City of Golden Fiber Master Plan & Broadband Study

Version 3.0

July 2019

Prepared By Magellan Advisors

Table of Contents

Table of Figures

Executive Summary

Forward thinking cities rely upon municipal fiber-optic (fiber) networks to adapt to the changing digital landscape in their communities. As more civic functions are carried out online or require interconnectivity, these networks help local governments meet the growing demands of their constituents and the other local public organizations serving them. Municipal fiber networks have also become assets through which municipalities can foster the development of leading-edge broadband services in their communities. These “Gigabit Communities” utilize technology to support the economic and community needs of their constituents, bringing world-class broadband to their communities.

In November of 2016, Golden voters supported the override of Colorado Senate Bill 05-152, the bill that prohibits local government from supporting, either directly or indirectly, advanced telecom services, thus authorizing the City to investigate alternatives for promoting advanced telecom services to its Citizens. This Feasibility Study and Fiber Master Plan is the next major step that the City has taken to explore various options to expand broadband in Golden.

The first phase of the study considers the City’s internal communications and technology needs. To meet these needs, a fiber backbone was envisioned to support the City’s current and future functions and services. This backbone will supply fiber connectivity to key facilities from day one and serve as a foundation for all other opportunities for municipal uses and community connectivity.

As many cities have witnessed, the fiber backbone will become a much greater community resource that can be used to connect other public organizations, businesses and even residents, for cities that choose to do so. Therefore, the backbone is a necessity for the City’s own internal needs and has future potential to drive greater community benefits across Golden.

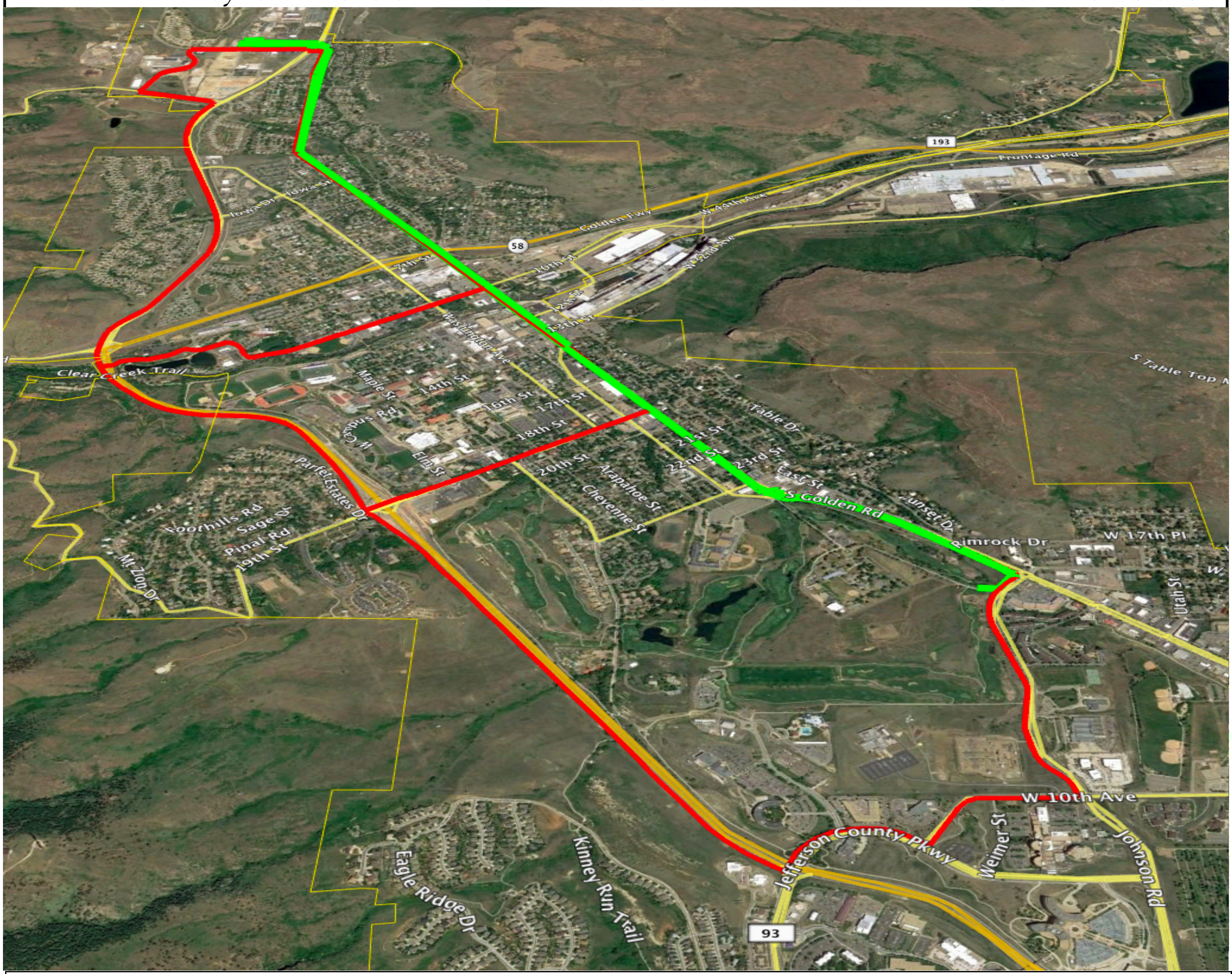
Some examples of neighboring communities that have deployed fiber backbones include:

- *City of Centennial – In 2017, the City built a $5.7 million fiber backbone to connect it key facilities. In 2018, the City formed a partnership with Ting Internet that now uses the City’s backbone to provide fiber Internet services to residents and businesses*
- *City of Boulder – The City has maintained an extensive fiber backbone for over 10 years that connects all City facilities, community partners and external organizations.*
- *City of Loveland – The City has an extensive fiber backbone, built initially for its electric communications needs. Today, Loveland is leveraging this backbone to deploy fiber Internet services to homes and businesses.*
- *City of Fort Collins – Similar to Loveland, Fort Collins’ fiber backbone was developed for use by the electric utility but now has become a platform to deliver fiber Internet services to residents and businesses.*
- *City of Longmont – Longmont’s fiber backbone became a jumping off point for the utility to begin offering fiber Internet services. Today, Longmont NextLight provides access to about 100% of its homes and businesses and was ranked by PC Magazine as the “Fastest ISP in America.”*

The Phase 1 Fiber Backbone will connect the major thoroughfares of the City with high capacity, redundant fiber to support municipal, utility, Smart City and future broadband applications. The backbone is illustrated on the next page along with the cost summary for the project. The cost of the Phase 1 Fiber Backbone is $3.8M, which includes a joint build with Verizon that saves the City about $300,000. The $3.8 million includes all capital costs to build the backbone and connect seven primary City sites. It also includes the equipment necessary to connect sites and three years of operations and management costs for the backbone. The network could be built to be built within 18 months, pending City Council approval to move forward

Proposed City of Golden Phase 1 Fiber Backbone

City Boundary
City of Golden Fiber Backbone – City Fiber Construction
City of Golden Fiber Backbone – Verizon Shadow Conduit



Phase 1 Fiber Backbone Cost Summary	
Fiber Backbone	$1,973,028
Fiber Laterals to Sites	$185,525
Equipment	$278,000
Project & Construction Management	$555,000
Operations & Maintenance Costs (Years 1 - 3)	$818,736
Total Budget, Years 1-3, Including 20% Contingency	$3,810,289

As the Phase 1 Fiber Backbone construction commences, the City could develop additional strategies to serve the community's broadband needs. Some of these include building fiber into Golden's economic development areas, providing dark fiber leasing to service providers and considering a future deployment of fiber-to-the-home broadband services, either provided by the City directly or through a partnership with a broadband provider.

The second phase of this Plan was developed to inform the City of how the Phase 1 Fiber Backbone could be expanded to support future broadband opportunities. The figure below illustrates a phased approach that many cities utilize to expand broadband from their initial fiber backbone deployment.

Fiber Backbone Deployment

1

1. Deploy core fiber infrastructure.
2. Develop broadband-friendly public policies
3. Engage partners for joint builds and broadband opportunities.
4. Connect critical facilities.
5. Demonstrate early success.

Municipal Connectivity

2

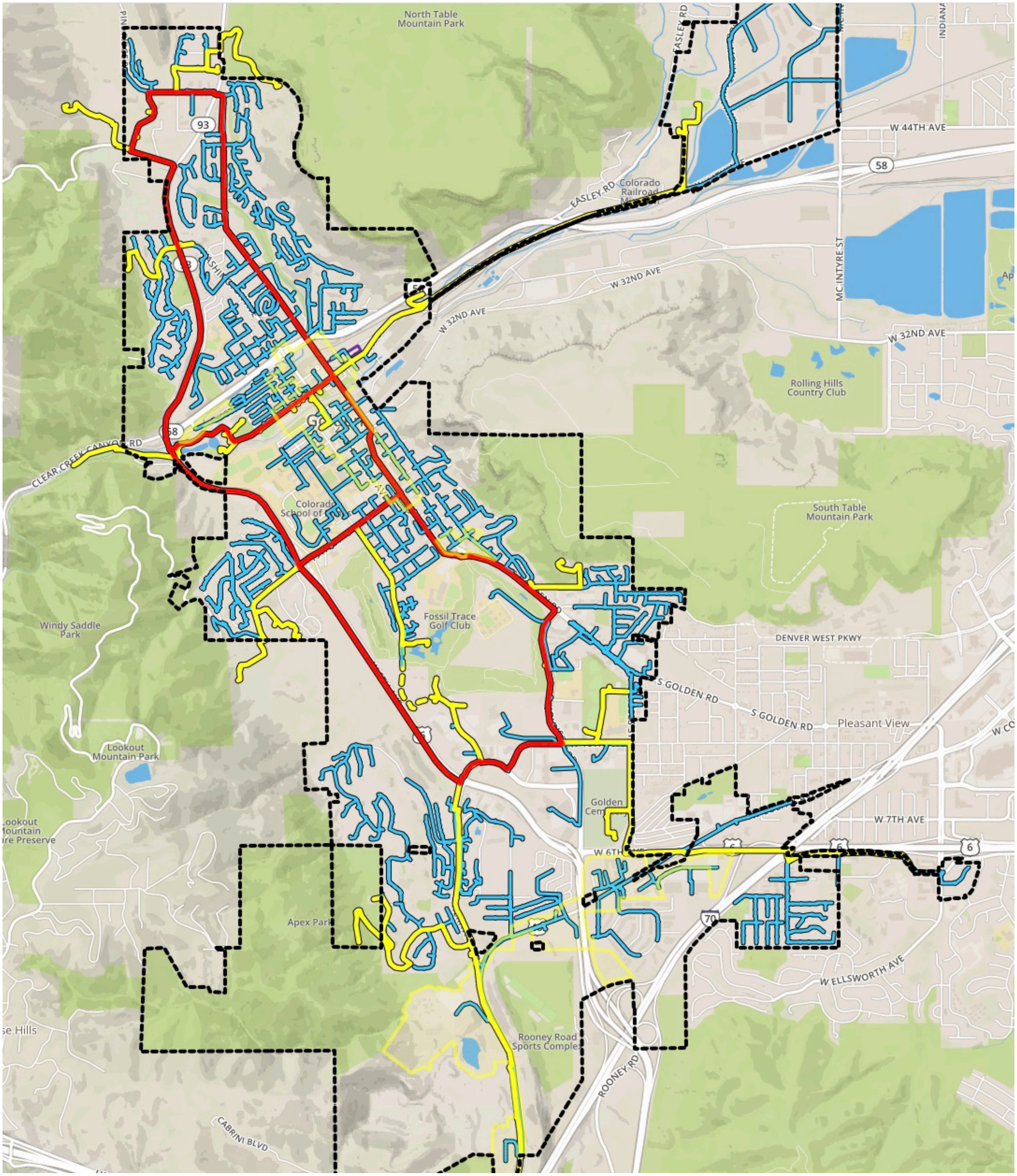
1. Assess progress toward goals and re-evaluate as needed.
2. Engage partners for joint builds and broadband opportunities.
3. Connect additional municipal sites.
4. Connect other public community anchors and partners.
5. Identify achievable broadband opportunities to support economic development.

Community Connectivity

3

1. Assess progress toward goals and re-evaluate as needed.
2. Engage partners for joint builds and broadband opportunities.
3. Identify community-wide broadband opportunities.
4. Utilize the network to support Smart City and IoT applications.

This "crawl, walk, run" approach would enable the City to begin taking measured steps to utilize the fiber backbone to support broadband needs. It could include connecting economic development areas with fiber to enhance economic development, leasing dark fiber to broadband providers and/or providing broadband services to the community directly. Several viable options are presented in this Plan for the City's consideration, but as many cities have found, many opportunities will arise to use the City's fiber infrastructure and therefore, the City should continually be open to new applications and additional uses. The following map illustrates the expansion of fiber for phases 1, 2 and 3 of the proposed network. All fiber network designs are provided as an attachment to this Plan in GIS Shapefile and KMZ formats for detailed review.



North Table Mountain Park
W 44TH AVE
EASLEY RD
Colorado Railroad
W 32ND AVE
W 32ND AVE
W 32ND AVE
MC INTYRE ST
Rolling Hills Country Club
CLEAR CREEK CANYON RD
South Table Mountain Park
Fossil Trace Golf Club
Windy Saddle Park
DENVER WEST PKWY
S GOLDEN RD
S GOLDEN RD
Pleasant View
Lookout Mountain Park
W 7TH AVE
Apex Park
W ELLSWORTH AVE
Rooney Road Sports Complex
ROONEY RD
CABRINI BLVD

Recommendations

This Plan recommends that the City immediately move forward with development of the Phase 1 Fiber Backbone. This will support the City's needs and build a foundation for future broadband, Smart City and community uses. On Council approval, the City will move into the design engineering phase of the Phase 1 Fiber Backbone. This phase will create the detailed design, validate costs and produce construction-ready documents that can be utilized to bid out a construction package to competitive construction firms. The design process will take approximately four months to complete, after which time the City could move directly into construction of the network. Construction of the Phase 1 Fiber Backbone is anticipated to occur between 12-16 months after the design engineering is complete.

The City should also begin immediately evaluating broadband opportunities that the fiber backbone will create, with a goal of crafting its long-term broadband strategy in the next twelve months. This will consist of additional Council and staff education, analysis and strategic planning to assess the best opportunities for the Golden community. This process should also engage Golden citizens and businesses to understand their requirements, desires and how they would like to see the City address the broadband issue.

Action Items & Next Steps

1. Engage the Golden Broadband Task Force to investigate broadband opportunities
   Utilize the resources of the task force to engage and educate the community, solicit valuable input and feedback and steer development of Golden's broadband strategy.

2. Appropriate $3.8 million to fund the Phase 1 Fiber Backbone
   Allocate funding to support the deployment and operations of the Phase 1 Fiber Backbone over the next three years, including capital and operational costs.

3. Approve moving forward with the design engineering phase to validate final costs
   Staff will immediately contract with a municipal broadband design engineer to create the detailed design, bill of materials and cost estimates.

1. Overview of Municipal Fiber Networks

Fiber is the gold standard for municipal communications, broadband services, and Internet access. Fiber is used to transmit large amounts of data securely over long distances with high reliability. It supports a wide range of applications and is scalable to support nearly unlimited data capacity. Cities that own fiber consider it a capital infrastructure asset similar to water, road, and electric infrastructure and it has a lifespan of up to 50 years.

Over 3,000 cities in the US own some form of municipal fiber and have used it for decades to support their communities. These networks are becoming increasingly important to cope with the rapid growth in connected devices, from utility assets, to street lights, to traffic signals, to surveillance cameras. Cities that maintain these networks are able to accommodate these "Smart City" technologies that make them more efficient, reduce costs and increase the value they deliver to their constituents.

Within the past 15 years, some cities have expanded the use of these networks to enhance local broadband Internet services in their communities in order to support the needs of residents, businesses, and community organizations. As high-speed Internet access has become essential to support economic development, education, healthcare, and other community functions, cities have leveraged their networks to provide fiber-based Internet services, either directly or through partnerships with private broadband providers.

1.1 Fiber Is Critical Infrastructure

The City should consider fiber as it does other infrastructure resources, a long-term asset that supports the municipal operations and community needs. Fiber maintains an economic life of up to 50 years; however, some municipal fiber networks have been in operation for more than 60 years. The City should view fiber as an infrastructure asset that will continue to drive value, cost reductions, and new capabilities in Golden.

The City should also consider establishing policy for the ongoing development of municipal fiber. As subsurface utility work occurs, it presents opportunities for the City to install new fiber in the right-of-way at reduced costs. Dig once and joint trench policies allow the City to take advantage of other subsurface utility projects for the installation of fiber. This enables the City to expand its ownership of fiber anytime subsurface utility work occurs, at preferential costs to new construction.

1.2 Fiber is an Investment in Golden's Future

For the City, building a fiber backbone is an investment in Golden's future. The City will own an asset that can accommodate smart and connected technologies as more municipal and community functions are carried out online. Smart City technologies and the Internet of Things are two growing ecosystems of devices that will change the way that cities carry out their missions. More devices, sensors, and people will be connected than ever before. By building a fiber backbone, Golden will be prepared to accommodate these emerging trends. The fiber backbone will keep Golden at the leading edge of innovation and support a range of municipal, community, and broadband applications. Without it, the City cannot consider the vast majority of them.

1.3 Fiber Development is a Long-Term Program

This Master Plan is a strategic roadmap for the development of the City's fiber backbone. The City should expect this backbone to grow over time to connect more locations and support more applications. The Fiber Master Plan is part of an ongoing strategy to support the evolving needs and opportunities for Golden's fiber backbone and proposes new fiber infrastructure to build on the City's existing network.

Golden should approach fiber infrastructure as a program rather than an individual project. Just as roads are extended and widened periodically to support more traffic, the fiber network will be expanded to support more users in Golden. The City should develop processes and procedures to plan, manage, and expand the network to ensure that the network continues to meet the needs of the City and its community.

The City should consider an organizational and policy framework for the construction and management of fiber and broadband. This will facilitate dedicated focus to ensure the network serves community needs. This may require the City to either manage the development of the network internally or work with a partner/vendor that has extensive experience deploying municipal fiber networks. In many cases, cities will outsource the initial development of the fiber backbone to an experienced third party and bring these functions in-house over time as internal staff gains experience.

Policies and procedures should govern how the City manages the fiber backbone, including access to fiber, customer allocation, reserve capacity, expansion, and management of records. Policies will also be required for any commercial transactions for public and private entities to utilize the network. Inter-governmental agreements can be utilized between the City and other public organizations for use of the network.

Standard contracts should be considered for transactions with private entities, which may include broadband providers, utilities and individual businesses. In addition, the City will need to design its policies and procedures around common telecommunications industry standards. This includes development of service level agreements ("SLA"), acceptable use policies ("AUP"), and other policies governing use of the network. Some examples of these are included in the Appendix to this Plan for reference.

2. Fiber Deployment Roadmap

2.1 A Phased Approach to Fiber Development

Municipalities that invest in fiber often utilize a staged approach that builds capacity and competency over time. An excellent example of this approach is found in the City of Santa Monica, where CityNet, the City's fiber backbone, was deployed in a long-term plan to first reduce cost and connect community organizations, then expand access to businesses, and finally create a platform to deploy a range of public WiFi and other community services. (A case study on Santa Monica is provided in Appendix A).

A second example is found in the City of Palm Coast, where the City employed a multi-year plan to build out its fiber backbone throughout the City. Its initial goals included reducing ongoing connectivity costs and improving the City's communications resiliency. Following the initial deployment, the City connected 17 local schools with 10 Gigabit fiber connectivity and saved the school district hundreds of thousands of dollars a year. Finally, the City deployed an open-access network that today is being used by multiple service providers to deliver leading Internet services to about 200 local businesses to support the City's economic development goals. (A case study on Palm Coast is provided in Appendix A).

At each stage, the City will have the opportunity to evaluate the deployment of the network based on its original goals to ensure that the network is serving the community as anticipated. This should be a methodological approach that assesses the realized value of the network to the City and its community. Some key questions will include:

- What have we learned through our deployment?
- Did we plan for needs and opportunities correctly?
- Has the network accomplished its objectives?
- What could we have done better?
- How will we improve future deployments based on what we've learned?

2.2 Backbone Deployment

Golden can be successful following a similar approach that first develops the fiber backbone infrastructure to support City needs and connects the most critical City sites. In this stage, the City will construct the initial fiber backbone, a high capacity fiber ring that follows the major thoroughfares within the City. This network is Golden's fiber foundation, a core infrastructure that will support many municipal and community fiber needs across the City.

It will provide connectivity to municipal offices, utility sites, and traffic intersections, and will become a platform for other community anchors in the City to utilize for connectivity. The City should also consider connecting the most important municipal sites to the backbone in this first phase. These would consist of seven facilities, including:

- Golden Community Center
- Golden Fire Station 1
- Golden History Center
- Clear Creek Campground

- Golden Public Works Administration
- Golden Public Works Facility
- City Hall
- New City Hall Complex

It will also provide a platform to support future broadband and will have the flexibility to support a number of different types of broadband strategies based on how the City decides to address the broadband question in its community.

2.3 Municipal Connectivity

The City should anticipate future investments beyond the initial fiber backbone deployment. Completion of the backbone will drive new opportunities to utilize the network by connecting additional City sites and municipal resources. It may also include other public stakeholders, such as local schools, the Colorado School of Mines and local libraries. The City should be prepared to evaluate the costs, benefits, and risks associated with these opportunities. The growth stage may also incorporate opportunities for public-private partnerships with broadband providers to address broadband needs among businesses and residents.

Or, the City may find opportunities to address these needs through wholesale business models that provide only fiber connectivity to these users, while retail broadband providers deliver Internet, voice, television, and other end user services. For example, expanding the fiber backbone into Golden's economic development areas could provide fiber access that broadband providers could utilize to serve local businesses. This would also allow the City to market these zones as "fiber ready" to prospective businesses.

2.4 Community Connectivity

As the network expands with incremental investments, the City should assess the opportunities that fiber can bring to the greater residential and business community. The network will become a platform for innovation and many municipal networks have deployed advanced technologies on a widespread basis to support utility operations, surveillance, weather and temperature monitoring, active traffic management, and other Smart City applications.

To support leading edge broadband services, some have decided to implement broadband utilities that provide retail services directly, while others have selected to pursue public-private partnerships. The City should build capacity and expertise on this range of options as its network develops to select the right model or models that will best fit Golden's needs. The City's fiber backbone has been designed to accommodate any of these opportunities in the future, enabling the City to maintain flexibility in its network to support a range of options and business models.

3. Near-Term & Future Benefits

3.1 Municipal & Smart City Services

The network will support the City's current operations, drive efficiencies, reduce cost, and expand capabilities. It can become a multi-purpose asset of the City that can be used between departments for multiple applications. Most importantly, it will help the City enhance currently provided community services.

With an eye towards the future, many applications and services that are collectively referred to as "Smart City" efforts are not possible without a foundational fiber backbone. This backbone serves as a means of robust data collection and support infrastructure for all applications deployed across the City. Although Smart City technologies are only in their infancy, more are being deployed every day across the spectrum of civic functions, including:

- Digital Transformation, the process of creating a digital City government experience, often called "e-Government," which includes digital services and open data;
- Smart Buildings & Facilities, connecting facilities and using integrated management systems for climate control, HVAC, energy;
- Smart Streetlights, Small Cells, and preparing for the deployment of 5G;
- Intelligent Traffic Signal Systems that adapt to real-time traffic conditions, making Golden streets more efficient;
- Autonomous vehicle preparation, supporting wireless connectivity throughout major corridors
- Public Safety, and using intelligence and data to help improve quality of life;
- Digital Inclusion, which entails connecting the unconnected and helping community members engage in the digital economy;
- Public Wi-Fi and infrastructure to drive economic development and bridge the digital divide.

Planning the Backbone to Support Municipal & Smart City Services

1) Support Innovation and Technology

a. Enable connectivity across City facilities to support secure departmental applications;
b. Design the backbone to maximize redundancy for City services;
c. Design the backbone with sufficient capacity to meet future departmental needs;
d. Plan connectivity from the backbone to the Front Range GigaPOP to enable low-cost Internet access and other services for governmental use;
e. Interconnect with Jefferson County for future application sharing.

2) Support Water/Wastewater Utilities

a. Work with water and wastewater utilities to determine locations for fiber connectivity;
b. Design the network to provide fiber access points to these locations;
c. Enable capacity in the network to support SCADA security and resiliency requirements.

3) Support Parks & Recreation

a. Identify City park facilities that may benefit from fiber and/or wireless connectivity;
b. Design future fiber connectivity to these locations.

4) Support Future Smart City Technologies

a. Design the network with sufficient strand capacity to support future applications that utilize fiber and wireless connectivity;
b. Maximize fiber access points across the network to accommodate interconnection of future applications;
c. Create splice points at all key intersections;
d. Plan fiber access points and termination for multiple applications;
e. Size fiber vaults, handholes, and splice cases appropriate along major corridors.

5) Enable Smart Pole Connectivity

a. Build sufficient capacity into the backbone to support smart street light connectivity;
b. Plan the network to support 5G fiber backhaul from street lights and utility poles;
c. Design access points (vaults/handholes) for easy access at intersections.

3.2 Economic Development

Economic development could become a key beneficiary of the fiber network. The City's asset could be used as a tool to reduce the cost of doing business in the City while enabling the City to market business districts as fiber-ready. To do so, the fiber backbone could be interconnected to local data centers in the area, such as the Front Range GigaPoP and the 910 Telecom co-location facility in Denver.

Access to these data centers would enable Golden to interconnect with hundreds of telecommunications providers that could be accessed by Golden's businesses. With these connections, local businesses would have more choices for their communications and technology needs, bringing more competition to the local market and lower prices. The City could also develop strategic partnerships with current and future broadband providers to market the benefits of Golden's network and services to businesses.

Planning the Backbone to Support Economic Development

1) Attract & Retain Business

a. Identify economic development areas within the City;
b. Identify businesses that are in close proximity to fiber routes;
c. Work with local providers to make City fiber available to serve local businesses;
d. Ensure sufficient splice points exist to support future connections to businesses.

2) Support Teleworking & Home-Based Businesses

a. Identify concentrations of home-based businesses in Golden, commuting patterns, and teleworking trends;
b. Design the fiber backbone network along key residential thoroughfares that may provide future potential to connect neighborhoods in partnership with broadband providers;

c. Work with neighborhood organizations to aggregate demand for last-mile connectivity to Golden's backbone network.

3) Promote Golden as a Connected Community

a. Work with broadband providers to solicit interest in using Golden's broadband infrastructure;
b. Develop a plan to interconnect the Golden network to local data centers;
c. Identify immediate opportunities to use existing assets and small incremental investments that will show immediate progress and demonstrate the City's capabilities;
d. Identify potential users within close proximity to the existing network;
e. Identify pilot projects and business cases;
f. Market the network as a resource of the City that contributes to Golden's status as a highly connected community for business.

3.3 Public Safety

Public safety agencies in Golden could benefit from additional fiber to connect agencies with one another and provide added redundancy for mission critical applications. The connectivity improvements from interconnecting the multiple public safety agencies on a single, robust dark fiber backbone include enhanced dispatch abilities, improved communication in the event of an emergency, and preserving opportunities for future enhancement.

Enabling fiber connectivity at key intersections along the fiber backbone could facilitate the installation of more surveillance cameras, traffic cameras and license plate recognition technologies. The network provides very high capacity to support many high-definition video feeds and route these to the first responders that need them both in the field and at police and fire stations.

Network Design Principles Supporting Public Safety

1) Support More Access to Video Applications

a. Set aside capacity to support fiber connectivity at intersections for traffic cameras, in conjunction with intelligent traffic systems.

2) Support High Security, High Resiliency Communications

a. Design the fiber network to maintain compliance with law enforcement security standards;
b. Design high levels of redundancy into the network to support mission critical applications;
c. Emergency operations in Golden's public safety environment;
d. Facilitate communications and technology sharing between public safety organizations.

3.4 Education

The City's fiber backbone could provide dark fiber connectivity to local schools directly or in conjunction with broadband providers that serve the schools today. Many school systems seek redundant connectivity as their Internet and application needs have grown. Golden's fiber backbone could provide back-up connectivity if required by local schools. In addition, connectivity to the Colorado School of Mines may enable redundant connectivity that the college could utilize for more robust communications.

Network Design Principles Supporting Education

1) **Support High-Quality, Resilient Internet Access at School Facilities**
    a. Identify school facilities across the City;
    b. Design the network to pass as many of these organizations as is economically feasible;
    c. Design the network to provide fiber access points to these locations;
    d. Design the network for potential regional interconnection with research and education networks, such as Internet2 and Front Range Gigapop.

2) **Support Increased Access and Adoption of Internet Services for Students**
    a. Identify locations where public Internet access may be improved, including libraries, community centers, and WiFi hotspots;
    b. Design the network to provide fiber access points to these locations;
    c. Allocate sufficient capacity and splice points to support WiFi in public places, schools, and libraries that may facilitate more public access to the Internet;
    d. Design the network to pass neighborhoods to facilitate potential upgrades by broadband providers.

3.5 Transportation

The fiber backbone can facilitate better control and management of the City's traffic control system. Since the fiber backbone will pass Golden's major corridors, it presents the opportunity to connect most of the traffic signals and traffic cabinets to the network. This will allow each intersection to be equipped with high-speed connectivity to support advanced traffic management systems. Fiber-ready traffic cabinets will also enable the City to deploy many applications, such as high-definition traffic monitoring cameras, which can also be uplinked to public safety to allow monitoring of accidents and other events at Golden's intersections and along thoroughfares.

Many cities utilize fiber to support their complete streets programs to help ensure pedestrian and bike safety. The network could allow the City integration of safety signaling to support all three modes of transportation.

Network Design Principles Supporting Transportation

1) **Enable Connectivity for Transportation**
    a. Identify all signals and cabinets along the fiber backbone running lines;
    b. Design access locations at key intersections along major fiber routes;
    c. Connect traffic signals to the fiber network;
    d. Connect these signals to the City's traffic management center;
    e. Enable additional connectivity on major thoroughfares for traffic sensors.

3.5 Smart Street Lighting & Wireless 5G

As the City continues to take ownership of the street lighting system, it should consider the opportunities the street lights can bring for both energy management and future wireless connectivity. Many cities are developing smart street light programs that implement adaptive lighting technologies to brighten and dim street lights at appropriate times. These technologies can also geographically control lighting where it is needed most.

Additionally, many cities are utilizing their street lights for wireless connectivity. By retrofitting the lighting heads with wireless adaptors, they can provide direct WiFi connectivity at each street light, or alternatively, allow carriers to utilize the street lights to deploy 5G wireless antennas. This benefits cities and carriers by minimizing the amount of new vertical structures in the City and reusing existing ones for new purposes.

This can also become a potential revenue source for the City. Some warless carriers would rather rent access on City poles rather than build new ones. For example, in Carlsbad, CA, a wireless carrier leases 110 light poles from the City at $1,500 per year to bring 5G signal into the downtown corridor. The carrier also leases City fiber that interconnects these poles. This not only benefits the City from a revenue perspective but has also enabled faster deployment of 5G technologies to serve the community, while eliminating any new construction of tower infrastructure.

A requirement for any of these technologies is the fiber backbone. Each street light needs connectivity to the backbone for high-speed access back to a central location. The Phase 1 Fiber Backbone passes a significant number of street lights and as the City considers additional fiber deployment off of the backbone, it can connect more street lights to create a citywide system.

Network Design Principles Supporting Smart Street Lighting & Wireless 5G

1) **Provide Fiber Backbone Capacity and Access Along Major Thoroughfares**
   a. Identify street lights along the fiber backbone running lines;
   b. Designate sufficient capacity in the network to support dedicated fiber for street lights
   c. Design access locations at key intersections along major fiber routes;

4. Phase 1 Fiber Backbone Design

Based on an understanding of the goals of the City and locations of key facilities, a high-level design was developed for the first phase of the fiber backbone. The backbone provides high capacity fiber-optic cables throughout the major corridors of the City.

The City has a valuable opportunity to partner with Verizon on construction of the fiber backbone. Verizon will also facilitate the installation of 3.5 miles of conduit for a significantly reduced cost to the City. Verizon will install an additional conduit ("shadow conduit") for the City and transfer ownership of this facility to the City once constructed. This will save the City about $300,000 on the construction of the backbone. In addition to the Verizon shadow conduit, the City will install another 6.5 miles of underground conduit and fiber to complete the main ring of the backbone. Figure 1, on the following page, illustrates the fiber backbone.

The entire backbone will be about 10.5 miles in length, forming a ring around the City and providing high capacity, redundant fiber connectivity. Splice points are strategically placed throughout the network to allow easy interconnection with facilities, City assets and business districts and neighborhoods, for future broadband capabilities, if the City chooses to move in that direction.

Additionally, the network, as designed, runs in close proximity to a large amount of Golden's businesses. About 45% of all businesses in Golden are within 1,500 feet of the fiber backbone. This will facilitate simple connectivity to businesses that may desire fiber access in the future, while keeping costs low for "last mile" connectivity to reach them.

The fiber backbone will consist of 432-count fiber-optic cable on major routes. This cable size will enable the City to allocate capacity among multiple applications, including:

- City municipal functions
- Future Smart City applications
- Community anchor connections
- Broadband applications
- Spare capacity

Lateral fiber connections should consist of 12 to 48-strand cable connecting individual community organizations and other end user locations. The network will use an in-and-out splicing design that allows City facilities and community organizations to interconnect their locations in a "ring" topology that supports high redundancy for their communications needs. A range of specialized connections can be made to accommodate additional traffic cabinet, smart technology, and broadband applications that should be individually engineered based on the application.

General specifications of the backbone are found below. Actual specifications may change based on a forthcoming engineering design, which should be the next step for the City to validate costs and overall constructability. It is important that the City maintain compliance with these key specifications for Golden to achieve its goals.

Fiber Specifications

- Underground construction, directional boring or trenching
- Backbone cable size – 432-count fiber
- Lateral cable size – 12-count to 48-count fiber
- Singlemode, loose-tube non-armored cable
- Jacketed central member, outer polyethylene jacket
- Sequential markings in meters
- All dielectric
- Gel-free/dry buffer tubes
- 12 fibers per buffer tube
- Color coded buffer tubes based on ANSI/TIA/EIA-598-B Standard Colors

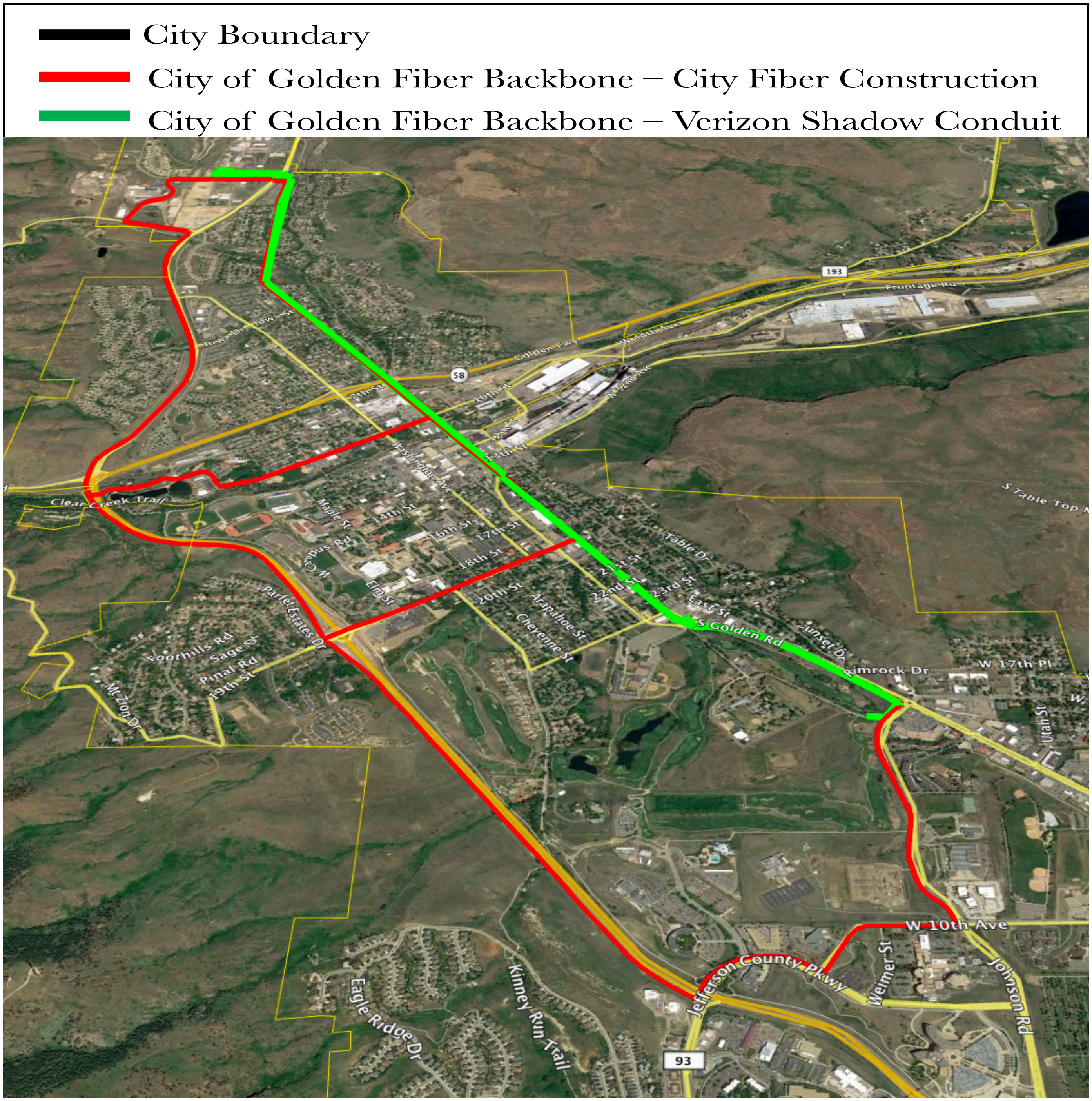
Conduit Specifications

- 24" minimum acceptable depth
- 2" HDPE smooth wall reel-mounted pipe, Quantity 2
- Maxcell innerduct where required
- Hand holes every 500 feet
- Rock adder assumed for 10% of the buildout
- Straight splicing every 5,000 feet
- Includes soft surface restoration and maintenance of traffic

Vault/Handhole Placement

Each route (Backbone / Lateral) will require a unique design and exact box placement will depend on a variety of factors to be determined in the final engineering analysis. Boxes along the backbone are generally placed every 500 feet to allow for pulling in the fiber and splicing to adjacent buildings and infrastructure. Conduit sweeps into handholes shall enter in flush with the cut-out mouse holes aligned parallel to the bottom of the box and come in perpendicular to the wall of the box. Conduits shall not enter at any angle other than near parallel. Sweeps from the mainline to the conduit shall be accomplished using radii recommended by the manufacturer. Handholes will be sized based on the size of cable(s) transiting the structures, the total number of cables, and the specific applications required by the City.

Figure 1: Phase 1 Fiber Backbone



5. Phase 1 Fiber Backbone Costs

5.1 Capital Costs

Construction costs were estimated by utilizing current pricing from construction contractors working in the Front Range markets as of Q1 2019. Magellan has also included a 20% contingency on costs covering all design, engineering and construction line items in the budget.

Capital costs for the fiber backbone are $1.97M, as illustrated in Figure 2, on the following page. This includes the costs of engineering design, permitting, construction and contract close out. It also includes the costs of the shadow conduit build with Verizon, totaling $73,894. Verizon is charging the City $3.35 per foot to install a new shadow conduit; for comparison, if the City would build this portion new, it would cost, at a minimum, $15.00 per foot.

These fiber backbone construction costs do not include the costs of connecting individual sites to the network. From the backbone, each lateral provides a fiber connection from a site into the backbone network. This study identified 51 potential sites that the City could connect to the network and enable the City's facilities to be equipped with direct fiber connectivity.

For the Phase 1 Fiber Backbone, Figure 3, on page 23 of this Plan, provides the 7 essential sites that will be connected to the network with their corresponding costs. The connections for these sites are approximately $185,000.

To connect all 51 City sites to the fiber backbone, the total costs would be $1.5 million. This would include all municipal, utility, fire, police and park facilities. Most cities will deploy fiber laterals in phases, with the highest priority sites to be connected to the network first with the initial fiber backbone and lower priority sites connected over time as budgets allow. For example, the City may want to connect City Hall, the community center, fire stations and public works with the backbone in the initial deployment. The second phase would connect water utility sites, parks and secondary sites. These sites and costs are itemized in Figure 4, on page 24 of this Plan.

Figure 2: Fiber Backbone Capital Costs

Item	Labor	Price	Unit	Quantity	Subtotal
1	Directional Bore (1) 2"	15.00	feet	34,434.00	$516,510.00
2	Verizon Shadow duct installation for backbone	3.35	Feet	22,058.00	$73,894.30
3	Budget for OSP design & permitting	1.50	Ft	56,492.00	$84,738.00
4	Furnish & Install Muletape in New duct	0.25	feet	56,492.00	$14,123.00
5	Rock Adder	80.00	feet	3,443.40	$275,472.00
6	Install #12 Tracer wire	0.25	feet	56,492.00	$14,123.00
7	Install Fiber Cable in Duct - Including All Slack	0.85	feet	61,199.67	$52,019.72
8	Remove & Restore Concrete	18.00	sq. feet	344.34	$6,198.12
9	Install Handhole	450.00	each	57.39	$25,825.50
10	Estimated Verizon installed HH's for shadow duct portions	0.00	Each	36.76	$0.00
11	Install New Splice Case & Prep Cable - for ring connections	250.00	each	9.00	$2,250.00
12	Install New Splice Case & Prep Cable - for straight splices	250.00	each	12.24	$3,059.98
13	Ground Splice Case	150.00	each	21.24	$3,185.99
14	Prep Cable in Panel	750.00	each	2.00	$1,500.00
15	Splice Fibers	25.00	each	6,151.65	$153,791.28
16	Install Loaded 144 Port Panel	250.00	each	6.00	$1,500.00
17	Install Splitter Cabinet	2500.00	each	0.00	$0.00
18	Terminate Fibers	25.00	each	864.00	$21,600.00
19	Test Network	2500.00	all	1.00	$2,500.00
20	Install Marker Post	35.00	each	70.62	$2,471.53
21	Install Marker Post with Test Station	50.00	each	23.54	$1,176.92
22		Labor Subtotal			$1,255,939.33
		20% Contingency			$251,187.87
		Labor Total			**$1,507,127.20**

Item	Material	Price	Unit	Quantity	Subtotal
23	Mule tape	0.05	feet	56,492.00	$2,824.60
24	432ct Fiber	2.78	feet	64,259.65	$178,770.35
25	Splice Trays	45.00	each	256.32	$11,534.35
26	Splice Cases	706.00	each	21.24	$14,995.39
27	Handholes	750.00	each	94.15	$70,615.00
28	#12 Tracer Wire	0.35	feet	56,492.00	$19,772.20
29	Ground Rods	25.00	each	21.24	$531.00
30	Marker Post	45.00	each	70.62	$3,177.68
31	Marker Post with Test Station	65.00	each	23.54	$1,529.99
32	2" Pipe	1.00	feet	56,492.00	$56,492.00
33	4u Fiber Panels - Loaded	4668.00	each	6.00	$28,008.00
34		Material Subtotal			$388,250.55
		20% Contingency			$77,650.11
		Material Total			**$465,900.66**
		Total Backbone			**$1,973,027.86**

Figure 3: Phase 1 Fiber Backbone Sites & Laterals

Location Name	Address	Lateral Distance	Composite Price Per Ft	Subtotal
Golden Community Center	1470 10th Street	521	$31.83	$16,583.43
Golden Fire Station 1	911 10th Street	258	$31.83	$8,212.14
Golden History Center	923 10th Street	250	$31.83	$7,957.50
Clear Creek Campground	1401 10th Street	608	$31.83	$19,352.64
Golden Public Works Administration	1445 10th Street	250	$31.83	$7,957.50
Golden Public Works Facility	1300 Catamount Drive	259	$31.83	$8,243.97
City Hall	911 10th Street	250	$31.83	$7,957.50
New City Hall Complex		2,326	$33.68	$78,339.68
			20% Contingency	$30,920.87
			Total Cost	**$185,525.23**

Figure 4: Fiber Lateral Capital Costs

Location Name	Address	Footage	Composite Price/Ft	Subtotal
Golden Fire Station 3	16023 West 5th Avenue	6,920	$31.83	$220,263.60
West Metro Fire Station	15100 West 6th Avenue	3,368	$31.83	$107,203.44
The Splash Aquatic Park	3151 Illinois St	2,834	$31.83	$90,206.22
Fossil Trace Golf Club	3050 Illinois St	1,166	$31.83	$37,113.78
Clear Creek Regional Trail	CO-58E	3,755	$31.83	$119,521.65
Tony Grampsas Memorial Sports Complex	4471 Salvia Street	11,381	$31.83	$362,257.23
Tony Grampsas Park	4471 Salvia Street	1,159	$31.83	$36,890.97
Tony Grampsas Dog Park	4471 Salvia Street	6,967	$31.83	$221,759.61
Ulysses Dog Park	1100 Johnson Street	1,491	$31.83	$47,458.53
Ulysses Park	1205 Ulysses Street	1,244	$31.83	$39,596.52
Ulysses Skate Park	1205 Ulysses Street	250	$31.83	$7,957.50
Golden Fire Station 2	1201 Ulysses Street	808	$31.83	$25,718.64
Golden Cemetery	755 Ulysses St	4,200	$31.83	$133,686.00
Golden Community Center	1470 10th Street	521	$31.83	$16,583.43
Golden Fire Station 1	911 10th Street	258	$31.83	$8,212.14
Golden History Center	923 10th Street	250	$31.83	$7,957.50
Clear Creek Campground	1401 10th Street	608	$31.83	$19,352.64
Golden Public Works Administration	1445 10th Street	250	$31.83	$7,957.50
Golden Public Works Facility	1300 Catamount Drive	259	$31.83	$8,243.97
City Hall	911 10th Street	250	$31.83	$7,957.50
Parfet Park	719 10th Street	285	$31.83	$9,071.55
Clear Creek White Water Park	10th and Maple Streets	278	$31.83	$8,848.74
Lions Park	902 11th Street	359	$31.83	$11,426.97
Astor House Museum	822 12th Street	1,192	$31.83	$37,941.36
Golden Visitors Center	1010 Washington Avenue	298	$31.83	$9,485.34
Golden Fire Station 4	151 Heritage Rd.	4,994	$31.83	$158,959.02
Gateway Village Water Tank	18493 Mt Vernon Canyon Rd	7,150	$33.68	$240,812.00
Gateway Village Pump Station	18493 Mt Vernon Canyon Rd	200	$33.68	$6,736.00
Welch Ditch Pump Station	1231 10th St	72	$33.68	$2,424.96
6000 North Water Tank	815 Brickyard Cir	1,846	$33.68	$62,173.28
Pump Station 6170	815 Brickyard Cir	131	$33.68	$4,412.08
6170 Water Tank	4758 CO-93	3,547	$33.68	$119,462.96
S Golden Rd Pump Station	3082 Lookout View Dr	289	$33.68	$9,733.52
Rimrock Water Tank	17755 Rimrock Dr	2,658	$33.68	$89,521.44
6000 South Water Tank	2109 Lookout Mountain Rd	848	$33.68	$28,560.64
6200 Pump Station	2109 Lookout Mountain Rd	1,056	$33.68	$35,566.08
6200 #1 Water Tank	2163 Lookout Mountain Rd	2,120	$33.68	$71,401.60
TGB Pump	2163 Lookout Mountain Rd	250	$33.68	$8,420.00
6400 Water Tank	2 De France Way	5,790	$33.68	$195,007.20
6200 #2 Water Tank	461 De France Dr	1,738	$33.68	$58,535.84
6400 Pump Station	461 De France Dr	250	$33.68	$8,420.00
Johnson Rd Pump Station	Johnson Rd	250	$33.68	$8,420.00
Fossil Trace Pump Station	3050 Illinois St	4,183	$33.68	$140,883.44
Pump Station 6130	355 N Washington Ave	499	$33.68	$16,806.32
Raw Water Pump Station	21690 US-6	2,689	$33.68	$90,565.52
Seasonal Pump Station	US-6 Clear Creek	550	$33.68	$18,524.00
6130 Water Tank	440 Mesa View Way	2,752	$33.68	$92,687.36
6260 Water Tank	21407 Golden Gate Canyon Rd	2,755	$33.68	$92,788.40
Bulk Water Pump Station	1165 Catamount Dr	160	$33.68	$5,388.80
WTP Water Tank	1385 10th St	285	$33.68	$9,598.80
New City Hall Complex		2,326	$33.68	$78,339.68
				$3,256,821.27

5.2 Equipment Costs

Ethernet equipment will provide connectivity between sites on the City's fiber backbone. Each site will need equipment supporting 10 gigabit connectivity, upgradeable to 100 gigabit in the future. Most networking platforms support scalable growth from 10 to 100 gigabits with a change in the equipment line cards and interface optics; therefore, Golden can purchase the equipment with this future upgradeability in mind without needing to replace significant equipment when scaling from 10 gigabit to 100 gigabit.

The architecture for the backbone should consist of a "core ring," created through the interconnectivity between primary sites along the fiber backbone. These primary sites will each have two connections out to neighboring sites along the backbone to form one continuous ring. This will enable the City to maintain redundant connectivity between all primary sites in the event either a fiber cut interrupts services, or an equipment failure causes a loss of connectivity. Figure 5 illustrates the equipment budget needed to connect the Phase 1 Fiber Backbone.

Figure 5: Phase 1 Fiber Backbone Equipment Budget

Location Name	Equipment Budget
Golden Community Center	$ 25,000.00
Golden Fire Station 1	$ 25,000.00
Golden History Center	$ 25,000.00
Clear Creek Campground	$ 25,000.00
Golden Public Works Administration	$ 25,000.00
Golden Public Works Facility	$ 25,000.00
City Hall	$ 64,000.00
New City Hall Complex	$ 64,000.00
Total Equipment Budget	**$ 278,000.00**

5.3 Other Capital Costs

Other capital costs include system and project management costs that the City will bear in construction of the fiber backbone. Project management costs include an independent "Owner's Rep" function that will ensure that the construction and implementation of the network is carried out according to the specifications set forth in the engineering design. This "owner's rep" function includes overall program management, construction management, inspections, network activation, testing and final acceptance. Most cities capitalize these costs and include them with the budget for the initial backbone construction. Figure 6 provides an estimate of these costs.

Figure 6: Other Capital Costs

Task	Monthly Cost	Months of Construction	Total Cost
Program Management	$10,000.00	12	$120,000.00
Construction Management	$15,000.00	12	$180,000.00
Construction Inspections	$15,000.00	12	$180,000.00
Network Testing	$5,000.00	3	$15,000.00
Network Activation	$10,000.00	3	$30,000.00
Contract Close Out	$10,000.00	3	$30,000.00
Total Costs			**$555,000.00**

5.4 Operations & Maintenance Costs

Ongoing costs include annual operations and maintenance ("O&M") expenses to support the fiber backbone. First, the City will require a contractor to support the physical fiber maintenance. Most cities hire a contractor to provide standard and emergency maintenance on the network in the event of changes, new installations and emergency repair. A number of fiber operations and maintenance contractors exist on the Front Range and the City should consider issuing a competitive RFP to retain such services.

In addition to these costs, the City will also incur software maintenance costs for any equipment connected to the City's fiber backbone. These include annual software subscription and hardware support costs and are generally provided by the hardware manufacturer whose equipment the City utilizes.

Finally, the City should consider potential staffing costs that may be required to manage the fiber backbone development. This would consist of an internal project manager that will work with the owner's rep during construction of the backbone. This project manager should be familiar with fiber networks and general construction projects within the City and have a working understanding of the construction process that the City follows. The project manager would be responsible for overseeing the owner's rep, who in turn will report day-to-day engineering, construction, inspection and contract status to the City. In some cases, this function is also outsourced by cities that do not currently have this expertise internally.

As the construction project is completed, the project manager will shift to a more operational role. Many cities utilize this project manager to continue development of the backbone, from the initial deployment through subsequent years of lateral connections and new applications. If the City decides to pursue broadband deployment, the City should expect to hire additional resources and potentially a broadband manager that would be responsible for the fiber backbone and broadband services. These resources are covered in the subsequent broadband development sections.

Finally, the City should consider implementing an FMS, or Fiber Management System. An FMS is a GIS-Based application specially designed to manage fiber network resources. Most FMS systems are applications that integrate with ESRI ArcGIS as an "add on" component. These applications provide fiber strand mapping, resource utilization, asset tagging and splice matrices to help municipalities more easily manage their fiber resources. Several FMS vendors include:

- ETI Overture - https://etisoftware.com/
- OSPInsight - https://www.ospinsight.com/
- Vetro Fibermap - https://www.vetrofibermap.com/
-

Figure 7: Operations & Maintenance Costs

Item	Year 1	Year 2	Year 3
Fiber O&M Contractor	$60,000.00	$61,200.00	$62,424.00
Hardware & Software Maintenance	$60,000.00	$61,200.00	$62,424.00
Project Manager	$80,000.00	$81,600.00	$83,232.00
Fiber Management System Software	$50,000.00		
Fiber Management System Software Maintenance		$10,000.00	$10,200.00
Contingency (20%)	$50,000.00	$42,800.00	$43,656.00
Total Costs	**$300,000.00**	**$256,800.00**	**$261,936.00**

6. Community Connectivity & Broadband Opportunities

The fiber backbone is a precursor to any broadband opportunities in Golden. It positions the City to consider a range of ways to improve the local broadband environment, under any business model and in any direction, whether simply leasing dark fiber to current providers, creating a public-private partnership or providing retail Internet services directly. The backbone is the foundation for broadband in Golden.

Next-generation broadband ("broadband") services based on fiber-optic technologies are on their way to becoming a reality in a number of cities across the country. On the Front Range, the City of Longmont provides residential and business Internet services and has some of the lowest rates for high-speed Internet in Colorado, with charter memberships as low as $50 per month for 1 gigabit services. The Cities of Fort Collins and Loveland are following suit by deploying their own Internet services in their respective cities.

In these cases, all three cities had pre-existing fiber backbones that helped lower their barriers to providing Internet services. These three cities also own municipal electric utilities, which lends capabilities to building a broadband utility. However, cities that don't own electric utilities are also seeing broadband improvements in their communities by making investments in fiber. For example, the City of Centennial built its $5.7 million fiber backbone in 2017 and today leases access to Ting Internet, a private Internet service provider ("ISP") who provides Internet services to homes and businesses, up to 1 gigabit. The City of Fort Morgan utilized its fiber backbone to attract an ISP partner, Allo Communications, to bring high-speed Internet to its residents and businesses.

6.1 Common Reasons Municipalities Invest in Broadband

High-speed Internet has a net positive economic and social impact to communities by enhancing key functions such as, economic competitiveness, workforce development, training, educational capabilities, municipal operations, and digital equity. Therefore, as the City considers how to approach the broadband question, it should understand what benefits broadband could bring to Golden and appropriately measure these against the costs and risks. Many communities consider the "off balance sheet" benefits equally important to the financial aspects, although most cities believe that broadband projects should in general be able to pay for themselves over time.

Increase Broadband Utilization

The mission of cities is different than that of broadband providers. While competitive providers focus on purely a financial return on investment, cities can invest for the long-term and accept lower returns. The "off balance sheet" benefits of the improved connectivity can be far reaching. Many cities look to expand access to their residents and businesses because they understand that this supports economic development, enables an educated community and reduces digital equity issues found in many cities today.

Increase Broadband Adoption

Broadband adoption is influenced by two key factors: relevancy and affordability. Cities invest in broadband to improve both affordability and relevancy by making measured investments in infrastructure and services. Affordability, adoption and utilization of broadband services are positively correlated; as affordability increases, so does adoption; when adoption increases so does utilization; following utilization comes the anticipated socioeconomic benefits.

Improve Affordability

Many cities invest in broadband infrastructure not only to enhance local Internet services, but also to support their own operational needs and other community organizations in their area. Investment in fiber backbone infrastructure is generally utilized to provide a foundation for broadband. This allows cities to allocate some of the costs of broadband to their own purposes, which has a positive impact on the overall cost structure for deploying broadband.

Enhance Economic Development

Cities leverage their investments in broadband to support fiber-ready business corridors to attract new business and retain existing ones. More choices coupled with higher-speed and lower prices helps to reduce the cost of doing business in cities that have invested in broadband. This has a positive effect on local business retention. Also, fiber is a "must have" for medium and large businesses considering new locations. Ensuring key business parks are equipped with fiber allows site selectors to "check the box" for advanced telecommunications versus eliminating a location for further consideration.

Increase Availability and Installation Times

The time to install and activate customer broadband services is significantly determined by the availability of infrastructure in the area. Businesses are negatively impacted by fiber construction lead-times that may result in delays to activate their services. 30 to 60 days is the typical industry standard lead-time for activation of fiber-optic broadband services, without a provision for special construction. In many cases, the lead-time may double or triple depending on how much additional fiber construction is necessary to reach the end user's location. Many cities build fiber-rich communities to reduce the overall lead times for businesses to connect new service.

6.2 Broadband Business Models

Building knowledge around broadband is important for the City as it considers broadband investments. Real-world results examples are important, and this study provides an appendix with case studies from some notable cities that have deployed broadband, either directly or through partnerships.

Determining the right business model is key to the success of a City's broadband project. Selecting appropriate business models should be based on a number of factors, including the City's capabilities, local environment, investment requirements, organizational capabilities and desired benefits to the community. Exploring all available options will help cities understand which business models fit best within their current environments using a context of risk, reward and control.

Three common broadband options emerge for cities that consider expanding broadband in their communities. These include dark fiber leasing, retail services, and public-private partnerships. Each is explored in detail in the following sections.

6.3 Dark Fiber

Upon building its fiber backbone, the City could lease excess dark fiber strands to service providers. Broadband providers would likely use fiber for the following:

1. Point to point fiber connectivity for local Golden businesses
2. Connection to tower and small cell sites
3. To provide backbone connectivity they can use to build off of for residential and commercial broadband services

In a dark fiber leasing model, the City would provide individual strands of dark fiber between two points on its fiber backbone. The City would enter into a contractual arrangement with one or more service provider(s) to use this fiber for a fee. Dark fiber is generally priced on a per mile basis, per strand of fiber leased. Some common rates for dark fiber are shown in Figure 8.

Figure 8: Municipal Dark Fiber Lease Rates

Municipality/Municipal Utility	State	Monthly Lease Rate
City of Lakeland	FL	$100/strand mile
City of Bartow	FL	$125/strand mile
Eugene Water & Electric Board	OR	$21/strand mile
Palo Alto Utilities	CA	$336/strand mile
Springfield Utility Board	OR	$16/strand mile
City of Holly Springs	NC	$50/strand mile
City of Rock Falls	IL	$100/strand mile

Cities differ on their policies for dark fiber access. Some cities require customers to pay the upfront costs of the fiber construction to reach their facilities and levy a smaller monthly operational charge to manage the fiber connection. Other cities will finance the cost of the fiber construction and charge the customer a higher monthly fee that includes the amortized amount of the fiber construction, spread over a period of several years.

Many cities have realized that financing the fiber construction leads to higher uptake of their services by SMBs in the local market. Generally, an SMB cannot afford the upfront cost of the fiber construction so a city will develop a pricing policy for its fiber service that recoups the investment over the term of the contract. In some cases, the city will take a bet on a longer payback of the fiber construction costs simply to ensure that the SMB is able to afford the service. Cities realize the economic development value of getting their businesses connected to fiber is an important factor to consider along with the payback on their investment.

Dark fiber is a challenging business to model, financially. Since most cities that lease dark fiber do so in an incremental way without a specific buildout plan, forecasting revenues and costs is more difficult than in the established retail and partnership models. Most dark fiber leasing programs are built on individual business cases, one by one. In these cases, cities determine the cost of the fiber extension off of their current backbone and negotiate a leasing rate for the fiber to ensure a repayment of the capital cost over a period which may range from three to fifteen years.

6.4 Retail Services

Municipalities that provide end user services to residential and business customers are considered retail service providers. Most commonly, local governments offer Internet as the primary service, with some offering television and voice. As a retail provider, the City would be responsible for a significant number of operational functions, including management of the overall business, network operations, billing, provisioning, network construction, field services and engineering.

Municipalities that compete with broadband providers in business and residential markets must be effective in their sales and marketing efforts to gain sufficient market share to support investments needed to build and operate these networks. Retail providers must carefully develop their market strategy, product portfolio, rate structures, and service packages. They must also create the right organizational and governance structure around their broadband programs.

The competitive and low margin nature of residential broadband services means that a provider must achieve a sizable market share to operate profitably. Residential broadband is a volume business and without sufficient market share, providers are challenged at covering their costs of operating, investing in network expansion, maintaining reserves, and covering debt service. Many municipal providers have achieved significant market share, with most targeting 35% - 45% share of the total market. In some cases, such as the City of Longmont, they have exceeded these shares. Longmont maintains approximately a 50% market share today.

Municipal retail providers have deployed FTTH to compete on speed, quality, and price to win market share. Municipal retailers that provide residential services, in most cases, also serve businesses, community anchors, and wholesale customers in their markets. This enables them to make greater use of their resources to serve more customers.

Retail Services Financial Analysis

What would it take for the City to provide retail Internet services to residents and businesses? The following information summarizes the revenues, costs and financial metrics for a Citywide retail option, including enabling access to 100% of homes and businesses within the City. Figure 9 summarizes the financial results of the retail option.

Figure 9: Retail Services Capital Summary

Category	Funding Required
Engineering Design	$1,900,000
Feeder & Distribution Fiber Plant	$16,198,449
Fiber Service Drops & Optical Network Terminal	$3,814,922
In-Home Equipment	$605,056
Network Equipment	$1,742,096
Facilities & Data Center	$350,000
Vehicles & Equipment	$1,020,000
Total Investment in Capital Assets	**$25,630,522**

Deployment of retail broadband services would take approximately 3-4 years. This assumes a conservative approach with the City building to about 25% of homes and businesses each year. The City could choose to accelerate this schedule if funding permitted and build to 100% of homes and businesses in two years.

Following the more conservative 4-year schedule, the City could have the first customers connected by the end of 2020. This study assumes a conservative investment schedule over the first five years to support buildout of the network. It assumes that the City would invest about $8 million a year for the first three years, followed by $10 million in year four and $3 million in year five, for a total investment of about $37 million. This covers all initial capital costs of $25 million, plus startup/operational costs of $12.5 million. Startup/operational costs cover all ongoing direct, staffing and overhead costs as the program begins, providing funding to cover these costs before the time that revenues are sufficient to cover them.

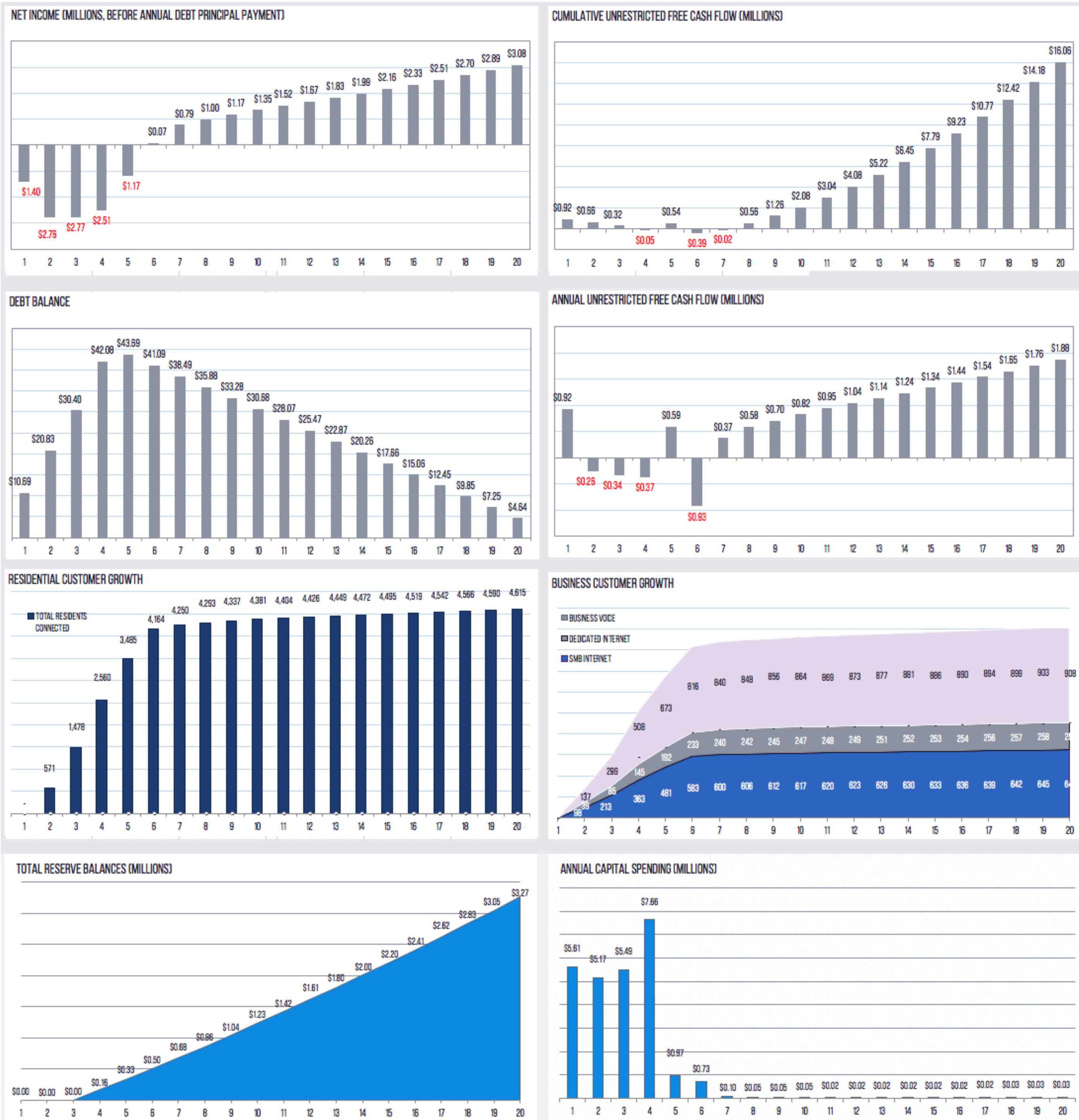
Figure 10: Annual Funding Required for Retail Services

Category	Year 1	Year 2	Year 3	Year 4	Year 5
Fiber Feeder Distribution Plant	$1,694,851	$4,143,885	$4,143,885	$6,215,827	$0
Engineering Design	$800,000	$400,000	$400,000	$300,000	$0
Fiber Service Drops	$0	$542,602	$818,254	$989,683	$834,700
Home Equipment	$0	$85,607	$130,065	$157,006	$132,680
Headend Equipment	$1,742,096	$0	$0	$0	$0
Facility & Office Improvements	$350,000	$0	$0	$0	$0
General Equipment	$1,020,000	$0	$0	$0	$0
Startup/Operational	$2,500,000	$2,500,000	$2,500,000	$2,500,000	$2,000,000
Total Funding Per Year	**$8,106,947**	**$7,672,094**	**$7,992,204**	**$10,162,516**	**$2,967,380**
Total Funding Required					**$36,901,141**

If the City were to make these investments, it would be in a position to deliver high-speed Internet services to the entire Golden community. Based on the assumptions in the following section, the City would achieve a break even in 17 years. This break even assumes that the broadband program uses system revenues to pay all of its expenses, service debt, fund its reserves and fund renewal and replacement.

The program would achieve positive net income in its sixth year and positive free cash flow in its eighth year. Between year eight and year ten, the program would generate $2 million of excess cash that the City could utilize to contribute to the general fund or use to lower future Internet rates to residents and businesses. From years 11-20, the program generates $16 million of free cash flows, demonstrating that the broadband program could entirely fund itself and provide a new revenue source to the City. Figure 11 illustrates the results of this financial analysis.

Figure 11: Financial Results of the Retail Model



A number of key assumptions drive the overall financial results and must hold true for the City to realize the financial performance stated above. The City should understand the important drivers of revenues and costs to ensure long-term financial sustainability of the broadband program. The following itemized list discusses the most important pricing and cost factors that will lead to long-term financial sustainability of the program. A breakdown of all revenue and cost assumptions is provided in the attached Excel financial package.

1. Take Rates:
   a. Residential: 45%

      45% of Golden households would need to sign up for Internet service over a five year period. A number of municipal broadband providers have achieved this rate, but the City must be successful at executing its business strategy to achieve 45%; otherwise take rates will be lower, leading to less revenues and a less financially sustainable system.

   b. Commercial: 30%

      30% of Golden businesses would need to sign up for Internet service over a five year period. A number of municipal broadband providers have achieved this rate, but the City must be successful at marketing and selling to business customers in the area. Business sales and service take specialized skillsets and dedicated salespeople to ensure Golden's local businesses trust the City to provide quality Internet services.

2. Rates for Internet Service
   a. Residential:
      i. 1 Gigabit - $89.99
      ii. 500 Megabit – $59.99
      iii. 100 Megabit - $39.99

      Based on the local market analysis, these rates are competitive with other providers' offerings today. The City should consider being price competitive with existing providers or slightly lower to incentivize customers to sign up. Retail Internet is a volume business that utilizes economies of scale. Higher uptake through lower prices offers more revenue to cover fixed costs and grow. However, the City must not set pricing too low or it may not be able to cover its costs.

   b. Commercial: 30%
      i. 1 Gigabit - $799.99
      ii. 500 Megabit - $499.99
      iii. 250 Megabit - $299.99
      iv. 100 Megabit – $109.99
      v. 50 Megabit - $49.99

      Business Internet rates tend to be higher than residential. These prices were estimated based on current business Internet offerings in Golden. Although the City will have lower overall business customers, the margin is considerably higher on business Internet than on residential Internet, creating greater contribution margin from these services.

3. Cost Assumptions

   A number of capital and operating cost assumptions must hold true to yield the financial results in the retail model. The most sensitive of these is construction costs. Magellan utilized comparable construction contractor rates in the area for underground fiber construction, considering the subsurface terrain, rock (particularly in the western portion of the City), transportation management, restoration and materials required. The following cost metrics for construction and operations drive the financial results:

   Construction Costs

   - Average cost per foot for underground backbone: $37.00 (see detailed attachments)
   - Average cost per foot for underground laterals: $33.68 (see detailed attachments)

   Operational Costs

   - Direct Costs as a Percent of Revenue – 63%
   - General and Administrative Costs as a Percent of Revenue – 16%
   - Interest Rate on Debt – 3.5%
   - Term of Debt – 20 Year

6.5 Public-Private Partnerships

Public–Private partnerships ("P3s") are generally unique to the communities and ISPs that develop them and entail specific parameters that benefit both the community and the chosen private partner. So, before getting into the specifics of network and financial models, this section offers some points around the pros and cons of entering a broadband partnership.

As the City evaluates broadband approaches, it should consider both the opportunities and the potential pitfalls by paying attention to three interwoven concepts:

- Risk
- Reward
- Control

These factors are key considerations for both the City and a private partner. A successful partnership must balance each partner's needs, and there will inevitably be some tradeoff within this framework for each model. For example, every partner would likely welcome lots of rewards, but in reaping rewards, the partner must be willing to take on a certain amount of risk. Another partner may value the control aspect of the partnership, but to do so means that partner must be willing to share in the other aspects.

Risk

It is not possible to entirely avoid risk at any level in broadband deployment. But calculated and measured 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 somewhat reduce the City's risk while helping achieve its broadband goals.

Public financing to support the partnership could be one of the City's greatest risks, though this could be a worthwhile investment to enable the City to retain some ownership and control of the assets in a partnership. Although it will entail some financial and political risk due to required financing, the long-term rewards in terms of community benefits and economic growth are likely to be advantageous. This is especially true if the City can execute a meaningful partnership with a private entity that will share in the risk.

Trade-offs may be required even if the City enters an agreement that doesn't require it to directly seek capital investment. Several private "broadband developers" are now offering leaseback models, whereby the partner provides the capital to build the network, but requires a 10-20 year guaranteed lease by the City to collateralize the partner's investment.

In these cases, the City must commit to a guaranteed lease payment schedule regardless of the financial success of the network. These leaseback options generally have a clawback whereby the network developers can force the City to raise taxes to appropriate funds to cover the annual lease payments. And, in these cases, the City is not in control; the partner maintains all rights to operating and managing the network. Therefore, the City must be sure the partner is capable, well-funded and has a strong brand to ensure performance of the broadband network. Most importantly, these are very new business models and have a very short history to measure their success or failure. Therefore, it is important for the City to maintain caution in exploring public-private partnerships, as risk can be shifted, but not eliminated.

Reward

As the City considers broadband, it should continually weigh the benefits it expects to receive as part of a partnership against its potential risk. One important component of a partnership is that there is potential for a great degree of flexibility between partners, and financial returns aren't the only reward valued by some partners. That is, the City can consider its priorities and pursue those benefits and rewards on the frontend of a partnership arrangement.

Although public–private partnership models are relatively new and evolving all the time, there are several examples that the City can look to for guidance on how it might want to proceed. It can begin by determining the rewards and benefits that it would like to see from the broadband initiative.

Although benefits cannot be reliably calculated at this stage, the City can potentially look to other cities 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. Several of these examples are provided in the appendix to this report.

Control

During the negotiation process, the City can choose its desired level of involvement in infrastructure deployment, network maintenance, and operations. That is, the City can 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.

There are ways that the City can retain control within the public–private partnership, and the most important is through retaining ownership of physical assets. This must be balanced with risk, as it is likely that the City will be required to fund part or most of the capital investment, but the more ownership the City maintains, the greater its degree of control. This enables the City to make decisions about placement of assets, rate of deployment, and the overall network footprint. Further, it ensures that if the partnership fails for any reason, the City still has a physical asset that it can use to negotiate a new partnership or begin its own direct retail operations.

Public-Private Partnership Financial Analysis

The financial analysis for a P3 is similar to retail in terms of the City's potential investments in fiber infrastructure. Where P3s differ financially is in the amount of equipment investment, the revenue yield and the cost structure. A P3 will require the City to fund a portion or all of the capital investment in fiber plant. Therefore, the City's investment will be similar to that of retail. The equipment is generally provided by the partner, since the partner is responsible for all operations and maintenance of the network in its duties to provide retail services. The City becomes a passive infrastructure owner in P3 model.

The partner assumes all operational costs in the partnership, less the partnership oversight and management functions that the City will need to manage. This significantly reduces the City's ongoing costs, staffing requirements and systems.

The partnership model also changes the revenue distribution. The City no longer collects all revenues as in the retail model. In the P3 model, the partner collects all retail revenues and the City charges a fee to the partner for use of the network. Generally, these fees are set on a monthly basis per subscriber that signs up for service. This fee must be high enough to cover the City's debt service to fund the fiber plant plus any ongoing expenses it may incur to manage the partnership. These rates must also be low enough to incentivize the partner to sign up more customers. If the fee is too high, the partner must either set retail rates higher or accept a lower profit, neither of which is favorable to the partner or the City. Therefore, rates must be set at the right amount to cover the City's costs, ensure the partner's return on investment and keep rates competitive in the market.

The P3 model assumes deployment would take approximately 3-4 years, similar to the retail model. About 25% of homes and businesses could be deployed to each year. Following this schedule, the City could have the first customers connected by the end of 2020. If the partner contributed capital for the buildout, or the City chooses to more aggressively fund the buildout it could accelerate the timeframe to two years. The P3 model assumes that the City would invest about $8 million a year for the first three years, followed by $10 million in year 4 and $3 million in year five.

Figure 12: Public-Private Partnership Capital Summary

Category	Funding Required
Engineering Design	$1,900,000
Feeder & Distribution Fiber Plant	$16,198,449
Fiber Service Drops & Optical Network Terminal	$2,071,811
Home Equipment	$0.00
Network Equipment	$0.00
Facilities & Data Center	$0.00
Vehicles & Equipment	$0.00
Total Investment in Capital Assets	**$20,170,260**

Figure 13: Annual Funding Required for Public-Private Partnership

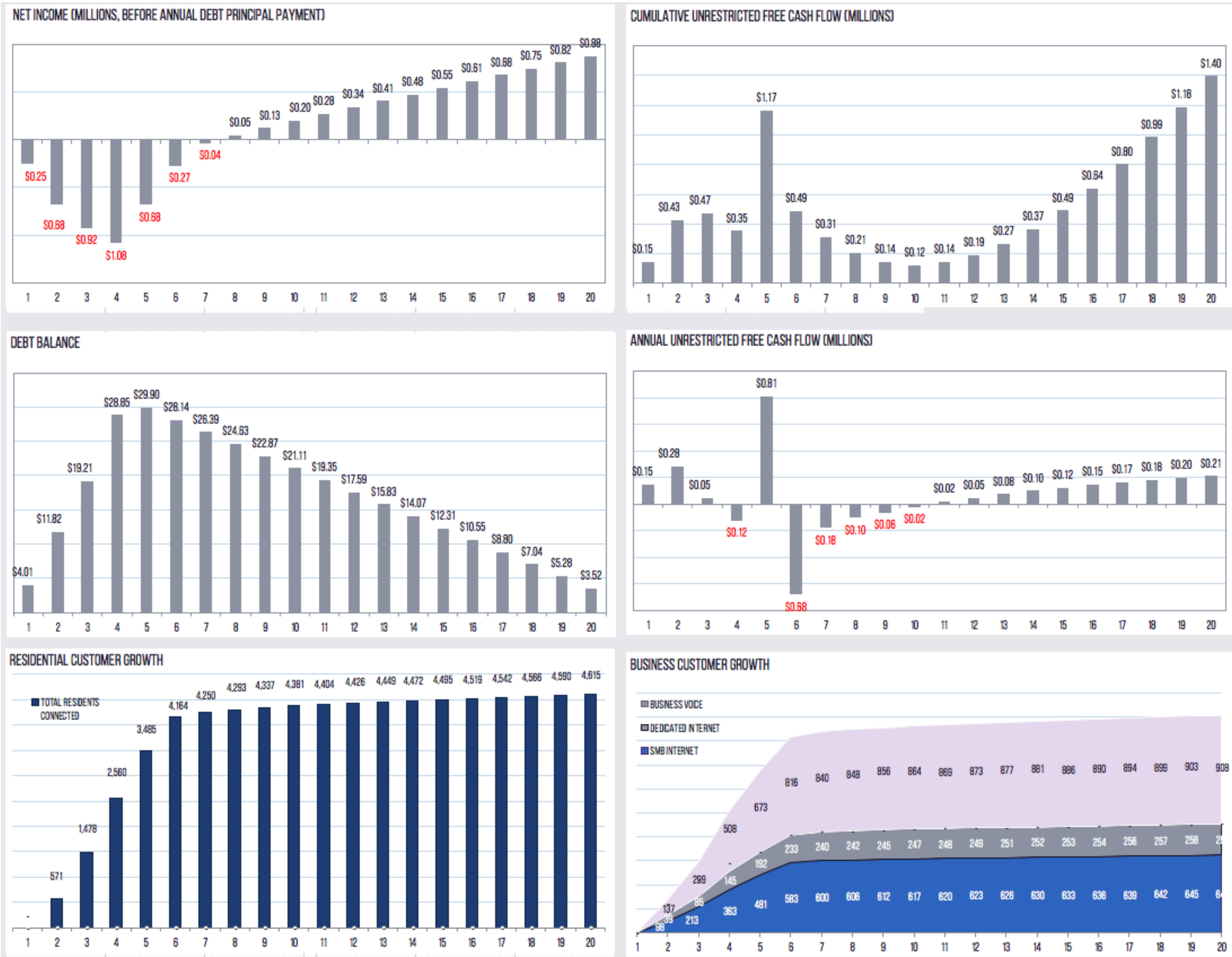
Category	Year 1	Year 2	Year 3	Year 4	Year 5
Fiber Feeder Distribution Plant	$1,694,851	$4,143,885	$4,143,885	$6,215,827	$0
Engineering Design	$800,000	$400,000	$400,000	$300,000	$0
Fiber Service Drops	$0	$294,677	$444,378	$537,478	$453,310
Home Equipment	$0	$0	$0	$0	$0
Headend Equipment	$0	$0	$0	$0	$0
Facility & Office Improvements	$0	$0	$0	$0	$0
General Equipment	$0	$0	$0	$0	$0
Startup/Operational	$1,000,000	$1,000,000	$1,000,000	$1,000,000	$1,000,000
Total Funding Per Year	**$3,494,851**	**$5,838,562**	**$5988,263**	**$8,053,305**	**$1,453,310**
Total Funding Required					**$24,828,291**

City investments in fiber infrastructure would be about $20 million over the first five years. It would also allocate $5 million for startup/operational funding to cover operating costs in the first few years of operations.

If the City were to make these investments in the partnership, service could be delivered to 100% of the community in four years. Based on the assumptions in the following section, the City would achieve a break even in 20 years. This break even assumes that the broadband program uses system revenues to pay all of its expenses, service debt, fund its reserves and fund renewal and replacement.

The program would achieve positive net income in its eighth year and positive free cash flow in its eleventh year. From years 11 through 20, the project generates $1.4 million of free cash flow, considerably less than in the retail model. Figure 14, on the following page, illustrates the results of this financial analysis.

Figure 14: Financial Results of the Public-Private Partnership



A number of key assumptions drive the overall financial results and must hold true for the City to realize the financial performance stated above. The City should understand the important drivers of revenues and costs to ensure long-term financial sustainability of the broadband program. The following list discusses the most important factors pricing and cost factors that will lead to long-term financial sustainability of the program. A breakdown of all revenue and cost assumptions is provided in the attached Excel financial package.

4. Take Rates:
    a. Residential: 45%
       45% of Golden households would need to sign up for Internet service over a five year period. A number of municipal broadband providers have achieved this rate, but the City and partner must be successful at executing the P3 business strategy to achieve 45%; otherwise take rates will be lower, leading to less revenues and a less financially sustainable system.

    b. Commercial: 30%
       30% of Golden businesses would need to sign up for Internet service over a five year period. A number of municipal broadband providers have achieved this rate, but the City and partner must be successful at marketing and selling to business customers in the area. The partner must have qualified business sales and service personnel to ensure Golden's local businesses trust the provider to provide quality Internet services.

5. Rates for Internet Service
    a. Residential:
        i. 1 Gigabit - $89.99
        ii. 500 Megabit – $59.99
        iii. 100 Megabit - $39.99
        Based on the local market analysis, these rates are competitive with other providers' offerings today. The City should consider being price competitive with existing providers or slightly lower to incentivize customers to sign up. Retail Internet is a volume business that utilizes economies of scale. Higher uptake through lower prices offers more revenue to cover fixed costs and grow. However, the City must not set pricing too low or it may not be able to cover its costs.

    b. Commercial: 30%
        i. 1 Gigabit - $799.99
        ii. 500 Megabit - $499.99
        iii. 250 Megabit - $299.99
        iv. 100 Megabit – $109.99
        v. 50 Megabit - $49.99
        Business Internet rates tend to be higher than residential. These prices were estimated based on current business Internet offerings in Golden. Although the City will have lower overall business customers, the margin is considerably higher

on business Internet than on residential Internet, creating greater contribution margin from these services.

6. Cost Assumptions
   A number of capital and operating cost assumptions must hold true to yield the financial results in the retail model. The most sensitive of these is construction costs. Magellan utilized comparable construction contractor rates in the area for underground fiber construction, considering the subsurface terrain, rock (particularly in the western portion of the City), transportation management, restoration and materials required. The following cost metrics for construction and operations drive the financial results:

   Construction Costs
   - Average cost per foot for underground backbone: $37.00 (see detailed attachments)
   - Average cost per foot for underground laterals: $33.68 (see detailed attachments)

   Operational Costs
   - Direct Costs as a Percent of Revenue – 11%
   - General and Administrative Costs as a Percent of Revenue – 14%
   - Interest Rate on Debt – 3.5%
   - Term of Debt – 20 Year

Appendix A: Municipal Fiber Case Studies

1. City of Morristown FiberNET

Community Overview

Morristown is the seat of Hamblen County, Tennessee, and has a population of 29,304 across the City's 27.9 square miles, giving it a population density of 1,044 people per square mile. There are 11,020 households in Morristown, with the median household income of $33,217, with per capita income at $17,690. About 26.2% of the population is below the poverty line. It is the principal city of the Morristown Metropolitan Statistical Area, which encompasses all of Grainger, Hamblen, and Jefferson counties. The Morristown MSA is part of the Knoxville Combined Statistical Area.

Public schools in Morristown are operated by Hamblen County Department of Education. There are four middle schools and two high schools. The main campus of Walters State Community College is located in Morristown, with King University and Tusculum College having satellite campuses.

In the post-WWII years, the community evolved from an agricultural economy to a manufacturing based economy, producing such a wide range of products as textiles and furniture to automotive parts and high tech plastics. Located on Interstate 81 at the crossroads of US highways 25E and 11E, and less than eight miles from Interstate 40, with access to major railways, Morristown has now grown into an industrial and manufacturing center for east Tennessee, with 70% of the utility's electricity serving industrial and large commercial customers.

Morristown serves as the hub of the Lakeway Area for employment, manufacturing, healthcare, and educational services. Tourism is a sizeable industry as well, anchored by Cherokee Lake, which has 463 miles of shoreline in Hamblen County that attracts 2.5 million visitors annually, and within an hour of the Great Smoky Mountains National Park, which attracts over 10 million annual visitors.

Development of the Initial Network

Among the first three or four utilities in the nation to develop their own fiber-to-the-home broadband system, the desire to deploy the network in Morristown was actually born out of the desire to provide better television service. In 2004, a new mayor and some new council members responded to the call from the public to do something about the incumbent cable TV provider, which had consistently increased rates and had terrible customer service. The City tried to negotiate with Charter without success to hold down rates, so they asked the utility to enter the business.

Besides cable TV rates, there was concern about the need to improve broadband capabilities to support existing businesses and recruit new industry. After some surveys of customer interest, Morristown filed a business plan with the state comptroller, and asked for a referendum to be sure the citizens supported borrowing the money to enter the business. The results were overwhelmingly in favor of the Morristown Utility Systems (MUS) proceeding with the plan.

At the time of Morristown's initial deployment in 2004, fiber-to-the-home was not a common practice, and leadership was not comfortable with the investment. However, once they realized that fiber was a way to secure the network investment for the future, it was an easy decision. The decision has certainly paid off, as nearly a decade later the upgrade to Gigabit capability did not have to touch the fiber network – the electronics were simply changed on either end.

From a municipal perspective, MUS connects all County libraries and several of the hospitals, for which it is also developing a new traffic control system in conjunction with the County fire and police departments and the 911 system. All the Board of Education schools are connected, except for a couple in the County that are not served by MUS, along with two local colleges. All connected organizations have either Gigabit or 100 Mbps connections.

Development of Broadband Services

Morristown Utility System (MUS) FiberNet started signing up customers in May 2006, and by late 2008 already had a take rate of 33%, with take rates in July 2015 over 44% of homes passed, and an even greater percentage of businesses. In fact, 100% of Morristown households have access to broadband Internet. Out of the four service providers that Morristown has for broadband, 80% of residents have availability to choose from at least two of those providers.[1]

The leadership of MUS believes that the most important thing they can do is provide superior customer service, so a local call center was established, with technical support, right on Main Street in downtown. With that, response times have been minimized; whether customer equipment needs replacing or a new business is opening, they can react to customer needs quickly.

For businesses, speed and reliability of Internet are critical. Regarding speed, MUS's perspective is not to sell a customer more bandwidth than they need just to drive profit. Most businesses start out with 4Mbps of guaranteed symmetrical bandwidth, while most commercial service providers start at 12Mbps, best effort. Morristown's Gigabit speeds are available should a customer need it, but MUS is not going to sell a Gigabit of service simply for the sake of profit grabbing.

For the electric side, MUS uses the network to deploy real-time advanced metering services. This allows MUS to automate demand response, which lowers wholesale power bills, provides better services, and reduces operational costs, by remote disconnect, where trucks aren't dispatched as often. Meters can be checked in a matter of seconds, so the network is redefining the way MUS provides services and conducts its business.

FiberNet's strong financial performance resulted in MUS becoming cash flow positive just two years after launch, and net income positive after five years. Both of these key milestones were reached significantly quicker than initially projected. In terms of revenue, FiberNet generated \$8.6 million during 2013 and \$8.9 million during 2014. FiberNet's solid financials have translated into a 35% increase in MUS's payments in lieu of taxes to the City, which now amount to \$350,000 per year, up from \$150,000 in 2010.

[1] http://www.musfiber.net

Impact to the Community

Morristown businesses and residents are saving $3.4 million annually thanks to MUS FiberNet's introduction of lower prices in the local broadband market. MUS thinks that if the FiberNet service wasn't available in Morristown, cable, and Internet rates would be much higher. Therefore, MUS prevents the incumbents from taking advantage of the City residents and businesses. This approach appears to be working because incumbents have not raised cable TV prices since MUS entered the business, and because of MUS pressure, the incumbents have improved their services and their systems. Moreover, it's a win for the community to the tune of $3.4 million every year, which can be spent locally rather than being siphoned out of the community to corporate shareholders.

MUS FiberNet's impact on economic development is also notable. Oddello Industries, a contract furniture manufacturer that relies on FiberNet for its communications, recently announced a $4 million expansion in Morristown, resulting in 228 new jobs. Oddello CEO, Tom Roberts, cited "reliable utilities" among the reasons for investing in Morristown to grow its Morristown presence from 35 to 415 employees in just the past year.

Another sign of FiberNet's impact on economic development is the recent decision by Molecular Pathology Laboratory Network (MPLN), a global leader in personalized laboratory medicine, to locate its primary backup facility in Morristown. As a global provider of diagnostics to hospitals, medical labs and physician groups, MPLN requires ultra-reliable data replication and disaster recovery services, which FiberNet enables.

Local leaders cannot claim that there has been a major industry to locate in the community solely because of fiber. However, today many employees work from home and it is important for them to have access to high-speed broadband to complete work tasks from a variety of locations. Access to fiber can enable 1,000 people to work from home instead of working at 1,000-employee factory, thus increasing quality of life.

The president of the Chamber of Commerce says, "When site selectors look for something, this is the nugget that sets us apart. You see about six or seven utilities in the state doing this and they knew it was a risk. A lot are unsuccessful at it so that really justifies the commitment our utilities have made here. I think a lot of people who in the community are pleased with their broadband offers and the affordability we have because of healthy competition."[2]

In looking at cost savings for Morristown's City government, MUS points to $840,000 in total savings from a smart meter program - a combination of lower annual power consumption and operational efficiencies. The fiber, as an electric asset, enabled the utility to receive $4 million in grants from the Tennessee Valley Authority for smart grid development. These developments have further provided a path to lower rates through better technology. Another $20,000 in annual savings is due to the County

[2] http://www.wbir.com/story/news/2015/05/06/municipal-internet-as-utility/26964309

not having to pay out-of-town contractors to maintain the network because the required expertise can now be found locally thanks to MUS's dedicated network specialists.

Challenges

Although there are many benefits that outweigh the challenges, MUS admits that broadband and telecommunications is a tough business for a small community, due primarily to the economies of scale. The extra challenge for Morristown leaders was to gain the political will to be successful, to battle the telecom lobby and the Tennessee legislature, and to make some good business decisions with vendors. MUS leadership says it takes determination because it is not an easy business.

2. Santa Monica CityNet

Community Overview

The City of Santa Monica is a beachfront City in Los Angeles County, California. Santa Monica is home to approximately 91,812 people across 8.3 square miles, giving it a population density of 10,662 people per square mile. The City has approximately 50,192 households with a median household income of $71,400. With a mild and agreeable climate, Santa Monica has long been a resort town and home to many people involved with the Hollywood entertainment industry. The City has experienced a boom since the 1990s with the revitalization of its downtown core, along with significant job growth and increased tourism.

The City of Santa Monica has grown its fiber business steadily over the past five years and in conjunction with technology programs that reduce costs for the government itself. Connecting community anchors provided Santa Monica valuable anchor tenants that helped build the business case for its fiber expansions. The City accommodated future investment in its network by setting a policy that reinvested any excess revenues and savings that the network generated back into expanding the network. The City successfully markets its fiber services in Santa Monica and provides a list of "lit buildings" where fiber connections are available.

Development of the Initial Network

In 2002, when the City renewed its franchise with the local cable provider, it also included as a provision to the agreement a lease of fiber-optic network capacity to connect 43 City sites and a variety of school and community college sites. The City paid upfront construction costs of $530,000 and shared the ongoing costs of the network with the schools and community college. These organizations saved a combined $400,000 in annual telecommunications costs which grew to $500,000 over several years.

The savings were used as seed capital for the development of the City's own fiber-optic network. The City invested in fiber connectivity and 10 Gigabit networking equipment to power the network. The City expanded its own fiber to connect traffic signals, surveillance cameras, smart signs, and other municipal applications to the network. As the network grew, the City built fiber into local data centers for its own Internet connectivity needs, but this quickly became a resource that created demand for business connectivity using Santa Monica's fiber.

Development of Broadband Services

The City began leasing its fiber network to local businesses in 2006. Larger businesses became the first users of Santa Monica's fiber to establish connectivity between their locations within the City. In most cases, these businesses paid the upfront costs for fiber extensions from the City's current network to reach their facilities. The City connected about 15 customers to its network initially between 2006 and 2008. The City started a marketing campaign to determine the demand for City fiber from the small and medium business community. The campaign focused on businesses in close proximity to the City's current network, surveying about 3,000 businesses within 200 feet of the current network. The results indicated that there was demand for the City's fiber; however, businesses were looking for a complete solution for their Internet services, rather than just dark or lit fiber.

The City realized the demand for these services warranted the investment in building an Internet infrastructure capable of providing commercial Internet services to businesses. The City leased a wholesale Internet circuit connected to the One Wilshire colocation facility in downtown Los Angeles and purchased equipment necessary to provide Internet services. It chose to enable both direct Internet services and open access services as part of its offering, which allowed other providers to utilize its network to deliver Internet access to businesses in the City. The City now offers a combination of dark fiber, transport, and Internet access services to organizations in Santa Monica.

Today, 126 businesses are currently connected to CityNet and approximately five additional ones are added on a monthly basis. CityNet has also been successful with its MDU strategy. Facing high vacancy rates, the City encouraged property owners to install fiber cabling into their buildings as a way to entice tenants to occupy commercial properties. CityNet heavily discounted the cost of installing, operating, and maintaining fiber infrastructure into buildings if the owners passed that savings directly to potential tenants and aggressively marketed the gigabit broadband service. The City reported increases in tax revenues and commercial property values for parcels that were equipped with fiber. The network covers approximately eight square miles of Santa Monica and soon will be delivering up to 100Gbps per second of symmetrical broadband access. Prices for services are negotiated for each business customer individually.

Impact to the Community

Santa Monica's CityNet fiber network was able to achieve the following goals for the community:

- Lower costs of Internet access for the City and schools
- Centralize or integrate municipal services through core data systems
- Establish free WiFi in 35 public hot zones as well as distribute 375 computers in kiosks and libraries in town for free access
- Nurture existing businesses, attract new businesses, support startups, VCs, and incubators
- Create an environment for other incumbents to invest in City infrastructure. The City has no plans to provide residential service to its 90,000 people

Challenges

Santa Monica faced challenges in providing only dark fiber services to local businesses. As demand for high-speed Internet services grew over the past five years, small and medium businesses desired an affordable Internet solution that was enabled by a single provider. This differed from Santa Monica's model of providing simply dark fiber or bandwidth services to local businesses. While larger organizations had IT staff capable of managing dark fiber and bandwidth, small and medium businesses looked for a solution that was handled directly by the provider, as many of them lacked the sufficient resources to manage dark fiber alone. The struggle Santa Monica faced was maintaining lean operations and a "hands off" approach while still serving a range of business customers. Retail was a new business model that Santa Monica had not encountered yet. This required Santa Monica to "change its thinking" and to have true impact in the small and medium business market, it made the decision to offer direct Internet services as part of its portfolio of services.

3. Palm Coast FiberNET

Community Overview

Palm Coast is a City of 75,000 residents in northeast Florida about an hour south of Jacksonville. The City provides a wide range of services including development services, fire services, street construction and maintenance, parks and recreational activities. Palm Coast contracts with the Flagler County Sheriff's Office for law enforcement services. The municipality's number one goal is to "Provide quality services, maintaining the City's financial soundness." From this goal emerged several initiatives designed to provide a greater level of service and an expansion of capabilities while reducing the government's costs. Information Technology has been a key driver for innovation and increased efficiencies across various departments.

Development of the Initial Network

In 2006, the Palm Coast City Council approved a five-year fiber-optic deployment project funded at $500,000 annually for a total investment of $3.2 million. The network was developed to support growing municipal technology needs across all public organizations in the area, including City, County, public safety, and education. It was also planned to support key initiatives such as emergency operations, traffic signalization, collaboration, and video monitoring.

Palm Coast utilized a phased approach to build its network using cost-reducing opportunities to invest in new fiber-optic infrastructure. As each phase was constructed, the City connected its own facilities and coordinated with other public organizations to connect them, incrementally reducing costs for all organizations connected to the network. Showing a reasonable payback from each stage of investment allowed the City to continue to fund future expansion of the network. About $500,000 in annual funding was appropriated from the general fund each year to build various components of the backbone network. The City achieved offsetting cost reductions by disconnecting its current connections with telecom providers in the area.

Through deployment of this network over the five-year period, the City realized a savings of nearly $1 million since 2007 and projects further annual operating savings of $350,000 annually. In addition to these savings, the network provides valuable new capabilities that enhance its mission of serving the residents and businesses of the community.

Development of Broadband Services

Palm Coast experienced staggering population growth between 2000 and 2010, which nearly doubled its size; however, the housing downturn in the late 1990s hit the City particularly hard. Palm Coast's economy suffered from this retraction and the City began a program in 2006 to stimulate economic development. Palm Coast determined that its network could provide enhanced benefits to economic development and launched a program to take its network commercial. The City evaluated the opportunities to use its network to expand broadband services, particularly focused on retaining local businesses. The City developed a business plan to expand its network in cooperation with local service providers and executed this plan to deploy the network in 2007.

The City employed an open-access business model whereby the City provided the physical fiber-optic network and electronics to connect broadband providers with individual businesses in key serving areas of the community. Broadband providers were charged monthly access fees based on the speed (bandwidth) of the service required by the business. The City builds new connections from its current fiber network to individual businesses, deploys premise equipment to businesses, and interconnects broadband providers to them. Broadband providers are responsible to market, sell and manage all retail services on the network and pay the City access fees to utilize the system, on a per customer basis.

As FiberNET was deployed, the City realized that its network could become a significant resource for other public organizations in Flagler County. In 2009, the City bid and won a competitive E-Rate contract with the Flagler County School Board to provide Gigabit and 10 Gigabit fiber services to 16 County schools. The City incurred a $250,000 upfront cost to extend the network to these schools and generates about $300,000 in annual revenue from this contract. In addition, the City has connected Flagler County offices and various other public organizations that make use of the competitively priced fiber services. In 2010, the local hospital contracted with the City to provide Gigabit connectivity to its main campus in Palm Coast and upgraded fiber connectivity to eight of its affiliated doctor's offices throughout the community. This provided significant upgrades for each local doctor's office and reduced each office's costs from approximately $750 to $300 per month.

The City manages FiberNET through its internal Information Technology Department. FiberNET is managed by shared staff resources within IT, providing technical expertise, engineering, customer management, provider management and related services for FiberNET; approximately two full time employees manage FiberNET today. The City outsources operations and management of the physical fiber-optic network to a local fiber contractor who provides design, construction, repair and maintenance.

Impact to the Community

In a market where local fiber was scarce and unaffordable for all but the largest businesses, Palm Coast FiberNET now provides cost-effective fiber access for as little as $50 per month for a 10Mbps connection. Service providers utilize the network to deliver Internet and business communications services for significantly lower costs than were previously available. FiberNET has reduced the costs of business Internet services across the City by 30%. The City has enabled new competition and introduced a competitively priced fiber product into the wholesale market within Palm Coast. Doing so has enabled competition among local providers using the network and the local incumbents.

Most recently, the Allier Fiber Backbone, a long-haul fiber network that interconnects Miami to Atlanta has been integrated into Palm Coast FiberNET, and providers connected to Allied Fiber have now entered the Palm Coast market. This further diversifies the competitive landscape in Palm Coast and enables local businesses more choices for their broadband needs. FiberNET has four providers operating on its network to date, two of which are new to the Palm Coast market. Key benefits include:

- Multi-use network connecting City, county, school, healthcare, and support organizations
- Reduced overall government spend by nearly $1 million per year
- Lowered business Internet costs by 30% across the City
- Reduced education spending by $300,000 annually
- Upgraded education services to 1 and 10 Gbps speeds
- Secured future bandwidth needs for the community, 100 Gigabit and beyond
- Financially sustainable, cash flow positive within 6 years
- Expanded competition, choice and availability of broadband services for local businesses
- Increased reliability, performance and availability of fiber broadband across the City
- Introduced two new service providers to the Palm Coast market
- Reinvested system revenues into expand the network to cover more of the City's geography
- Future-proofed local business needs with speeds up to 10 Gigabit
- Secured future bandwidth needs for the community, 100 Gigabit and beyond

Challenges

Palm Coast has struggled with developing the business case for new fiber connections in circumstances where local businesses are not in close proximity to the network. FiberNET attempts to set rates for fiber services consistently across the City so that broadband providers pay the same wholesale rates across the entire service area of the network. This ensures that Palm Coast businesses pay consistent costs for their broadband services, regardless of location.

The municipality has experienced some issues with its broadband providers in building new fiber connections that may not present a strong business case. In these cases, the costs for fiber connections exceed the City's payback threshold; however, the broadband provider has customers ready to subscribe for service. Fox example, a new 2,500 foot fiber connection to a business costs the City $20,000 in construction costs with a revenue opportunity of only $1,200 per year, which results in a payback of 16.6 years.

Palm Coast must make the decision whether to build out to this customer in line with City's overall goals of supporting local economic development. In some cases, where the payback has been beyond the City's threshold, it has opted to not build the connections; however, in most cases the City has proceeded with these connections. In some cases, the City has declined to build where these connections are infeasible and the revenues generated do not achieve a reasonable payback on the investment. In most cases, the City has been successful at building out these connections; however, this has been a recurring issue facing FiberNET and several other municipally owned networks. General connection costs range from $2,500 to $10,000 per business and the City is looking at ways of reducing these costs through alternative construction methods.

Appendix B: Glossary

	The third generation of mobile broadband technology, used by smart phones, tablets, and other mobile devices to access the web.
4G – Fourth Generation	The fourth generation of mobile broadband technology, used by smart phones, tablets, and other mobile devices to access the web.
ADSL – Asymmetric Digital Subscriber Line	DSL service with a larger portion of the capacity devoted to downstream communications, less to upstream. Typically thought of as a residential service.
ADSS – All-Dieletric Self-Supporting	A type of optical fiber cable that contains no conductive metal elements.
AMR/AMI – Automatic Meter Reading/Advanced Metering Infrastructure	Electrical meters that measure more than simple consumption and an associated communication network to report the measurements.
ATM – Asynchronous Transfer Mode	A data service offering that can be used for interconnection of customer's LAN. ATM provides service from 1 Mbps to 145 Mbps utilizing Cell Relay Packets.
Bandwidth	The amount of data transmitted in a given amount of time; usually measured in bits per second, kilobits per second (kbps), and Megabits per second (Mbps).
Bit	A single unit of data, either a one or a zero. In the world of broadband, bits are used to refer to the amount of transmitted data. A kilobit (Kb) is approximately 1,000 bits. A Megabit (Mb) is approximately 1,000,000 bits. There are 8 bits in a byte (which is the unit used to measure storage space), therefore a 1 Mbps connection takes about 8 seconds to transfer 1 megabyte of data (about the size of a typical digital camera photo).
BPL – Broadband over Powerline	A technology that provides broadband service over existing electrical power lines.
BPON – Broadband Passive Optical Network	BPON is a point-to-multipoint fiber-lean architecture network system which uses passive splitters to deliver signals to multiple users. Instead of running a separate strand of fiber from the CO to every customer, BPON uses a single strand of fiber to serve up to 32 subscribers.
Broadband	A descriptive term for evolving digital technologies that provide consumers with integrated access to voice, high-speed data service, video-demand services, and interactive delivery services (e.g. DSL, Cable Internet).
CAD – Computer Aided Design	The use of computer systems to assist in the creation, modification, analysis, or optimization of a design.
CAI – Community Anchor Institutions	The National Telecommunications and Information Administration defined CAIs in its SBDD program as "Schools, libraries, medical and healthcare providers, public safety entities, community colleges and other institutions of higher education, and other community support organizations and entities". Universities, colleges, community colleges, K-12 schools, libraries, health care facilities, social service providers, public safety entities, government and municipal offices are all community anchor institutions.
CAP – Competitive Access Provider	(or "Bypass Carrier") A Company that provides network links between the customer and the Inter-Exchange Carrier or even directly to the Internet Service Provider. CAPs operate private networks independent of Local Exchange Carriers.
Cellular	A mobile communications system that uses a combination of radio transmission and conventional telephone switching to permit telephone communications to and from mobile users within a specified area.
CLEC – Competitive Local Exchange Carrier	Wireline service provider that is authorized under state and Federal rules to compete with ILECs to provide local telephone service. CLECs provide telephone services in one of three ways or a combination thereof: 1) by building or rebuilding telecommunications facilities of their own, 2) by leasing capacity from another local telephone company (typically an ILEC) and reselling it, and 3) by leasing discrete parts of the ILEC network referred to as UNEs.
CO – Central Office	A circuit switch where the phone lines in a geographical area come together, usually housed in a small building.
Coaxial Cable	A type of cable that can carry large amounts of bandwidth over long distances. Cable TV and cable modem service both utilize this technology.
CPE – Customer Premise Equipment	Any terminal and associated equipment located at a subscriber's premises and connected with a carrier's telecommunication channel at the demarcation point ("demarc").

CWDM – Coarse Wavelength Division Multiplexing	A technology similar to DWDM only utilizing less wavelengths in a more customer-facing application whereby less bandwidth is required per fiber.
Demarcation Point ("demarc")	The point at which the public switched telephone network ends and connects with the customer's on-premises wiring.
Dial-Up	A technology that provides customers with access to the Internet over an existing telephone line.
DLEC – Data Local Exchange Carrier	DLECs deliver high-speed access to the Internet, not voice. Examples of DLECs include Covad, Northpoint and Rhythms.
Downstream	Data flowing from the Internet to a computer (Surfing the net, getting E-mail, downloading a file).
DSL – Digital Subscriber Line	The use of a copper telephone line to deliver "always on" broadband Internet service.
DSLAM – Digital Subscriber Line Access Multiplier	A piece of technology installed at a telephone company's Central Office (CO) and connects the carrier to the subscriber loop (and ultimately the customer's PC).
DWDM – Dense Wavelength Division Multiplexing	An optical technology used to increase bandwidth over existing fiber-optic networks. DWDM works by combining and transmitting multiple signals simultaneously at different wavelengths on the same fiber. In effect, one fiber is transformed into multiple virtual fibers.
E-Rate	A Federal program that provides subsidy for voice and data circuits as well as internal network connections to qualified schools and libraries. The subsidy is based on a percentage designated by the FCC.
EON – Ethernet Optical Network	The use of Ethernet LAN packets running over a fiber network.
EvDO – Evolution Data Only	EvDO is a wireless technology that provides data connections that are 10 times as fast as a traditional modem. This has been overtaken by 4G LTE.
FCC – Federal Communications Commission	A Federal regulatory agency that is responsible for regulating interstate and international communications by radio, television, wire, satellite and cable in all 50 states, the District of Rock Falls, and U.S. territories.
FDH – Fiber Distribution Hub	A connection and distribution point for optical fiber cables.
FTTN – Fiber to the Neighborhood	A hybrid network architecture involving optical fiber from the carrier network, terminating in a neighborhood cabinet with converts the signal from optical to electrical.
FTTP – Fiber to the premise (or FTTB – Fiber to the building)	A fiber-optic system that connects directly from the carrier network to the user premises.
GIS – Geographic Information Systems	A system designed to capture, store, manipulate, analyze, manage, and present all types of geographical data.
GPON- Gigabit-Capable Passive Optical Network	Similar to BPON, GPON allows for greater bandwidth through the use of a faster approach (up to 2.5 Gbps in current products) than BPON.
GPS – Global Positioning System	a space-based satellite navigation system that provides location and time information in all weather conditions, anywhere on or near the Earth where there is an unobstructed line of sight to four or more GPS satellites.
GSM – Global System for Mobile Communications	This is the current radio/telephone standard developed in Europe and implemented globally except in Japan and South Korea.
HD – High Definition (Video)	Video of substantially higher resolution than standard definition.
HFC – Hybrid Fiber Coaxial	An outside plant distribution cabling concept employing both fiber-optic and coaxial cable.
ICT – Information and Communications Technology	Often used as an extended synonym for information technology (IT), but it is more specific term that stresses the role of unified communications and the integration of telecommunications, computers as well as necessary enterprise software, middleware, storage, and audio-visual systems, which enable users to access, store, transmit, and manipulate information.
IEEE – Institute of Electrical Engineers	A professional association headquartered in New York City that is dedicated to advancing technological innovation and excellence.
ILEC – Incumbent Local Exchange Carrier	The traditional wireline telephone service providers within defined geographic areas. Prior to 1996, ILECs operated as monopolies having exclusive right and responsibility for providing local and local toll telephone service within LATAs.

IP-VPN – Internet Protocol-Virtual Private Network	A software-defined network offering the appearance, functionality, and usefulness of a dedicated private network.
ISDN – Integrated Services Digital Network	An alternative method to simultaneously carry voice, data, and other traffic, using the switched telephone network.
ISP – Internet Service Provider	A company providing Internet access to consumers and businesses, acting as a bridge between customer (end-user) and infrastructure owners for dial-up, cable modem and DSL services.
ITS – Intelligent Traffic System	Advanced applications which, without embodying intelligence as such, aim to provide innovative services relating to different modes of transport and traffic management and enable various users to be better informed and make safer, more coordinated, and 'smarter' use of transport networks.
Kbps – Kilobits per second	1,000 bits per second. A measure of how fast data can be transmitted.
LAN – Local Area Network	A geographically localized network consisting of both hardware and software. The network can link workstations within a building or multiple computers with a single wireless Internet connection.
LATA – Local Access and Transport Areas	A geographic area within a divested Regional Bell Operating Company is permitted to offer exchange telecommunications and exchange access service. Calls between LATAs are often thought of as long distance service. Calls within a LATA (IntraLATA) typically include local and local toll services.
Local Loop	A generic term for the connection between the customer's premises (home, office, etc.) and the provider's serving central office. Historically, this has been a copper wire connection; but in many areas it has transitioned to fiber optic. Also, wireless options are increasingly available for local loop capacity.
MAN – Metropolitan Area Network	A high-speed intra-City network that links multiple locations with a campus, City or LATA. A MAN typically extends as far as 30 miles.
Mbps – Megabits per second	1,000,000 bits per second. A measure of how fast data can be transmitted.
MPLS – Multiprotocol Label Switching	A mechanism in high-performance telecommunications networks that directs data from one network node to the next based on short path labels rather than long network addresses, avoiding complex lookups in a routing table.
ONT – Optical Network Terminal	Used to terminate the fiber-optic line, demultiplex the signal into its component parts (voice telephone, television, and Internet), and provide power to customer telephones.
Overbuilding	The practice of building excess capacity. In this context, it involves investment in additional infrastructure projects to provide competition.
OVS – Open Video Systems	OVS is a new option for those looking to offer cable television service outside the current framework of traditional regulation. It would allow more flexibility in providing service by reducing the build out requirements of new carriers.
PON – Passive Optical Network	A Passive Optical Network consists of an optical line terminator located at the Central Office and a set of associated optical network terminals located at the customer's premise. Between them lies the optical distribution network comprised of fibers and passive splitters or couplers. In a PON network, a single piece of fiber can be run from the serving exchange out to a subdivision or office park, and then individual fiber strands to each building or serving equipment can be split from the main fiber using passive splitters / couplers. This allows for an expensive piece of fiber cable from the exchange to the customer to be shared amongst many customers, thereby dramatically lowering the overall costs of deployment for fiber to the business (FTTB) or fiber to the home (FTTH) applications.
PPP – Public-Private Partnership	A Public–Private Partnership (PPP) is a government service or private business venture that is funded and operated through a collaborative partnership between a government and one or more private sector organizations. In addition to being referred to as a PPP, they are sometimes called a P3, or P^3.
QOS – Quality of Service	QoS (Quality of Service) refers to a broad collection of networking technologies and techniques. The goal of QoS is to provide guarantees on the ability of a network to deliver predictable results, which are reflected in Service Level Agreements or SLAs. Elements of network performance within the scope of QoS often include availability (uptime), bandwidth (throughput), latency (delay), and error rate. QoS involves prioritization of network traffic.
RF – Radio Frequency	a rate of oscillation in the range of about 3 kHz to 300 GHz, which corresponds to the frequency of radio waves, and the alternating currents which carry radio signals.

Right-of-Way	A legal right of passage over land owned by another. Carriers and service providers must obtain right-of-way to dig trenches or plant poles for cable systems, and to place wireless antennae.
RMS – Resource Management System	A system used to track telecommunications assets.
RPR – Resilient Packet Ring	Also known as IEEE 802.17, is a protocol standard designed for the optimized transport of data traffic over optical fiber ring networks.
RUS – Rural Utility Service	A division of the United States Department of Agriculture, it promotes universal service in unserved and underserved areas of the country with grants, loans, and financing. Formerly known as "REA" or the Rural Electrification Administration.
SCADA – Supervisory Control and Data Acquisition	A type of industrial control system (ICS). Industrial control systems are computer controlled systems that monitor and control industrial processes that exist in the physical world.
SNMP – Simple Network Management Protocol	An Internet-standard protocol for managing devices on IP networks.
SONET – Synchronous Optical Network	A family of fiber-optic transmission rates.
Steaming	Streamed data is any information/data that is delivered from a server to a host where the data represents information that must be delivered in real time. This could be video, audio, graphics, slide shows, web tours, combinations of these, or any other real time application.
Subscribership	Subscribership is how many customers have subscribed for a particular telecommunications service.
Switched Network	A domestic telecommunications network usually accessed by telephone, key telephone systems, private branch exchange trunks, and data arrangements.
T-1 – Trunk Level 1	A digital transmission link with a total signaling speed of 1.544 Mbps. It is a standard for digital transmission in North America.
T-3 – Trunk Level 3	28 T1 lines or 44.736 Mbps.
UNE – Unbundled Network Element	Leased portions of a carrier's (typically an ILEC's) network used by another carrier to provide service to customers. Over time, the obligation to provide UNEs has been greatly narrowed, such that the most common UNE now is the UNE-Loop.
Universal Service	The idea of providing every home in the United States with basic telephone service.
Upstream	Data flowing from your computer to the Internet (sending E-mail, uploading a file).
UPS – Uninterruptable Power Supply	An electrical apparatus that provides emergency power to a load when the input power source, typically main power, fails.
USAC – Universal Service Administrative Company	An independent American nonprofit corporation designated as the administrator of the Federal Universal Service Fund (USF) by the Federal Communications Commission.
VDSL – Very High Data Rate Digital Subscriber Line	A developing digital subscriber line (DSL) technology providing data transmission faster than ADSL over a single flat untwisted or twisted pair of copper wires (up to 52 Mbit/s downstream and 16 Mbit/s upstream), and on coaxial cable (up to 85 Mbit/s down and upstream); using the frequency band from 25 kHz to 12 MHz.
Video on Demand	A service that allows users to remotely choose a movie from a digital library whenever they like and be able to pause, fast-forward, and rewind their selection.
VLAN – Virtual Local Area Network	In computer networking, a single layer-2 network may be partitioned to create multiple distinct broadcast domains, which are mutually isolated so that packets can only pass between them via one or more routers; such a domain is referred to as a Virtual Local Area Network, Virtual LAN or VLAN.
VoIP – Voice over Internet Protocol	An application that employs a data network (using a broadband connection) to transmit voice conversations using Internet Protocol.
VPN – Virtual Private Network	A virtual private network (VPN) extends a private network across a public network, such as the Internet. It enables a computer to send and receive data across shared or public networks as if it were directly connected to the private network, while benefitting from the functionality, security and management policies of the private network. This is done by establishing a virtual point-to-point connection through the use of dedicated connections, encryption, or a combination of the two.
WAN – Wide Area Network	A network that covers a broad area (i.e., any telecommunications network that links across metropolitan, regional, or national boundaries) using private or public network transports.
WiFi	WiFi is a popular technology that allows an electronic device to exchange data or connect to the Internet wirelessly using radio waves. The Wi-Fi Alliance defines Wi-Fi as any

	"wireless local area network (WLAN) products that are based on the Institute of Electrical and Electronics Engineers' (IEEE) 802.11 standards".
WiMax	WiMax is a wireless technology that provides high-throughput broadband connections over long distances. WiMax can be used for a number of applications, including "last mile" broadband connections, hotspot and cellular backhaul, and high speed enterprise connectivity for businesses.
Wireless	Telephone service transmitted via cellular, PCS, satellite, or other technologies that do not require the telephone to be connected to a land-based line.
Wireless Internet	1) Internet applications and access using mobile devices such as cell phones and palm devices. 2) Broadband Internet service provided via wireless connection, such as satellite or tower transmitters.
Wireline	Service based on infrastructure on or near the ground, such as copper telephone wires or coaxial cable underground or on telephone poles.