City of Boulder! Bring us a world-class internet system that outshines the competition in every respect: speed, price, reliability.
1	I regularly check my download/upload speeds. Down is consistently 90 mbps. I have a cable modem. I don't know how your statement about 100mbps being 5x to 10x faster than cable was derived but it's categorically not true in my case.
1	Please listen to what supporters of municipal internet want. Do not assume the town council knows what's best and please pay attention to what the younger voices want. They understand the Internet and this type of technology far better than the older generations ever will, which is why Comcast and Century Link exist the way they do. The city should be responsible for getting legislation passed to allow for municipal broadband and set up some guidelines but it should up to local providers to maintain the system.
1	High speed internet access would absolutely improve the quality of life in Boulder. I own a home and live in Boulder, as well as own a startup company with an office in downtown Boulder, and I would love to have high speed reasonably priced fiber internet. I honestly don't mind paying more for it because I hate Comcast so much. They have terrible customer service, terrible choices, not the most reliable internet, BUT they are the only reasonably priced high bandwidth-ish internet.
1	Please do this as soon as possible. I hate Comcast with a passion, and I believe that in this day and age it's undemocratic to deny any citizen access to the internet. We get all our information about the government and community from the internet.

Count	Response
1	I hate that Concast has a monopoly. The developer of our neighborhood entered into an exclusive agreement with Comcast so we have no choice unless we get satellite which we are not interested in because we don't watch a lot of TV. A Municipal Internet option for residences would break Comcast's stranglehold and allow for more fairness in the market for consumers.
1	Please bring high speed internet to Boulder. The current options are slow and expensive. I don't mind paying a higher price if the internet is really fast.
1	I feel extorted by our internet provider options. We are a captive audience with very limited choice. Comcast uses a sliding scale to offer tiered internet. We end up paying a high price for internet only or bundling. Boulder could make a meaningful economic impact-to homeowners, renters, and businesses if we had reasonably priced, high speed internet. Everyone benefits.
1	Should have asked if people rent or own. I rent so I would not be willing to pay an exhorbitant fee to hook up when I will likely move in a year or two.
1	It's important that the monthly price is low. I really don't use much internet, so I just want an inexpensive reliable option that's sufficiently fast for most things. 10-20mbps is good enough. In general, I would be willing to pay a high hookup fee if the monthly price is low, but I am a renter, so I would not make a large investment unless I owned property here.
1	I'd be very concerned with licensing use of high speed broadband to providers such as comcast and century link, because I do not trust them when it comes to price. The city would not be looking to profit, and could possibly do this at a better price.
1	An affordable, fast alternative to Comcast or other corporate options should be on the table. Comcast is a bad deal financially at best, with prices too high for the mediocre service they offer and abysmal customer service.
1	"Install state-of-the-art services and enter leases with competing private companies to offer services to the public" Anything but this.
1	We currently have Comcast for Internet and we are very unhappy with the reliability factor. We have business Internet (which costs more per month) and we still lose our service frequently.
1	The current model of private companies offering mediocre service for inflated prices is ridiculous. If Boulder wants to facilitate it's current population of entrepreneurs and please its tech savvy residents, offering a municipal high speed fiber optic connection would be a great method.
1	Fiber is only 1 block from my house. It's soooooo close! Sad to use old tech for that last block. Ah well, at least it is cheap and fairly reliable. I stopped using Comcast years ago because they throttled certain classes of connections. Please don't do that if you run an isp. Thx.
1	Please subsidize the cost of installation for people living in affordable housing or are under some poverty line.
1	Cell coverage is so spotty at my address that we have to have a landline. High-speed internet that is reliable and relatively inexpensive is what we expect for Boulder.
1	Cable currently has a monopoly in Newlands neighborhood. It is the only choice for speed > 2mbps. :(
1	For too long, we've had few choices for Internet providers (Comcast or CenturyLink). These providers are unwilling to provide superior speeds, reliability, and service at affordable prices. I would love to see something like Google Fiber come to Boulder or the city itself become the primary internet provider. Our city definitely needs some robust Internet competition to drive up innovation, speed, and reliability while driving down costs. The big providers are ripping us off.
1	I'm not sure government should be managing internet services, but more competition can't be worse than the current situation. We really need to break up the current ISP monopolies from a federal level.
1	Though I live outside the City limits, I spend the vast majority of my time within the City limits at my job, recreation and services.

Count	Response
1	I think any competition for Comcast and CenturyLink will be excellent for Boulder residents and businesses. There is currently a tremendous void in the Boulder market when it comes to true upper-tier internet - something faster and more reliable than cable, but less expensive than dedicated, antique optical carrier or ethernet-to-the-premesis solutions.
1	I support and encourage the City of Boulder to become the infrastructure provider for internet connectivity for all locations within the City. Partnering with private enterprise, or better yet a non-profit, to provide the maintenance services is a good approach. However, private enterprises running and managing the network is a very poor approach. A non-profit would be ok, but I very much prefer City employees to be responsible for the day to day operation of the network. Internet connectivity is an infrastructure requirement for successful communities, and I trust my local government much more than a profit above all else private entity to provide my infrastructure.
1	Really, if you offer any service which competes with Comcast directly for Internet on a similar (or, most likely, far superior) service level, I will switch immediately. I would qualify Comcast's internet service as "barely passable," in that they usually deliver the advertised data rate, but the rate is unacceptably slow for the modern era. I have had nothing but unpleasant experiences with Comcast customer services, both here in Boulder and elsewhere in the country; unfortunately, every city I have lived in has been a Comcast monopoly, so I cannot vote with my wallet, no matter how much I want to. I believe that today, Internet access is necessary for personal - and business - economic success, and thus should be treated as a neutral utility or service, like water, electricity, or the post. To me, it makes perfect sense for municipalities to provide this service to residents. It is one of the most straightforward ways to locally provide value to residents.
1	If the city council wants to generate enormous, wonderful feelings of undying gratitude from residents, this would do it! Please give us an alternative to Comcast at a good price. My mother lives in the not-too-cutting-edge Detroit area and her internet service is better than mine and half the price. Comcast and CenturyLink are gouging us.
1	Internet access is becoming a basic human right, today. In a city that is today BUILT BY THE VERY EXISTENCE of the Internet, it only makes sense to make high-quality or above-standard internet service to residents. I urge the city of Boulder to subvert the consumer-resenting, Machivellian-style of current ISPs, and make the Internet work for everyone, not just those who can pay $100 bills every month. I will say, if gigabit broadband was installed, as long as it was near the cost of Comcast's current prices, I would pay in a heartbeat.
1	The emphasis of the questions seems to favor very high data speeds. What I really want is good speed at a good price. 40GB at $20 for example. And it would have to be very dependable if I choose to use it for phone calls too. At home we have traditional phone service because the quality of the call is so much better than mobile. Using VOIP is a viable alternative, but the up-time on the data connection has to be 99.99%, otherwise it's unacceptable. At the higher data speeds that you talk about in your survey I'd probably choose to cut satellite for TV, which would not be hard if the over-the-air TV signals were better in Boulder.
1	This is something that needs to be done in Boulder. Multiple surrounding towns have already built to begun to build municipal fiber internet that supports both the residents and local businesses. As a student who used to live on campus as CU Boulder, I know what a hard wired fiber connection can be like and I believe that Boulder should expand this functionality to the rest of the town in order to support the growth of our growing tech sector as well as the community at large.
1	The US in general is far behind the curve of Internet service. Friends of mine in the UK get connections 8 times faster for half the cost (and yes, I did the currency conversion). I live in the Wonderland Hill neighborhood, and when I moved to Boulder four years ago, I was surprised that I was being quoted speeds of 6 Mb/s. It has since improved to 20 Mb/s, but that is still terribly slow. I have no qualms about paying for decent service, but there is none to be had. I do think that infrastructure should be controlled by municipalities. As to whether the government or private companies should provide the services, I'm not sure which I prefer, but Boulder is already taking on massive projects (like its own power utility), so I think it should lease Internet services, at least initially.
1	This is really important. Boulder needs to get involved in getting first class net access to the city. This will never, ever happen with Comcast.
1	My cable provider (Comcast) I think is very expensive ~$60/mo. The speed is acceptable but not worth the money.

Count	Response
1	As an IT Professional with a spouse who runs her own business in Boulder from home I feel I am perfectly suited to answer this, please keep that in mind. Boulder needs to do this themselves. Longmont is going to become the place everyone in the area wants to live unless Boulder can compete on service and price. We need gigabit service at $60/month or less or it's not worth it. No caps on data. Make Boulder attractive to business and the high tech people who want to live here. I hate Comcast. I want to have fast internet and not have to pay them. Also static IP addresses for an extra cost would be welcomed by all tech people even outside businesses. Please make this happen ASAP as it's much more important than who I get my energy from.
1	This would be extremely helpful for my business. I am currently with Comcast, and there are people times of the day when my Internet connection is inoperable. The speeds would also help with my video conferencing and large file uploads that typically take a long amount of time and/or are in low-quality and affect my productivity.
1	The BRAN needs to consider local players in the non- profit arena for inclusion in their pricing structure. These organizations create a fourth leg in our city's social fabric that is as important as the govt, federal labs and university.The omission of NPOs along th BRAN fiber route was a serious misstep by the city technology office and needs to be rectified regardless of the city potentially creating a new residential fiber system. The resources that were traded for BRAN's dark fiber came out of what would be general fund revenue. This is citizens money, not the technology office's money to create tech haves and havenots. Carter.johnson@ Juno.com
1	The city really needs some inexpensive (~$20/mo.) basic speed+bandwidth options. The average single user doesn't need a lot of speed or bandwidth but these types of plans are going away or becoming more expensive.
1	I would rather have competitively priced fast internet service (an option besides the current ones) than expensive super fast service that I can't afford.
1	The pure hatred we have due to horrible experiences with Comcast and CenturyLink are enough to move this forward - please do it!
1	A municipal broadband network would be amazing!!! I'm for it! Data caps on residential networks don't make sense (outside of abusive use) given the vast array of cord-cutting type services (Netflix, etc).
1	I hate our two current choices of Comcast or Qwest. They are overpriced and offer outdated speeds/technology.
1	Boulder Municipal fiber is an absolute necessity if Boulder is to remain a competitive tech hub and retain/attract talent for local businesses.
1	Please hurry! :) Internet is such an important part of everyone's life, productivity, and happiness and should be a public service. The service provided by Comcast and century link are crippling and the pricing is extortion. I would be ecstatic to have similar service that Longmont has. Please don't wait long though. Do what's necessary to make this happen ASAP.
1	Internet service today is run by a quasi-monopoly (Comcast) with all the high prices and poor service associated with it. It galls me that the City Council doesn't see municipally provided internet as a priority, as high speed internet could dramatically improve productivity and opportunity for residents at all economic levels and potentially reduce the need for commuting. That the city fathers place a higher priority on fighting Xcel when they can far more easily and effectively fight for affordable, universal access to the internet is a travesty.
1	I think Comcast and other companies are currently able to provide speeds adequate for today at rates that you might find difficult to compete with...providing the homeowners negotiate good rates. In adding fiber optic networks, your role provides for future speeds of download/upload that I am sure will become necessary with future technology. The trick will be insuring it can be done at a competitive rate. In my mind, the greater current need is improved cell coverage. Many in my neighborhood cannot make a cell call from home, forcing us to get a landline.
1	I'd like an ISP that I don't have to regularly renegotiate a good deal with. We have a DVR in the garage because a bundle was cheaper than an ISP alone, but are not interested in cable/satellite TV service.

Count	Response
1	please gigabit fiber do it. Boulder is now a tech center. second only to Silicon Valley. it's necessary to be able to recruit technical talent, etc. please please. Boulder needs to be a leader here. lead. put this extremely wealthy city into gear. tech and businesses make it wealthy. support businesses and people by getting up to speed on Internet. not a single person on earth likes Comcast or centurylink. please.
1	An affordable alternative to Comcast would be incredible, especially if there's no ambiguity about billing, price bundles, or package options -- they're a money-hungry corporation that's eager to mislead consumers and withhold information from them to maximize their profit.
1	CenturyLink and Comcast run based on the "two big to fail" model. Their customer service is terrible, overall speeds vs. price offered is terrible and they're just not good/honest people to work with. Boulder needs a 3rd party solution (i.e. Google Fiber) or a community sponsored (built internally) or "branded", but backed by Boulder ISP. We need transparency, reliability and speed on par with the level of businesses operating in town. Boulder is quite advanced in many areas but this is not one of them.
1	I think the most important thing is that Internet access be considered a utility to which all residents have a right for a modest fee. It is no longer optional. Low income people must have access to the Internet from their home.
1	In addition to the bundling question, I think it's important to have good "unbundled" offerings and prices. It drives me crazy that with Comcast it costs me more to have just internet service than it does to have internet with the most basic cable service. But it does, so we have cable.
1	This is for my business Imatest LLC. We pay too much for our fiber connection, over 1000 a month. Please give me an alternative to Comcast!
1	Boulder needs 1 gig fiber to remain competitive in the tech industry. Comcast is a monopoly that gouges customers with high prices, provides slow speeds relative to their capacity, has data caps, horrendous customer support, etc. Century link doesn't offer very high speed service. Boulder needs a 1 gig fiber network badly.

URL Variable: action

Count	Response

URL Variable: controller

Count	Response

URL Variable: id

Count	Response

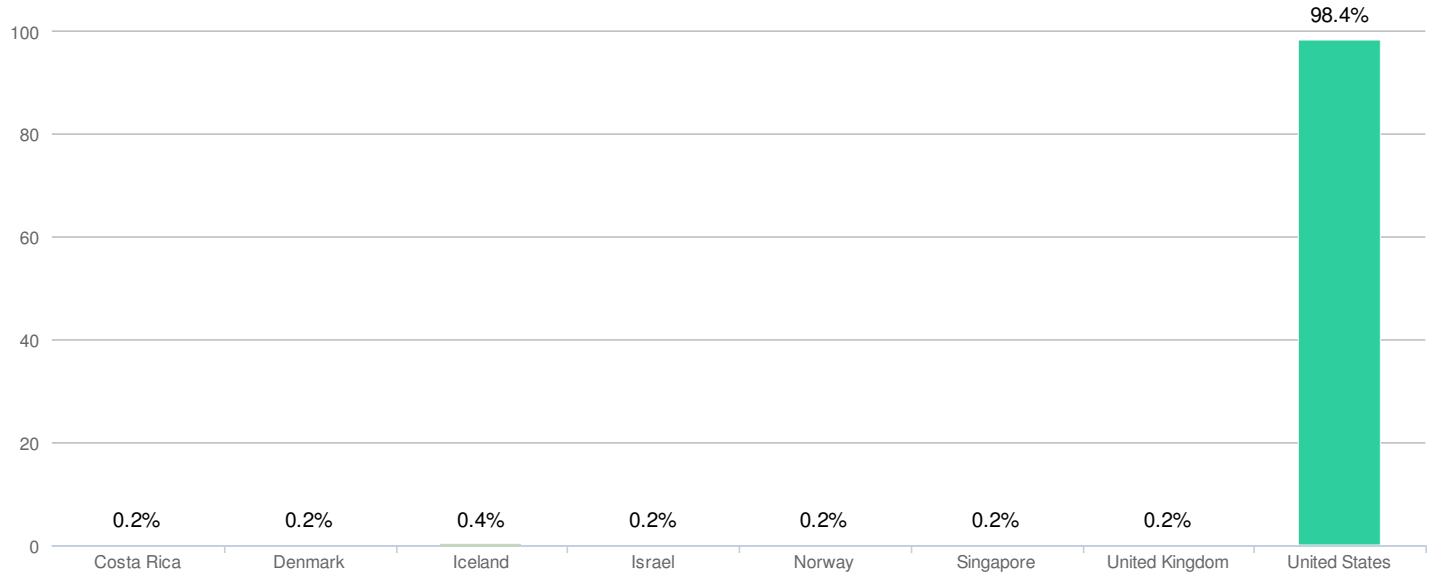
URL Variable: link_id

Count	Response

URL Variable: module

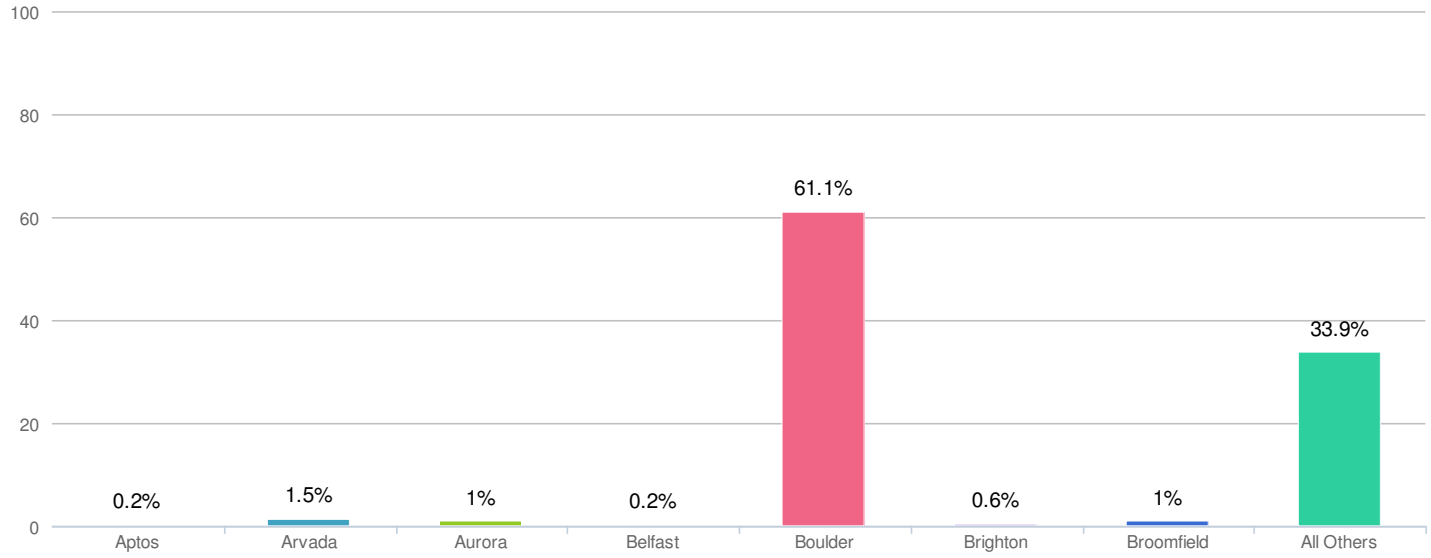
Count	Response

Source Countries



Value	Percent		Count
Costa Rica	0.2%		1
Denmark	0.2%		1
Iceland	0.4%		2
Israel	0.2%		1
Norway	0.2%		1
Singapore	0.2%		1
United Kingdom	0.2%		1
United States	98.4%		490
		Total	498

Source Cities



Value	Percent	Count
Aptos	0.2%	1
Arvada	1.5%	7
Aurora	1.0%	5
Belfast	0.2%	1
Boulder	61.1%	294
Brighton	0.6%	3
Broomfield	1.0%	5
Chicago	0.4%	2
Colorado Springs	0.2%	1
Denver	18.5%	89
Detroit	0.2%	1
Elk Grove Village	0.2%	1
Englewood	0.6%	3
Erie	0.6%	3
Fort Collins	0.2%	1
Fort Lupton	0.2%	1
Grand Junction	0.2%	1
Great Falls	0.2%	1
Huntington Park	0.2%	1
Kansas City	0.2%	1
Lady Lake	0.2%	1
Lafayette	0.6%	3
Littleton	1.7%	8
Longmont	1.7%	8
Louisville	1.0%	5
Makawao	0.2%	1
Marina Del Rey	0.2%	1
Matawan	0.2%	1
Montrose	0.2%	1
Nederland	0.2%	1
	Total	481

Value	Percent		Count
New Haven	0.2%		1
New York	0.2%		1
Orange	0.2%		1
Oxon Hill	0.2%		1
Parker	0.2%		1
Phoenix	0.4%		2
Plano	0.2%		1
Portland	0.2%		1
Redmond	0.2%		1
Redwood City	0.4%		2
Reykjavík	0.2%		1
Rødekro	0.2%		1
San Antonio	0.2%		1
San Francisco	0.4%		2
San José	0.2%		1
Seattle	0.6%		3
Singapore	0.2%		1
Smithtown	0.4%		2
Somerville	0.2%		1
South San Francisco	0.2%		1
Suwanee	0.2%		1
Tavares	0.2%		1
Tel Aviv	0.2%		1
		Total	481

Appendix B – Common Community Objectives

ctc technology & energy

engineering & business consulting

Appendix B – Common Community Objectives

Prepared for the City of Boulder

May 2016

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Contents

1 Introduction 1
2 The Relationship Between Common Broadband Objectives 2
3 Detailed Descriptions of Common Objectives 5
3.1 Ubiquity – Service Is Brought to All Areas of a Community 5
3.2 Affordability – Service Can Be Purchased by Citizens at All Income Levels 7
3.3 Consumer Choice – Citizens Can Purchase Service from Various Providers 8
3.4 Competition in the Market – Enabling Multiple Providers to Compete 9
3.5 Ownership and Control of Assets 10
3.6 Performance – Standing Out with a Superior Network 11
3.7 Risk Aversion – Minimizing the City's Exposure and Liability 12
3.8 Positive Cash Flow – Becoming Financially Sustainable 14

Figures

Figure 1: Interplay between Objectives 4
Figure 2: Ubiquity Aligns with Choice, Competition, and Ownership 5
Figure 3: Ubiquity Conflicts with Affordability, Cash Flow, and Risk Aversion 6
Figure 4: Ubiquity Alignments, Conflicts, and Potential Outcomes 7
Figure 5: Risk and Reward Matrix 13

Tables

Table 1: Common Goal Alignment 3

1 Introduction

No matter how demographically and geographically different they are, most localities that seek to deploy fiber-to-the-premises (FTTP) networks share certain objectives. Sometimes the primary objectives align, but they also may directly conflict with one another. It is important for the City to consider at the outset its primary, nonnegotiable goals—and to expand to other objectives from that starting point.

This analysis seeks to help the City understand the interplay between common objectives so that it can make decisions about which of its goals are most important, and how to achieve access to broadband in a way that makes sense for Boulder.

Instead of considering open access separately, this analysis looks at the objectives that drive the desire for it, and how the City might attain those goals. As OTT programming and applications become increasingly prevalent, the need for traditional open access, which relies on access to dark fiber—and all the operational details and costs associated with it—is waning. The City may find that it can achieve its open access goals, thus promoting competition and consumer choice, through alternative means. If the City builds a ubiquitous network, and then partners with a private entity to manage operations and provide an unfettered data service, this introduces a new competitor into the market and drives competition at the applications layer.

2 The Relationship Between Common Broadband Objectives

Many communities share common objectives when considering an investment in a broadband network. In our experience, most localities have some or all of the following goals:

- Ubiquity
- Affordability
- Consumer choice
- Competition in the market
- Ownership and control of assets
- Performance
- Risk aversion
- Positive cash flow

Choosing which goals to prioritize can be challenging; we sought to provide the City with information to empower decisions about its connectivity needs that will have ongoing positive outcomes. We used as the basis for our analysis the assumption that the City wants to pursue a universal, or ubiquitous, build-out. It is our understanding that the City wants to bring a fiber connection to every home and business in the City of Boulder, and that the City is resolute about serving traditionally underserved residents.

It is important for the City to understand how these objectives interact with each other, how pursuing one objective may mean foregoing another, and how prioritizing objectives can impact the City's decision-making process as it moves forward. Each community must balance its needs so that it can achieve its goals without sacrificing objectives it deems essential. It is important to understand what is behind each of these objectives, and why the City may be compelled to pursue one over another.

As an example, risk aversion is top priority for some communities; it may be politically challenging to build a network, and the only way to complete it is to assure key stakeholders and the public that there is minimal risk involved. As we explain below, however, risk aversion directly conflicts with the goal of building the network throughout an entire community.

We illustrate in Table 1 below the intersection of common objectives. As the key at the top of the table shows, one objective may have no impact on another (NI), objectives may align (A), or they may conflict (C).

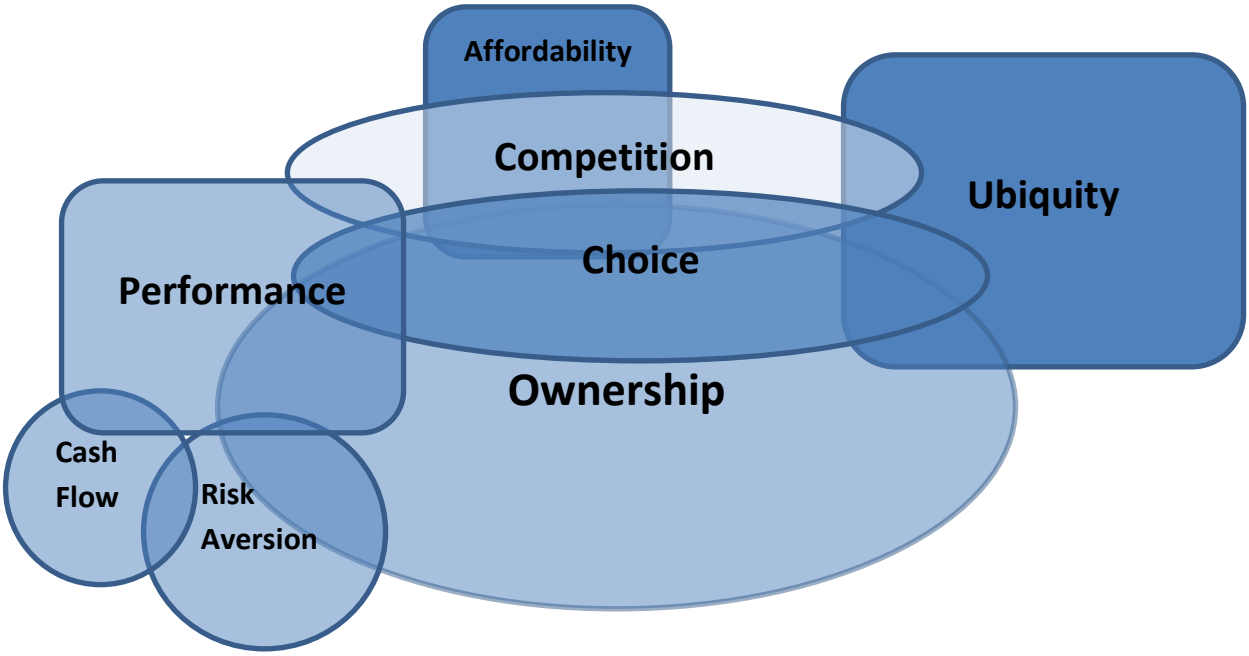
Table 1: Common Goal Alignment

A: Align **C:** Conflict **NI:** No Impact

	Ubiquity	Choice	Competition	Ownership	Performance	Affordability	Risk Aversion	Cash Flow
Ubiquity		A	A	A	NI	C	C	C
Choice	A		A	A	A	A	C	NI
Competition	A	A		A	A	A	C	NI
Ownership	A	A	A		A	A	A	C
Performance	NI	A	A	A		NI	A	A
Affordability	C	A	A	A	NI		C	C
Risk Aversion	C	C	C	A	A	C		A
Cash Flow	C	NI	NI	C	A	C	A	

In the sections below, we further define these objectives, explain this table, and outline how the objectives listed here interact and overlap with one another. We also describe how prioritizing one objective may impact the City's ability to focus on another. Figure 1 below shows a visualization of Table 1 to illustrate the relationship between common objectives.

Figure 1: Interplay between Objectives



There are numerous possible outcomes associated with different objectives, and the City has to determine what it believes will best serve its unique needs, and have the greatest impact on the community. This analysis does not seek to urge the City in any particular direction, but takes into consideration the City's articulated goals, and attempts to clarify and flesh out what may drive a desire to achieve certain objectives.

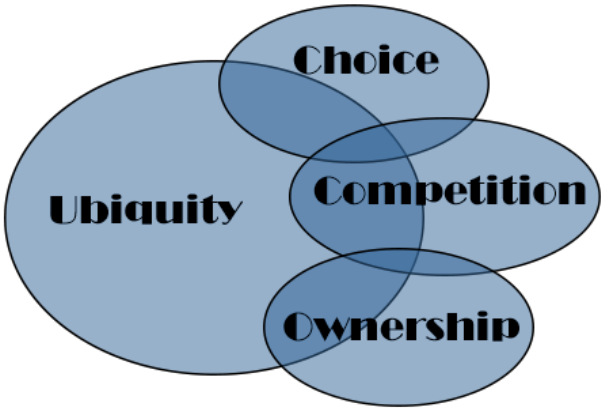
As we noted, some objectives may interact favorably with others, overlap, or have no impact. For example, performance either interacts favorably or not at all with other objectives, and prioritizing performance can have a significant positive impact on the FTTP network's viability by setting it apart from incumbent providers. There are no real disadvantages to making performance a top priority for the FTTP network because doing so does not require the exclusion of any other objectives. The City has already demonstrated a commitment to performance through its meticulous documentation and successful operation of its existing network. We encourage a continued commitment to performance and pursuing other objectives in parallel.

3 Detailed Descriptions of Common Objectives

3.1 Ubiquity – Service Is Brought to All Areas of a Community

For most communities that opt to build and operate a network, ubiquity—which refers to designing and building the network so that it connects every residence, business, and institution in the community—is a key objective. Incumbent providers have traditionally often built only to the most affluent areas of a community where they are sure to see a return on investment (ROI), a practice known as "cherry picking." Many communities are compelled to build a ubiquitous network to safeguard against leaving behind those parts of a community that may not be desirable to private providers. Communities throughout the nation have prioritized ubiquity as a primary goal in their broadband pursuits,[1] and our analysis assumes this as a baseline objective for the City. As illustrated in Figure 2, ubiquity aligns with choice, competition, and ownership.

Figure 2: Ubiquity Aligns with Choice, Competition, and Ownership



This is a reasonable objective for any community; it makes sense that leaders want to bring service to the entire community, and we recognize the City's commitment to building a ubiquitous network. However, it is important to note that immediate communitywide build-out often entails significant risk and cost. The financial risk alone is considerable, and in order to make the model sustainable, the service may have to be priced out of some consumers' reach.[2] If the City opts to pursue an FTTP build-out where it retains ownership of the fiber optic network, it will likely have to seek large municipal bonds to cover the capital costs of building the network. It will then be responsible for making principal and interest (P&I) payments, or debt service.

[1] See, for example: http://www.cnet.com/news/connecticut-communities-join-together-for-gigabit-broadband/, http://broadband.blandinfoundation.org/_uls/resources/Vision_Statement_FINAL_0228.pdf, and https://www.portlandoregon.gov/revenue/article/394185.

[22] This is not to say that pricing cannot be adjusted through various means to absorb additional costs to consumers, but this will likely come with a higher price tag for the City.

If the City seeks to use revenues from the FTTP network and any retail service offered over it to cover its debt service payments, service fees will have to be calculated with the total cost of P&I in mind. Unless the City is able to implement a sliding scale fee structure for its most vulnerable populations, those prices may not be affordable to all residents; thus, service prices based on the City's need to pay for a ubiquitous build-out will likely conflict with the City's goal of ensuring that service is truly *accessible* to all its citizens.

A full-scale build-out is typically not compatible with avoiding risk, as localities that seek ubiquity are likely to face stringent deadlines and much higher capital costs than a phased build-out. We note that even a phased build-out in a City the size of Boulder will be expensive.[3]

Maintaining positive cash flow is another objective that conflicts with ubiquity. While the City likely does not expect to make a profit on the FTTP network, it is important for the network to be financially sustainable, covering at least any debt service payments and operating costs. This is often referred to as "positive cash flow" or "breakeven." Assuming the City is responsible for the cost of deploying the fiber network, the higher cost to build to every structure in the City means that the point at which the FTTP network is able to establish positive cash flow will come much later than if the City slowly built out and began generating subscriber revenue earlier in the build-out process. While a partnership may enable the City to reach positive cash flow sooner than a fully-municipal deployment, ubiquity generally conflicts with positive cash flow. Figure 3 illustrates the conflict between ubiquity and affordability, cash flow, and risk aversion.

Figure 3: Ubiquity Conflicts with Affordability, Cash Flow, and Risk Aversion

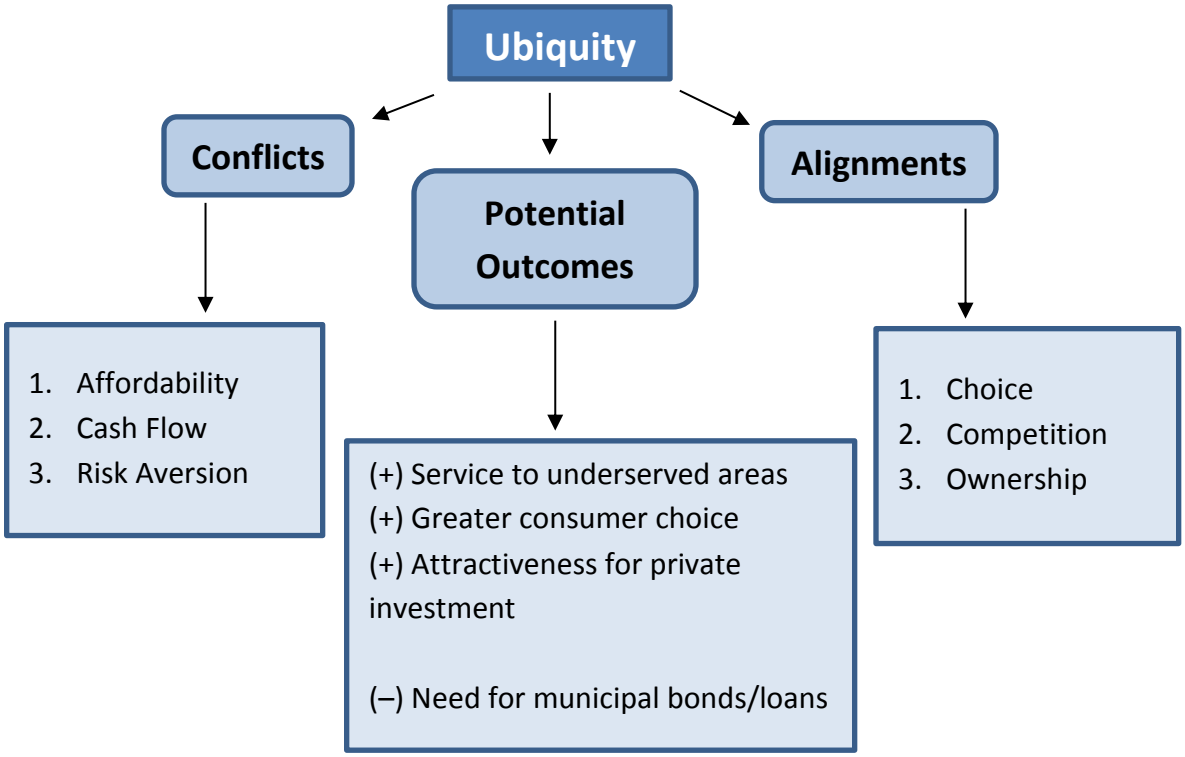
The City may determine that the advantages of pursuing a ubiquitous network build-out will outweigh any of the potential conflicts with other common objectives. Further, as we noted, the City can take steps to manage some of the potential challenges associated with conflicting

[3] See *Appendix E and Appendix F for projected costs in Boulder.*

objectives (e.g., developing programs to help cover subscriber fees to ensure the service is not priced out of some consumers' reach).

The conflicts, alignments, and potential outcomes associated with prioritizing ubiquity are summarized in Figure 4.

Figure 4: Ubiquity Alignments, Conflicts, and Potential Outcomes



3.2 Affordability – Service Can Be Purchased by Citizens at All Income Levels

Affordability is important even in communities that may have few low-income areas. While this objective is certainly more important for vulnerable portions of the community, still affordability is often a necessary objective for localities. For example, the City may prioritize affordability in an effort to ensure that its entrepreneurs and tech startups can afford the robust connectivity necessary to support their business endeavors.

There are areas in Boulder where demand is likely low enough that private providers are unlikely to build there. Private providers typically cherry pick based on where they determine they are most likely to recover their cost to build. While the City may not be faced with the choice to potentially offset service costs for a large number of low-income residents, still it may benefit from choosing to invest in infrastructure throughout the community.

Providing affordable service to the entire community would likely create benefits for the City in terms of enhanced quality of life and economic benefits. Further, the City could work with local government and nonprofit agencies to fully leverage benefits that are not monetarily quantifiable. These "benefits beyond the balance sheet" cannot be measured on a financial statement, but their impact communitywide is often profound.

The City may be able to balance ubiquity and affordability by negotiating an agreement with one or more private partners that includes sensitivity to the need for affordable, accessible services in all parts of the community. Similarly, the City may decide to subsidize services for certain portions of the community.

Choice, competition, and ownership all interact favorably with affordability. If the City is able to reduce pricing to a level that is attainable to all of its residents, the expansion of choice and the likelihood of increased competition will be notable. And if the City retains ownership of its assets, it can make choices about affordability similar to the control it can exert over performance.

If the City decides to subsidize services, it may find that prioritizing risk aversion and attaining positive cash flow become more difficult. The more debt and responsibility the City takes on, the higher its risk and the longer it will take for the FTTP network to be cash-flow positive. Similarly, even if the City does not directly subsidize services, prioritizing affordability may mean pricing the product low enough that it is challenging to also prioritize risk aversion and cash flow. It will be important for the City to determine its priorities, and to strike a balance so that one objective is not achieved at the exclusion of another.

3.3 Consumer Choice – Citizens Can Purchase Service from Various Providers

Localities often pursue open access as a means to increase consumer choice; this is an important consideration and a high priority for many communities. Incumbent cable and Internet providers may have little economic incentive to expand to areas of the community where they believe they will not recover significant portions of their cost.

A ubiquitous network that fosters open access, boosts competition, and reaches all parts of the community enhances consumer choice on a number of levels. In addition to gaining access to residential services that may previously have been unavailable, consumers often end up with greater flexibility to access services at various community locations. Ubiquity and competition enable enhanced services at community centers, religious institutions, educational facilities, and other locations that benefit residents.

Affordability of services ties directly with competition and consumer choice—being able to pay for services is often a major barrier for consumers. Having affordable access to services with competitive speeds can significantly improve quality of life, make residential areas more

desirable, and spur business growth. Access to premium residential services at affordable prices can also incite home-based businesses, support continued education, and enable access to basic human services like healthcare and education.

Risk aversion could negatively impact consumer choice. If the City decides that it will slowly and organically build out its network and does not take steps to prioritize particularly vulnerable areas, it is possible that only the consumers who have traditionally enjoyed provider choice will be positively affected. The City may find that it can balance risk mitigation with community benefit by deliberately funding service to portions of the community that may be undesirable for a private entity. If the City chooses to seek a partnership, this could be negotiated.[4]

3.4 Competition in the Market – Enabling Multiple Providers to Compete

Fostering competition in the market is generally the second component of an open access pursuit. That is, communities often seek to develop an open access infrastructure to enable multiple providers to offer service over the network and enhance competition. Like consumer choice, this is generally a major reason communities attempt to pursue a traditional open access infrastructure. Similar to consumer choice, competition in the market can be achieved through open access in the traditional sense as well as through other means.

The key for most objectives is to determine whether they are primary, how they may conflict with others, and how best to pursue whatever a community deems is its most important goal(s). We believe that competition both upholds and is upheld by other potential primary objectives—it aligns with, does not impact, or is not impacted by other common community objectives. The only potential exception to this is risk aversion, which we explain below.

Choice and competition go hand in hand, and seeking ways to encourage competition will likely only result in greater consumer choice in communities. Similarly, a ubiquitous network build will probably result in greater competition among local providers. This is not only through providers potentially offering services over the City's network, but also in the form of incumbent providers lowering prices and enhancing services in response to improved services by other providers.[5] This also speaks to competition vis-à-vis affordability and network performance: the greater the market competition, the greater the likelihood that other providers will seek to improve their services and lower their prices.

[4] The Urbana-Champaign Big Broadband (UC2B) public network negotiated a similar partnership with a private entity, which will be passed on in the event of any sale or transfer of the network.

[5] Marguerite Reardon, "Google's fiber effect: Fuel for a broadband explosion," *CNet*, April 30, 2014, http://www.cnet.com/news/googles-fiber-effect-fuel-for-a-broadband-explosion/, accessed April 2016.

Competition in the market and consumer choice can be prioritized simultaneously with other objectives without negative consequences, and localities often find that focusing on the overall well-being of their communities and citizens has numerous advantages.

It is important to note, however, that there may be some risk involved with creating competition in the market. The service provider industry can be inhospitable, particularly when the perception is that a public entity is attempting to compete with private industry. A major challenge faced by networks built and operated by public institutions is opposition from existing, private-sector providers. There are a number of reasons for this, some of which are related to perception while others relate to the market itself. Criticisms could range from unauthorized use of general or other funds for debt service coverage, to questioning the need or demand for public-based connectivity services.

An important risk that the City should keep in mind is the potential for litigation from objectors ranging from incumbent providers to watchdog groups. Lafayette Utilities System (LUS) was sued by incumbent providers the same year it proposed creation of a separate utility for FTTP,[6] and the Tennessee Cable Telecommunications Association filed a lawsuit against Chattanooga's Electric Power Board (EPB).[7] These are only two examples of the litigation that public sector entrants to the market have faced from incumbent providers and others.

3.5 Ownership and Control of Assets

Retaining ownership of outside plant (OSP) assets is important to mitigate risk; owning assets is an important way for communities to retain some control of their networks. This includes a scenario in which a community pursues partnership with a private provider; a good way to balance risk and reward is for the City to maintain ownership and control of the fiber assets while it assigns operational responsibilities to a private partner. This enables both parties to perform functions that highlight their strengths while not having to expend resources and energy attempting to carry out tasks for which they are ill-equipped.

Cash flow could potentially conflict with ownership and control of assets, depending on the degree to which the City chooses to exert control. Maintaining a fiber optic network can be costly, particularly if the City opts to be the retail provider for the service. Operational expenses are a sizable and often unpredictable portion of overall network cost, and it can be difficult to get the take rate necessary to reach positive cash flow.

[6] "About LUS Fiber: Timeline," LUS Fiber, http://lusfiber.com/index.php/about-lus-fiber/historical-timeline.
[7] "Cable Group Files Suit To Try To Block EPB Fiber Optic Plan," *The Chattanoogan*, Sept. 21, 2007, http://www.chattanoogan.com/2007/9/21/113785/Cable-Group-Files-Suit-To-Try-To-Block.aspx, accessed April 2016.

Other objectives either interact favorably or not at all with ownership and control of the assets. If the City retains complete control of the assets, it can make determinations about which provider(s), if any, can offer services over the network. It can regulate which service providers offer services and to what degree, thus allowing for considerable quality control.

The City may choose to oversee and maintain the network—a function with which it is already well accustomed and for which it is already staffed to some degree—and rely on a private partner to deliver retail services. The City may also be able to govern price points to support consumer affordability and service speeds to enhance performance. And because the City would own the network, it would be in control of performance.

3.6 Performance – Standing Out with a Superior Network

Many communities are already served to some degree by incumbent providers—whether by large national cable or telephone companies, or small local ISPs. Network performance can thus be a powerful differentiator for a community broadband endeavor.

Prioritizing performance in a retail offering is not only advantageous, we believe it is necessary to make the City's offering stand out among existing broadband providers. Market entry is generally a major challenge for public sector retail providers, and even a public–private partnership will likely benefit from focusing on one or two highly specialized offerings to allow it to thrive among incumbents.

The City has already proven its ability to successfully operate a dark fiber network. While the City likely will not offer retail services directly, if it retains ownership and control of the dark fiber and partners with one or more private entities to provide service, it may want to build into its contract a high bar for performance standards.

The City may find that its FTTP endeavor will struggle and be more prone to failure if it attempts to compete with incumbent providers by offering services similar to existing packages. Instead, it is prudent to recognize gaps in the existing broadband market and seek to fill those with a unique service offering that incumbents are not currently able to provide. A 1 Gbps niche service may enable the City's and/or a private partner to enter the market and avoid competing with "me too" services.

A 1 Gbps service that is expandable to 10 Gbps and beyond may be the differentiator that the City needs to stand out. By focusing on an extremely powerful data-only offering and communicating with potential subscribers about the advantages of a high-performance, unfettered data product, the City may spark the shift in the market it needs to be successful. The goal is to focus on *unbundling* from the traditional triple-play (i.e., focusing on data, not on cable

and phone service), and effectively encouraging consumers to leverage the data service to its fullest capacity.[8]

Performance interacts favorably or not at all with other objectives, which is shown in the visual breakdown in Figure 4. There are no disadvantages to prioritizing performance as a key objective in a community build, and we believe that this should be a main focus of any fiber enterprise.

If the City retains ownership of its assets, it also has better control over performance. By owning the network over which services are provided and overseeing a private entity that is serving end users, the City can require the level of performance that it deems appropriate to best serve the community's needs.

Risk aversion and cash flow both interact well with performance. We believe that the City minimizes its risk by entering the market with a 1 Gbps high-performance network. The City can set itself apart from other providers by offering a high-speed data product that incumbents cannot.[9] Further, it can differentiate itself by having an always-on, extremely reliable service that customers can use in new and beneficial ways—like to operate a home-based business, telecommute to their job, or pursue an advanced degree.

3.7 Risk Aversion – Minimizing the City's Exposure and Liability

There are numerous potential risks that the City may face as it considers FTTP deployment—financial, legal, and political, for example. While it is necessary to avoid risk to some degree, it is equally important to balance risk and reward. It may take considerably longer to design, build, and deploy a network if risk aversion is the City's top objective. The "slow and steady" approach is not without merits, but it is also unlikely to give a community a competitive edge. Decreased speed to market—or building out slowly—gives competitors more time to respond to the City's approach.

Figure 5 shows a risk and reward matrix that highlights the City's most likely low-risk-low-reward, low-risk-high-reward, high-risk-high-reward, and high-risk-low-reward outcomes. The lowest risk with the highest potential reward lies in building the network in a phased approach, specifically based on the Google Fiber build-to-demand model.[10] In this approach, the company signs up subscribers by neighborhood (known as "fiberhoods" in the Google Fiber model); once a

[8] It may be challenging to attract users who are accustomed to triple play services, but it will be a far greater challenge to compete with incumbent providers by offering the same packages.
[9] It is important to note that products like AT&T's GigaPower and Comcast's Gigabit Pro do not set their advertised 1 Gbps and 2 Gbps service as a baseline, which is what we have suggested to the City. Rather, these products offer a 10 Mbps to 100 Mbps baseline with the potential to deliver 1 Gbps to 2 Gbps service as occasional exceptions. The City, on the other hand, may be able to provide service up to 10 Gbps and beyond with 1 Gbps as its baseline.
[10] Alistair Barr, "Google Fiber Is Fast, but Is It Fair?", *The Wall Street Journal*, August 22, 2014, http://www.wsj.com/articles/google-fuels-internet-access-plus-debate-1408731700, accessed May 2016.

neighborhood has reached a certain threshold level of committed subscribers, fiber will be built there.

Figure 5: Risk and Reward Matrix

Reward \ Risk	High	Low
High	○ Deploy a ubiquitous communitywide FTTP build, partner with a private provider to operate the retail component, City maintains ownership and control of assets	○ Prioritize risk aversion to avoid bonding, slowly expand network in a phased approach and engage a private partner for operation and retail services
Low	○ Compete with tiered services similar to incumbents – a "me-too" offering.	○ Maintain current network and do not pursue expansion of services

If the City chooses this approach, it must recognize that it necessarily sacrifices certain other objectives like affordability and consumer choice. Risk aversion will generally come at the expense of objectives like these, and is especially in conflict with a ubiquitous build-out.

These objectives do not have to be mutually exclusive; instead, the City has to decide to what degree it wants to prioritize which objective, and be prepared for possible conflicts and how to mitigate those. For example, if the City chooses a phased approach, it may opt to first expand service to a location that can demonstrate the power of the network. This will support marketing, and can potentially help convince consumers to sign up for service, thereby achieving ubiquity in a lower risk fashion.

Risk aversion conflicts with ubiquity, choice, competition, and affordability. As we previously noted, it will be challenging to obtain a ubiquitous build-out at all, and especially not within a few years if the City prioritizes risk aversion as its key objective. Because the network is unlikely to be built out quickly in this case, it also reduces the likelihood of increased competition and choice.

If the community chooses to prioritize risk aversion, it will align with ownership, cash flow, and performance. Ownership of the assets usually means lower risk for the City because it has greater control and flexibility.

3.8 Positive Cash Flow – Becoming Financially Sustainable

Becoming cash flow positive is an important goal for any business or entity, and it is also a bit complex to define. Net income is often referred to as "cash flow," though this is technically incorrect because depreciation is a non-cash expense.

Earnings before interest, taxes, depreciation, and amortization (EBITDA) is the difference between operating revenues and operating expenses; it is a key metric in designing a viable financial model, along with net income. In a capital-intensive business such as an FTTP enterprise, EBIDTA must quickly become positive to keep the enterprise afloat. When EBITDA becomes positive, the business can be said to be cash flow positive. Net income then deducts interest, taxes, and depreciation. Revenues are tied to an enterprise's ability to be sustainable or cash flow positive. Collecting revenues to pay off debt and support business operations bolsters the net income and increases the likelihood that it will become positive.

Several objectives may conflict with cash flow, like affordability, ownership, and ubiquity. As we noted, revenue collection directly impacts cash flow so higher revenues mean a greater likelihood of being cash flow positive. If the service is priced affordably, this may mean lower monthly service fees and a longer path to the enterprise becoming cash flow positive, or self-sustaining.

Ownership may also impact cash flow, especially if the City elects to retain ownership of all network electronics, including customer premises equipment (CPEs). Depreciation costs are significant, and it is important to reserve funds for equipment and infrastructure replacement. Typically, last-mile fiber and CPEs are replaced after approximately five years, core network equipment is replaced after seven years, and outside fiber and facilities are replaced after 20 to 30 years. Because the useful life of fiber is considered to be 20 years or more, our financial analyses do not account for its replacement. If the City opts to build and own only the dark fiber portion of the network, its risk will be much lower than if it is responsible for core network equipment and CPE replenishments.

Another element of ownership in the context of cash flow is the need for network maintenance and locating costs. Although the City has experience with maintaining a fiber optic network, increased costs associated with serving an increased volume of end users may be significant in terms of both locating and replacing equipment at customer homes and businesses.

Appendix C – Financial and Strategic Considerations for Partnership Negotiations

ctc technology & energy

engineering & business consulting

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June 2016

Prepared for the City of Boulder

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Contents

1 Introduction 1
2 The City's Key Objectives Are the Basis for Partnership 2
3 Financial Elements of a Partnership Agreement 4
3.1 Capital Expenditures 4
3.2 Expenses 5
3.2.1 Maintenance 5
3.2.2 Operations 5
3.3 Financing Options 6
3.3.1 General Obligation Bonds 7
3.3.2 Revenue Bonds 8
3.4 Debt Service 8
3.4.1 Payments 8
3.4.2 Guarantees 9
3.5 Net Present Value and Internal Rate of Return 9
3.6 Escalation Payments 10
3.6.1 Applying a Consumer Price Index (CPI) Escalation 10
3.6.2 Be Wary of CPI Escalations Applied to Capital Expenditures 17
4 Emerging Partnership Models 19
4.1 Risk 20
4.2 Benefit 21
4.3 Control 21
4.4 Model 1: Private Risk, Public Facilitation 22
4.4.1 Strategies for Encouraging Private Investment 23
4.4.2 Potential Benefits and Pitfalls 24
4.4.3 Case Study: Holly Springs, NC 25
4.5 Model 2: Private Execution, Public Risk 25
4.5.1 Macquarie Capital 27
4.5.2 SiFi Networks 27

4.5.3 Symmetrical Networks 28
4.6 Model 3: Shared Risk and Investment 28
4.6.1 Case Study: Westminster, MD 29
4.6.2 Case Study: Santa Cruz, CA 31
4.6.3 Case Study: Garrett County, MD 32
5 Additional Strategic Considerations for Public–Private Partnerships 34

Figures

Figure 1: City Goals Are Interconnected 3
Figure 2: Market-Based Finance Rate with and Without CPI Escalation (Annual Payments) 11
Figure 3: Market-Based Finance Rate with and Without CPI Escalation (Total Payments) 12
Figure 4: Market-Based Finance Rate with and Without CPI Escalation (NPV of Payments) 13
Figure 8: Market-Based Finance Rate with and Without Escalation & Discounted Finance Rate With Escalation (Annual Payments) 14
Figure 9: Market-Based Finance Rate with and Without CPI Escalation and Discounted Finance Rate With CPI Escalation (Total Payments) 15
Figure 10: Market-Based Finance Rate with and Without Escalation & Discounted Finance Rate With Escalation (NPV of Payments) 16
Figure 11: Market-Based Finance Rate Without CPI Escalation and Discounted Finance Rate with CPI Escalation (Annual Payments) 17

1 Introduction

A public–private partnership with an entity that is willing to share some of the risk (and some of the reward) of fiber-to-the-premises (FTTP) deployment is an attractive avenue toward addressing the City of Boulder's broadband needs. In early 2016, the City released an RFI to solicit input on potential partnership arrangements; the RFI was designed to allow the City to explore opportunities with for-profit and nonprofit entities that might be interested in a long-term relationship for FTTP deployment in Boulder.

In this analysis, we outline some of the emerging partnerships in the broadband industry today (including the models presented to the City through RFI responses), and the implications of various financial approaches (including some financial relationships suggested in RFI responses), and how those models and financial factors may affect the City's partnership negotiations.

2 The City's Key Objectives Are the Basis for Partnership

The City's understanding of its vision, and the key results its hopes to achieve through broadband deployment, are critical to enabling the City to negotiate a partnership relationship. Based on our discussions with City staff and our understanding of community goals, we believe the following objectives are the baseline for the City's broadband initiative:

- Ubiquity – Service is deployed to the entire City
- Competition in the marketplace – The infrastructure enables multiple providers to compete
- Consumer choice – Citizens can purchase service from various providers
- Control – The City has a long-term stake in the asset

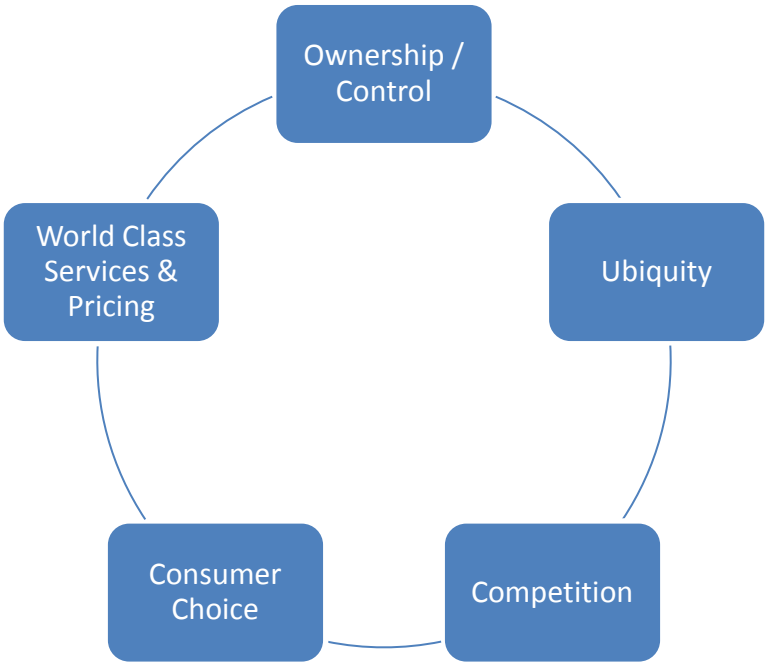
These goals are interconnected; pursuing one can potentially help the City achieve another.[1] For example, ubiquity—which refers to designing and building the network so that it connects every residence, business, and institution in the community—is foundational to the City's broadband initiative. The City aims to ensure that none of its residents, businesses, or community anchor institutions (CAIs) is excluded from access to broadband service. In contrast, incumbent providers have often built only to the most affluent areas of a community—a practice known as "cherry picking"—because those areas are where they are more likely to see a return on investment (ROI).

By developing a ubiquitous network that allows multiple providers to compete, the City can address competition in the marketplace, which leads to greater consumer choice. This, of course, is contingent on the City retaining a level of ownership of the network that enables it to mandate that the network is built to every part of the community.

Prioritizing ubiquity aligns with the City's other core goals, and ideally supports increased competition. And consumer choice would ideally flow naturally from increased competition in the marketplace. Another important City goal is that Boulder consumers have access to world-class services and pricing. Depending on the structure of the partnership agreement, certain service and pricing levels may be negotiated into the contract. Further, if the fiber is deployed ubiquitously throughout Boulder, and the marketplace becomes more competitive, the caliber of service and associated pricing ideally would also improve.

[1] In Appendix B, we evaluated these and other common goals that drive localities as they consider the feasibility of deploying FTTP networks.

Figure 1: City Goals Are Interconnected



Competition in the marketplace and consumer choice are complementary objectives, and are often sought through a pursuit for open access. In fact, many communities have prioritized open access as an essential, nonnegotiable objective. But as technology, applications, and content delivery services have evolved, it may no longer be necessary to focus on open access in the traditional sense to achieve competition and consumer choice.

The City is interested in control of the assets, which will be a fundamental aspect of any partnership agreement. Ownership of the assets is not necessarily required; the City is willing to forego direct ownership for the minimized risk of allowing a partner to directly invest in the assets—as long as the City can retain long-term input.

Each of these objectives drives the City's FTTP initiative, and informs its evaluation of potential public–private partnership models.

3 Financial Elements of a Partnership Agreement

One of the most important aspects of any partnership is the financial agreement between the City and its potential partner, which is based on several factors. It is important for the City to understand its own vision and a partner's willingness to share financial risk and reward. Unfortunately, as partnership models have evolved in the broadband industry over the past many years, some private companies have made bold claims that seemed too good to be true—and ended up being exactly that.

The reality is that it is expensive to deploy an FTTP network, which is part of the reason that incumbent providers often upgrade their legacy networks or build new fiber only when increased competition in the market forces them to do so. The City has to consider whether it is able or willing to pay for some or all of the network construction, either by issuing municipal bonds or through a guaranteed payment to a partner.

To help explain the financial complexities that are emerging in current partnership models, we outline some financial concepts in this section.

3.1 Capital Expenditures

Capital expenditures, or capital costs, are funds used to purchase physical assets—such as the fiber assets necessary to build an FTTP network. These are sometimes called "CAPEX" for short. These costs are assumed to be a one-time expenditure for an asset that has a specified value for a set amount of time; for fiber, this is generally 20 to 30 years. Capital expenditures are also known as "fixed costs," because they will not recur until an asset has to be entirely replaced.

For an FTTP network, the City or its partner(s) would conduct detailed engineering and planning, and then spend a certain, fixed amount of money on the physical layer, or fiber assets. The physical layer is both the most expensive part of the network and the longest lasting. Because fiber is expected to have a life of 20 to 30 years, it is assumed that—with the exception of some minor repairs and emergency replacements—there would not be another large, upfront expenditure for fiber for another 20 to 30 years after its original installation. At that point, there would be a new, separate fixed cost to deploy new fiber.

To illustrate this concept, let's say a pet food business spends $1 million constructing a building for its warehouse and administrative operations; this large, one-time cost for constructing the asset (the building) is a fixed cost. Certainly, the business can expect to put some additional money into the asset over the years. For example, a storm might damage the building's roof, which the business will have to pay to repair (see Section 3.2). But the business will not have to spend the $1 million again until it is time to completely replace the building.

Network electronics, vehicles, high-end test equipment are also a capital expenditure, this equipment may need to be replenished every so often—maybe every five, seven, or 10 years, depending on advances in technology, and generally how well the equipment ages.

3.2 Expenses

3.2.1 Maintenance

As the name implies, maintenance expenses are the costs incurred to maintain an asset. For an FTTP network, maintenance costs can include emergency repairs to underground fiber that has been cut or damaged by construction—or aerial fiber that has been damaged by weather events like ice storms. Unlike capital expenditures, these expenses are variable and unpredictable.

In the pet food business analogy, the costs incurred to fix the roof after a storm would fall under maintenance expenses. Other maintenance costs for an FTTP network might include the expense incurred when aerial fiber must be moved to accommodate additional attachers to a pole, or when a handhole for access to underground fiber must be moved to accommodate a new sidewalk.

3.2.2 Operations

Like maintenance expenses, operating expenses are variable. Using the same pet food business analogy, the operating expenses include items like the cost of personnel to staff the warehouse and office, the equipment necessary to support the staff and to produce the pet food, and the cost for utilities to the building.

Although network electronics is a capital expenditure, they do require frequent replacement and upgrades. Often to prepare for this frequent replacement of electronics, a depreciation reserve account is established. This account is funded each year and builds up a reserve that can be used to replace electronics and other lower-life capital equipment as needed.

Other operating expenses include costs for marketing and advertising, day-to-day office equipment, and staff salaries. Operating expenses can be expected to fluctuate over time, especially as personnel costs rise. We discuss in Section 3.6 the accounting for annual increases in operating costs.

For an FTTP endeavor, there are three distinct types of operating expenses:

- **Fiber operating expenses –** Often grouped with maintenance, and referred to as "O&M," these are the recurring costs associated with the outside plant (OSP), or the dark fiber portion of the network. The OSP portion of the network includes all the hardware associated with the physical layer of the network. These costs also include salaries or contracts for the technicians required to maintain the dark fiber network.

- **Network operating expenses –** These costs are associated with the network electronics, including the hardware and software necessary to "light" the fiber and keep it operational. These costs include salaries or contracts for network engineers and other personnel necessary to ensure the fiber network operates smoothly. The cost to staff and operate a network operations center (NOC) is also included in this category.
- **Retail business operating expenses –** These are the costs associated with the retail Internet service provider (ISP) business, such as marketing and advertising, and call center personnel. They might also include the cost to staff and run a retail store where current and potential customers can seek assistance with billing, obtain marketing materials, and see service demonstrations.

3.3 Financing Options

A key consideration for any FTTP network deployment is how to finance upfront capital construction costs, or the fixed costs to construct the network. These costs represent a large expenditure that is generally slow to yield a return; the lack of a quick return on investment (ROI) sheds some light on why the private sector is not clamoring to upgrade existing legacy networks with fiber infrastructure, or to build new FTTP networks.

The City can seek bonding, or borrow funds, to cover construction costs to deploy FTTP, and in consideration of fiber O&M costs. Municipal bonds may also factor into a public–private partnership. While not every partnership will require the City to pursue bonding, all potential private partners will likely request some contribution from the City.

The City may be required to finance[2] some portion of an FTTP network, even if it engages a partner, and especially if it opts to retain ownership and control of the network, which is often a desirable approach for the City. One partnership structure entails the City owning and operating the infrastructure while a private partner lights the fiber and offers retail services over it. In this scenario, the likelihood of bonding is much greater because the City would likely be responsible for funding the construction of the network.

A partnership structure that requires the City to seek bond financing to construct the network may not be the most desirable approach for the City, and the potential partners that have emerged may not require the City to directly seek bonding. Still, it is important to understand how municipal bonds may factor into any partnership dynamic.

[2] The term "financing" generally refers to any borrowing required or investments provided. The amount financed requires repayment, typically with interest—such as through a bond or loan. By comparison, "funding" means resources that can include subscriber revenues, taxes, or other sources of capital that are used to cover operation, maintenance, debt service, and other expenses. Federal grants are an example of funding. Funding does not require repayment.

We discuss here some of the common types of bonds that municipalities typically rely on for capital projects, and the advantages and disadvantages of each. Please note that the following is a summary, does not include every financing mechanism available to the City, and does not offer any legal or tax advice.

3.3.1 General Obligation Bonds

General obligation bonds are directly tied to the City's credit rating and ability to tax its citizens. This type of bond is not tied to revenues from any specific municipal projects, but is connected instead to citywide taxes and revenues can be used to repay this debt. City leadership is likely very familiar with this type of bonding, as general obligation bonds are commonly sought in municipal organizations to fund capital improvement projects.

General obligation bonds can be politically challenging because they generally require a public approval process. These bonds are usually issued for projects that will clearly serve the needs of the entire community, such as roadway improvements. While it is our opinion that a fiber enterprise serving the public clearly meets this condition, incumbent opposition is likely. The City will need to develop a clear vision for its messaging to clearly convey to the community that it intends for the fiber network to serve all members of the community, and to serve all citizens' needs.

Further, a clearly and publicly stated goal of network ubiquity may help ease the process of general obligation bond approval. That is, if the City is willing and able to commit to expanding the network to serve *all* members of the community, it may be politically palatable to request approval of general obligation bonds. In addition, a model which opens fiber access to multiple providers enables new and existing providers to offer new service and give Boulder consumers a choice and alternatives. Given the City's dedication to deploying a ubiquitous network, general obligation bonds could be a reasonable option for Boulder.

It may be especially helpful if the City can work within existing initiatives and with other public, quasi-public, and private institutions to demonstrate how the fiber network can effectively benefit the entire community. For example, the City may want to consider how engaging economic development representatives—either internally or within the community—could demonstrate a fiber network's role in bolstering the community's economic development success. This, coupled with a concerted effort to ensure the network passes every potential customer in the City so that anyone may potentially access service, could illustrate fiber's potential as a community resource.

3.3.2 Revenue Bonds

Revenue bonds are directly tied to a specific revenue source to secure the bond and guarantee repayment of the debt. For example, the revenue stream from a municipality's electric, natural gas, or water utility may be used to secure a revenue bond.

Theoretically, any municipal service that generates some sort of revenue that could be used to pay back the debt might be used to secure a revenue bond—municipally owned public transportation or hospitals, for example. In light of this, it might make sense that the revenues generated from owning a fiber optic network and leasing it to providers could be used to guarantee a revenue bond—but this is typically not an accepted practice within the bonding community. Municipal broadband projects without a proven revenue stream are usually viewed as high-risk in the bonding community, and the projected revenues from the network will likely be viewed as too uncertain to support repayment of the loan.

If the City wishes to pursue revenue bonds, it may find that other utilities departments' revenues are more likely to be approved as an acceptable stream to support a revenue bond. These bonds are less politically challenging than general obligation bonds, but the City will still need to be prepared to explain why it must pursue this form of bond to help support FTTP network deployment.

3.4 Debt Service

3.4.1 Payments

To "service" debt means to make payments toward the principal and interest (P&I) of a bond or loan. The payment is calculated based on the total amount borrowed (principal) and a percentage rate (interest). If a locality issued municipal bonds to pay for fiber infrastructure, it would then service that debt for a period of time—usually for 10, 20, or 30 years, depending on the locality's bonding procedures, credit rating, and projected life of the capital expenditure.

When a locality issues new bonds, it typically establishes an interest reserve account with funds equal to the interest expenses that will be incurred in years one and two. This account ensures that the locality can make interest payments for the first two years, when the project has not yet achieved positive cash flow.

There is also typically a separate fund called a debt service reserve fund, which is an account that is maintained at some percentage of the total issuance amount of a bond. (We assumed 5 percent in our financial analysis.) This reserve fund is used if the City is unable to make a P&I payment. Typically, the reserve would be used for the final P&I payment.

3.4.2 Guarantees

The City's partnership may require some sort of guaranteed payment structure—either from the City to the partner, or from the partner to the City. The idea behind such a payment is to manage the risk of the entity that finances the network. In many proposed partnerships, the private partner is looking for the City to guarantee "anchor payments" to ensure that the partner's revenues are sufficient to cover its debt service payments.

The idea in a partnership is that ultimately the subscriber revenues and other potential sources of income (e.g., dark fiber leases or wholesale agreements) will be sufficient to cover the cost to deploy and maintain the network and retail business. Ideally, the endeavor would also generate enough income for there to be a profit beyond just breaking even. A community anchor payment guarantee is a backstop in case the network does not yield enough revenue to sustain itself. This anchor payment is suggested in many proposed partnerships, and is made to the partner by the City. Often, the anchor payment is used to secure the financing that the partner obtains.

3.5 Net Present Value and Internal Rate of Return

The value of money changes over time—$100 today is not equal to $100 in one year, or five years, or 10 years—and its present value is important for the City to consider as it anticipates potentially engaging a private partner with which it will have a financial relationship. This is especially true because the City's relationship with a partner is expected to be decades-long, and money will likely flow between the two entities for the duration of the partnership.

For the sake of simplicity, consider $100, at a time that the average inflation rate is 3 percent. At a 3 percent inflation rate, a good or service costing $100 today would be $103 next year. So, $100 in May 2016 is equivalent to $103 in May 2017. Put another way, the *present value* of $103 next year is $100, assuming a 3 percent discount rate.

The *net present value (NPV)* is the difference between the present value of cash inflows and/or outflows over a series of years. This is particularly important in the context of any sort of guaranteed payment structure, where the City or the partner may be responsible for paying one another.

The internal rate of return (IRR) is the interest rate that makes the NPV equal zero. Typically, the higher the IRR, the more desirable a project becomes. Private sector firms would generally require an IRR of approximately 20 percent to consider investing in a project. Venture capital firms often require an IRR of 30 percent or higher to consider financing a project.

3.6 Escalation Payments

3.6.1 Applying a Consumer Price Index (CPI) Escalation

Some partners suggest a business model that allows a locality to forego a public bonding process (see Section 4.5). If the City enters into a partnership with a private entity that will be financing the network with a guarantee from the City—thus allowing the City to avoid a public bonding process—many partners will apply some sort of escalation payment, likely based on one of the several published Consumer Price Indices (CPI). In general, a CPI measures the "average change over time in the prices paid by urban consumers for a market basket of consumer goods and services."[3]

The escalation payment that different partners might use will vary. Some partners may base an escalation payment on the current market interest rate, while others may apply an escalation to a "discounted" finance rate. The idea behind a discounted finance rate is that it will allow for lower P&I payments in the early years of the FTTP enterprise when fiber is still being constructed and the business is getting off the ground. In both cases (market rate and discounted rate), when a CPI is applied, the payments will be higher in later years. Depending on the difference between the market rate and the discounted finance rate, applying an escalation can mean that the total cost of the money borrowed (i.e., the sum of all payments over the life of the financing) may be higher with the initial discounted rate than if market-based financing were applied with no escalation.

Note that when applying escalation, the difference between annual costs under market-based and discounted finance rates has to do with the initial calculation of the annual payment. The subsequent annual payments are calculated based on the CPI, which is applied the same way for both market-based and discounted finance rates. We illustrate this in the sections below.

In general, a CPI escalation should not be applied to the capital expenditures portion of a project. A CPI escalation should be applied *only* to the O&M portion of the P&I payment. The exception to this is a CPI escalation being applied on a capital expenditure that is based on a substantially discounted finance rate.

3.6.1.1 Example of Market-Based Finance Rate Escalation Payment

Assume that the FTTP network is financed for $100 million at 4 percent interest (the assumed market-based interest rate in this example) for 30 years. If the annual debt service payment starts in year 1 at approximately $5.78 million, and no escalation is applied, the annual debt service payment will still be approximately $5.78 million in year 30. However, if a 2.5 percent CPI

[3] "Consumer Price Index," *Bureau of Labor Statistics,* accessed May 20, 2016, http://www.bls.gov/cpi/cpifaq.htm.

escalation is applied to the payment each year, then the annual payment in year 30 will be $11.83 million (see Figure 2). This increase illustrates the effect of "compounding."

Figure 2: Market-Based Finance Rate with and Without CPI Escalation (Annual Payments)

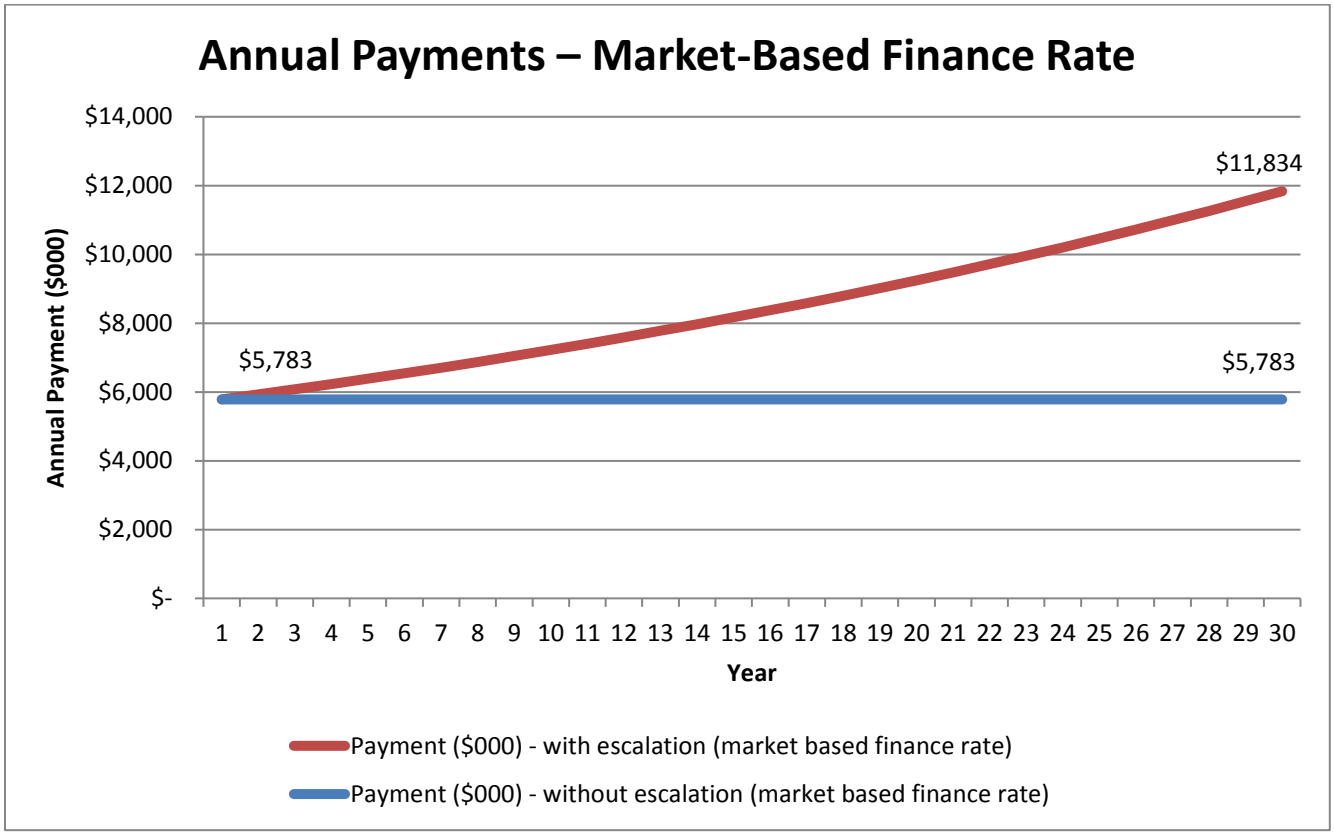


Figure 3 shows that if escalation is not applied and payments are based on market rates, the total payments will amount to approximately $173.5 million over the life of the debt service. Figure 3 also shows that if escalation is applied and payments are based on market rates, the total payments will be approximately $253.89 million by year 30. This is a difference of nearly $80.4 million.

Figure 3: Market-Based Finance Rate with and Without CPI Escalation (Total Payments)

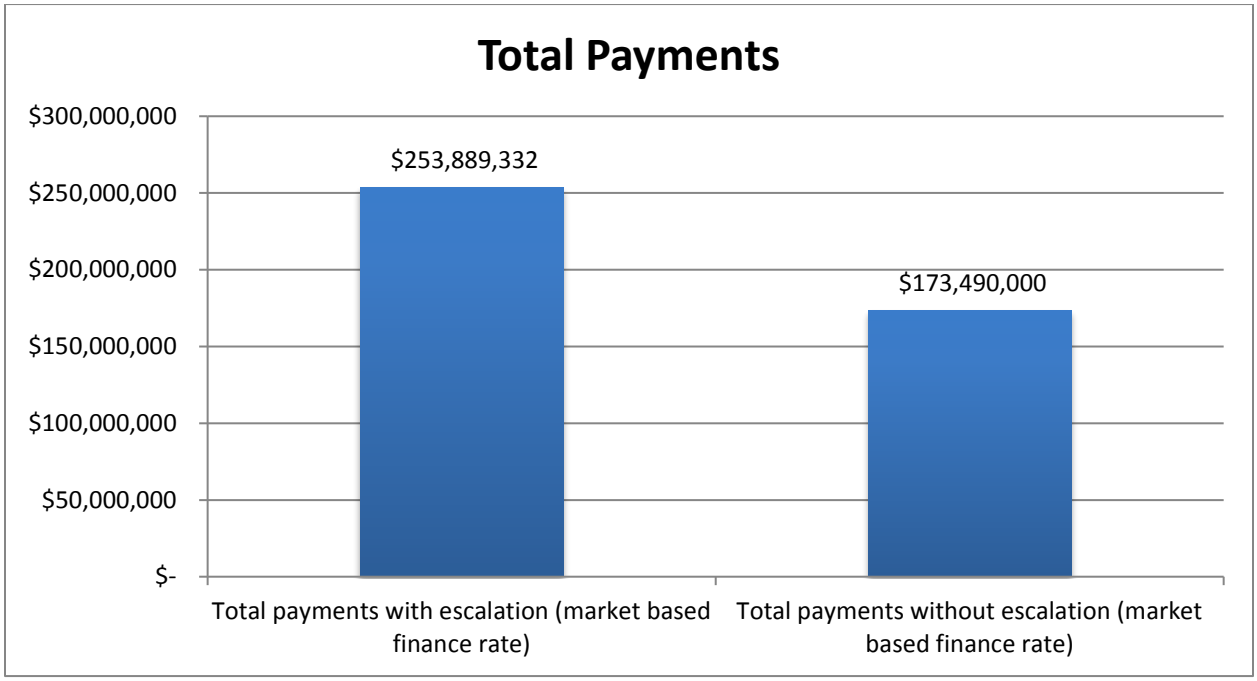
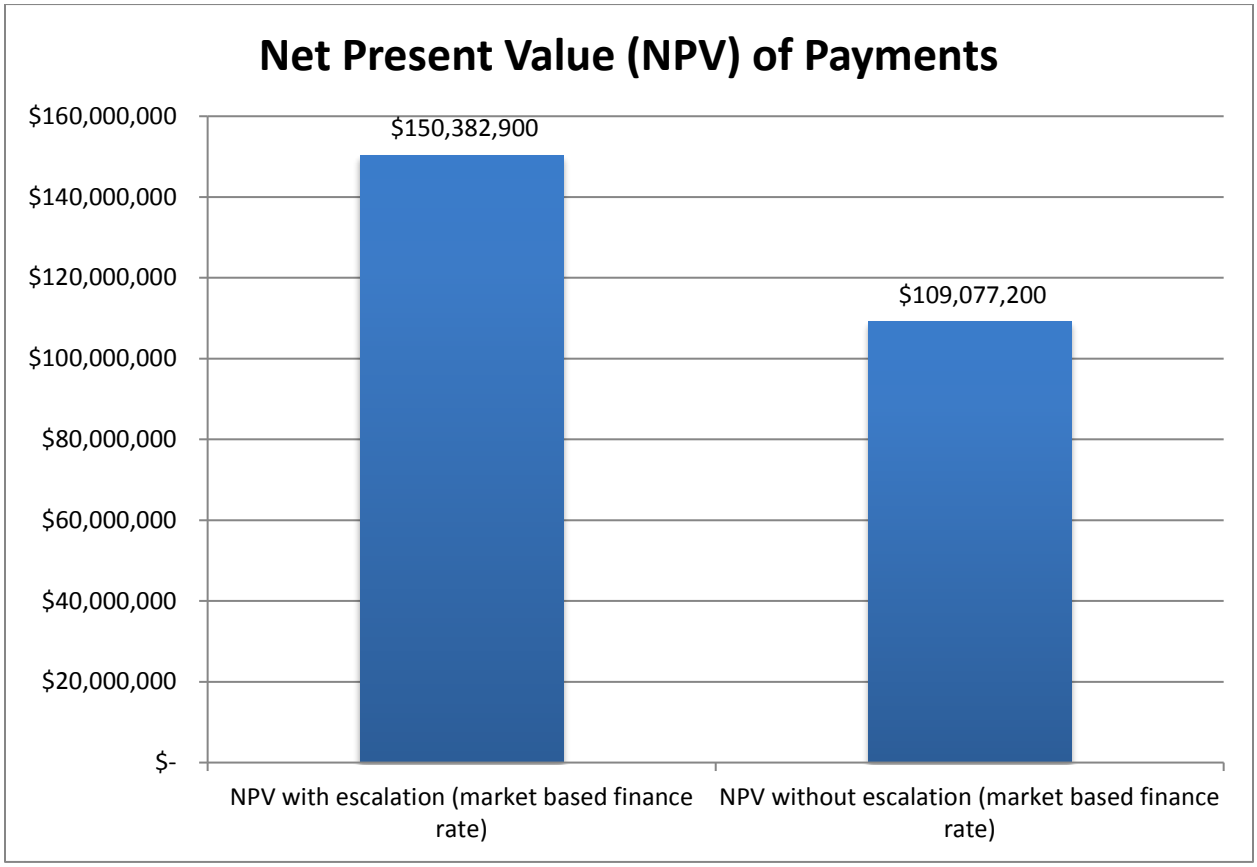


Figure 4 shows that the NPV of payments based on a market finance rate without escalation is approximately $109.18 million. The NPV calculation uses a discount rate of 3.30 percent, which is the US inflation average from 1914 to 2015. For payments based on the market finance rate with CPI escalation applied, the NPV is approximately $150.38 million. This is a difference of approximately $41.2 million.

Figure 4: Market-Based Finance Rate with and Without CPI Escalation (NPV of Payments)



3.6.1.2 Comparing Market Rates and Discounted Finance Rates for Escalation Payments

Another option for applying an escalation is to apply a discounted finance rate to the annual payment. This will ostensibly allow for lower payments in early years, when cash flow is likely to be leaner and the City or its partner may have less to put toward servicing the debt as the FTTP enterprise works toward building a customer base and becoming cash flow positive.

Below, we compare the difference between a market-based finance rate with and without a CPI escalation, and a discounted finance rate with a CPI escalation. In this example, we use the same assumptions as above, but with a discounted finance rate of 2 percent.

Figure 5 shows that an annual payment toward $100 million with no CPI escalation, based on market finance rates, is approximately $5.78 million in year 1 and approximately $5.78 million in year 30—that is, the annual payment remains the same for the life of the debt service. An annual payment with a CPI escalation applied based on market finance rates is approximately $5.78 million in year 1 and approximately $11.83 million in year 30. An annual payment with CPI escalation applied based on a discounted finance rate is approximately $4.47 million in year 1 and approximately $9.14 million in year 30 (see Figure 5).

In this example, the annual payment with a CPI escalation applied in year 30 is lower with a discounted finance rate than it is if a CPI escalation is applied to a payment based on the market finance rate. It is important to note that these rates are subject to change, and the discount rate that a partner uses if they opt to apply escalation may be entirely at the partner's discretion.

Figure 5: Market-Based Finance Rate with and Without Escalation & Discounted Finance Rate With Escalation (Annual Payments)

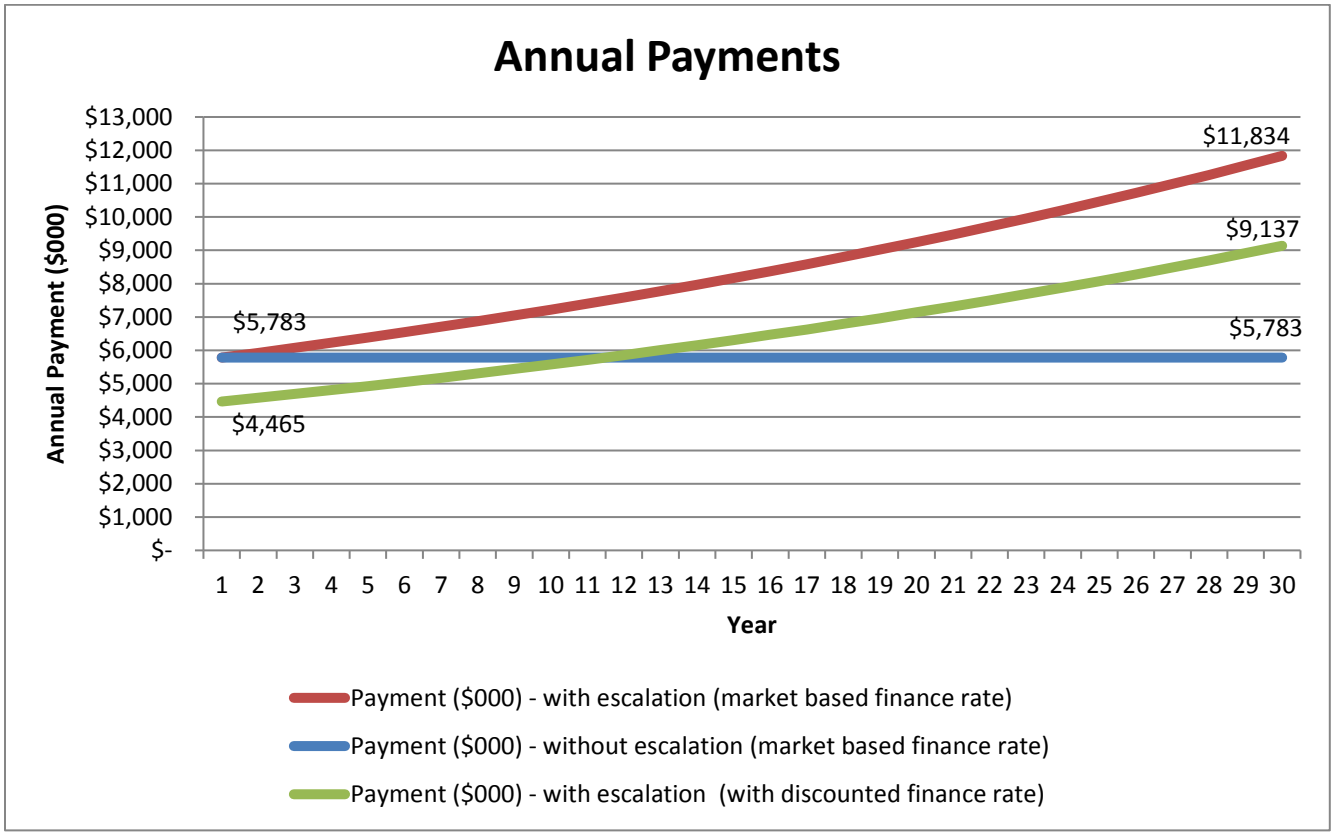


Figure 6 shows the total payments for a market-based finance rate with and without CPI escalation applied, and for a discounted finance rate with CPI escalation applied. The total annual payments for a market-based finance rate without CPI escalation applied is approximately $173.49 million. The total annual payments for a market-based finance rate with CPI escalation applied is approximately $253.89 million. The total annual payments for a discounted finance rate with CPI escalation applied is approximately $196.03 million.

The difference between the total payments for a market-based finance rate and a discounted finance rate where CPI escalation is applied to each is approximately $57.86 million.

Figure 6: Market-Based Finance Rate with and Without CPI Escalation and Discounted Finance Rate With CPI Escalation (Total Payments)

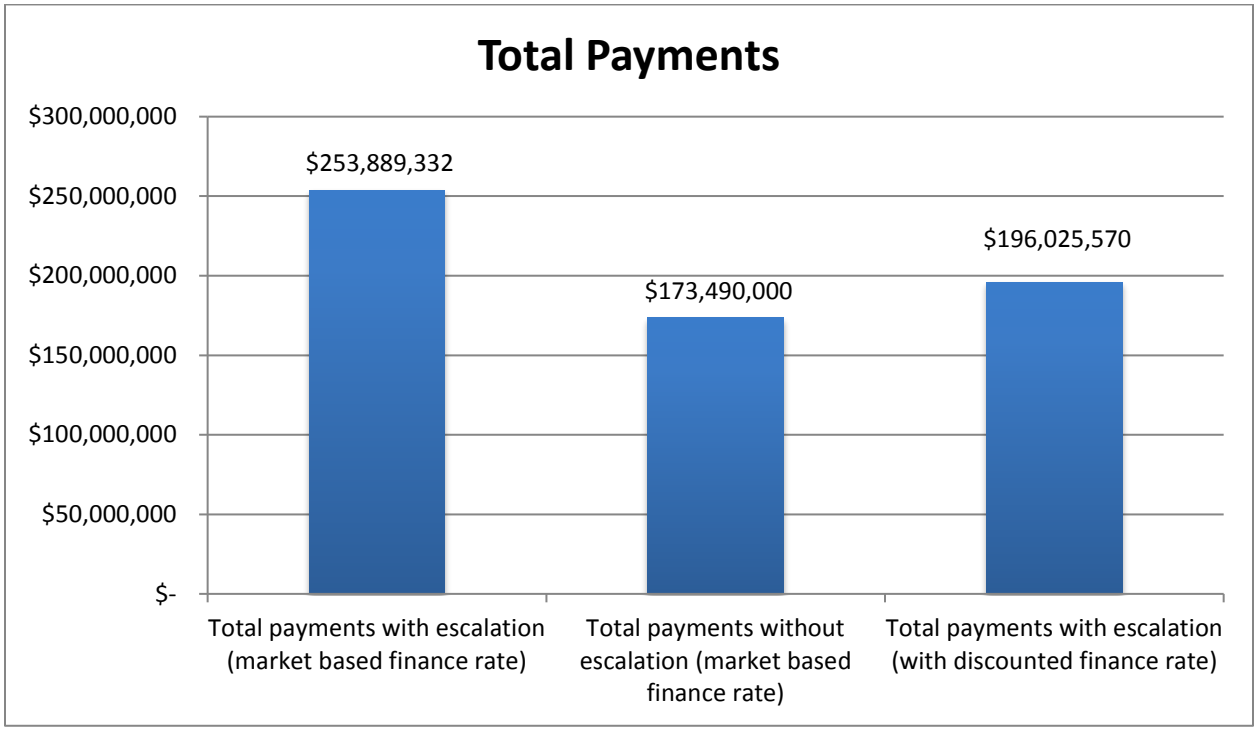
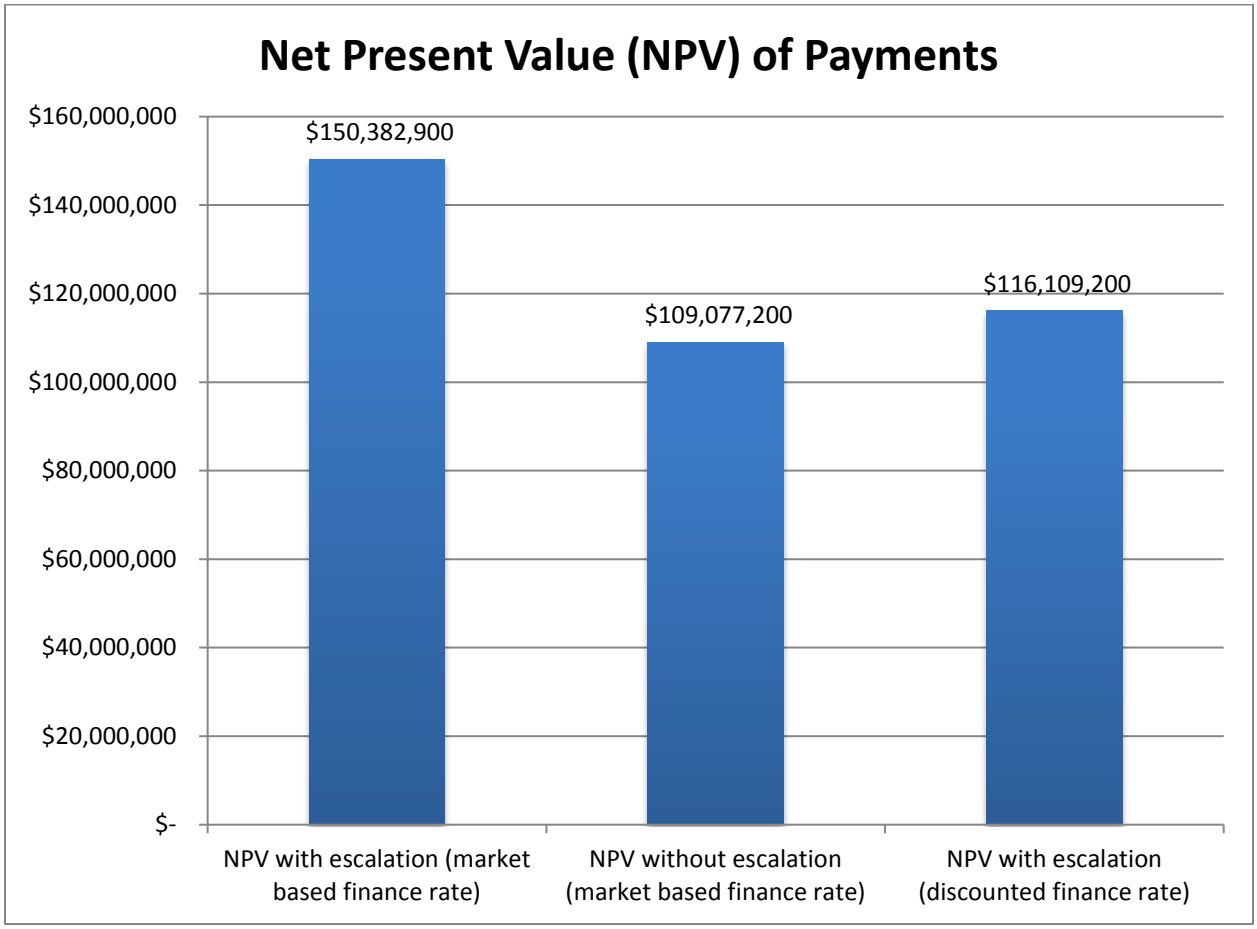


Figure 7 shows the NPV of payments for market-based finance rate with and without a CPI escalation applied, and payments based on a discounted finance rate with a CPI escalation applied. The NPV of payments for a market-based finance rate without a CPI escalation applied is approximately $109.08 million. The NPV of payments for a market-based finance rate with a CPI escalation applied is approximately $150.38 million. The NPV of payments for a discounted finance rate with a CPI escalation applied is approximately $116.11 million.

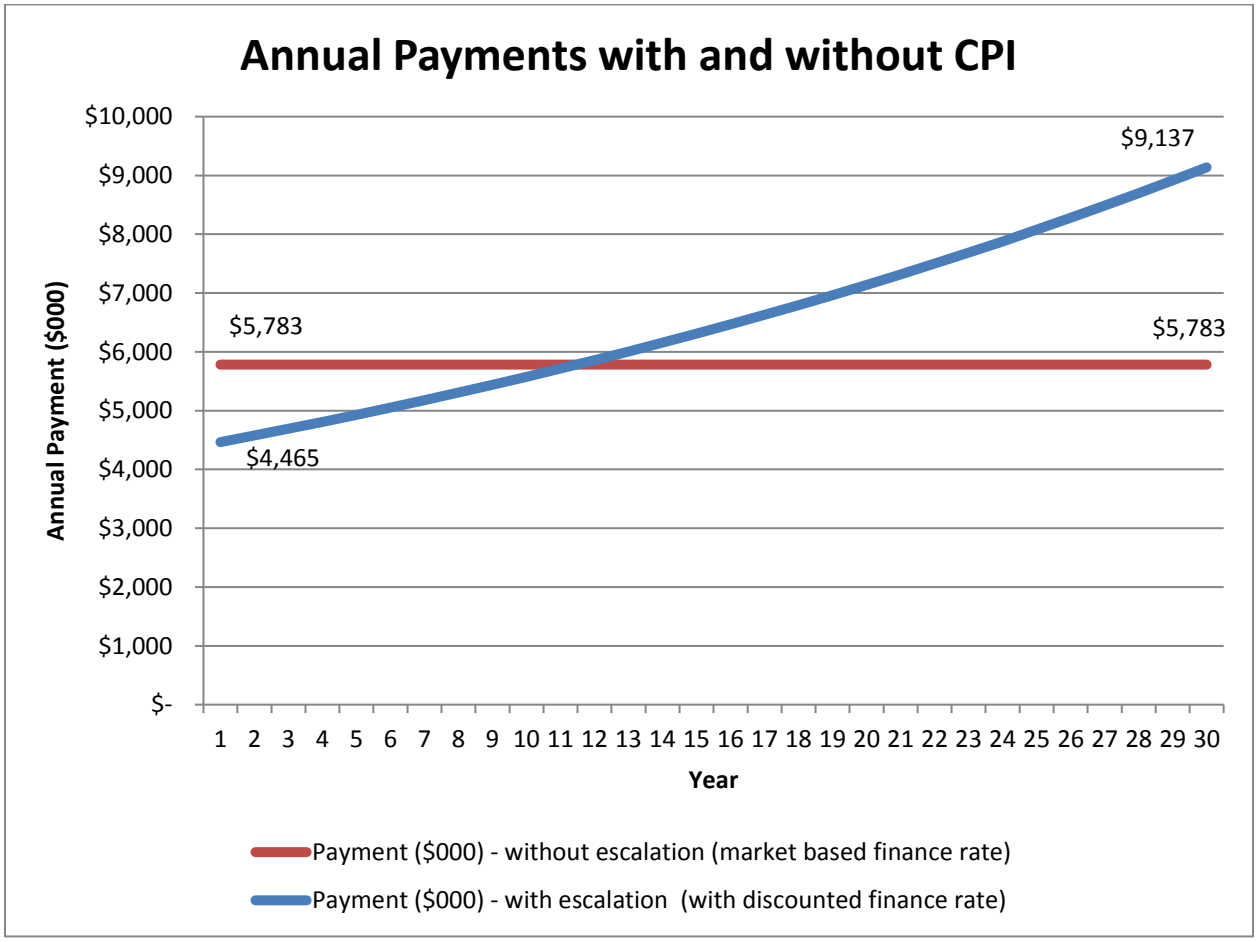
Figure 7: Market-Based Finance Rate with and Without Escalation & Discounted Finance Rate With Escalation (NPV of Payments)



Another important consideration is the difference between annual payments based on a market finance rate without escalation compared to annual payments with escalation based on a discounted finance rate. Figure 8 shows that the annual payment based on market finance rates without a CPI escalation applied would be approximately $5.78 million in year 1, and would remain the same each year through year 30. The annual payment based on a discounted finance rate with escalation applied would be approximately $4.47 million in year 1, and would be approximately $9.14 million in year 30. Note that the payments based on a discounted finance rate with a CPI escalation applied are lower in early years than the payment based on market finance rates without a CPI escalation applied.

In the scenario in Figure 8, the discounted rate annual payment with escalation applied catches up to the market-based annual payment without escalation by about year 11. At that point, the discounted rate annual payment with a CPI escalation applied continues to rise, while the market-based rate annual payment without escalation stays flat throughout the life of the debt service.

Figure 8: Market-Based Finance Rate Without CPI Escalation and Discounted Finance Rate with CPI Escalation (Annual Payments)



Based on this, even if a discounted finance rate is used, a CPI escalator does not save the locality money in the long-run. It does lower payments in the early years of the endeavor, but unless there is a substantial discount on the market interest rate, the locality ultimately ends up spending more over the life of the project.

3.6.2 Be Wary of CPI Escalations Applied to Capital Expenditures

While the RFI review process has eliminated from the City's potential partners those companies that appear to apply a universal CPI escalation, this is an important nuance of the financial breakdown that the City should keep in mind.

As we noted, an escalation assumes that a cost will increase each year. Thus, it makes sense to apply a CPI escalation to O&M costs because the expenses associated with operating the network (e.g., personnel) will likely increase. However, it would not be appropriate to apply a CPI escalation to the capital expenditure associated with constructing a network because that is a fixed, one-time cost. Again, as shown in the section above, the exception to this is if the partner

offers a finance rate substantially below than what the City could obtain with general obligation bond financing.

For example, let's say a locality's partner finances a network for $150 million—of which, $100 million is for constructing the network and $50 million is allocated for O&M in early years. (It is common to finance O&M during the early years of an FTTP enterprise to give revenues an opportunity to catch up, and to allow the network to begin to essentially "break even.") In this scenario, applying a CPI escalation to the $50 million is appropriate, because that portion of the overall cost can be expected to fluctuate over the coming years—it is *not* a fixed cost. However, it would not be appropriate to apply a CPI escalation to the $100 million capital expenditure.

4 Emerging Partnership Models

We note that some of the companies we discuss here in a general context provided RFI responses to the City, though the parameters they propose in Boulder may differ from the models they have demonstrated in other markets. They are outlined here simply to illustrate what the market looks like today, based on recent events in other communities. It is still too early to tell how these partnerships may unfold in coming years, and whether the models that are prominent today will still exist in the future. Further, it is not yet fully apparent whether the current models will unfold in practice consistent with how they are designed to function.

Based on our experience, three types of public–private partner models are emerging today in diverse cities throughout the U.S.:

- ***Private investment, public facilitation*** – The model focuses not on a public sector investment, but on modest measures the public sector can take to enable or encourage greater private sector investment. Google Fiber is the most prominent example, but there is significant interest among smaller companies such as Ting Internet.

- ***Public risk, private execution*** – This model, which involves a substantial amount of public investment,[4] is a variation on the traditional municipal ownership model for broadband infrastructure—but with private rather than public sector execution of deployment and operation. The model removes significant logistical barriers from large-scale public broadband projects. While the field is constantly changing, at least three companies have emerged with fully articulated business propositions for localities.

- ***Shared risk and investment*** – In this model, localities and private partners find creative ways to share the capital, operating, and maintenance costs of a broadband network. The City of Westminster, Maryland, partnered with Ting Internet in a prominent example of this approach;[5] and most recently, the City of Huntsville, Alabama partnered with Google Fiber.[6]

These partnerships are generally unique to the communities that develop them, and entail specific parameters that directly benefit both the community and the chosen partner. As the City

[4] Investment definition includes payment guarantees in order for the private partner to obtain financing.
[5] Heather Cobun, "Westminster selects fiber network operator," *Carroll County Times*, last modified January 12, 2015, http://www.carrollcountytimes.com/news/local/ph-cc-westminster-meeting-011315-20150112-story.html.
[6] Kia Kokalitcheva, "Google Fiber Is Heading to This City Next," *Fortune*, last modified February 22, 2016, http://fortune.com/2016/02/22/google-fiber-alabama/.

evaluates broadband public–private partnerships, it should consider both the opportunities and potential pitfalls, and pay particular attention to three interwoven issues:

1. Risk
2. Benefit
3. Control

These factors are key considerations for both the City and its potential partner(s). A successful partnership must balance each partner's needs, and there will inevitably be some tradeoff within this framework for each model.

4.1 Risk

It is not possible to entirely avoid risk if the City opts to be involved at any level in broadband deployment. But calculated risk often yields benefits that would otherwise have been unattainable. One of the most enticing components of a public–private partnership is that it can considerably reduce the City's risk while helping achieve a community's broadband goals.

Public financing (directly with bond issuance or indirect with payment guarantees; see Section 3) to support the partnership will likely be one of the City's greatest risks, though we believe this is a worthwhile investment to enable the City to retain some control of the assets. Although it will entail some financial and political risk because it will likely require public financing—either through municipal bonds or leveraging tax funds—the long-term dividends will likely be advantageous. This is especially true if the City is able to execute a meaningful partnership with a private entity that will share in the risk. The partners that have emerged from the City's RFI process seem willing to take on a portion of the risk.

The City may enter into an agreement that requires it to directly seek bonding for capital investment, or it may find a partner that is willing to use its own capital. It is important to note that even if the City does not directly seek bonds, and the City must commit to a guaranteed payment, the City's credit rating and bonding ability may still be impacted if a private partner obtains the financing.

Operations tend to be unpredictable and costly and often represent a great risk for municipal fiber networks. Cities that try to enter the retail market directly are often targeted by hostile incumbent providers that make it very challenging for the City to compete. Part of the attraction to the public–private partnership model is that private entities tend to be equipped to understand the retail business and to help the City mitigate its risk in this area.

We encourage the City to find ways to balance risk and reward, but also caution against engaging a partner solely on the basis of the partner reducing the challenges and complexities of a retail model. There are some very attractive "turnkey solutions" in the industry today, but many of

these may come with hidden risk to the City; if a partnership seems too good to be true, it generally is.

4.2 Benefit

As the City considers this endeavor, it should continually weigh the benefits it might expect to receive as part of a public–private partnership against its potential risk. One positive component of emerging partnerships nationwide is that there is potential for a great degree of flexibility. That is, the City is in a position to consider its priorities and pursue those benefits on the frontend of a partnership arrangement.

Conversely, although public–private partnership models are relatively new and evolving all the time, there are several recent examples that the City can look to as guidance on how it might want to proceed. It is too soon to fully map what long-term benefits of partnership might look like, but there are some lessons that can be picked up from some communities that have sought various degrees of partnership.

Although benefits cannot be reliably calculated at this stage, the City can potentially look to other communities to get a sense of the goals other partnerships prioritized for the public entity's benefit. This may help the City determine how to balance its risks, and which areas to focus on in its pursuit of a partner.

4.3 Control

Because this is the start of the City's broadband initiative, it can choose in the negotiation process its desired level of involvement in infrastructure deployment, network maintenance, and operations. That is, the City can essentially determine from the outset what level of involvement it would like to have at every stage and in every arena of the public–private partnership process. The purpose of the RFI process was to determine the willingness of potential partners to negotiate with the City on a number of key items; there are several companies that are interested in Boulder and amenable helping meet the City's goals.

There are numerous ways that the City can retain some control within the public–private partnership, and perhaps the most important is through retaining ownership of the physical assets. Again, this must be balanced with risk, as it is likely that the City will be required to fund at least part of the capital investment in assets if it hopes to retain control.

The more ownership the City has, the greater degree of control it can maintain. This enables the City to make decisions about placement of the assets, rate of deployment, and the network's overall footprint. Further, it ensures that if the partnership does not succeed, the City still has a physical asset that it can use to deliver services directly or to negotiate a new partnership.

Ownership of assets is an important way the City can retain control. There are also other potential mechanisms that enable the City to retain some control over the network and enterprise, and to ensure that the partnership consistently works in its favor. For example, the City and its legal counsel may negotiate certain contractual provisions that provide it with some amount of control.

We understand that the City does not necessarily desire to directly own the assets. Some of the partnership models that were proposed to the City indicate that the private entities are willing to invest directly and still give the City some degree of control. It is important to note that, in general, the degree of control a locality has is directly related to its level of financial investment. Even partners with the most altruistic intentions are still private businesses and must make a profit in order to succeed. Emerging Public–Private Partnership Models

To help frame the discussion about what partners proposed to the City, we outlined some of the common partnership frameworks that have emerged in the industry in recent years.

4.4 Model 1: Private Risk, Public Facilitation

In this approach to public–private partnership, the public sector's cost is significantly reduced. The model focuses not on a public sector investment, but on modest measures the public sector can take to enable or encourage greater private sector investment. The most prominent example of this model is Google Fiber's deployments, including its networks in Austin, Kansas City, Nashville, and elsewhere. Ting Internet[7] is taking a similar approach in smaller markets, including Holly Springs, North Carolina.

This model is seen as the ideal for many communities that wish to minimize public cost. At least in Google Fiber's deployments, the private sector partner's requirements have largely focused on making local government processes more efficient. In return for these relatively low-cost public sector commitments, the communities that are partnering with Google Fiber or Ting Internet benefit from the company's deployment of fiber-to-the-premises (FTTP) infrastructure (and, in many cases, competitive upgrades by the incumbent cable and telephone companies).

This model relies on the private companies to make the investment, while partner communities take certain steps to enable them to build in an expeditious, efficient, low-cost manner. Though Google Fiber is the most prominent example, there is also significant interest among smaller companies—which have fewer resources than Google but can deliver next-generation broadband to businesses and institutions on a targeted basis.

While this model reduces the public sector's cost and risk compared to other models, there is a potential public relations risk. Public expectations can get very high with the announcement of

[7] Ting, https://ting.com/.

new fiber deployment. If a local government is strongly identified as a partner, it may be held accountable by the community if something goes wrong with the private sector partner's business plan or deployment.

4.4.1 Strategies for Encouraging Private Investment

There are a number of strategies the City can take to encourage new private investment and reduce some of the costs and time for private sector entities to deploy advanced broadband services. These can, for example, take the form of specific economic development incentives such as tax benefits to encourage providers to build new infrastructure. MetroNet, a small Midwest ISP, developed a partnership with the City of Crawfordsville, Indiana, to purchase the municipal utility's fiber network.[8] The city is assisting MetroNet with financing the purchase and expanding the footprint of the fiber network.

Communities typically offer this type of benefit to new entrants in a market that are willing to invest in next-generation infrastructure, but they can offer those benefits to incumbents if the incumbents will also invest in the same kind of infrastructure.

Another key strategy is for the community to develop and strengthen the local infrastructure assets that enable the deployment of broadband.[9] These include public assets such as fiber, conduit, and real estate. For example, new network deployments can benefit enormously from access to existing government fiber strands, underground communications conduit in which fiber is placed, or real estate where equipment or exterior huts can be located.

Communities can further facilitate the underground construction of conduit and fiber by implementing a "dig-once" policy for all road and related transportation projects, and facilitating in-building access through construction specifications for new buildings.[10]

Building and expanding community infrastructure over time is a low-cost, low-risk strategy that will have real impact and expand options down the road. For example, the City of Mesa, Arizona, began a dig-once initiative in the early 2000s; the city intended to install its own rings of conduit during private sector construction projects, then sell access back to the private sector. Any time the city opened up a street, such as to install water or sewer utilities, it put in conduit.[11] In some instances, the city also added fiber to empty conduit for city purposes or to potentially lease to private providers. In total, the city installed as much as 200 miles of conduit. Mesa targeted four

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[8] "MetroNet plans to expand current fiber optic system," *The Paper of Montgomery County Online,* last modified March 18, 2014, http://goo.gl/5eHuJt.

[9] "Gigabit Communities: Technical Strategies for Facilitating Public or Private Broadband Construction in Your Community," CTC Technology & Energy, last modified January 2014, p. 6–12, http://www.ctcnet.us/gigabit/.

[10] For more discussion of "dig once" policies and related collaborative strategies, see "Gigabit Communities."

[11] "Transcript: Community Broadband Bits Episode 139," Institute for Local Self-Reliance, last modified February 26, 2015, http://goo.gl/pFzN6k.

economic development areas in particular, with redundant conduit, fiber, and electric infrastructure. Among those areas was the land around the Phoenix-Mesa Gateway Airport, where Apple announced in early 2015 that it would build a $2 billion data center.

A third important strategy is to improve access to information—an asset that communities might not have considered.[12] Sharing information demonstrates a willingness to engage with the private sector to spur investment. Communities should seek to make data available wherever possible both for public and private uses.

Geographic information systems (GIS) or similar databases that hold information such as street centerlines, home and business locations, demographics, and details on existing utilities, public infrastructure, rights-of-way, and available easements can be extremely helpful for a locality's own broadband planning, potential public–private partnerships, or a network service provider that is evaluating the deployment of new infrastructure in a community.

Access to this information may attract and speed new construction by private partners, while enabling the community to meet its goals for new, better broadband networks—and potentially to realize revenues for use of the assets.

Finally, the City can take steps to enable broadband construction by making government processes around permitting, rights-of-way access, and inspections more efficient and smooth. In some communities, for example, permitting processes have been moved online, alleviating the need for wasteful and time-consuming paper-based processes. These actions can signal to private partners that there is an investment opportunity in the jurisdiction and that the City will not be a bottleneck or create additional costs.

These steps should take into consideration the needs of the community, balance public interest and public safety, and account for local resources and capacity. For example, the City can choose to be fully transparent about its permitting and rights-of-way processes—including timelines—to enable the communications industry to expeditiously plan and deploy networks.

4.4.2 Potential Benefits and Pitfalls

The above strategies can make a difference in the economics of buildout for a private partner. However, they will not dramatically change the underlying economics of broadband network construction and operation. In a best-case scenario, the public sector can reduce the cost of outside plant construction for a broadband network by up to an estimated 8 percent.[13]

[12] "Gigabit Communities," p. 13–16.
[13] "Gigabit Communities."

Thus these measures can be substantial, but not transformative. Indeed, many incumbent providers overstate the extent to which local government and regulation are hurdles for developing next-generation broadband infrastructure.

Communities should be wary, then, of private sector entities seeking benefits without offering concrete investment proposals. From a business standpoint, for example, incumbents do not need additional support from the City to keep maintaining (or even upgrading) their existing broadband networks and services.

4.4.3 Case Study: Holly Springs, NC

Over the course of many years, the Town of Holly Springs designed, engineered, and constructed a backbone fiber network to connect municipal buildings. To their great credit, Holly Springs' visionary elected officials chose to build a fiber network with dramatically higher capabilities than the need apparent at the time—knowing that a robust fiber backbone might attract interest from private ISPs that recognize the potential to leverage that backbone to more efficiently build their own FTTH infrastructure.

But a robust backbone network was not enough. The town's government also developed policies and strategies to attract private broadband investment. As a result, Ting Internet announced in mid-2015 that it will bring "crazy fast fiber internet" to the homes and businesses of Holly Springs. Ting plans to expand on Holly Spring's existing fiber pathways and offer symmetrical gigabit Internet access to homes and businesses.

A key factor in Ting's decision to invest in Holly Springs was the fact that the town not only was willing to lease excess fiber in its backbone, but that it also brought best practices to bear in its willingness to work with Ting and facilitate Ting's efforts. Among other things, the town offered efficient government processes, access to information and facilities, and facilitation and support—all of which boosted Ting's confidence about this community as an investment opportunity.

4.5 Model 2: Private Execution, Public Risk

This model, which involves a substantial amount of public investment, is a variation on the traditional municipal ownership model for broadband infrastructure—but with private rather than public sector execution. In this model, a selected private partner takes responsibility for some combination of design, construction, financing, operations, and maintenance,[14] funded by the public partner over some period of time.

[14] "Financial Structuring of Public–Private Partnerships (P3s)," U.S. Department of Transportation, 2013, http://goo.gl/gCJIZK.

While this public–private partnership structure is new to broadband, it is used in Europe and increasingly in the U.S. for traditional infrastructure projects such as highways, toll roads, and bridges. The model seeks to leverage the strengths of the private sector to deliver turnkey services and solutions over an extended time of 20 to 40 years.

Unlike transportation or utility infrastructure, however, broadband does represent a somewhat competitive marketplace. Thus, applying the model to broadband in the U.S. creates political and financial risk for the public sector because public funding is used to fund an infrastructure that some residents may not want or choose to use. Indeed, if the broadband network is unsuccessful at generating revenue to cover all public sector costs, the public sector often remains on the hook for those payments. At its core, this model thus involves the public sector essentially becoming the guarantor in the event that the partnership does not secure sufficient revenue to cover all costs, including the profit margins required by the private partners.

And for communities that think this is a way to get financing without bonding, that is only partially true. The public sector partner does not have to bond, but the partnership financing will most likely be considered by auditors, state authorities, and the bond markets as counting against the public sector entity's borrowing capacity.

Despite these risks, the model offers benefits to the public sector by removing significant logistical barriers from large-scale public broadband projects and offering a comprehensive solution (including extensive turnkey private execution and private capital) for the entire community.

One of the most fascinating aspects of the huge escalation in interest in this space over the past few years (catalyzed significantly by Google Fiber) is the emergence of a group of companies that are working with traditional public–private partnership models to develop strategies for enabling local governments to get FTTP networks built.

While the field is very fast developing and constantly changing, at least three companies have emerged so far with fully articulated business models and business propositions for localities: Macquarie Capital, SiFi Networks, and Symmetrical Networks.

All three companies are proposing interesting approaches—each with the same core concept (though with considerably different detail): The public sector's willingness to contract in the long term is what will enable and secure construction of the network. To date we are not aware of any commitments that these entities have reached with a public entity to deploy an FTTP network.

These variations on the private execution, public funding model are as of yet untested; we urge caution for that reason. But we note that this model is a potential means by which to develop a

network that can serve the entirety of the community, not just the parts selected by a private investor.

4.5.1 Macquarie Capital

Macquarie Capital and its partner companies, which have pioneered (on paper not in implementation) this model in the broadband market in the U.S.,[15] propose to provide financing, construction, operations, and service delivery over the network. To fund all this activity and investment, the locality will pay Macquarie on an ongoing basis by placing a monthly fee on all local property owners' utility bills. Macquarie intends that multiple ISPs will compete over the network, giving consumers a choice of providers and the benefits of price competition (and creating a revenue stream for ISPs, who will pay Macquarie). Macquarie projects that network revenues will grow substantially over time; as service revenues generated by the ISPs increase, Macquarie commits to sharing some of its revenues with the locality.

Macquarie is an experienced and sophisticated entity, and offers an comprehensive solution. We note, however, that its open access business model is not tested and that the utility fee is likely to prove a heavy lift politically in most American communities.

4.5.2 SiFi Networks

In the SiFi Networks approach to this model, a local FTTP network is built and operated by SiFi and its partners at public sector expense. SiFi will provide financing and, with its partners, turnkey construction and operations—all of which will be compensated by lease payments from the public sector partner. SiFi will then bring to the community one or more ISP partners, with which the locality will contract to provide open access services over the network.

In SiFi's vision, the ISPs will make minimum payment guarantees to the locality in return for the opportunity to provide services over the network; those amounts will be negotiated and based on the public sector partner's actual costs. If multiple competing ISPs or even a single ISP is willing to make such commitments on a long-term basis, and if those ISPs are viable entities—with commitments backed by real resources—then the model will reduce the public sector partner's risk in terms of the ongoing payments to SiFi and its partners.

The viability of the model thus hinges on the willingness of ISPs to make such commitments, and the ISPs' confidence that they can realize sufficient revenues and margins to justify the commitments.

As with the Macquarie model, the SiFi model is interesting, but, so far, untested.

[15] "Macquarie Capital," Macquarie Group, http://goo.gl/uvUEjv.

4.5.3 Symmetrical Networks

In Symmetrical Networks' version of this model, Symmetrical and its partners will build the network, which will be operated by an ISP chosen by the public sector partner. That operator may be an ISP that is a partner to Symmetrical, it may be the public sector entity itself, or it may be any other qualified network operator.

Symmetrical does not follow the multiple-ISP open-access approach anticipated by SiFi and Macquarie; rather, it intends that open access will happen "over the top" (OTT), when consumers select their own application providers over an unfettered data connection with no data cap.

Symmetrical will build, finance, and provide turnkey construction for an FTTH network, and the public sector partner will make a lease payment to Symmetrical that will cover the company's debt service, operating costs, and margin. The public sector entity will, in turn, be paid by the ISP; in Symmetrical's modeling, the ISP will pay the locality an amount equal to the locality's obligations to Symmetrical.

Symmetrical believes that this model is viable based on a minimum community-wide take rate of 35 percent. To reduce the public sector partner's risk, Symmetrical will not undertake a project unless city-wide, aggregated commitments at this level have been secured in advance.

As with the SiFi and Macquarie models, the viability of this model hinges on the selected ISP's ability to generate sufficient revenues to cover its required payment to the public sector entity (which equals the locality's required payment to Symmetrical), its costs, and, presumably, an acceptable operating margin. While Symmetrical is confident that this model is viable, it is also quite frank that the public sector entity bears the risk in the event that network revenues fall short of the obligated levels.

4.6 Model 3: Shared Risk and Investment

A public–private partnership model based on shared investment and risk plays to the strengths of both the public and private sector partners. Most localities consider FTTH deployment not as a moneymaker, but as a powerful tool for education and economic development. Thus in a shared investment model, the risk is shared but the community still receives 100 percent of the benefits it seeks—recognizing that the benefits do not all appear on the project's financial statements. For the private partner, a shared investment means less upfront capital (risk), with an opportunity for future revenues.

Among other enormous benefits to this model, cities can not only provide fiber to the private sector—for compensation and to get gigabit and beyond service to the public—but can also secure extensive fiber throughout their communities for internal uses, including municipal and municipal utility operations, public safety, and emerging Smart City and Internet of Things (IoT) applications.

This model will provide an institutional or public sector network of the future—more extensive than any network that served city or county needs in the past, because the fiber will go everywhere in the community. It will have the potential to serve every conceivable application, from traffic signal control to air quality monitoring, from robust and secure public safety communications to high-end videoconferencing between universities and schools.

This benefit is ancillary to the core benefit of enabling a competitive gigabit (and beyond) product over fiber to every home and business in the community—but, in the long run, it has the potential to enable transformative public sector use and services. And indeed, local governments' track record of securing considerable savings and enormous operational capabilities over fiber is already demonstrated.[16]

We note, however, that while this model offers an extraordinary opportunity for innovation, it is in no way a sure thing for communities. We do not have the data points to develop the best practices necessary for success. At the moment, early actors are developing new and exciting partnerships to bring next-generation broadband to their communities. We describe some of those projects in the brief case studies below.

4.6.1 Case Study: Westminster, MD

The City of Westminster, Maryland, is a bedroom community of both Baltimore and Washington, D.C. where 60 percent of the working population leaves in the morning to work elsewhere.[17] The area has no major highways and thus, from an economic development perspective, has limited options for creating new jobs. Incumbents have also traditionally underserved the area with broadband.

The city began an initiative 12 years ago to bring better fiber connectivity to community anchor institutions through a middle-mile fiber network. In 2010, the State of Maryland received a large award from the federal government to deploy a regional fiber network called the Inter-County Broadband Network (ICBN) that included infrastructure in Westminster.[18]

Westminster saw an opportunity to expand the last mile of the network to serve residents. At the time, though, it did not have any clear paths to accomplish this goal. City leaders looked around at other communities and quickly realized that they were going to have to do something unique. Unlike FTTH success stories such as Chattanooga, Tennessee, they did not have a

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[16] *See, for example:* "Community Broadband Creates Public Savings," Fact Sheet, Institute for Local Self-Reliance, https://goo.gl/kCEZeC.

[17] Case study is based in part on a presentation by Dr. Robert Wack, President, Westminster (Maryland) City Council, during a webinar hosted by the Fiber to the Home Council and facilitated by CTC Technology & Energy. *See*: http://goo.gl/x82Ro7 (password required). See also: Robert Wack, "The Westminster P3 Model," *Broadband Communities Magazine* (Nov./Dec. 2015), http://goo.gl/op1XpH.

[18] "The Project," Inter-County Broadband Network, http://goo.gl/GjBC26.

municipal electric utility to tackle the challenge. They also did not have the resources, expertise, or political will to develop from scratch a municipal fiber service provider to compete with the incumbents. As a result, they needed to find a hybrid model.

As the community evaluated its options, it became clear that the fiber infrastructure itself was the city's most significant asset. All local governments spend money on durable assets with long lifespans, such as roads, water and sewer lines, and other infrastructure that is used for the public good. The leaders asked, "Why not think of fiber in the same way?" The challenge then was to determine what part of the network implementation and operations the private sector partner would handle and what part could be the city's responsibility.

The hybrid model that made the most sense required the city to build, own, and maintain dark fiber, and to look to partners that would light the fiber, deliver service, and handle the customer relationships with residents and businesses. The model would keep the city out of network operations, where a considerable amount of the risk lies in terms of managing technological and customer service aspects of the network.

The city solicited responses from potential private partners through a request for proposals (RFP). Its goal was to determine which potential partners were both interested in the project and shared the city's vision.

The city eventually selected Ting Internet, an upstart ISP with a strong track record of customer service as a mobile operator. Ting shared Westminster's vision of a true public–private partnership and of maintaining an open access network. Ting has committed that within two years it will open its operations up to competitors and make available wholesale services that other ISPs can then resell to consumers.

Under the terms of the partnership, the city is building and financing all of the fiber (including drops to customers' premises) through a bond offering. Ting is leasing fiber with a two-tiered lease payment. One monthly fee is based on the number of premises the fiber passes; the second fee is based on the number of subscribers Ting enrolls.

Based on very preliminary information, given that this is a market in development as we write, we believe this is a highly replicable model.

What is so innovative about the Westminster model is how the risk profile is shared between the city and Ting. The city will bond and take on the risk around the outside plant infrastructure, but the payment mechanism negotiated is such that Ting is truly invested in the network's success.

Because Ting will pay Westminster a small monthly fee for every home and business passed, Ting is financially obligated to the city from day one, even if it has no customers. This structure gives

the city confidence that Ting will not be a passive partner, because Ting is highly incented to sell services to cover its costs.

Ting will also pay the city based on how many customers it serves. Initially, this payment will be a flat fee—but in later years, when Ting's revenue hits certain thresholds, Ting will pay the city a small fraction of its revenue per user. That mechanism is designed to allow the city to share in some of the upside of the network's success. In other words, the city will receive a bit of entrepreneurial reward based on the entrepreneurial risk the city is taking.

Perhaps most significantly, there is also a mechanism built into the contract that ensures that the two parties are truly sharing risk around the financing of the outside plant infrastructure. In any quarter in which Ting's financial obligations to the city are insufficient to meet the city's debt service, Ting will pay the city 50 percent of the shortfall. In subsequent quarters, if Ting's fees to the city exceed the debt service requirements, Ting will be reimbursed an equivalent amount. This element of the financial relationship made the deal much more attractive to the city because it is a clear demonstration of the fact that its private partner is invested with it.

4.6.2 Case Study: Santa Cruz, CA

In what we believe is the first of many similar projects to come nationwide, the City of Santa Cruz has adopted a variation on the Westminster model (see Section 4.6.1 above). In December 2015, the City Council in Santa Cruz signed an agreement that potentially delivers tremendous value to local residents while sharing risk between the public and private sector.

The Santa Cruz City Council approved an agreement between the city and a local ISP, Cruzio. The city will build, own, and maintain a fiber network; Cruzio, which is a DSL reseller, will migrate many of its DSL customers over to the city's fiber network—and will actively pursue additional new customers to buy broadband services over the fiber. As in the Westminster agreement, Cruzio will pay the city both a per-passing and a per-subscriber fee for its use of the city's fiber.

Cruzio is a small company, which creates a certain amount of partnership risk for the city. But from the city's standpoint, it is a very attractive partner—a locally based, locally owned company that employs Santa Cruz residents. In fact, the name of the company incorporates the city's name.

For Santa Cruz, identifying a local partner was a key factor in its negotiations. Cruzio's localism was so important to the city that in early 2015, the Council directed city staff to negotiate exclusively with Cruzio.

Cruzio has operated in the city since the early days of the Internet when it was a dialup ISP. In the broadband era, it migrated to some wireless service and to reselling phone company DSL.

The logical next step is for Cruzio to migrate to fiber—which is what the relationship with the city will enable it to do.

The benefits of the partnership to the city include not only owning a next-generation network—and all the positive externalities that come with such a network—but also supporting and enabling an important local employer and longtime partner in the community.

4.6.3 Case Study: Garrett County, MD

The case studies presented above are incredibly promising, but those projects may be more challenging to replicate in rural communities, where the cost of fiber deployment, even in a shared-investment scenario, may still be prohibitive. The shared investment and shared risk strategy, however, is still applicable to rural communities—perhaps using other technologies that secure the benefits of broadband even if they do not result in the kinds of speeds that fiber enables.

For example, Garrett County, in far western Maryland, is a relatively remote Appalachian community bordered by West Virginia and Pennsylvania. The county has struggled to get broadband in a number of its remote, mountainous areas. Where broadband is available, it is inadequate DSL service that does not meet the Federal Communications Commission's (FCC) new speed benchmark for broadband service, let alone the requirements for home-based businesses or home schooling. The incumbent provider has not made any plans to expand or upgrade service offerings.

Though mobile broadband is available in some parts of the county, data caps mean that it is not viable for economic or educational activities. (Parents who home-school their children can run through their monthly bandwidth allotment in one day of downloading educational videos.) Beyond these challenges for residents, the county has struggled to attract and retain businesses and teleworkers.

In response, the county has gradually and incrementally built out fiber in some areas, with a focus on connecting specific institutions. And in September 2015, the County Council approved a contract with a private partner to leverage some of that fiber and additional public funding to support the deployment of a fixed-wireless broadband network that will serve up to 3,000 currently unserved homes in the most remote parts of the county. The private partner, Declaration Networks Group (DNG), will also put its own capital toward the construction of the network, and will apply its technical and operational capabilities to managing the network.

The partnership involves cost to the county, but also massive benefit for residents and businesses in the newly served areas.

The county's outlay of funds will be $750,000, which will be matched by a grant from the Appalachian Regional Commission (ARC)—and which will be more than matched by DNG's commitment of both capital and operating funds. That relatively modest county contribution (which was then leveraged for the ARC economic development funding) made the economics of this opportunity very attractive to DNG, and secured a broadband buildout for an area that would otherwise not be attractive for private sector broadband investment.

From an economic development perspective, the county's investment represents enormous value for the dollar. This investment will enable residents in 3,000 homes to buy cost-effective broadband service that they cannot access now, and that will make possible telework, home-based businesses, and home schooling. This investment will also enable the county to close the homework gap for many students in the county schools who do not currently have broadband in their homes—an increasingly critical lack of service.

As the network is deployed over the next few years, the county will reduce to nearly zero the number of homes in the county that do not have access to some kind of broadband communications options. These options may be modest—not the robust speeds available in metro markets—but they are significantly better than nothing, and a huge economic development achievement from the county's standpoint.

5 Additional Strategic Considerations for Public–Private Partnerships

As public sector entities of all sizes and capabilities evaluate potential models for public–private partnerships, it is important to approach each proposal with a healthy dose of common sense. Next-generation fiber deployment, particularly on a large scale to reach all residences and businesses in a community, is a valuable and future-proof investment. But it will not be cheap or easy. If anyone claims otherwise, or claims that they will deliver enormous benefits at little or no cost or risk, ask for examples of projects where they have accomplished what they are promising. If it were easy, we would already have seen enormous private investment in FTTP across the country. Communities should be skeptical of rosy projections.

It is also critical to look for private sector partners that are interested in developing meaningful partnerships to deploy next-generation infrastructure. A significant risk around economic development incentives and other measures to facilitate investment is that private companies will request that localities take on additional costs as a condition of the private investment. For example, a private partner might ask the local government to hire dedicated inspectors and provide free access to real estate—and provide in return only tacit commitments for new services or technological upgrades. The goal of these partnerships is not simply to shift private sector costs to the public sector. If a company is a true partner, it will be willing to make firm commitments to invest in the community in return for the actions the locality takes to lower the cost of deploying infrastructure.

In addition, partners and partnerships will differ in different parts of the country, and with the size of a community. A primary challenge for localities seeking buildout to every residence and business is that the larger the community, the more difficult it may be for a private partner to deploy its service universally. By taking on the risk of fiber construction and finding a partner to light the network and provide service, a locality can increase the potential for a universal fiber buildout to every location.

Finally, do not underestimate the importance of the political element in tackling these challenges. Political concerns will play a huge role in finding solutions. Community and political leaders must jointly decide to pursue a project of this scope, to solve the problems that may arise along the way, and to bring fiber and its benefits to the community.

Appendix D – Glossary of Terms

AE – Active Ethernet; a technology that provides a symmetrical (upload/download) Ethernet service and does not share optical wavelengths with other users. For subscribers that receive Active Ethernet service—typically business customers that request a premium service or require greater bandwidth—a single dedicated fiber goes directly to the subscriber premises with no optical splitting.

CPE – Customer premises equipment; the electronic equipment installed at a subscriber's home or business.

Distribution Fiber – The fiber in an FTTP network that connects the hub sites to the fiber distribution cabinets (see below).

Drop – The fiber connection from an optical tap in the right-of-way to the customer premises.

FDC – Fiber distribution cabinet; houses the fiber connections between the distribution fiber and the access fiber. FDCs, which can also house network electronics and optical splitters, can sit on a curb, be mounted on a pole, or reside in a building.

Access Fiber – The fiber in an FTTP network that goes from the FDCs to the optical taps that are located outside of homes and businesses in the rights-of-way.

FTTP – Fiber-to-the-premises; a network architecture in which fiber optics are used to provide broadband services all the way to each subscriber's premises.

GPON – Gigabit passive optical network; the most commonly provisioned FTTP service—used, for example, by Verizon (in its FiOS systems), Google Fiber, and Chattanooga Electric Power Board (EPB). GPON uses passive optical splitting, which is performed inside FDCs, to connect fiber from the Optical Line Terminals (OLTs) to multiple customer premises over a single GPON port.

IP – Internet Protocol; the method by which computers share data on the Internet.

LEC – Local Exchange Carrier; a public telephone company that provides service to a local or regional area.

MDU – Multi-dwelling unit (i.e., an apartment or office building).

OLT – Optical Line Terminal; the upstream connection point (to the provider core network) for subscribers. The choice of an optical interface installed in the OLT determines whether the network provisions shared access (one fiber split among multiple subscribers in a GPON architecture) or dedicated Active Ethernet access (one port for one subscriber).

OSP – Outside plant; the physical portion of a network (also called "layer 1") that is constructed on utility poles (aerial) or in conduit (underground).

OSS – Operational Support Systems (OSS); includes a provider's provisioning platforms, fault and performance management systems, remote access, and other operational support systems for FTTP operations. OSS is housed in a network's core locations.

OTT – Over-the-top; content, such as voice or video service, which is delivered over a data connection.

Passing – A potential customer address (e.g., an individual home or business).

POTS – "Plain old telephone service;" delivered over the PSTN.

PSTN – Public switched telephone network; the copper-wire telephone networks that connect landline phones.

QoS – Quality of service; a network's performance as measured on a number of attributes.

ROW – Right-of-way; land reserved for the public good such as utility construction. ROW typically abuts public roadways.

VoIP – Voice over Internet Protocol; telephone service that is delivered over a data connection.