City of Columbia

701 East Broadway, Columbia, Missouri 65201

Agenda Item Number: REP 76-14
Department Source: Water & Light
To: City Council
From: City Manager & Staff
Council Meeting Date: August 18, 2014
Re: Broadband Planning Study

Documents Included With This Agenda Item

Council memo
Supporting documentation includes: Broadband Needs Assessment & Planning Study

Executive Summary

In August of 2013 the City of Columbia contracted for consulting services with Magellan Advisors to produce a Broadband Needs Assessment and Planning Study. In May of 2014 Magellan presented their preliminary findings at a Pre-Council work session. In June of 2014 Magellan submitted their final report for acceptance. Based on the recommendations from this report, a Lit Network Open-Access model appears to be the most appropriate use of the City's fiber network. Their recommended next step would be the development of a detailed Broadband Business Plan using the City's fiber optic network to develop a Lit Network Open-Access community telecommunication infrastructure.

Discussion

Over the past two years Water & Light has been engaged in a process to develop strategies for community telecommunication infrastructure. In recognition that a high speed community broadband deployment is critical to future economic and civic growth, Water & Light has partnered with Regional Economic Development Inc. (REDI) and contracted with a consultant to develop strategies for this deployment. In support of this the City has contracted with Magellan to define this community plan.

In the development of this study, Magellan met with City departments, City Council members, Boone County Staff, healthcare organizations, educational institutions and local businesses. These meetings were to gain understanding of the current telecommunications landscape, thoroughly review current service levels and pricing and assess the challenges faced by operating in Columbia.

Magellan has presented their final report from this planning effort. Based on the recommendations from this report, a Lit Network Open-Access model appears to be the most appropriate use of the City's fiber network. Their recommended next step would be the development of a detailed Broadband Business Plan using the City's fiber optic network to develop a Lit Network Open-Access community telecommunication infrastructure.

Staff's recommendation to Council is acceptance of this Broadband Planning Study and support for the development of a Broadband Business Plan based on this study.

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701 East Broadway, Columbia, Missouri 65201

Fiscal Impact

Short-Term Impact: Development of a Broadband Business Plan
Long-Term Impact: Based on results from Broadband Business Plan

Vision, Strategic & Comprehensive Plan Impact

Vision Impact: Community Facilities and Services, Economic Development
Strategic Plan Impact: Infrastructure
Comprehensive Plan Impact: Infrastructure

Suggested Council Action

Staff's recommendation to Council is acceptance of this Broadband Planning Study and support for the development of a Broadband Business Plan based on this study.

Legislative History

Pre-Council work session May 2014

Department Approved

City Manager Approved

City of Columbia
701 East Broadway, Columbia, Missouri 65201

SUPPORTING DOCUMENTS INCLUDED WITH THIS AGENDA ITEM ARE AS FOLLOWS:

Broadband Needs Assessment & Planning Study



Broadband Needs Assessment & Planning Study

City of Columbia, University of Missouri & Boone County

June 9, 2014

Magellan ADVISORS

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1. Executive Summary

As more of our lives transition to the digital world, access to the Internet and its multitude of applications becomes increasingly more important. Where Internet access was once just a complement to our physical lives, the virtual world of the Internet has become a crucial part of what we do every day. Online applications for business, health, education, security, and entertainment have all become integrated into our daily lives. These applications and new ones continue to grow at an amazing pace.

A high-speed, reliable broadband infrastructure is required for these applications and future ones to function properly. Broadband is indeed the highway of the electronic world. The City of Columbia has recognized that next-generation broadband infrastructure is required to attract and retain the tech-savvy residents and businesses that will drive civic and economic growth. The City of Columbia's understanding of the importance of next-generation broadband has developed and advanced with its recent participation along with the University of Missouri in the Google Fiber solicitation and the "GigU" project.

The City of Columbia, and The University of Missouri ("MU") have commissioned this Broadband Planning Study to understand the options they have in improving current and future broadband services within the community. With a particular focus on Columbia Water & Light's ("CW&L's") fiber-optic network, this Study examines potential opportunities for the City of Columbia to expand use of this network to foster next-generation broadband services for the residents, businesses and community anchor institutions ("CAI")[1] in Columbia.

The Study conducted a comprehensive broadband needs assessment across all stakeholders to determine how the community utilized broadband currently and planned to in the future. In response to these needs, the Study assessed how stakeholders' broadband needs were currently being met by broadband providers and identified the key issues that impacted their ability to use the Internet. It also focused on how future needs would or would not be met as broadband speeds continued to increase from new applications used by stakeholders.

The Study found that although Columbia has a significant amount of broadband providers in the area, segments of Columbia's business community and community anchors are not receiving the services they need for their organizations due to either a lack of availability or prohibitively high costs. Businesses are facing issues receiving the broadband services they need to become more efficient, productive, and competitive, limiting their overall sustainability and growth in Columbia. Economic development has

[1] CAIs are generally education, healthcare, government and public safety organizations along with non-profit organizations supporting the community. See full definition in Appendix A: Glossary.

difficulty retaining business and attracting new business to the area due to a lack of affordable, available broadband. Community anchors including schools, MU, hospitals and support organizations have significant plans for growth which require high-speed, reliable broadband; they are questioning how they will be able to implement these programs without this type of broadband.

Based on this analysis, the Study evaluates how CW&L's fiber-optic network could be utilized to provide a solution to these broadband issues. CW&L's network already provides significant benefits to the community, connecting the City of Columbia, Columbia schools, MU, hospitals, and businesses to high-speed broadband. After evaluation of the network's capabilities, the Study found that the City has a significant opportunity to expand the network to serve stakeholders throughout the community. Focused first on local businesses and community anchors in the Downtown Core, the network has the capabilities to provide next-generation broadband services at lower rates than customers are currently paying today. The cost of this type of expansion to serve business and community anchors in the Downtown Core is estimated between $2.5 million and $3.5 million with a payback period of 8 – 9 years, conservatively. The City of Columbia can likely reduce these upfront capital costs through careful value engineering and a strategic approach to deployment.

The benefits would be significant to Columbia, including:

- Reducing the costs of doing business in Columbia by positively influencing the prices business pay for broadband services.
- Bringing affordable next-generation broadband services to Columbia that rival the fastest, most advanced broadband networks.
- Promote and market Columbia as a Gigabit Community able to deliver cost-effective 1 Gigabit and 10 Gigabit services to businesses, schools, hospitals, and other anchors throughout Columbia enhancing the City of Columbia's economic development strategy.
- Leverage an existing City public asset for a new purpose and drive additional value for the community by building a broadband utility.
- Support long-term capabilities for the City of Columbia and its utilities by providing a foundation for integration of further functionalities and other utility development.

Based on the findings of this Study, Magellan Advisors recommends that the City of Columbia begin development of a Columbia Broadband Business Plan that will lay out the key strategies to implement, manage, and finance the network. In addition, Magellan recommends the City take steps to begin implementation of cost-effective public policy tools that will accelerate the deployment of next-generation broadband throughout the community.

2. Introduction

As more of our everyday lives are lived online, broadband has become increasingly important for our homes, businesses, and communities. Broadband reaches many facets of everyday life by improving the delivery of healthcare services, enriching the educational experiences of children and adults, aiding in the management and conservation of energy resources, assisting public safety personnel in the performance of their duties, and facilitating citizen interaction with government agencies. An "Internet of things" has begun to take shape using the broadband network to carry data via IP communications from sensors and actuators embedded in physical objects, sparking opportunities for innovative technologies and applications.[2] For businesses, broadband has become a driving force behind competitiveness, innovation, and efficiency. Affordable, available access to broadband means the difference between thriving in the new economy[3] and becoming obsolete.

Throughout history, infrastructure networks have connected people, places, ideas, and products. The development of major infrastructure networks has facilitated American innovation, progress, and prosperity. Before the 1800s, port cities were the world's economic and educational hubs. In the 19th century, the transcontinental railroad system allowed people, goods, and ideas to branch out into new territories, creating new opportunities and encouraging entrepreneurship and prosperity. The 20th century witnessed the development of large-scale electric grids and the interstate highway system; innovations that once again allowed Americans to be more productive, mobile, and opportunistic. Similarly, communications infrastructure, telephony, radio, and television also transformed the American economy and culture; now, broadband has become critical infrastructure that connects people, communities, and commerce.

Broadband is a transformational infrastructure that transcends the physical limitations of more traditional infrastructures such as the road system or electric grids. Rather than connecting one community to another, it connects a community to the entire electronic world and global marketplace. This is a key reason why broadband is so important to the future of communities. Communities that have access to high-speed broadband will continue to take advantage of all of the opportunities the global marketplace affords them, in business, education, healthcare, entertainment, and general well-being. Communities without access will fall further and further behind, lacking access to those opportunities and becoming less and less connected to the digital world.

A Glossary of broadband related terms is provided as Appendix A.

[2] Business, policy and technical issues regarding the "Internet of things" continue to evolve.

[3] "New Economy" is a coined term describing new, high-growth industries that are on the cutting edge of technology and are the driving force of economic growth. The new economy is commonly believed to have started in the late 1990s, as high tech tools, such as the Internet, and increasingly powerful computers, began penetrating the consumer and business marketplace.

3. Project Background

The City of Columbia, in Partnership with the University of Missouri, issued a Request for Proposal seeking a qualified consultant to develop a Broadband Planning Study for the region. The Planning Study was focused on how Columbia Water & Light could promote the development of an affordable, high-speed fiber, broadband infrastructure. A Broadband Committee composed of representatives from Regional Economic Development, Inc. (REDI), The City of Columbia, The University of Missouri, and local businesses was assembled to conduct the evaluation and selection of the consultant.

Magellan Advisors was selected by the Columbia Broadband Committee through this competitive procurement to develop the Broadband Planning Study. Magellan Advisors works with hundreds of municipalities nationwide addressing broadband and technology issues in communities that realize the importance of high-speed broadband services to their futures. Magellan specializes in developing broadband strategies that local governments can use to foster the development of affordable, high-speed broadband services, in conjunction with local service providers, community anchors, businesses, and residents.



www.magellan-advsors.com

Magellan and REDI began the project in October of 2013 and through an 8-month planning process developed Columbia's Broadband Planning Study. The project conducted a number of stakeholder interviews and discussions with the help of REDI. The stakeholder interviews provided the information needed for a broadband needs assessment for the Columbia community to specifically detail the broadband and technology needs of business, education, healthcare, local government, public safety, and community support. It also aligned with City's economic and community development initiatives to ensure that the Planning Study accounted for long-range planning opportunities. In sum, Magellan used a variety of resources to create this report including:

1. Coordination with City and University project leaders to facilitate site visits, two-way interview meetings with community stakeholders, and development of further information. Site visits and interviews with stakeholders were conducted on October 21st and 22nd, December 9th and 10th, and March 10th and 11th.
2. Census data, market demographics, and mapping data provided by various telecommunications providers and Columbia Water and Light.
3. Broadband data drawn from surveying businesses in the community, FCC Form 477, and MoBroadband.
4. Magellan's own knowledge and experience from designing and implementing broadband networks for local and regional entities across the United States, including many projects involving municipal utility authorities.

Using stakeholder meetings and other tools and data, Magellan conducted a comprehensive market analysis that evaluated the current broadband environment in Columbia and documented the services, pricing, providers, and availability within Columbia. From this assessment an analysis was conducted comparing the current availability and pricing for services against the needs of the community stakeholders. This analysis evaluated the gaps in relation to availability and affordability of broadband services in Columbia.

Based on the gaps that were identified, community strategies were developed that would aid in bridging these gaps. These community strategies focused on initiatives that the City of Columbia could undertake to positively influence the affordability, availability, and expansion of broadband services within Columbia.

The Planning Study's objective is to provide the information and recommendations to the City that will allow them to make informed decisions on what broadband strategies to pursue for their community, and importantly, what roles the public organizations should play and what commitments should they make. Magellan's recommendations range from low-cost strategies such as implementing broadband-friendly public policy and adoption programs to active investment strategies to build broadband infrastructure in partnership with private service providers. It is for the City of Columbia to decide what strategies are most appropriate based on the long-term objectives of the communities they serve.

The following three strategy elements were developed:

- Public-policy strategies detailed specific measures that the City could undertake in conjunction with local service providers to reduce the cost of broadband infrastructure in Columbia and to provide new options to expand it.

- Information and adoption strategies provided for educational and data sharing programs that the City could develop to raise awareness of the available broadband services in Columbia.

- Public-investment strategies detailed potential public funding mechanisms that would allow for the expansion of new broadband infrastructure in the region in cooperation with local service providers using public/private partnerships.

The community strategies are discussed in detail and include actionable initiatives that have been identified for the City of Columbia to consider. These initiatives are intended to promote the development of high-speed broadband in Columbia over a 10-year period. The premise of these strategies is that public organizations and private service providers each have tools at their disposal to mutually expand broadband services in the region. Cooperation between public organizations and these private providers has

been proven to reduce the cost of local broadband and hasten its expansion in communities across the country.

4. Current Broadband Environment

Realizing the importance of broadband to the development of our nation, the Federal government has taken a significant role in creating public policy and funding programs to accelerate the development of broadband and enhance existing infrastructure. Then-Chairman of the Federal Communications Commission, Julius Genachowski, stated:

"Broadband is the indispensable infrastructure of the digital age – the 21st Century equivalent of what canals, railroads, highways, the telephone, and electricity were for previous generations."[4]

In early 2009, Congress directed the Federal Communications Commission (FCC) to develop a National Broadband Plan to ensure that every American has "access to broadband capability." Congress also required this plan to include a detailed strategy for achieving affordability and maximize the use of broadband to advance "consumer welfare, civic participation, public safety and homeland security, community development, health care delivery, energy independence and efficiency, education, employee training, private sector investment, entrepreneurial activity, job creation and economic growth, and other national purposes."[5] The following goals set out in the National Broadband Plan apply specifically to expansion of these critical services in communities across the country.

Goal Number 1: At least 100 million U.S. homes should have affordable access to actual download speeds of at least 100 Megabits per second and actual upload speeds of at least 50 Megabits per second, by 2020.

Goal Number 2: The United States should lead the world in mobile innovation, with the fastest and most extensive wireless networks of any nation.

Goal Number 3: Every American should have affordable access to robust broadband service, and the means and skills to subscribe if they so choose.

Goal Number 4: Every American community should have affordable access to at least 1 Gigabit per second broadband service to anchor institutions such as schools, hospitals and government buildings, by 2020.

[4] "Oversight of the Federal Communications Commission: The National Broadband Plan" Hearing before the Subcommittee on Communications, Technology, and the Internet. United States Senate. March 25, 2010
[5] "National Broadband Plan" http://www.broadband.gov/plan/executive-summary/. Accessed September 10, 2013.

Subsequent trends and developments have borne out the appropriateness of the FCC's direction. For example, Cisco is known in the industry as providing objective academic-quality analyses on topics related to the Internet through its "white papers". The 2013 Cisco White Paper "The Zettabyte Era – Trends and Analysis" provides very useful high level projections regarding internet traffic as follows:

- Busy hour traffic will grow faster than average traffic, due to video traffic which tends to have a "prime time". The Internet now has a much busier busy hour peak. The composition of video traffic is changing toward greater use of real time video – live video, ambient video and video calling.
- Nearly one half of IP traffic will come from TVs, handsets, and other non-PC devices by 2017.
- Internet traffic from Wireless, Wi-Fi, and mobile devices will surpass wired devices by 2017.
- Fixed Broadband speeds will nearly quadruple (to 39 Mbps) by 2017 resulting in increased consumption and use of high-bandwidth content and applications such as high definition TV and consumer cloud storage.
- Metro Traffic will grow faster than long-haul traffic, due in part to development of content delivery networks for video and other traffic.
- IP Video will accelerate IP traffic growth through 2017. With video growth, Internet traffic is evolving to a more dynamic (rather than steady) traffic pattern. Traffic is not becoming more symmetric as had been expected.
- Cisco states its approach to forecasting IP traffic is conservative, indicating that the projections above can be exceeded.

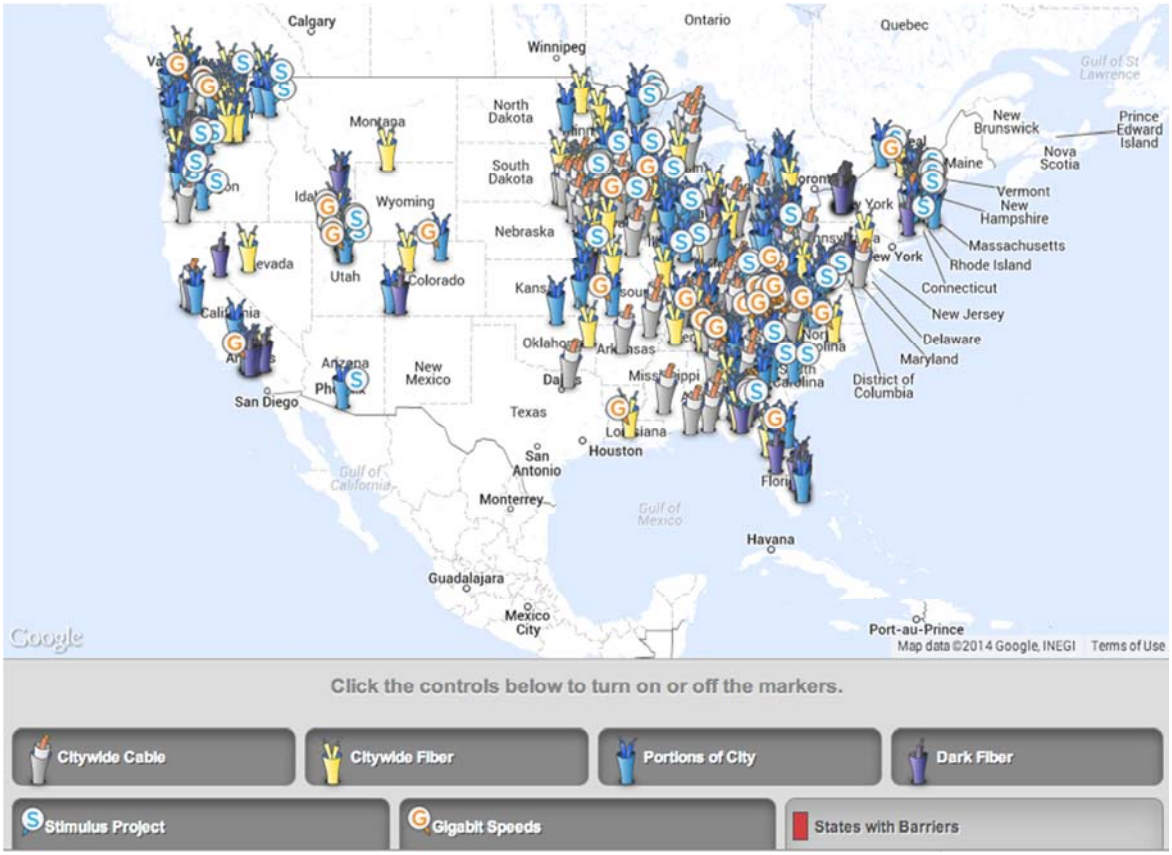
Columbia's Broadband Needs Assessment and Planning Study is crucial to meeting these trends to support the community's social and economic development.

Local Broadband Initiatives and Broadband Technology Overview

Broadband is truly a local issue for communities. The infrastructure deployed in communities defines how their residents, businesses, and anchors interact in the digital world. Many communities have taken a fundemental interest in their local broadband infrastructure in effort ensure their communities are on par with the rest of the country.

The City of Columbia desires to leverage existing City-owned fiber-optic facilities, and plan for next-generation broadband infrastructure needed to meet the technological requirements of current and future businesses, educational institutions and other Community Anchor Institutions (CAI), and the City's citizens. The City of Columbia appropriately views broadband infrastructure as a key to economic and community development. Broadband infrastructure consists of the cabling and electronics that connects homes and businesses into the telecommunications network through local cable company networks, telecommunications company networks, or other provider

networks. Broadband infrastructure from a wider perspective also includes the people and support assets necessary to operate the broadband network.



The City of Columbia's understanding of the importance of broadband infrastructure has developed and advanced with its recent participation along with the University of Missouri in the Google Fiber solicitation, and the "GigU" project. The City of Columbia has recognized that next-generation broadband infrastructure is required to attract and retain the tech-savvy residents and businesses that will drive civic and economic growth.

Broadband is deployed throughout communities as wired and wireless infrastructure that carries digital signal between end users and the content they want to access. The content comes in many forms and from many locations across the world in the networks that connect the local community to the Internet backbone. Websites, television, streaming video, videoconferencing, cloud services, and even telephone service are just a few types of content that are delivered across local broadband networks. Access to this content is made available through the type of infrastructure and kinds of connections available in the local network. Robust local infrastructure results in faster, more reliable access to content. Conversely, local infrastructure that is aging and built on older technologies results in slower, less reliable, access to content.

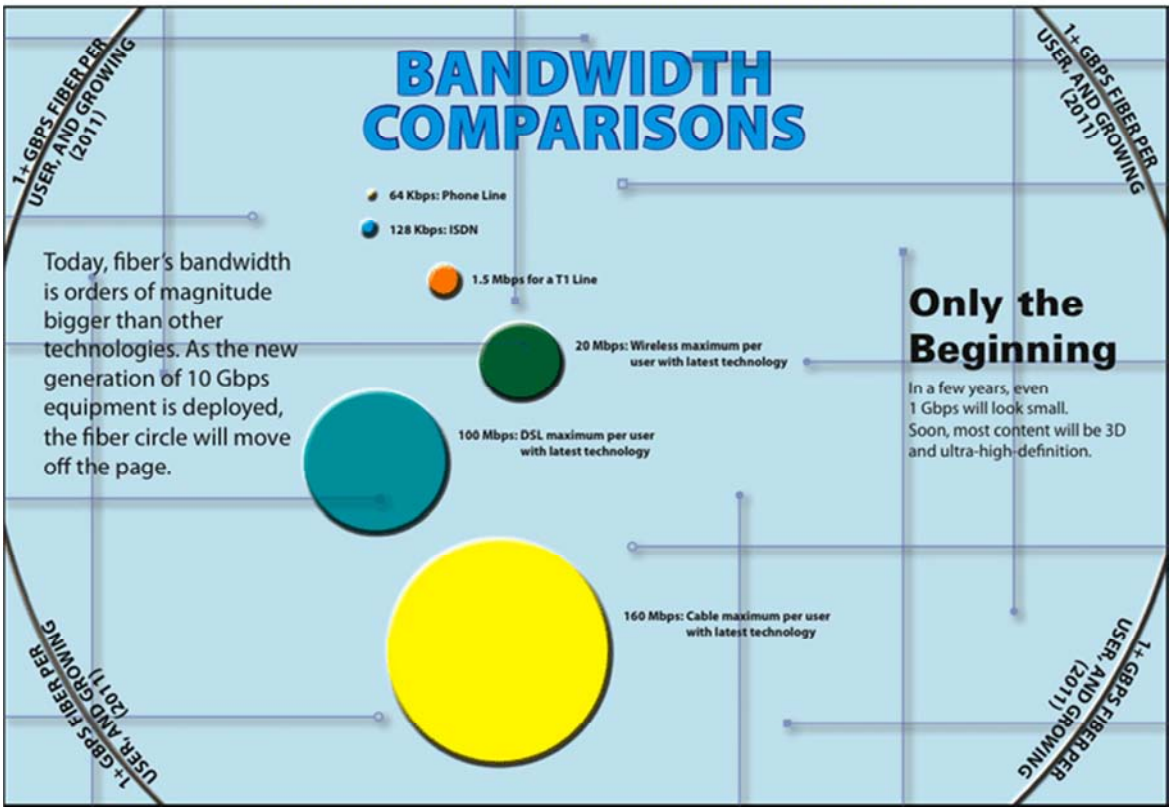
The majority of America's broadband infrastructure still utilizes copper-based media to transmit information from a user to the Internet (the "last mile" or "local loop"); this media includes twisted-pair copper telephone and coaxial cable television lines. Most of this infrastructure was installed years ago but in many areas of the country, it is still being installed in new communities today. As time has progressed, broadband providers have continued to upgrade equipment in their networks to make these lines faster and more reliable, however; several fundamental issues exist with underlying copper infrastructure:

1. Broadband signals degrade significantly as distances increase in copper-based networks.
2. Broadband signals are susceptible to electrical interference and signal degradation in copper-based networks, particularly as they depreciate.
3. Copper-based networks delivering broadband services generally utilize shared bandwidth among pools of users which results in an uneven distribution of speed to these users.

The limitations of local copper-based networks are overcome by deployment of fiber-optic infrastructure in local communities. The old standard of copper in local broadband networks is transitioning to fiber-optic slowly. Costs for deployment of fiber-optic infrastructure are high, particularly in areas where no fiber-optic infrastructure exists. Providers understand that fiber-optic broadband provides the only long-term solution to the ever-growing bandwidth needs of homes, businesses, and community anchors. Fiber-optic broadband connectivity is considerably different than its copper-based predecessor.

- Fiber-optic technology converts broadband data signals to light and sends the light through transparent glass fibers about the diameter of a human hair. Fiber transmits data at speeds far exceeding current DSL or cable modem speeds, typically by tens or even hundreds of Mbps.
- Actual speeds are always dependent on the services provisioned by the service provider who operates the system however, speeds generally range from 10Mbps to 100Gbps.
- Telecommunications providers sometimes offer fiber broadband in limited areas and have announced plans to expand their fiber networks and offer bundled voice, Internet access, and video services.
- Variations of the technology run the fiber all the way to the customer's home or business, to the curb outside, or to a location somewhere between the provider's facilities and the customer.

VISUALIZING FIBER-BORNE BANDWIDTH



White Spaces

Spectrum is assigned to TV broadcasters under FCC rules and policies. TV broadcasts previously used analog wave transmission over this FCC-assigned spectrum until the Federal Communications Commission (FCC) mandated use of digital transmission – Digital TV – by full power TV stations by June 13, 2009. Under either TV broadcast technology, "white spaces" exist between TV channels and also via unused channels in each geographic area, or where the TV spectrum is not being used by licensed services. Technology developments allow the use of these "white spaces" without interfering with TV broadcasts or other licensed uses of the spectrum. In particular, the nature of digital communication (transmission of digital on/off pulses) frees up spectrum creating additional white spaces by reducing the need for large spectrum buffers that were necessary to protect analog waveforms from other transmissions as well as realizing spectral efficiencies. The FCC has undergone a lengthy and contentious process to establish rules that permit use of white spaces on an unlicensed basis.

White spaces are considered to be "prime real estate" since they have,

> *"…excellent propagation characteristics that allow signals to reach farther and penetrate walls and other structures. Access to this spectrum could enable more powerful public Internet connections or super Wi-Fi hot spots, with extended range, fewer dead spots, and improved individual speeds as a*

result of reduced congestion on existing networks. The potential uses of this spectrum are limited only by the imagination."[6]

Earlier releases of unlicensed spectrum yielded such wireless marvels as remote controls, keyless entry, Wi-Fi, and Bluetooth to name a few. Broadband using white spaces is expected to be particularly valuable in providing high speed broadband access in rural areas by extending the service range of wireless Internet service providers (WISPs). While white spaces for broadband has shown great promise, it has also suffered from the "chicken or egg" problem; demand is not clear so manufacturers are not devoting resources to lower equipment costs and without lower costs, demand will not be sufficient to drive this innovation.

In July 2013, West Virginia University began network implementation in partnership with AIR.U to provide free public Wi-Fi access for students and faculty on its tram system transporting 15,000 riders daily as well as elsewhere on campus.[7] More recently, one of the AIR.U co-founders, Declaration Networks Group, announced a "Quick Start Network Program" available to AIR.U member institutions.[8] This would be a primary means for the City of Columbia in concert with one of Columbia's higher education institutions to further explore viability of white spaces for broadband access in rural and underserved/low income areas in the City.

Columbia's Broadband Network Inventory

It is important to assess the degree to which high-speed broadband infrastructure has been deployed in Columbia to understand where this Planning Study can have the most impact for the community and minimize duplication of potential broadband overbuild. This study has identified the existence of the necessary facilities, networks, and backhaul capacity to enable expansion of high-speed broadband in Columbia. Providers have the necessary capabilities, infrastructure, and service platforms to deploy and manage services within the region and have done so in certain areas.

Fiber-optic broadband services are available in some of the City's corridors and through multiple providers. Outside of the City proper this infrastructure is sparse and generally follows the highways that interconnect Columbia to neighboring communities. In many cases this fiber-optic infrastructure may not be available to provide services directly because of its use as backhaul to interconnect communities in the Columbia area and to connect the region to long-haul networks that connect to Internet points of presence in the Midwest.

[6] Second Memorandum Opinion and Order, Federal Communications Commission, ET Docket Nos. 02-380 and 04-186, Released September 23, 2010, at page 2.
[7] http://wvutoday.wvu.edu/n/2013/07/09/nation-s-first-campus-super-wi-fi-network-launches-at-west-virginia-university
[8] http://www.airu.net/press-release-quickstart/

Magellan has studied and evaluated the current state of the broadband network in Columbia. Where information is available, we have documented and inventoried network assets to define a baseline from which to evaluate the networks' capabilities, network gaps, and potentials for future applications and expansions. We include documentation where possible of physical fiber routes, conduit, poles and pole lines, rights of way, splice points, and other information related to physical plant. The analysis primarily focuses on fiber-optic facilities rather than wireless since wireless spectrum is a shared capacity (including that used for 4GLTE) such that if some users are consuming the full capacity, additional users have no access to capacity.[9]

The broadband network in Columbia is composed of networks built by private companies such as the telephone and cable TV providers as well as the network built by the City's municipal electric and water utility, Columbia Water and Light (CW&L).

Private Broadband Inventory

A variety of companies provide broadband infrastructure in the retail markets in the greater Columbia area.

- AT&T provides wireless services in Columbia, as well as leasing Type II circuits in Columbia, as part of larger customer networks. AT&T Wireless recently launched 4G LTE service in Columbia and is installing Distributed Antenna Systems to serve campus buildings using fiber-optic facilities obtained from CenturyLink for backhaul. AT&T does not use CW&L fiber since it has to get back to the CenturyLink central office and no capacity exists.

- Blue Bird Networks is headquartered in Columbia and operates extensive networks in Missouri and Illinois. Blue Bird built broadband network facilities in northern Missouri and areas nearby Columbia using funds provided by ARRA. Blue Bird notes that all the Columbia Water & Light fiber strands from the CenturyLink wire center are leased. Blue Bird generally uses underground construction.

  A map depicting Blue Bird's broadband infrastructure was provided in support of this study.

- CenturyLink is the incumbent local exchange provider holding certification from the Missouri Public Service Commission. The Columbia exchange was formerly owned and operated by General Telephone and Electronics Corp. (GT&E), which was later acquired by Verizon. As the incumbent LEC, CenturyLink provides both retail services to consumers and wholesale services to other telecommunications providers. According to stakeholder interviews, there are "lots" of changes in

[9] Wireless can be a good solution for point-to-point applications where capacity can be guaranteed and fiber optic solutions are less feasible.

copper gauge along the routes in circuits which makes it difficult to manage DSL QOS.

CenturyLink has begun deployment of its "Prism" service in Columbia which provides for bundling of Internet access, telephone service, and various entertainment services including TV.

- Charter Communications is a cable telecommunications provider serving Columbia. Charter has major fiber connectivity in the City while coaxial services are available on the outer rings of the City. Charter leases fiber strands from CW&L.

- Full Stream Wireless is a wholesale provider of secure, high-speed, 4G Wireless Broadband and Microwave Internet services in Columbia and Central Missouri.

- Level 3 maintains a fiber long haul network which passes through Columbia interconnecting Kansas City and St. Louis.

- Mediacom is the incumbent cable telecommunications provider serving Columbia. Mediacom is receiving many requests for fiber-based services and indicates it is able to "close" many of the requests. The requests are typically about availability, not performance. In some instances Mediacom uses Sho-Me Technologies. Des Moines is the POP for Mediacom.

- Sho-Me Technologies provides fiber-optic networking throughout central and southern Missouri using both leased and owned fiber-optic facilities including fiber strands leased from Columbia Water & Light and dark fiber from Fiber Path[10]. Sho-Me built network facilities in southern Missouri using funds provided by ARRA. Sho-Me uses leased facilities to connect Columbia to St. Louis. Sho-Me does not provide end-user services to residences, instead focusing on providing wholesale services and services to businesses such as Ethernet wide area networks, point-to-point connections, dedicated Internet access, disaster recovery services, and other business-to-business and capacity services. Sho-Me is E-rate registered and supplies facilities to MOREnet.

  A map depicting Sho-Me Technologies broadband infrastructure was provided in support of this study.

- Socket Telecom is a local telecommunications company that was established in 1994. Socket began with dial-up modems and then shifted to the CLEC

[10] Fiber Path is a subsidiary of Central Electric Power Cooperative that only provides dark fiber from point of presence to point of presence. Fiber Path provides no managed services. It operates an interconnect point at 904 Elleta Boulevard in Columbia where several companies interconnect.

(competitive local exchange carrier) model and has now passed many homes in Columbia with a mix of leased and owned facilities including fiber strands leased from Columbia Water & Light and other facilities leased from CenturyLink.

Public Broadband Inventory

The Home Rule Charter of the City of Columbia includes rate, finance and other provisions associated with operation of Columbia Water and Light to provide utility services to Columbia residents. As is common with municipal electric utilities and electric utilities generally, CW&L has deployed fiber-optic facilities for operational reasons. CW&L had originally used copper twisted pair for station to station communications however, this became unreliable. Fiber-optic facilities were installed to replace copper facilities and provide the necessary reliability. Since the fiber facilities originally are placed for CW&L operational reasons, the fiber routing runs through CW&L substations.

As the fiber-optic facilities were deployed it became apparent other parties would pay for installation in return for deployed strands. CW&L now operates a SONET ring among its substations using the fiber facilities and leases remaining strands to others as available while prioritizing for city/county government and school use. CW&L intends to add connectivity for various additional locations associated with water services.

Since the major costs of fiber-optic deployment are the placement costs (i.e., opening streets followed by trenching, conduit, ground restoration, etc.) CW&L has followed the common practice of installing a number of fiber strands (24 -72) on each route. The fiber is currently single mode. CW&L is also installing 3 inch conduit on a forward looking basis any time the electric department digs to open ground for facilities.

CW&L allows others to use individual strands where available on a prioritized basis. The fiber is first reserved/placed for CW&L use, then for city use, schools, and other government. CW&L is an approved provider under the federal "E-rate" program and supports Internet services to 34 schools using two fiber loops. There are approximately 60 city sites on the CW&L fiber network on an extended star topology. CW&L notes a need to modify the network architecture to a ring-based topology.

Other entities are allowed to use the CW&L fiber pursuant to Master Fiber Agreements with an initial five year term and annual renewals. Most agreements are in annual renewal now. The agreements are all for lease of "dark" fiber[11], and no services or individualized capacity is provided. CW&L has agreements with 12 entities and is not signing any more agreements due to bottlenecks (for example, downtown to the west, and downtown to the south) and lack of fiber in certain locations. It is increasingly difficult for these 12 entities to obtain additional fiber due to capacity constraints. These

[11] Dark Fiber or unlit fiber is an unused optical fiber available for use in fiber-optic communication.

constraints as experienced by others are affected by CW&L's mission and capital budget. CW&L has a separate budget for fiber/telecommunications. The fiber/telecommunications section of CW&L has a capital budget of $100,000 for fiber construction.

While CW&L has agreements with 12 entities, it should be noted that the benefit of the fiber facilities extends beyond just those 12 entities. For example, CW&L fiber leased by the University of Missouri is used to support connectivity to the Missouri Research and Education Network (MOREnet) for institutions located in Columbia, such as Stephens College and Daniel Boone Public Library.

Pricing for lease of fiber strands was established some time ago at $250 per month for a point to point fiber strand (regardless of distance), and $3847 per month for a fiber loop (also regardless of distance). The 12 entities currently utilizing CW&L fiber pursuant to agreement are:

Entity Name	Number of Circuits	Annual Revenue
Sho-Me Technologies	41	$ 252,492.00
City of Columbia	40	$ 123,000.00
University of Missouri	17	$ 94,164.00
Socket Telecom	14	$ 85,164.00
Missouri Network Alliance	12	$ 67,164.00
Columbia Public Schools	6	$ 104,328.00
Boone Hospital	2	$ 46,164.00
Boone County	2	$ 46,164.00
Columbia College	2	$ 6,000.00
Charter Communications	1	$ 3,000.00
ISG	1	$ 46,164.00
Missouri Public Utility Alliance	1	$ 3,000.00
		$ 876,804.00

Missouri Policy Environment

Magellan Advisors has reviewed the regulatory and policy environment in Missouri and in the City of Columbia pertaining to municipal broadband.[12] Information was gained from stakeholder interviews, management staff at the City of Columbia and Columbia Water and Light, contacts with the Missouri Public Service Commission ("PSC") staff, the Missouri Public Utility Alliance (MPUA), and the Missouri Municipal League, as well as through Magellan's own research and knowledge base. Broadband facilities and service are generally not regulated at the federal (Federal Communications Commission) or state (Missouri Public Service Commission) levels.

[12] This discussion and analysis does not constitute a legal opinion and should not be construed as such.

We conclude there are no direct regulatory impediments in Missouri to the provision of an open access wholesale municipal broadband platform. Furthermore, no laws or policies have been identified which would impede or impair additional development of fiber-optic facilities by the City of Columbia to expand availability of high speed broadband services via an open access wholesale municipal platform.

The most topical statute is Chapter 392, Section 410 of the Missouri Revised Statutes.[13] It arose due to controversy over interest in retail provision of voice (and other) telecommunications services by municipalities. Voice telecommunications services were regulated by the Missouri PSC at the time (although regulation has since changed). Section 392.410.7 Mo. Revised Statutes provides:

> *No political subdivision of this state shall provide or offer for sale, either to the public or to a telecommunications provider, a telecommunications service or telecommunications facility used to provide a telecommunications service for which a certificate of service authority is required pursuant to this section. Nothing in this subsection shall be construed to restrict a political subdivision from allowing the nondiscriminatory use of its rights-of-way including its poles, conduits, ducts and similar support structures by telecommunications providers or from providing to telecommunications providers, within the geographic area in which it lawfully operates as a municipal utility, telecommunications services or telecommunications facilities on a nondiscriminatory, competitively neutral basis, and at a price which covers cost, including imputed costs that the political subdivision would incur if it were a for-profit business. Nothing in this subsection shall restrict a political subdivision from providing telecommunications services or facilities:*
>
> 1) *For its own use;*
> 2) *For 911, E-911 or other emergency services;*
> 3) *For medical or educational purposes;*
> 4) *To students by an educational institution; or*
> 5) *Internet-type services*

The impact of this statute is to prohibit a "political subdivision" from providing voice telecommunications of the type that require "certificate of service authority" from the PSC, however; the provision of "Internet-type services" and telecommunications for medical, educational, public safety, and internal uses is clearly enabled.

Furthermore, and equally as important, the statute provides:

[13] Chapter 392 sets out statutes which govern the PSC's regulation of telecommunications in Missouri.

> *Nothing in this subsection shall be construed to restrict a political subdivision from [...] providing to telecommunications providers, within the geographic area in which it lawfully operates as a municipal utility, telecommunications services or telecommunications facilities on a nondiscriminatory, competitively neutral basis, and at a price which covers cost, including imputed costs that the political subdivision would incur if it were a for-profit business.*

This appears to clearly enable the City of Columbia to provide a lit fiber open access platform to telecommunications service providers.

Also important is the statutory framework regarding imposition of fees for use of rights of way. The City is allowed to continue "imposing any linear foot fees on any public utility right-of-way user" as a "grandfathered political subdivision" under Section 67.1846 Mo. Revised Statutes. The City is grandfathered in because in 2000 it authorized an entity to use of rights of way for placement of fiber-optic cable, through a right of use agreement.[14] The agreement contained a price of $1.91 per linear foot per year for use of the rights of way regardless of whether and how the fiber-optic cable was used. Other utilities pay for use of rights of way through franchise fees paid on retail gross revenues. This agreement allows access to rights of way for fiber-optic construction for an entity that does not generate a base of retail gross revenues, such that the fee stands in the place of the franchise fee. Some perceive the current linear foot fee arrangement to favor incumbents since that fee can be offset by franchise fees.

Regarding access to Interstate 70 rights of way, this is a separate matter and is limited because the state of Missouri has an exclusive agreement with a telecommunications provider such that it is not possible for others to access those rights of way.

[14] Ordinance No. 016634, passed October 2, 2000, authorizing the City Manager to execute a right of use agreement with PF. Net Network Services Corporation to install fiber optic cable within city right-of-way.

5. Broadband Needs Assessment

Defining High-speed Broadband in Context

It is important to scope the definition of broadband in this Study. A key goal of the Broadband Planning Study is to ensure businesses in Columbia are equipped with the necessary broadband infrastructure to meet their current and future needs. A concurrent goal is to ensure that the proposed broadband infrastructure will support Columbia's economic development programs and make them more effective in attracting new business to the area and retaining existing businesses.

In parallel, these services are also utilized among Columbia's Community Anchor Institutions, or CAIs, which include education, healthcare, public safety, local government, and community support. Schools require ever-increasing speeds to meet their online testing requirements, provide access to online resources, and develop blended learning[15] programs. In the healthcare sector, the needs of hospitals, clinics, and imaging centers continue to grow as electronic health records, information exchanges, and telehealth initiatives are developed. For public safety, broadband provides connectivity to interconnect local agencies with one another and state and federal law enforcement networks. Finally, for local government, broadband provides connectivity that improves efficiency, reduces cost, and delivers new capabilities to make these organizations more effective in serving their constituencies.

Therefore, broadband in this plan denotes connectivity services that are provided to small, medium, and large businesses as well as community anchors such as educational, healthcare, local government, and public safety organizations. In this grouping the technologies, delivery systems, service levels, and speeds may vary but common underlying features remain constant. These features include the following five items:

1. Services that are always connected, unlike dial-up services.
2. Services that are able to transmit and receive large amounts of data in symmetrical transmission (meaning the same upload and download speed).
3. Services that are able to support multiple types of traffic simultaneously.
4. Services that are able to support specific performance requirements of applications such as voice and video.
5. Services that are able to provide items 1-4 consistently and without interruption, supporting critical business and community anchor functions.

[15] Blended learning is a formal education program in which a student learns at least in part through online delivery of content and instruction with some element of student control over time, place, path or pace.

Magellan interviewed and discussed high speed broadband in Columbia with all identified service providers. Maps of service provider infrastructure were requested for this Study to gain an understanding from each of Columbia's current providers what infrastructure was available in the area. Columbia Water and Light and Sho-Me Technologies provided detailed maps illustrating their broadband fiber-optic facilities in the Columbia area.

Columbia falls into a category of mid-sized cities that are in between the rural, underserved communities, and those that are larger and well served. Outside of the City proper, Boone County quickly becomes very rural and suffers from common broadband access issues found in rural communities. The broadband services that businesses utilize are not always dependent on company size but as a general rule, small and medium businesses utilize cable and DSL services while large businesses utilize fiber-based broadband services. Community anchors are served similarly depending on their size and geographic location. Anchors such as schools, hospitals, City of Columbia, and County facilities utilize fiber-optic broadband services while anchors in Boone County lack this access and generally utilize cable, DSL, and T1 services.

Community Survey Responses

Magellan Advisors and REDI conducted an on-line survey of businesses regarding broadband uses and needs. Please see Appendix B for charts which depict survey results for each question. 106 businesses took the time to respond to the survey and these responses are greatly appreciated and beneficial to broadband planning for the Columbia community.

Out of 106 businesses surveyed, 70% were small businesses with 50 or fewer employees. The top four sectors by NAICS code were Professional Scientific & Technical Services, Finance and Insurance, Real Estate, and Healthcare. The vast majority of businesses surveyed were within Columbia's city limits. Businesses reported that Internet services were important to their operations and the majority reported that interruptions in their Internet services were detrimental to their businesses. 45% of businesses reported that their Internet services were not currently meeting their needs due to inadequate speed or insufficient reliability. Of that percentage, 32% had not upgraded because services were not available and 43% had not upgraded because the price was too high.

Further details from the survey of businesses include:

- More than half of respondents (58%) were small businesses with 25 or fewer employees. Approximately one third (30%) were large businesses with over 50 employees.
- Finance and Insurance, real estate, professional, scientific and technical services, and health care were the top four industries represented in the survey.
- Businesses use the Internet in a variety of important ways:

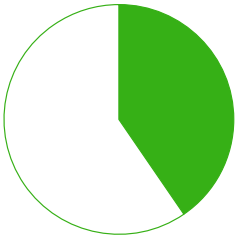
    - 99%: Email and general browsing
    - 84%: Social Media, i.e., Facebook and Twitter
    - 81%: Research and Information
    - 78%: Business applications such as accounting and payroll
    - 74%: banking and financial
    - 61%: data backup
    - 59%: file sharing and collaboration
    - 51%: credit card processing
    - 46%: web hosting
    - 42%: video and/or television, video conferencing
    - 40%: telephone services such as Skype or Vonage
    - 37%: security monitoring
    - 36%: design
- Other uses of the Internet include uploading large video files multiple times per day, billing services, streaming video, record and test transfers, and ERM.
- Businesses currently not using the Internet for these functions have significant interest in future use particularly in the areas of data backup services, social media applications, banking and financial, security monitoring, and research and information.
- Almost three quarters of businesses have experienced moderate, severe, or total disruption of their business from Internet problems with reliability and speed.
- 44% of businesses state current Internet services are insufficient for their business needs, and a further 16% are not sure that current Internet services are sufficient. Reasons current Internet services are not sufficient include:
    - 54%: not fast enough
    - 33%: unreliable
    - 10%: lack of options
    - All additional explanatory responses are: "we struggle with getting fast enough Internet and also the overall affordability"; "too many outages"; "multiple locations across the state"; "also unreliable"; and "need to expand bandwidth".
- Lesser reasons that businesses have not upgraded service to remedy these insufficiencies include lack of technical skills (7%), and lack of knowledge of options (2%).
    - All additional explanatory responses are:
        - "we have looked at ALL available carriers and they are similar in unreliability factors"
        - "no provider can deliver adequate bandwidth. We've tried them ALL."
        - "it's the best available for where I am located."
        - "Speeds are too low, price is too high. Need fiber."
        - "We are actively seeking alternative solutions."

        - "Too high and no reasonable option that also provides a landline."
        - "this is a corporate decision, not local."
        - "We have the highest Internet speed."
        - "We contract with two providers because they are both so unreliable so we can remain live."
        - "limited services"
        - "Tied to corporate system"
        - "I am told I have the best they have to offer"
        - "not sure who would really do any better. Conflicting info"
        - "Just need to get it done."
        - "I think we have the best available in Columbia at this time"
- 99% of businesses rank Reliability as "Very Important" or "Extremely Important".
- 91% of businesses rank Speed as "Very Important" or "Extremely Important".
- 76% of businesses rank Customer Service as "Very Important" or "Extremely Important".
- 55% of businesses rank Price as "Very Important" or "Extremely Important".
- 65% of businesses state it is "Very Important" or "Extremely Important" to the long term success and growth of the business to have multiple choices of broadband providers, offering a wide range of pricing options and features.



73%

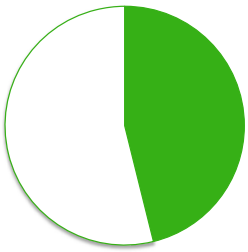
Of Columbia businesses reported moderate, severe or total disruption of their business from Internet problems related to reliability or speed.



38%

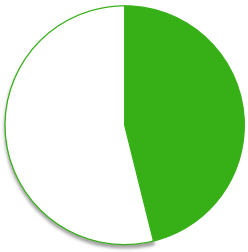
Of Columbia businesses reported that their current Internet services are insufficient for their business needs due to reliability and speed issues.

Of the 38% of Columbia businesses that reported their Internet services being insufficient for their business needs:



42%

Of Columbia businesses reported that they have not upgraded their Internet services because the price is too high



42%

Of Columbia businesses reported that they have not upgraded their Internet services because the service is not available



13%

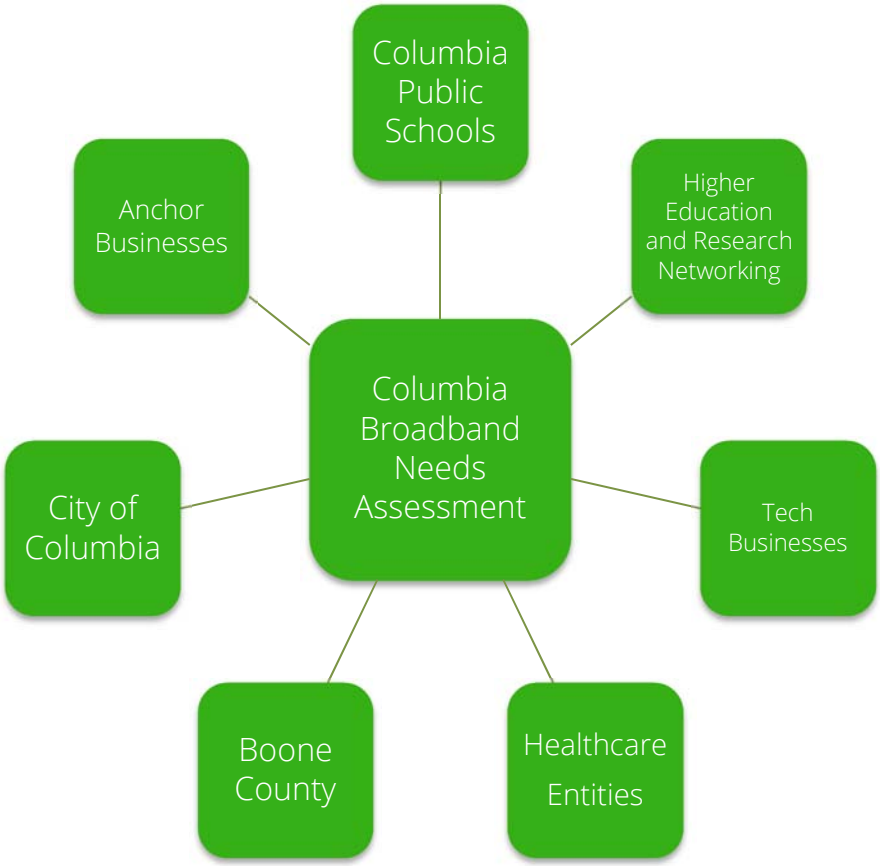
Of Columbia businesses reported that they have not upgraded their Internet services because they don't know what options are available

Stakeholder Interviews, Issues, Opportunities, and Analysis

To enable Magellan to assess community needs and resources for high speed broadband, REDI arranged stakeholder interviews with the complete spectrum of stakeholders in community broadband infrastructure. The stakeholder interviews were generally "one on one" but there were some interviews that were conducted in a group setting by mutual agreement. Magellan carefully noted the views expressed by the stakeholders and in some cases requested additional and follow-up information.

Stakeholder interviews and business survey data along with Magellan's own research substantially shaped the Needs Assessment for the City of Columbia. The interviews and survey data reveal and highlight the fact that Columbia is home to many successful and vibrant organizations and businesses that are highly dependent on broadband connectivity. These organizations and businesses build community wealth in a number of ways that are not merely financial however; the growing sophistication and demands of these entities has highlighted weaknesses in the broadband infrastructure both currently and in the future.

A community broadband strategy is a long-term plan to positively impact the technology and communications needs of the greater Columbia region. Communities that have implemented high-speed broadband successfully use a community-wide approach that incorporates the needs of all stakeholders in the project. This allows the community to aggregate demand in the project which is important to make a case for building new infrastructure in partnership with local service providers who want to serve these customers. For Columbia, Magellan recommends this whole community approach to include the key stakeholders in the community as shown in the diagram below. To accomplish that inclusion, Magellan's Study conducted a comprehensive broadband needs assessment for these organizations (and others) to determine their current and future requirements for broadband services that will support their long-range mission.



Issues and Opportunities

Stakeholder interviews combined with Magellan's experience and research indicate a number of current network issues and opportunities, as follows:

- There is significant need for data transport capability between Columbia and Jefferson City, for such functions as mirrored systems, backup, and recovery. Currently transport pricing for this capacity is perceived to be very costly. Enabling cost-effective data transport capability between Jefferson City and Columbia is viewed in the community as "a great cooperative project".
- The current lack of redundancy is viewed by many as a primary issue and problem. "If something happens to Cherry Street (CenturyLink's downtown central office), it's a big problem." "Fiber cuts have taken service down for whole days."
- It is noted that "the entire network slows down when students arrive on campus at University of Missouri.
- Security concerns emerge as being very serious. "Columbia is not immune from attacks." "It is happening all the time now, traffic from Russia trying to ping and get into businesses, run scripts against FTP, etc." Small companies do not have the staff or expertise to stay on top of security and intrusion attempts.

Columbia's broadband plan should consider and include resourcing and support for intrusion detection and prevention.

- City fiber is not available to everyone and it is generally unavailable at this time.
- If the city expands its fiber network, it has to be done at a carrier class level. "It cannot be operated as a city service."
- Many note that there is not a good, cost effective, data hotel in Columbia and believe this should be remedied.
- Some have noted it would be beneficial to expand affordable and cost effective Wi-Fi. Some perceive this as a good use of City of Columbia fiber for backhaul.
- Some private telecommunications providers are interested in dark fiber but only if it can be bought or swapped to enable placement of electronics.
- Providers are very interested in building access—conduit and building entrance. Currently this is a significant barrier especially downtown.
- Some providers are very interested in building out to fill in current network gaps for the city.
- Reliability of service over CW&L fiber is a concern to some due to perception CW&L would take down fiber circuits as necessary when restoring electric service.
- Some perceive a need for standby/backup facility that could be paid for on a utilization basis rather than paying for dedicated facilities on a monthly basis.
- Currently it appears that charges for rights of way and pole attachments for CW&L use are internal. There is a perceived need that these charges be made explicit.

Tech-Oriented Businesses

Columbia's tech-orientation and big data focus are an important forward-looking aspect of high-speed broadband for the business community. These organizations have significant needs for high-speed, reliable bandwidth options, which can generally only be provided through fiber-optic connectivity. To support and promote Columbia's focus on the big data sector, it is critical that the region has affordable, available fiber-optic broadband to meet the needs of current businesses and new startups entering the market.

Businesses and business applications increasingly are predicated on connectivity, transactional data delivery, large files, and report rendering in real time. Redundancy and continuity are very important in many businesses. Certain businesses would like to rely more on cloud services and video conferencing is of growing importance for many businesses. For some businesses cloud delivery is crucial.

Business organizations have data centers that are distributed both within Columbia and to locations outside of Columbia. Jefferson City is a primary "community of interest" from both a business and data networking standpoint. Businesses urge that a mid-Missouri

point of view be taken. Speed, cost, and reliability issues exist with current options between Columbia and Jefferson City.

Affordability is a key component of high-speed broadband services for this sector as many of the businesses are small or are in the startup stage. They report an obstacle of affordability in bringing fiber-optic connectivity directly to their businesses. For example:

> *From the outreach conducted with these businesses, they have communicated an urgent need for these services because the efficiency of their operations is directly tied to speed and reliability of their broadband services. Many of these businesses are currently utilizing either cable or DSL services and report intermittent issues with these services, and a lack of bandwidth available to grow.*

Stakeholders noted that connectivity in the downtown area is not consistently good. No buildings have direct access to fiber. Stakeholders consistently identified problems with speed/price, outages and limited or uneven availability of broadband service. These problems have risen to the CEO level – "when there are problems, you learn more about data communications" as one interviewee put it.

More than one stakeholder interviewee noted that investments and data center operations are being moved out of Columbia due to reliability, performance, and redundancy issues. While personnel in other operations will remain in Columbia, data center platforms are moving out. "Latency and resiliency issues must be resolved—cannot live with backhaul". Current "latency is only borderline acceptable for high end service". This is aggravated by the current circumstance that the closest backbone connections are "a few hops away" and "Columbia is in the middle of nowhere from a network perspective". Currently there is a significant cost for backhaul to Kansas City or St. Louis.

Small Businesses

Although small businesses do not utilize broadband in the same ways as tech-oriented and big data businesses, many of the applications they use every day are sensitive to the speed and reliability of their broadband services. This Study has captured trends that indicate that small businesses are using more and more bandwidth intensive applications in Columbia. The list below provides an overview from the survey of how these businesses are utilizing their broadband connections today. Lines highlighted in green represent those applications that are particularly sensitive to high-bandwidth and/or reliable broadband services.

- 98%: Email and general browsing
- 89%: Gathering online research and information
- 86%: Online banking and financial
- 86%: Social Media, i.e., Facebook and Twitter
- 77%: Business applications such as accounting and payroll

- 72%: Online file sharing and collaboration
- 66%: Video and/or television, video conferencing
- 59%: Web hosting
- 55%: Telephone services such as Skype or Vonage
- 52%: Online credit card processing
- 48%: Online data backup

Direct feedback and survey data from the small business community indicated moderate dissatisfaction with existing broadband services. A general theme across many of the survey respondents and focus group meetings was that these services lacked reliability and consistent speed; however businesses "just lived with it," believing that there was little they could do to upgrade or afford faster, more reliable services. The affordability factor was a recurring theme for small businesses across the Study.

General Broadband Profile for Columbia Businesses – By Size and Type

Type of Business	Example	Current Products Used	Monthly Affordability Range	Short-Term Benefits from High-speed Broadband	Long-Term Benefits from High-speed Broadband	Ability to Pay for High-speed Services In the Current Environment
Small Traditional Businesses	Restaurants, Small Markets, Hardware Stores	DSL or Cable Entry-Level Products	< $100	Low	High	No
Small Professional Businesses	Engineering Firms, Architects, Doctors	DSL or Cable Premium Products	$50 - $250	High	High	No
Small Big-Data Centric Businesses	GIS Mapping, Software Development, Web Analytics	DSL or Cable Premium Products	$50 - $500	High	High	No
Medium Businesses		DSL or Cable Premium Products, Fiber-Optic in Some Cases	$50 - $2,000	High	High	Some
Enterprises		Fiber-Optic	> $2,000	Low	High	Yes

Columbia Economic Development

Accessible, affordable, and reliable broadband services are a key economic development tool to attract and retain businesses in Columbia. The question posed to the City of Columbia's economic development organizations is the following:

"Will Columbia's broadband services keep pace with the growing needs of its businesses which compete in a global economy?"

In many cases, bandwidth consumption outpaces the broadband speeds local businesses are able to purchase and upgrading is often times not an option due to the prices businesses are able to afford as well as other IT related factors. When these broadband services cannot "keep up" with business needs, businesses lose productivity and efficiency impacting their bottom line and making them less competitive with regions that have more widely deployed high-speed broadband services at more affordable prices. This will eventually result in a less competitive business market from an economic perspective. It also leads to retention issues as businesses that are not able to gain efficiencies with their existing broadband services will, in many cases, move operations to communities that have more availability of these services.

In terms of attracting new business, a key focus of the City's economic development organizations is to target companies that are location-independent and value Columbia's quality of life in a vibrant community but outside of the "big cities." Broadband is a fundamental utility asset that these types of businesses will require as they will rely on broadband to maintain connectedness to the electronic world. The majority of location-independent businesses rely on online services to maintain their daily operations, therefore; it is critical that Columbia is able to promote the availability and affordability of broadband services in its recruitment efforts. This can be a true differentiator for Columbia; through promotion of the community's leading-edge broadband services, prospective businesses and site selectors can be assured that they can locate in Columbia and have robust access to the rest of the world. Available and affordable high speed broadband has also gone beyond being a differentiator to being a key part of the "minimum ante" for attracting and retaining desirable businesses and facilities.

Healthcare Organizations

Broadband is crucial for Columbia's healthcare providers that are interested in meaningfully leveraging electronic health records, as many of the capabilities of health IT such as telehealth and electronic exchange of health care information, require high performance broadband capability. Columbia's major hospitals currently maintain access to high-speed broadband services but outside of these organizations few healthcare providers maintain this type of access. Doctor's offices, clinics, and imaging centers all have growing broadband needs to ensure they stay connected as their organizations transition to the digital healthcare environment. For these smaller organizations, high-speed broadband becomes a critical need to fulfill their mission and long-term success.

There are a variety of trends and applications in the health care field that drive the need for broadband infrastructure. There will be medical instrumentation and measurement at home, faster than many people realize—which will require substantial bandwidth and "always on" connectivity. Medical record billing and coding often is done from home which requires substantial bandwidth.

The University of Missouri's University Hospital has engaged in partnership with Cerner to set standards for automation in health care. This is a joint nursing and engineering effort with Cerner under which the Hospital has outsourced its IT function to Cerner. Hospital employees are rebadged to Cerner. This is a bandwidth-intensive application that includes 40 data ports in every room, use of RFID, to create sensor-laden rooms that are monitored real time. For example, this will be used for aged care real time monitoring in combination with robotics to be predictive of a fall that hasn't happened yet. This revolutionary advance will extend out to real time home health care and telemedicine which will require broadband infrastructure to operate properly.

Both the University of Missouri Health System and Boone Hospital use CW&L fiber for connections among hospitals, clinics, and doctors' offices.

Boone Hospital uses CW&L fiber to connect the hospital with clinics, doctors' offices, imaging, and operations/administrative functions. There are many doctors' offices that would like better connection and would like to be on fiber for the capacity. Some are using Gigabit connections. Much better connectivity and bandwidth will be required in the near future for health care. Much is coming in the electronic health records area using cloud based systems.

Educational Organizations

Availability of broadband for education is critical for communities such as Columbia. As more curricula moves to an online format and programs such as distance learning and online testing are developed and implemented, high-bandwidth, reliable broadband services become a fundamental asset for schools, libraries, and universities. Columbia's public schools currently maintain satisfactory broadband services over dedicated fiber-optic connectivity however; will these services scale over time to meet future demands of the community?

As schools utilize more and more bandwidth, scalability of their broadband services will be critical to maintain connectivity with electronic resources, other educational institutions, and students, whether they are on campus or remote. This requires not only dedicated, high-bandwidth connectivity, but also symmetrical connectivity as much of the traffic transmitted by schools is upload rather than download. High-bandwidth upload traffic includes connections into online applications hosted by schools, distance learning programs, and online testing programs. Therefore, accessibility to symmetrical,

high-bandwidth broadband service will continue to be a critical need for Columbia's schools.

MU is a key community anchor in Columbia. On average the University of Missouri (MU) maintains 2.6 IP addresses live per student. This connectivity drives demand in nearby residences and apartments. Faculty and staff want the same level of connectivity. There are notable peaks such as during NCAA tournament games when 3000 students are streaming the game at any one time. MU sees a need for more widely available broadband to facilitate connections with businesses to interact with researchers and students. The business incubator has a minimal configuration but has to grow. There are many spin-offs from research efforts at MU.

MOREnet is a membership-based non-profit organization that provides high speed Internet access to hospitals, higher education, libraries, and K-12 schools, on a statewide basis in collaboration with the University of Missouri. MOREnet is the backbone provider for the University of Missouri. Bandwidth demand is growing at 45% per year based on demands such as statewide testing. MOREnet is reestablishing a relationship with the state of Missouri.

Stephens College uses MORENet over city fiber. Capacity utilization is doubling every year.

Columbia Public Schools (CPS) is a very large school district with approximately 40 sites connected using CW&L fiber. CPS participates in the E-rate program, and obtains its Internet connectivity as a member of MOREnet. CPS has several needs and objectives. Looking forward, capacity for online testing will be a huge need. Best practices in education have identified bandwidth targets, for which CPS's estimated need is as follows:

- Internet Service Provider connection to provide 20Gbps capacity per 1000 students and staff for the 2017-18 school year; and,
- Wide Area Network (internal CPS) to provide at least 10Gbps per 1000 students and staff for the 2017-18 school year.

Consistent with best practices in education, CPS is targeting/reaching a 2:1 ratio of students to devices or better. Currently there are 10,000 computing devices of which 5500 are iPads. Provision of computing devices has highlighted the lack of adequate Internet connectivity in different areas, as there are students who have no Internet connectivity at home.

Daniel Boone Public Library provides a fully functioning digital branch—anything that can be done in a building can be done digitally. Daniel Boone serves a large number of patrons with computers, Wi-Fi, and computer and technical classes. The Ashland and Fulton locations are both connected to the Internet and the bookmobiles are connected as well at each stop either by a pole with a DSL line (approximately 9 locations) or

wireless connection (approximately 20 locations). Daniel Boone foresees extensive growth of wireless demand and mobile devices. Daniel Boone uses CW&L fiber through MOREnet for connection.

City Initiatives

At the City level there are many long-term needs that can be met through the development of widespread high-speed broadband. The network will become a part of the region's long-term strategic planning and provide a valuable resource that the City of Columbia can leverage to achieve their organizational objectives.

The implementation of a regional community broadband network will create a high-speed, redundant, and scalable network environment that will support further efficiencies and functions in provision of municipal services that rely on network resources. As more of the City's operations are conducted electronically, the high-speed broadband will become more and more essential to meet the requirements of these applications. It will continue to provide the flexibility to serve the local government's many departments simultaneously and through many different applications.

Additionally, this new community broadband network platform will potentially facilitate greater collaboration between local government entities within the Boone County region. These organizations will potentially benefit in the following ways:

- New opportunities to collaborate with local government organizations across a common communications platform.
- Gain economies by sharing critical needs across multiple local government organizations including Internet, voice services, backup services, and others.
- Gain economies by sharing municipal applications across multiple local government organizations including GIS, expanded public safety dispatch/records management systems, web applications.
- Gain economies and promote enhanced public safety by development of shared disaster recovery and business continuity programs utilizing common infrastructure.
- Reduce taxpayer spending across all participating public organizations in the Boone County region.

Outreach to Citizens and Businesses

An integrated municipal broadband network would allow the City of Columbia to provide new communication channels to citizens and businesses in Columbia. Complementing a backbone network with wireless access-points, Columbia could enable public wireless ("public Wi-Fi") selectively to reach specific areas of the community. These could be used to disseminate information to the community, provide local advertising for business, and provide more online municipal services. A broadband network would also allow broad distribution of civic content including online information, emergency response, streaming video, stored video, and Go-Live broadcasting across multiple locations in the

City in near-real time. This would allow the City of Columbia to deliver content to citizens and businesses more efficiently through its own internal infrastructure.

Utility Operations

Future utility development for CW&L may require the expansion of broadband services that reach further into the community. Power grid applications for the electric utility and advanced metering for the water utility would both need an extensive broadband network to reap the benefits of demand response and continuous monitoring. Expansion of CW&L's network to serve more of the community, starting with commercial parcels and potentially moving into the residential community in the future would facilitate a communications network capable of supporting power grid and metering for the utility.

6. Key Broadband Issues Facing Columbia

Some organizations in Columbia are receiving next-generation, fiber-based service, including larger businesses, schools, hospitals, public safety, and local government organizations. These organizations are generally receiving high-speed, symmetrical fiber-optic services from local providers in the region. Speeds range from 100Mbps to 1Gbps and the networks in Columbia have the capability to support 10Gbps and greater speeds. Although these services are available in some areas, a key issue is the affordability of broadband services to organizations outside of the above stated customer segments and geographic areas. Large business and community anchor customers are generally able to afford these services. In some instances, Columbia schools receive federal subsidies (through the USAC Schools and Libraries Program) to support their procurement of high-speed broadband services.

For smaller businesses across most sectors prices for high-speed fiber-based broadband services have been a barrier to utilization therefore, they generally utilize lower cost options including cable, DSL, and sometimes wireless services to meet their broadband needs. In some cases these services are sufficient while other businesses report issues with their services as evidenced by the survey data collected in this project.

The issues of availability and affordability are intertwined. The definition of widespread availability is important to clarify in the context of this Planning Study. It is defined by the type of fiber-optic broadband infrastructure that is being deployed in the region. Providers in tier 2 and 3 American cities are beginning to deploy fiber-optic broadband services as part of their distribution strategies. Where once they deployed copper-based services such as DSL and cable, now they are deploying fiber-optic distribution technologies; enabling significant upgrades in speed and reliability in their service areas. Passive optical networks, including BPON, GPON, and EPON are slowly replacing traditional copper-based networks as providers overbuild this older infrastructure. This is within a larger trend of replacing circuit switched, time division multiplexed networks with Internet Protocol and Ethernet networks.

Carrier decisions to build these networks are often tied to many factors that include carrier capital allocation and national business plans, construction costs, density, market size, demographics, and competition. The introduction of these new distribution technologies enables greater availability and affordability of high-speed broadband services by increasing the overall density of fiber-optic infrastructure in the local area, more cost effective deployment methods and specialized equipment designed to provide lower cost fiber connections.

In Columbia, this Study found case-by-case deployment of fiber-optic distribution technologies being implemented by current providers but little if any in the nature of area wide deployment. The Study identified fiber-optic connections being provided to businesses using a more traditional point-to-point model, however; no widespread fiber-optic distribution technology was identified. The lack of these distribution technologies

limits the density of overall fiber-optic infrastructure in the region. GPON FTTH deployment is taking place in a few select locations in Columbia.

There are a variety of reasons why providers are not making investments in this infrastructure. The capital cost of doing so is significant and it is important to remember that private service providers operate under corporate capital budgets and allocations and must be able to make a reasonable rate of return on their investments in these networks. This is balanced against the fact that providers must also continue to invest in their networks to remain competitive and ensure they meet their customers' requirements, otherwise they will experience high rates of customer attrition as other providers offer substitute products and services.

Another important issue is that Columbia does not appear to have a high availability/high reliability network; there has been notable downtime experience on existing private networks. The business community has a "huge" focus on redundancy. Layer 2 and Layer 3 diversity issues exist in Columbia. Consistently throughout the stakeholder interviews and business surveys, respondents indicate a great need for reliability. Under the current arrangement all ISPs have failure points. Stability of Internet connections is an important requirement since if transmission of a transaction is interrupted it has to start all over again. Notably, as capacity increases there is a greater sensitivity to fiber types.

Service providers are interested in building access – conduit and building entrance facilities – especially downtown.

There is a strong perception of disjointed services in the greater Columbia area. There are significant holes in broadband availability and one does not have to go very far outside the city to see high speed broadband options diminish dramatically.

Although not a direct objective of the planning study, it has been learned that network security concerns are also emerging as a very serious issue.

7. Recommendations on Potential Strategies

There are many strategies that Columbia can utilize to promote the development of high-speed broadband services in its community. Magellan recommends that these strategies be developed with the support and coordination of Columbia's local service providers who play a critical role in Columbia's broadband future. These strategies fall into three categories: public policy tools, information and adoption programs, and public investment. To be successful, Columbia should take a multidimensional approach to broadband development utilizing a combination of these strategies to accelerate the availability, adoption, and investment in local broadband infrastructure.



Public Policy Recommendations

Magellan recommends that the City adopt broadband infrastructure policies that enable a process whereby basic broadband infrastructure can be installed through their capital project programs. Road widening, sidewalk, trail, and lighting projects all may be opportunities for the installation of basic conduit infrastructure at a very low cost. By installing conduit in concert with these related capital projects, the City of Columbia can avoid incurring the significant costs of constructing this infrastructure (or having other parties do so in connection with their construction) by installing conduit when the ground is already open. Since the majority of costs to build broadband infrastructure in Columbia are incurred through trenching and boring, this strategy can alleviate the high cost of implementing local broadband infrastructure within the community.

It's important that the City determine which projects will help build usable infrastructure; there's no reason to utilize this strategy in areas that already have available conduit and fiber-optic infrastructure. Magellan recommends implementing a process through which the City can evaluate their capital project programs to determine which ones should be identified for the addition of broadband infrastructure. Magellan also recommends that the City implement this process in their land development codes or engineering standards to ensure that broadband infrastructure becomes a part of the design for all relevant public and private capital projects. By doing so, these organizations can determine which projects add relevant broadband infrastructure to the community and which do not. Magellan also suggests that this process be coordinated with local service providers to minimize overbuilding and to ensure that service providers have an opportunity to place their infrastructure in capital projects as well (see joint trenching agreements below). Magellan has included sample high-speed broadband standards in the Appendix C to this Study.

To broaden the scope of this initiative for the City, Magellan recommends that the City implement a "Dig Once" policy as well. Dig once allows for more comprehensive utility coordination whenever excavation occurs within the City limits. It allows the City to apply a policy to utility construction whereby anytime a trench is open, participating utilities and providers are notified to consider installing facilities in the trench alongside the lead organization. This of course requires cooperation between utilities, providers, and the City. It also requires joint trenching agreements between multiple organizations to determine terms, conditions, and cost sharing among participants.

In addition to these standards, Magellan recommends that the City review any potential joint trenching agreements they maintain with utility and service providers in the Columbia area. Joint trenching agreements are developed between organizations to minimize the cost of constructing conduit in the local area by allowing one another to taking advantage of trenches that have already been opened through companion projects. They allow multiple providers to install conduits in a single trench, significantly reducing the cost of underground broadband infrastructure.

If these are not in place, Magellan recommends development of joint trenching agreements between the City and providers in the area (utility and broadband). Joint trenching agreements must be negotiated between parties individually and are generally exclusively held between each provider and the local government organization. Magellan has included sample joint trenching agreements in the appendices to this Study.

Education and Adoption Programs to Increase Demand

Through interviews and survey data, it was apparent that some lack of information on available services was evident in Columbia. Magellan recommends that the City build awareness of broadband services that are available in the area; particularly as they look to implement broadband initiatives in the community. Magellan also received feedback from providers that stated, "We need to do a better job of marketing our services to the community." Building awareness in cooperation with local providers will reinforce availability of services and support demand. Increasing the demand for broadband services will also help local service providers as they are able to generate additional revenues that may at some point be reinvested back into system expansion for high-speed broadband infrastructure. Magellan recommends that the City, and local service providers work together more closely to ensure the market understands what services are available and that local service providers are aware of the opportunities at hand.

Record Keeping and Information Sharing

The City of Columbia maintains Geospatial Information Systems (GIS) that contain detailed maps of the community, right of way, easements, and other information. As Columbia moves forward with its broadband initiative, the City should ensure that any public broadband infrastructure in the area is documented in GIS. This will allow both agencies to maintain a clear understanding and records of locations of broadband infrastructure; which may include conduit, vaults, pull boxes, transitions, fiber-optic cable, and other outside plant resources. Record keeping is a critical aspect of developing community broadband networks and if Columbia begins this process early, it will save significant costs in the long-term and ensure that the communities understand where this infrastructure exists. This information should be made available to broadband and utility providers in the area in effort to maintain better coordination of underground infrastructure.

Development of a Community Broadband Network

Columbia Water and Light should lead by developing a lit open-access network, the Columbia Community Broadband Network. This network would continue to provide connectivity throughout Columbia for the City, Schools, and other community anchor institutions located throughout Columbia, however; it would do so by provisioning lit circuits instead of dark fiber. The City of Columbia would essentially aggregate significant demand for telecommunications and Internet services onto a common fiber network for all government and community support facilities.

In addition, CW&L would expand its lit services into the downtown core and business and industrial parks throughout Columbia to provide a new source of fiber, which will be offered to Columbia businesses. Telecommunications providers would interconnect with the Columbia Community Broadband Network at a neutral meet point located in Columbia and would utilize the City's open-access platform to deliver services to the community anchors and business customers that are connected to the network.

Through the development of an open-access network, the City would introduce an optional source for fiber-based telecommunications services throughout Columbia. Businesses and anchors would receive highly available and redundant services at more affordable rates than are currently available in Columbia. Service providers would continue to contract with CW&L for capacity in the network, using Type II circuits instead of dark fiber strands. Finally, Columbia Water & Light would continue to drive innovation and support for the greater community through the development of a high-speed fiber-based community broadband network while increasing its revenue from the leased capacity on the network.

The use of dark fiber in the current manner is an inefficient use of resources. Dark fiber leasing agreements should be terminated and users migrated to the lit platform allowing for the repurpose of the existing fiber segments. There may be an impact to existing customers who utilize the current CW&L dark fiber. Those who primarily use dark fiber for Ethernet connections to their facilities should be migrated to the lit platform, while those users deploying WDM technologies may need to continue to lease dark fiber. Columbia Water & Light could develop a new dark fiber lease rate as part of the CW&L broadband business plan if its decided to keep dark fiber as a service offering due to this customer consideration.

Magellan recognizes that its recommendation for an open-access network will be welcomed by some service providers, while some incumbent service providers may view it as unnecessary. However, on balance as described in this Report, such a network is necessary to advance broadband in Columbia, and there is nothing that precludes any service provider from taking equal advantage of the open-access network – regardless of its status.

Building Support for Columbia's Community Broadband Network

Columbia's community broadband initiative will need to be built with grass roots support from its key stakeholders. Because this project impacts the entire community at some level, building support for the project should involve the major stakeholders who will receive benefit from the new technologies and services available. To begin this process, Magellan recommends that the City maintain a Broadband Working Group that will be tasked with carrying forward the objective of developing Columbia's community broadband network.

The Working Group should be relatively small and be composed of community and technology leaders in Columbia that understand the importance of broadband to the region's long-term success. Magellan suggests a group with representatives from each major stakeholder. At minimum, Magellan recommends that the following organizations submit one representative to the Working Group:

- City of Columbia
- Boone County
- Columbia Public Schools
- University of Missouri, Columbia
- REDI
- One or Two Key Business Representatives
- One Key Healthcare Representative

The Working Group will take ownership of the Planning Study and depending on how the public organizations' decide to move forward, the Working Group will carry out the recommendations and next steps; first of which will be the creation of a Broadband Business Plan for CW&L. As this work progresses, the Working Group will help guide the development of the business plan with external resources to ensure the Broadband Business Plan is aligned with each stakeholder's needs and those of the greater community. The Business Plan will be developed specifically for CW&L since it is the lead entity with ownership of the fiber-optic network, however; stakeholder engagement will be important to ensure the broadband utility will serve the needs of the community.

Case Studies

What Other Communities Have Built These Networks?

A significant number of communities across the country have built community broadband networks to provide reliable, high-capacity fiber infrastructure to their stakeholders. There are over 1,000 similar networks across all States, including California. Some of these include:

City of Palo Alto, CA

In 1996, Palo Alto built a 33-mile optical fiber ring routed within the City to enable better Internet connections. Since then, we have been licensing use of this fiber to businesses. For the past decade, this activity has shown substantial positive cash flow and is currently making in excess of $2 million a year for the city. We now have that money in the bank earmarked for more fiber investments."

Santa Cruz County, CA

The Santa Cruz County board of supervisors in November 2013 approved an eight-month timeline to overhaul its broadband infrastructure plans and regulations. Specific areas of focus include permitting fee reductions and a proposed "dig once" ordinance that would make it easier to install new fiber optic cables during other work on area roads or utilities lanes. "The County will continue a focus on broadband infrastructure throughout the county to enable businesses to function in the digital era, and students

and households to have high quality access to information and communication. The County will work with industry providers to develop a Broadband Master Plan in order to identify focus areas within the county that will be most suitable for gigabyte services, particularly as the Sunesys backbone line is constructed during 2014 and 2015. The County will work with service (last mile) providers to ensure that these focus areas are deemed a priority, in order to support streaming requirements, product development, job creation and online selling capability."

City of Palm Coast, FL

In 2006, the Palm Coast City Council approved a 5-Year fiber-optic deployment project funded at $500,000 annually for a total investment of $2.5 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. The City 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 broadband network. Showing a reasonable payback from each stage of investment allowed the City to continue to fund future expansion of the network. Through deployment of this network, the City has 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 City's network provides valuable new capabilities that enhance its mission of serving the residents and businesses of the community.

Seminole County, FL

Over the last 15 years, Seminole County, FL has developed its own fiber-optic network to serve the broadband needs of its municipal, public safety, education and utility needs. The 450-mile fiber network has connected 26 fire stations, 58 county buildings, 44 schools, 4 SCC campus, 41 city buildings and 17 water treatment plants to the fiber network and maintains and repairs over 375 traffic signals, 148 school flashers at 73 locations, 46 beacons and flashers and 29 VMS (variable message signs). The network saves taxpayers in the County millions of dollars a year and provides a significant backbone of high-speed broadband services to serve nearly all of Seminole's community functions.

8. Community Broadband Expansion

Expanding the CW&L Network for Community Broadband

Columbia Water and Light has built its fiber network to support the department's operations. In addition to internal operations, the network is heavily utilized by many anchor institutions and providers throughout Columbia. Revenues generated from these uses provide income to CW&L of approximately $900,000 per year. Under the current arrangement, CW&L leases strands of dark fiber to service providers and anchor institutions. To expand the CW&L network for community broadband, there are two critical issues that need to be addressed:

1. The current network architecture doesn't support widespread use by the greater Columbia community due to the lack of fiber capacity in many existing segments.

2. There is a lack of last-mile fiber access in the Columbia network, requiring service providers to build their own last-mile fiber to customers while interconnecting with the Columbia fiber backbone.

Through discussions with local service providers, this Study found that there are potential customers that desire CW&L fiber connections but that cannot currently be served due to the Columbia Water and Light "dark" fiber capacity constraints.

The CW&L network is a strategic asset for community broadband that can be used as a core backbone network to further the deployment of high-speed fiber-optic services. Through the adoption of a reasonable community broadband business model, the Columbia network could be used as an alternative fiber last-mile for local businesses, anchors, and potential residential applications to bridge the digital divide. Numerous business models are available for community broadband networks, each with their own levels of investment, risk, and benefits.

Through the broadband planning study process, Magellan has reviewed several different business models with City staff and leadership. These models include:

- Dark fiber open-access
- Lit network open-access
- Retail service provider

For Columbia an open-access model appears most appropriate for a number of reasons. First, Columbia has a large number of service providers in the City. Many own and operate copper and fiber plants and serve the majority of the business, residential, and community anchor markets. In fact, through our onsite meetings and interviews, we met with over eight (8) providers operating in the Columbia market (Charter, Mediacom, CenturyLink, Sho-Me Technologies, MOREnet, Blue Bird, Socket, and Full Stream Wireless.) Secondly, the City has not stated an interest in directly providing end user services such as Internet, video, or voice. The open-access option still allows the City to

leverage its fiber-optic network to enhance the broadband services in Columbia. It affords Columbia Water and Light the ability to remain an infrastructure provider managing similar services as it does today and it provides a new source of local fiber that the City's service providers can use to reach businesses or residents in the service area.

The dark fiber open-access business model is similar to what the City of Columbia is providing today with the exception of the last mile fiber segment. Using a more formal dark fiber open-access model, the City would build the last mile fiber into the end-user premise and would own the fiber path all the way back to a communications hut or colocation facility where service providers would be located for interconnection. Interconnections would take place using fiber patch panels; no active equipment would be owned or operated by the City of Columbia in this model. The City of Columbia would patch the service provider into the designated fibers for a specific end user and would be required to ensure the fiber path is available to the premise. This would include owning all the fiber-optics from service provider to customer as well as ensuring the correct splicing and allocation. This model is a continuation of the current dark fiber leasing that the City currently manages however; CW&L would expand into now providing last-mile fiber to individual premises as well.

While the dark fiber open-access model has many benefits by way of getting fiber to the end-users that require it, CW&L will still face challenges with this model. The most significant challenge to overcome is the sheer number of fiber strands required within the backbone routes to accommodate last-mile fiber to individual premises. This would require an additional backbone fiber build for many routes already in operation to support the future premise fiber growth. Additionally, the dark fiber network would lack fiber route diversity as the fiber routes used to serve customers would be linear between each service provider and each customer.

The recommended option for CW&L is to implement an open-access fiber network. This model transitions CW&L's current network from providing dark fiber services to providing lit transport services. Instead of providing dark fiber strands to service providers and individual customers, CW&L would implement a layer-2 transport network with active network electronics that would enable delivery of Ethernet services over the network. All end-user traffic would be aggregated onto the lit backbone which would allow the City to reclaim some dark fiber strands and conserve future dark fiber capacity. CW&L would maintain some dark fiber customers where required however; all new connections would utilize a lit fiber network provisioned by CW&L. The lit fiber network would aggregate traffic across a high-speed 10-Gigabit backbone that interconnects service providers to their customers, coordinated through W&L's equipment.

Service providers would interconnect with the City of Columbia's open-access network through a Network-to-Network Interface (NNI) with the City's network electronics. The City would strategically deploy field equipment known as Optical Line Terminals ("OLTs") in service areas throughout the City to serve local business districts (and potentially

neighborhoods in the future). This equipment would connect back to a centralized colocation facility or data center where service providers would interconnect with the City's network. Several data centers are currently available in Columbia that could accommodate these needs. Selection of the data center should be based on the location where the majority of service providers currently connect. This will enable the greatest number of service providers to interconnect with the City of Columbia's network at the lowest cost to both the service providers and the CIty. The network would provide a significantly higher amount of redundancy, enabling redundant 1 Gigabit and 10 Gigabit paths to service providers rather than linear dark fiber strands. This would introduce a level of fault tolerance or diversity into the core backbone providing higher reliability and availability to businesses and community anchors using the network.

Service providers would request new connections to their customers from the City. Once a customer signed with a service provider, the service provider would order transport service to the new customer. Once the service provider signed a service order with the City and paid any upfront charges, the City would build the last-mile fiber connection to the end customer and provision a transport service through its network back to the interconnection point with that service provider. The City would charge a monthly recurring fee to the service provider for use of the transport service for a certain contract term and at a certain bandwidth. The City of Columbia would maintain a rate structure based on bandwidth, with increasing charges for more bandwidth. This would allow the City to upcharge the service providers as customers utilized more bandwidth and implement a tiered pricing structure from lower-speed services to 1 Gigabit and 10 Gigabit services.

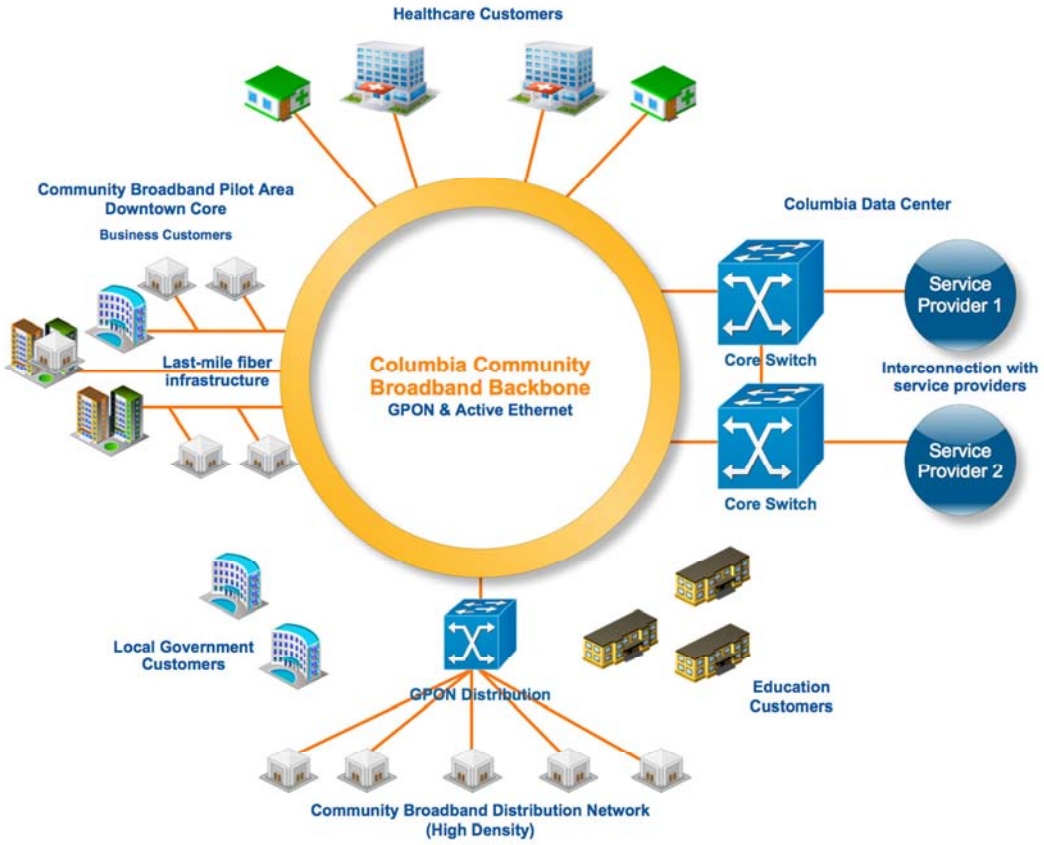
Development of the open-access network would result in the greatest benefits to Columbia's broadband environment and meet the objectives that the City of Columbia is looking to achieve in the broadband planning study. First, a single fiber-optic network with multiple service providers introduces a more competitive environment for businesses and community anchors as they now have access to more service providers than were previously available. Second, businesses and residents would have the opportunity to shop for services amongst a pool of providers and could potentially contract for services from multiple providers; Internet from one, voice from another, and transport or backup services from yet another. Third, businesses and community anchors have more control over their services and can switch providers more easily if they are not satisfied with their current provider. Since all providers will utilize a single City-owned fiber network, customers won't be charged a second round of installation fees if they switch from one provider to another; all participating providers will utilize the City of Columbia's open-access network[16]. Finally, open-access lit networks have traditionally introduced new providers into markets offering competitive rates as significant capital investment to enter these new markets is not required since the City is responsible for the costs of fiber construction and management.

[16] Customers will still maintain term contracts with service providers that may result in some barriers to switching.

An open-access lit network could also become a strategic asset for the City of Columbia's Water and Light Department as this network could be utilized in the future for various operational applications. Future metering options are dependent upon reliable communications to and from the grid management systems to the individual meters. This network would allow the Water and Light department the ability to run these operational type applications across the same infrastructure as the broadband services.

Some considerations for the City to evaluate in implementing an open-access network include the additional operations and management responsibilities required to maintain the network, recruitment, negotiation and provision of new services, and financing requirements to build the network. The City will be responsible for implementing and maintaining network electronics to manage services on the network. While this equipment is fairly simple to manage it does require the City to have technical resources to provision and monitor services as they are deployed. In order for service providers to consider providing services over the City of Columbia's network, the City must establish Service Level Agreements (SLA) that are similar to what service providers receive in the current telecommunications industry. The City of Columbia will also need to define business and operational processes to manage the network and ensure that service providers' needs are met. Further, deployment of an open-access network requires new funding for construction of last-mile fiber, network electronics, operational support systems, and potentially new staffing or an outsourced network management company who will operate the network on the City's behalf. These items are more fully described in the following sections.

Figure 9-1 – Columbia Community Broadband Network



The majority of the anchor institutions in Columbia are currently served by some type of fiber connectivity. Many of these anchors utilize the City of Columbia's fiber network for fiber connectivity between their facilities. For example, Columbia Public Schools uses the City's network to interconnect the various Schools to one another and to the School District's administration building. In addition, several service providers use the City's network to deliver fiber connectivity to business customers in the City. Analysis of last-mile fiber connectivity in Columbia clearly indicated that the City's fiber network could play a key role in additional build out of fiber connectivity to businesses and residents. This analysis includes detailed mapping performed by Magellan which is not included in this report due to requirements to keep critical infrastructure details as non-public information. Those who meet disclosure requirements may view these maps by contacting Columbia Water & Light.

Services

In an open-access network the City would not provide any retail services directly but would provide a new wholesale fiber solution to service providers that would utilize the network to serve residents and businesses within Columbia. In doing so, the City of Columbia could potentially provide a new source of next-generation broadband access to service providers while maintaining neutrality and non-discrimination and staying out of competition with service providers.

The CW&L network would provide Ethernet transport services originating from service providers to their customers. With open-access, the City's customers are service providers, rather than retail customers. This allows the City to maintain transparency and avoid any direct "customer service" issues with customers using the network.

Service Providers would deliver Internet, voice, video, and other broadband services using CW&L's open-access network

Operations

The operations of a Columbia Community Broadband Network would include backbone and last mile construction, provisioning, management and support, and operations and maintenance of the outside plant infrastructure. It is important to ensure these operational processes are within an organizations knowledge and experience. For Columbia Water and Light, many of these processes are engrained into their current business processes as a provider of electric and dark fiber services. CW&L also owns many of the systems, vehicles, trailers, and splicing equipment that would be used in a new communications utility.

The provisioning, management, and support of the active electronics used to power the network would be a new undertaking for CW&L. These processes could be developed in-house with the right staffing and training programs or they could be outsourced to a network operator. It will be necessary to develop a financial plan that develops an internal support structure using CW&L staff and systems benchmarking costs against a potential outsourced contract. Opportunities to partner with existing organizations that may be able to fulfill the network operator role should be explored as a locally sourced organization with a "local presence" could be very well received in the community.

Downtown Core Design

To illustrate preliminary design and cost considerations, the Downtown Core was identified as a location for potential Fiber-To-The-Premise (FTTP) build out due to the significant amount of existing fiber routes and the density of residential and commercial premises. For the Downtown Core, a FTTP build out would provide the opportunity to enable direct fiber-optic connectivity to businesses and residents throughout the area, through which the City could promote the downtown area as a "technology-enabled" region of Columbia equipped with 1 Gigabit next-generation broadband services. The Downtown Core represents an economic development opportunity for the City and establishing this area with a foundation of fiber-optic infrastructure would potentially allow stakeholders to gain access to these next-generation broadband services.

An important component of this analysis is the determination of the most appropriate fiber-optic architecture for the Downtown Core which contains a combination of commercial and residential parcels. The fiber-optic infrastructure could serve a mix of residents, small and medium businesses ("SMB"), enterprise businesses, and community anchor institutions. This mix requires that the fiber-optic infrastructure is able to handle

varying bandwidths from lower speed services that accommodate the needs of residents and small businesses to very high speeds that accommodate the needs of the enterprise businesses and community anchors. In addition, fiber-optic infrastructure must be value engineered to provide the greatest benefit to end users at the lowest possible cost. Fiber-optic construction costs can vary significantly based on the technologies required by the end users of the network. This analysis identifies the fiber-optic technologies that will meet the City's goals for economic and community development in the project while minimizing cost of deployment. It provides an evaluation of two likely scenarios the City would entertain in this infrastructure depending on the overall cost/benefit that the City would like to realize in the project and within the community.

Through analysis of the Downtown Core, Magellan developed a high-bandwidth, reliable fiber-optic infrastructure that would meet the needs of the various customer segments within this region of Columbia.[17] Magellan's analysis concluded that a Gigabit Passive Optical Network ("GPON") architecture with an Active Ethernet ("AE") overlay would provide the greatest benefits for the user base within the Downtown Core in terms of capacity, performance, reliability and future expandability, and for the lowest overall cost. The network consists of a fiber distribution and drop network that connects with the City's current backbone network and deploys new fiber throughout the District and into every premise. The network has the capability to provide any bandwidths required of end users up to and beyond 10 Gigabit to customers including residents, small and medium businesses, enterprise businesses, and community anchors.

Designed as an open-access network, it would allow the City of Columbia to remove some of the barriers of entry and more easily introduce multiple providers to the network which will promote competition in the Downtown Core and enable consumers to have more choices in their service providers. The City would also have the opportunity to significantly reduce pricing for next-generation broadband through careful financial planning, value engineering, and rate structuring of these services.

To accurately estimate costs in the Downtown Core, Magellan Advisors utilized a combination of current rates from the City's existing contracts with construction contractors and industry standard costs for those items that were not present in the City's current contracts. Any industry standard costs were derived from actual labor and materials costs from similar fiber construction projects in the Midwest region. Magellan Advisors entered all costing information into its FTTP Costing Model, providing a dynamic spreadsheet model that auto-calculates costs for FTTP construction (materials and labor) including the following categories:

[17] Magellan created mapping and preliminary engineering design for the Downtown Core estimates, but this detailed information is not provided within the report in order to keep critical infrastructure information non-public. Those who meet non-disclosure requirements may view this information by contacting Columbia Water & Light.

- Conduit construction
- Fiber-Optic feeder cable construction
- Fiber-Optic distribution cable construction
- Fiber-to-the-premise construction
- Common equipment
- Fiber-to-the-premise equipment

In order to accurately account for the number of potential premises passed, the Downtown Core was broken into 6 distinct zones. This allowed for an accurate count of residential and commercial premises which translated into the GPON and Active Ethernet architecture requirements as they relate to equipment and field components.

The estimated premise counts by zone are as follows:

Zone 1
- Residential – 57
- Commercial – 109

Zone 2
- Residential – 137
- Commercial – 58

Zone 3
- Residential – 155
- Commercial – 86

Zone 4
- Residential – 162
- Commercial – 128

Zone 5
- Residential – 0
- Commercial – 251

Zone 6
- Residential – 57
- Commercial – 83

With approximately 1300 premises in the Downtown Core, two field cabinets equipped with outside plant termination and equipment supporting GPON and Active Ethernet technologies will be required to provide access to customers in the area. The cabinets would ideally be placed on Columbia Water and Light property or other readily accessible sites or within City of Columbia right of way. The cabinets will be equipped with GPON splitters to provide fiber access to the immediate area while additional GPON splitter pedestals will be located strategically in each zone to provide access to the distribution cable which will provide connectivity to drop cable feeding each premise.

1 Gigabit or 10 Gigabit backbone connections between the cabinets will be required; ultimately providing a fully redundant self-healing ring for the network. Backbone fiber was not included in this estimate as it is assumed exiting Water and Light fiber could be used for this purpose.

The GPON and Active Ethernet architecture will allow the City to easily meet the needs of all current customers within the Downtown Core including residents, small to medium businesses, large enterprise businesses, and community anchor institutions and allow for future growth of high-bandwidth services in the Downtown Core. It will provide a simple upgrade path for customers without significant capital required to accommodate these needs. An Optical Network Terminal ("ONT") would be required to terminate premise fiber at each residential or commercial service location. There are many

different types of ONTs available to meet the need of single family, stand-alone commercial, or multi dwelling unit sites. In addition, several GPON and Active Ethernet manufacturers provide ONT devices which allow for auto detection of GPON or Active Ethernet service type; ultimately allowing for a standardized ONT device used for deployment as well as auto sensing technology which provides a service upgrade path to Active Ethernet where required.

Downtown Core Cost Estimates

The Downtown Core FTTP network as designed is estimated to cost approximately $2.25 million to $3.25 million dollars in the feeder, distribution, and drop network to connect roughly 1300 premises. It is assumed that several Columbia W&L fiber backbone segments could be utilized in the architecture, thereby utilizing existing backbone connectivity for interconnection of the OLT sites and cabinets. Drops to individual premise would be estimated to cost between $500 and $1250 per site with costs entirely dependent on the drop construction method.

The GPON/AE common equipment, including OLT and outdoor cabinets is estimated to cost $166,000, with an additional $30,000 in professional services. ONTs would have to be provided per premise and are estimated to cost $335 each or $430,000 for 1300 premises.

The Downtown Core Estimate Includes:

Feeder, Distribution and Drop Network	$2.25 - $3.25 Million
GPON/AE Platform (OLT)	$196,000
1300 ONT	$430,000
Total Capital Budget	$2.875 - $3.875 Million

Downtown Core FTTP Business Case

The goal of developing an FTTP Business Case for Columbia is to determine the feasibility of building an FTTP network to provide next-generation broadband to the community. To do so on a citywide level can be a significant undertaking and one that should be completed in the next phase to this Study. For the purposes of this Study, a targeted business case was developed that could be used to perform a much wider analysis of feasibility across Columbia. To do so, this Study evaluated the Downtown Core as a targeted business case for FTTP build out because it represented a high-cost area for constructing fiber infrastructure, had the potential to generate significant interest from the service provider community, and maintained a density of customers that could sustain a large capital investment.

Market Penetration

The Downtown Core sample build included the deployment of a fiber GPON/AE network to 1300 premises located within the area. Magellan believes attaining a take rate of 50% of premises over a 5-year period is reasonable with the right implementation, deployment, and marketing plan. This also warrants the buy-in and participation of service providers to market, sell, and compete for business and residential customers in the Downtown Core. Figure 9-2 on the next page shows estimated uptake of fiber transport services over the first 10 years of the project. Uptake is expected to slow after the first 5 years with an average annualized 5% growth rate. This results in the City serving 75% of the total premises in the Downtown Core.

Uptake	Year									
	1	2	3	4	5	6	7	8	9	10
Annual Uptake	5%	8%	12%	15%	10%	5%	5%	5%	5%	5%
Cumulative Uptake	5%	13%	25%	40%	50%	55%	60%	65%	70%	75%
Annual Connections										
Residential	28	45	68	85	57	28	28	28	28	28
Commercial	36	57	86	107	72	36	36	36	36	36
Cumulative Connections										
Residential	28	74	142	227	284	312	341	369	398	426
Commercial	36	93	179	286	358	393	429	465	501	536
Total Connections	64	167	321	513	642	706	770	834	898	962

Figure 9-2 – Estimated Uptake of Fiber Transport Services – First 10 Years

Service & Installation Revenues

In the open-access network, service providers will utilize what is known commonly in the telecommunications industry as a Type-II model. Type-II services are in essence fiber transport connections that service providers will lease from the City of Columbia using a standard wholesale rate structure offered by the City to participating service providers. Service providers will pay monthly recurring fees to the City for fiber connections based on the amount of bandwidth required by the service providers' end customers.

This study benchmarked the rates for these services against open-access community broadband networks currently operating throughout the country. It found that an average residential Type-II wholesale rate was $25 (rounded) per month and an average commercial Type-II wholesale rate was $150 (rounded) per month. The averaging process to determine these rates used market penetration for different bandwidth tiers to estimate the average rate.

Residential Average Rate Calculation

Type-II Bandwidth Tier	Uptake in Bandwidth Tier	Rate for Bandwidth Tier	Average Rate Calculation
10	60%	9.99	$5.994
20	30%	23.99	$7.197
50	9%	54.99	$4.949
100	4%	89.99	$3.600
1000	2%	179.99	$3.600
		Average Rate	$25.34

Commercial Average Rate Calculation

Type-II Bandwidth Tier	Uptake in Bandwidth Tier	Rate for Bandwidth Tier	Average Rate Calculation
10	50%	59.99	$29.995
20	35%	99.99	$34.997
50	10%	199.99	$19.999
100	5%	299.99	$15.000
1000	5%	999.99	$50.000
		Average Rate	$149.99

Using these average service rates and the projected connections over a 10 year period, the potential gross revenues over 10 years would be $6,765,980 as shown in Figure 9-3 on the following page.

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Revenues	Year									
	1	2	3	4	5	6	7	8	9	10
Annual Uptake	5%	8%	12%	15%	10%	10%	10%	10%	10%	10%
Cumulative Uptake	5%	13%	25%	40%	50%	60%	70%	80%	90%	100%
Service Charges										
Residential	$8,520	$22,152	$42,600	$68,160	$85,200	$93,720	$102,240	$110,760	$119,280	$127,800
Commercial	$64,350	$167,310	$321,750	$514,800	$643,500	$707,850	$772,200	$836,550	$900,900	$965,250
Total Service Charges	$72,870	$189,462	$364,350	$582,960	$728,700	$801,570	$874,440	$947,310	$1,020,180	$1,093,050
Installation Charges										
Residential	$710	$1,136	$1,704	$2,130	$1,420	$710	$710	$710	$710	$710
Commercial	$5,363	$8,580	$12,870	$16,088	$10,725	$5,363	$5,363	$5,363	$5,363	$5,363
Total Installation Charges	6,073	9,716	14,574	18,218	12,145	6,073	6,073	6,073	6,073	6,073
Total Gross Revenues	$78,943	$199,178	$378,924	$601,178	$740,845	$807,643	$880,513	$953,383	$1,026,253	$1,099,123

Figure 9-3 – Potential Gross Revenues – First 10 Years

Operating Costs

The City will need to decide how the community broadband network will be managed. Personnel, systems, and processes will be required to provide operations and management of the network once constructed.

The network would be supported either using in-house resources or outsourcing the operation to a network operator. While the City of Columbia has extensive experience in outside plant operations and maintenance, the equipment, associated provisioning, and monitoring processes may be a component that the City would rather outsource to a qualified network operator. These decisions should be weighed careful to determine the right mix of insourcing and outsourcing balanced with the financial performance of the network. This analysis would be a significant part of developing Columbia's Community Broadband Business Plan as the next step to this project.

Key operational costs that the City of Columbia will incur in its open-access network include:

- Outside plant operations and maintenance
- Inside plant operations and maintenance
- Network equipment maintenance, renewal, and replacement
- Software licensing and support
- Personnel costs to manage the open-access network
- Outsourced network operator costs for managing the network
- Debt service costs

For broadband utility operators, these costs vary, depending on the services provided, decision to insource or outsource, and type of network they support. Open-access networks are generally less costly to operate than other types of broadband utility networks that provide content and retail services. Based on analysis of cost structures from several active community broadband networks, The City of Columbia could expect its operating costs to average 25% of gross revenues and general overhead to average 15% of gross revenues. Additionally, The City of Columbia must factor in debt service costs if it plans to finance the network using a debt instrument, such as bonds or bank loans. If it uses a general fund or internal utility fund, these may not be applicable. Without debt service, the project would be expected to generate $4,059,588 of net income over the 10-year period. At this level, the City would achieve an 8-year payback on the project if the original network's capital $2.5 million and a 9-year payback if the project original capital cost of the network was $3.5 million.

Benefits to the Community

The results of the City's open-access network would be significant for the community. It would equip residents and businesses with the features they currently lack in broadband services, allowing them to conduct business more efficiently, enable new

capabilities, access more online applications, and do so reliably and at lower costs. For businesses, it results in gains in productivity, efficiency and overall competitiveness at a lower price point than they are paying today. For the City, it enables Columbia to showcase downtown as a technology corridor equipped for the needs of the largest and most data intensive businesses. It also supports technology transfer from MU to ensure the ideas and research becomes commercialized into new startups that will stay in Columbia, in part because of downtown's next-generation broadband services.

Measured in real dollars, the community broadband network provides a reasonable payback of between 8 – 9 years. When compared with other utility and infrastructure projects that may extend to 15 – 20 years at a minimum, the community broadband network provides a sound business case and soft benefits to the community. Beyond payback of the project, the soft, "off balance sheet" benefits to Columbia's community, in terms of potential job retention, job growth and GDP growth provide significant value that need to be included in the overall project.

Additional Community Broadband Expansion

The Downtown Core project can be used as a model for further evaluation of next-generation broadband deployment in other areas of Columbia. Building on this initial project the City of Columbia should evaluate its opportunities to expand the CW&L network to areas beyond the Downtown Core. Using open-access the City can continue this expansion in cooperation with service providers to serve other business and residential areas of Columbia with fiber-based broadband. In some cases these expansions will provide sound business cases for the City to consider while in others they may not, depending on the overall cost of the infrastructure, residential and business densities, and other factors.

Where sound business cases may not be available, particularly in the more rural areas of the community, the City of Columbia can complement its broadband utility development with analyzing funding opportunities that may be available in federal grant and loan programs; in cases where there is no business case to deploy, these programs allow broadband providers to build out into more rural areas with federal dollars. Federal grant and loan programs have been instituted to promote the expansion of broadband, primarily targeting communities in rural America. These programs are generally centered on key community functions such as public safety, education, and healthcare.

Communities can, in many cases, partner with private service providers to secure federal funding to build high-speed broadband infrastructure in their communities; mutually benefiting both the public and private partner. Some of these programs include the Department of Commerce's FirstNET Program, the Federal Communication Commission's Connect America Fund and Healthcare Connect Fund, and the Obama Administration's recently announced ConnectEd Program. Magellan suggests that the City of Columbia stay abreast of these programs as a key part of its broadband initiative and move forward to identify which programs may be appropriate to consider.

9. Next Steps

Columbia has a significant opportunity to expand its current fiber-optic network to broaden the service offerings provided throughout the community. The current network is a strategic community asset that can be enhanced with additional funding commitments and further build out. Doing so will allow the network to accommodate a new portfolio of communications, information, and entertainment services that may be provided to residents, businesses, and community anchors. Columbia's proposed broadband network would be capable of providing Internet and other telecommunications services with better reliability and performance than current services available in the community today.

Implementations of municipal broadband utilities are complex and challenging projects technically, operationally, and financially. Magellan Advisors recommends that the City of Columbia take a conservative and measured approach to implementing its utility; particularly focusing on building a sustainable operation through careful planning and phasing of the system.

There is much work still required to ensure that Columbia does so utilizing a conservative and measured approach. Based on the findings of this Study, Magellan has identified the following next steps for Columbia to consider in implementing its broadband utility. These items comprise pre-implementation tasks that Magellan believes are critical prior to Columbia implementing its broadband utility.

- Complete a full internal review of the Broadband Planning Study to ensure Columbia's management has a comprehensive understanding of the project, its financial and funding needs, technical and operational requirements, and timelines.

- Seek agreement and approvals from the Columbia City Council on the findings of the Broadband Planning Study.

- Gain approval from the Columbia City Council on the next steps in the CW&L broadband initiative, which would include the development of a formal Broadband Business Plan to begin immediately following approval of the Broadband Planning Study.

- Identify key resources within Columbia Water & Light who will manage the development of the Columbia Broadband Business Plan.

Implementing Public Policy Tools

The City of Columbia should begin to introduce public policy tools to assist in the deployment of fiber-optic broadband infrastructure. Policies and agreements such as Joint-Trenching agreements and Dig-once policies should be reviewed and implemented throughout the City of Columbia as applicable.

In addition, Broadband Infrastructure Standards for Outside Plant Facilities (see Appendix C), should be adopted by the City of Columbia and implemented in the City's engineering standards and applicable land use and development policies. These standards will ensure that the "right type" of broadband infrastructure gets deployed throughout Columbia whenever the opportunity presents itself.

Development of the Columbia Broadband Business Plan

The next step in the development of Columbia's Community Broadband Network is the creation of a comprehensive Columbia Broadband Business Plan. The business plan will lay out the business, market, technical, and operational strategies for the City of Columbia to use in further development of its network. It will focus on the City of Columbia's go-to-market strategy with participating service providers to deliver the best services at the lowest possible cost.

The Business Plan will also determine total costs for construction, operation, and management of the network and the timeline that the City of Columbia will use for build out; based on demand and feedback from service providers. It will entail a phased approach that maximizes the investments made in the network and a plan to recoup expenses in the shortest timeframe possible. A comprehensive financial and funding plan should be created as part of the Business Plan to measure financial performance of the network, identify sources of funding, and estimate the costs of debt service.

Magellan recommends that Columbia move forward to implement the Business Plan immediately to continue building momentum for the project towards a future implementation. Magellan estimates that a Business Plan can be completed within five (5) months. Once complete, the City of Columbia will have completed all planning and will be ready to begin implementation of the Columbia Community Broadband Network.

10. Appendix A – Glossary

3G – Third Generation	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 Columbia, 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	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.
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.

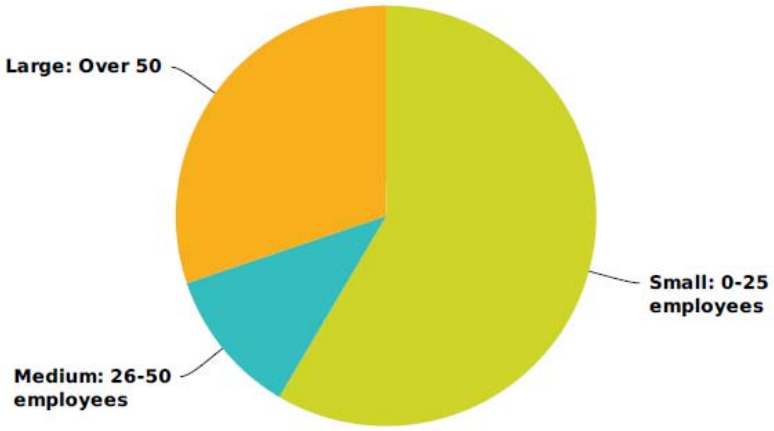
SONET – Synchronous Optical Network	A family of fiber-optic transmission rates.
Steaming	Streamed data is any information/data that is delivered from a server to a host where the data represents information that must be delivered in real time. This could be video, audio, graphics, slide shows, web tours, 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.

11. Appendix B – Survey Question Charts

Q1 Please provide the number of staff in your Columbia area location.

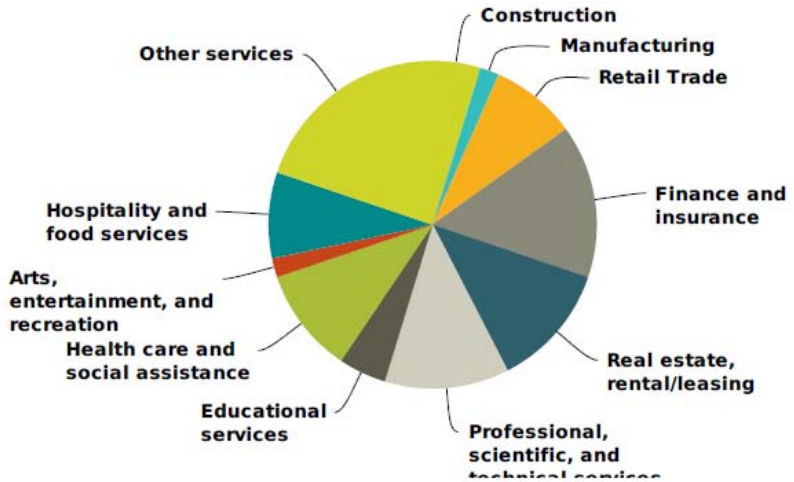
Answered: 106 Skipped: 2



Answer Choices	Responses	
Small: 0-25 employees	58.49%	62
Medium: 26-50 employees	11.32%	12
Large: Over 50	30.19%	32
Total		106

Q2 Please provide your industry.

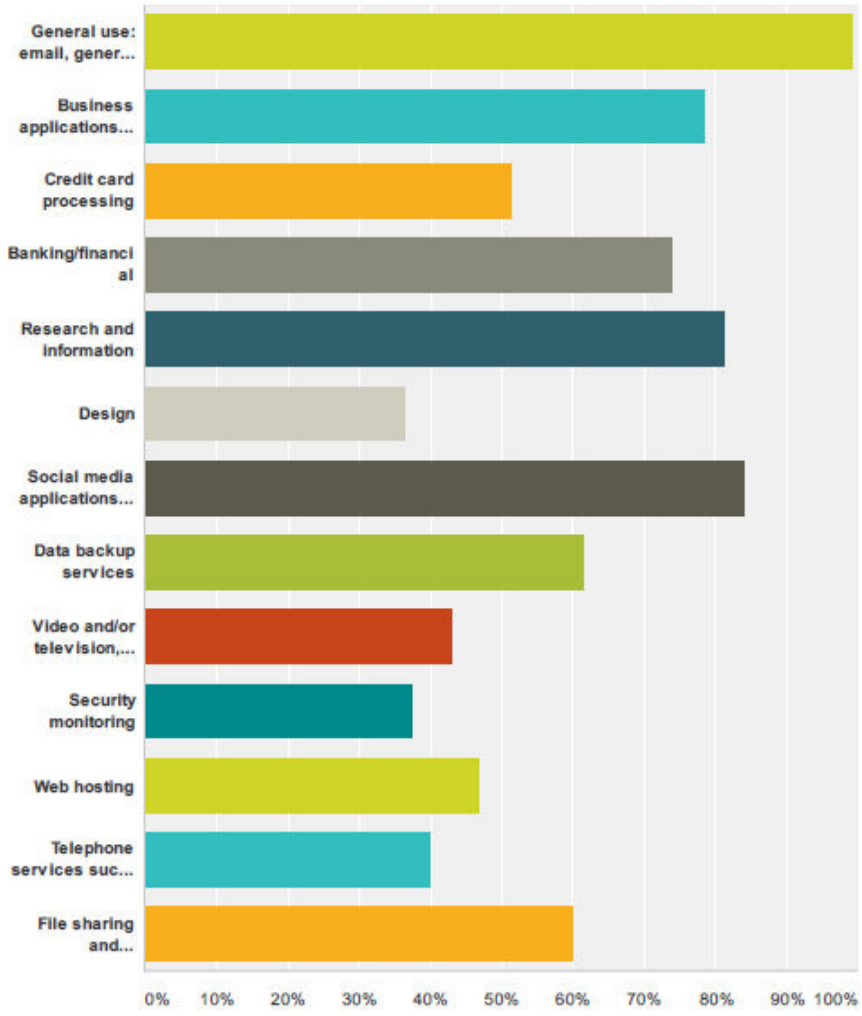
Answered: 106 Skipped: 2



Answer Choices	Responses	
Construction	4.72%	5
Manufacturing	1.89%	2
Retail Trade	8.49%	9
Transportation and warehousing	0.00%	0
Finance and insurance	15.09%	16
Real estate, rental/leasing	12.26%	13
Professional, scientific, and technical services	12.26%	13
Educational services	4.72%	5
Health care and social assistance	10.38%	11
Arts, entertainment, and recreation	1.89%	2
Hospitality and food services	8.49%	9
Other services	19.81%	21
Total		**106**

Q3 Please indicate all of the ways you use the Internet

Answered: 107 Skipped: 1



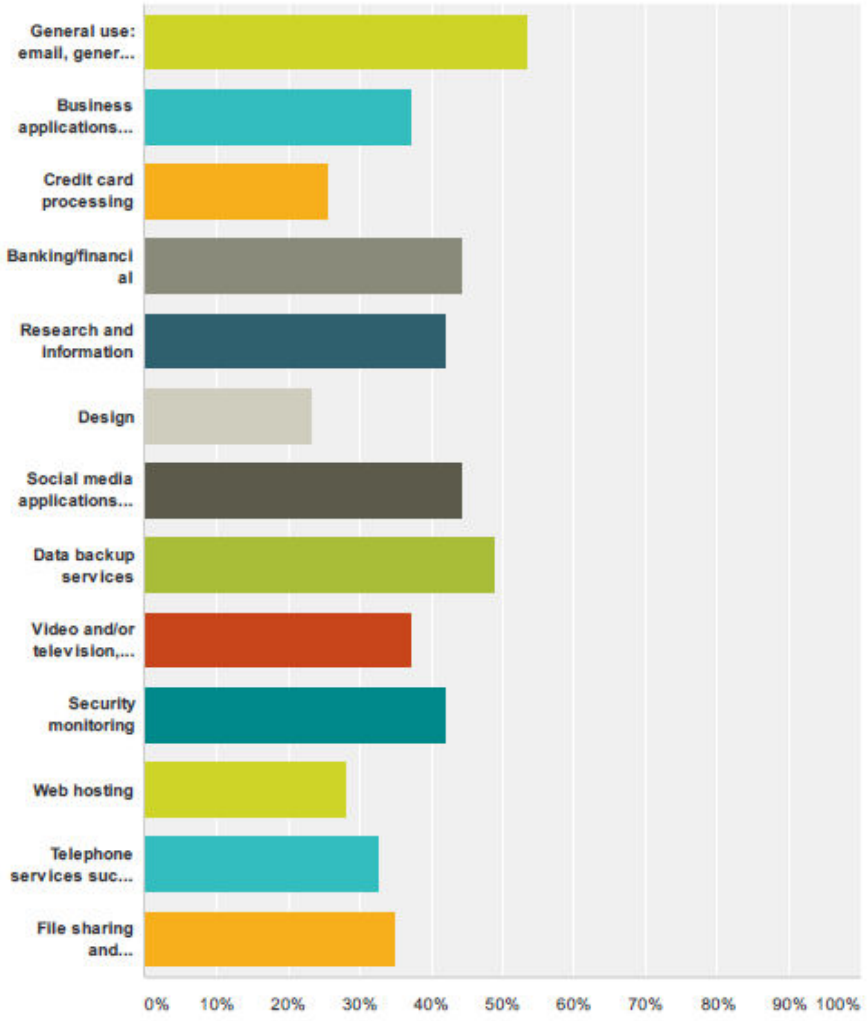
Answer Choices	Responses	
General use: email, general Internet browsing	99.07%	106
Business applications such as accounting, payroll or other	78.50%	84
Credit card processing	51.40%	55
Banking/financial	73.83%	79
Research and information	81.31%	87

Design	**36.45%**	39
Social media applications (Twitter, Facebook, etc.) for your business	**84.11%**	90
Data backup services	**61.68%**	66
Video and/or television, (including video conferencing)	**42.99%**	46
Security monitoring	**37.38%**	40
Web hosting	**46.73%**	50
Telephone services such as Vonage, Skype	**40.19%**	43
File sharing and collaboration	**59.81%**	64
Total Respondents: 107		

#	Other (please specify)	Date
1	We are a ISP	10/23/2013 11:55 AM
2	uploading big video files multiplt time throughout the day	10/21/2013 8:59 AM
3	Billing Services	10/11/2013 10:00 AM
4	streaming video	10/10/2013 8:08 PM
5	Tra	10/10/2013 5:27 PM
6	ERM	10/10/2013 4:58 PM
7	record and test transfers	10/10/2013 2:57 PM

Q4 Would your business benefit from the services below, if not in use currently? (all that apply)

Answered: 43 Skipped: 65



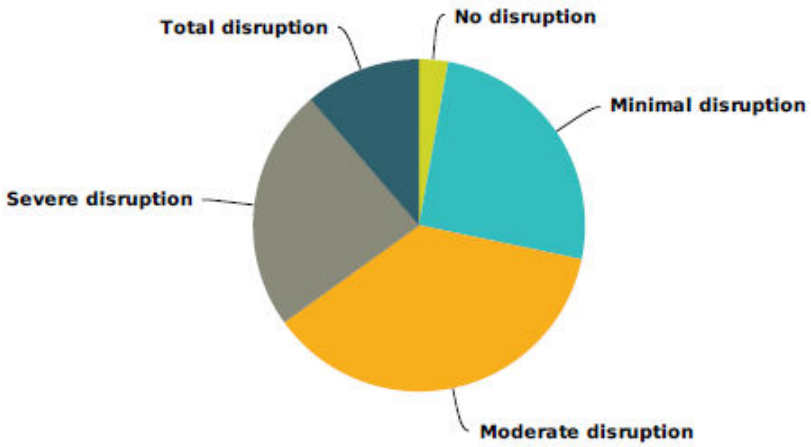
Answer Choices	Responses	
General use: email, general Internet browsing	53.49%	23
Business applications such as accounting, payroll or other	37.21%	16
Credit card processing	25.58%	11
Banking/financial	44.19%	19

Research and information	**41.86%**	18
Design	**23.26%**	10
Social media applications (Twitter, Facebook, etc.) for your business	**44.19%**	19
Data backup services	**48.84%**	21
Video and/or television, (including video conferencing)	**37.21%**	16
Security monitoring	**41.86%**	18
Web hosting	**27.91%**	12
Telephone services such as Vonage, Skype	**32.56%**	14
File sharing and collaboration	**34.88%**	15
Total Respondents: 43		

#	Other (please specify)	Date
1	Traffic Signals	10/10/2013 5:27 PM

Q5 Based on your current business use of the Internet, what impact do Internet problems, including reliability and speed, have on your business?

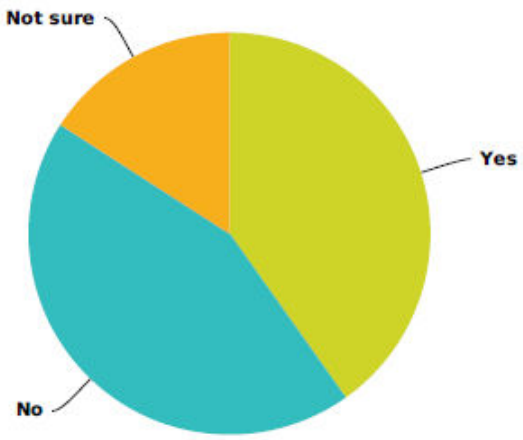
Answered: 106 Skipped: 2



Answer Choices	Responses	
No disruption	2.83%	3
Minimal disruption	25.47%	27
Moderate disruption	36.79%	39
Severe disruption	23.58%	25
Total disruption	11.32%	12
Total		106

Q6 Are your current Internet services sufficient for your business needs?

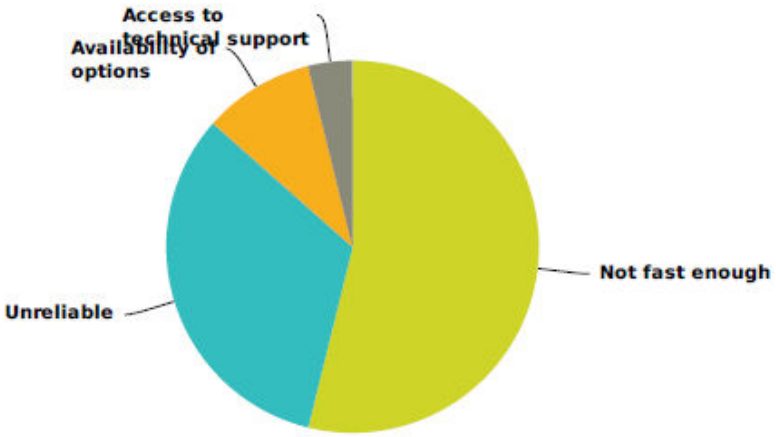
Answered: 107 Skipped: 1



Answer Choices	Responses	
Yes	40.19%	43
No	43.93%	47
Not sure	15.89%	17
Total		107

Q7 If you answered "No" to question 6, how are your Internet services insufficient for your business needs?

Answered: 52 Skipped: 56

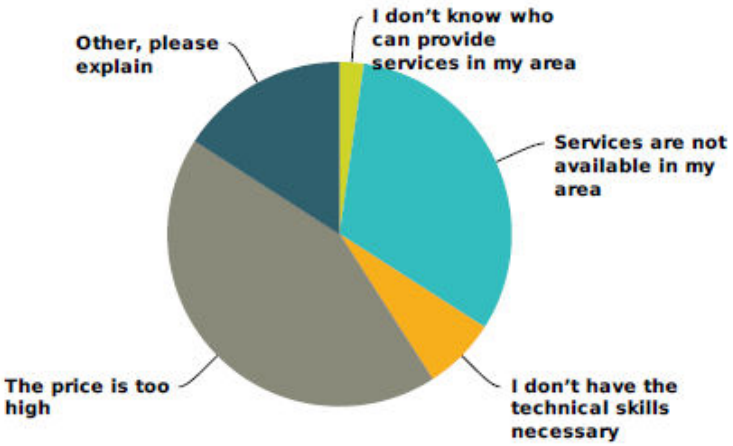


Answer Choices	Responses	
Not fast enough	53.85%	28
Unreliable	32.69%	17
Availability of options	9.62%	5
Access to technical support	3.85%	2
Total		52

#	Other (please specify)	Date
1	We struggle with getting fast enough internet and also the overall affordability	10/21/2013 9:01 AM
2	Too many outages	10/14/2013 4:10 PM
3	multiple locations across the state	10/11/2013 8:17 AM
4	also unreliable	10/10/2013 3:14 PM
5	Need to expand bandwith.	10/10/2013 3:02 PM

Q8 If you answered "No" to question 6 above, why haven't you upgraded your Internet services?

Answered: 44 Skipped: 64

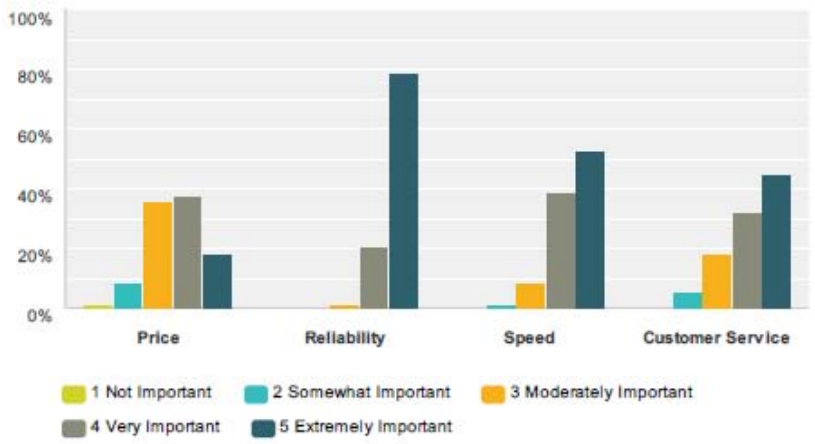


Answer Choices	Responses	
I don't know who can provide services in my area	2.27%	1
Services are not available in my area	31.82%	14
I don't have the technical skills necessary	6.82%	3
The price is too high	43.18%	19
Other, please explain	15.91%	7
Total		44

#	Other (please specify)	Date
1	We have looked at ALL available carriers and they are similar in unreliability factors	10/14/2013 4:10 PM
2	No provider can deliver adequate bandwidth. We've tried them ALL.	10/11/2013 9:41 PM
3	It's the best available for where I'm located	10/11/2013 11:06 AM
4	Speeds are too low, price is too high. Need fiber.	10/11/2013 9:56 AM
5	We are actively seeking alternative solutions	10/11/2013 9:33 AM
6	Too high and no reasonable option that also provides a landline	10/11/2013 8:15 AM
7	this is a corporate decision, not local	10/10/2013 5:25 PM
8	We have the highest internet speed.	10/10/2013 5:25 PM
9	We contract with two providers because they are both so unreliable so we can remain live.	10/10/2013 5:23 PM
10	limited services	10/10/2013 4:15 PM
11	Tied to corporate system	10/10/2013 3:48 PM
12	I am told I have the best they have to offer	10/10/2013 3:14 PM
13	Not sure who would really do any better. Conflicting info.	10/10/2013 3:12 PM
14	Just need to get it done.	10/10/2013 3:02 PM
15	I think we have the best availible in columbia at this time	10/10/2013 3:02 PM

Q9 Please rate your current Internet services on a scale of 1-5. With 5 being the most important.

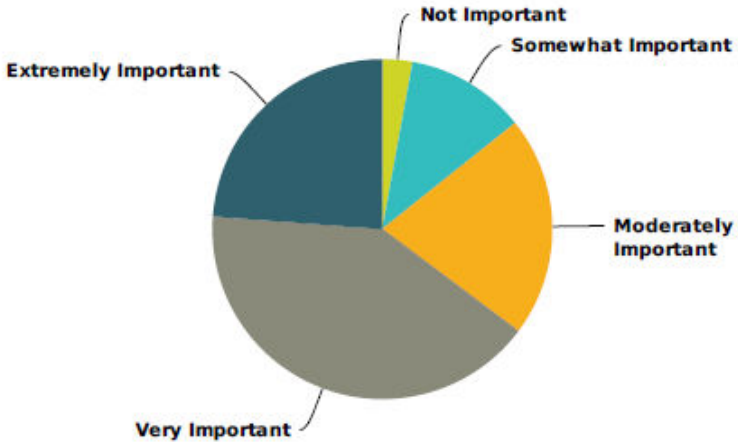
Answered: 107 Skipped: 1



	1 Not Important	2 Somewhat Important	3 Moderately Important	4 Very Important	5 Extremely Important	Total
Price	0.93% 1	8.41% 9	35.51% 38	37.38% 40	17.76% 19	107
Reliability	0.00% 0	0.00% 0	0.93% 1	20.56% 22	78.50% 84	107
Speed	0.00% 0	0.93% 1	8.41% 9	38.32% 41	52.34% 56	107
Customer Service	0.00% 0	5.66% 6	17.92% 19	32.08% 34	44.34% 47	106

Q10 How important is having multiple choices of Internet and broadband providers who can offer a wide range of pricing options and features from very economical to premium services to the long term success and growth of the business.

Answered: 105 Skipped: 3



Answer Choices	Responses	
Not Important	2.86%	3
Somewhat Important	11.43%	12
Moderately Important	20.95%	22
Very Important	40.95%	43
Extremely Important	23.81%	25
Total		105

12. Appendix C – Broadband Infrastructure Standards for Outside Plant Facilities

Broadband Infrastructure Standards for Outside Plant Facilities

Magellan has included the following sample high-speed broadband infrastructure standards as an example for Water & Light's consideration.

Communication Conduit for Fiber Optics

Scope of Standard

These guidelines identify and define the <INSERT NAME> requirements and policies for designing and installing telecommunications infrastructure and substructure at all <INSERT NAME> facilities and within the <INSERT NAME> limits and rights-of-ways. Use of, and compliance with these guidelines is mandatory for architects, engineers, and installation contractors working on <INSERT NAME> projects.

Design Guidelines

A. The <INSERT NAME> Infrastructure Standard is based upon the code requirements and telecommunications industry standards contained in the following guidelines. These guidelines will not duplicate the information contained in those references, except where necessary to provide guidance, clarification or direction.

B. In instances where several technical alternatives may be available to provide a design solution, these guidelines will identify the preferred solution to meet <INSERT NAME> needs. However, each facility and project is unique. Design for new construction will differ from design for retrofit of existing facilities. These guidelines will differentiate certain design approaches and solutions to be applied to new construction versus existing facilities, and different types of <INSERT NAME> facilities. However, designers and installers shall always use sound engineering judgment in order to comply with the requirements of the codes and standards identified in this section.

C. Designs will include, but not be limited to, all man-hole, hand-holds, conduits, roads, bridges, railway crossings, railways, buildings, utility poles, traffic light structures, traffic control boxes, other utilities structures, both existing and planned (new) that are pertinent to the construction of the fiber path.

D. As-builts will be provided in paper 8.5" x 14" format with all construction notes and geo-spatially correct measurements (verified by GPS), as well as digitally in AutoCAD 2008 or earlier and projected in the coordinate system <State of

California FIPS>. Scale should be 1ft. x 1 ft. As-builts will include cadastral boundaries to include right of ways and planimetric boundaries that includes edge of pavement. <INSERT NAME> base map can be provided upon request. As-builts shall be provided to designated City representative, incorporating any changes made during or after construction. Final As-builts shall be completed only once all Fiber-Optic cables in said project have been fully installed and tested and tests have been accepted by designated City representative prior to project closeout.

Reference Standards

A. Adherence to, and compliance with, the codes and standards referenced, and the <INSERT NAME>'s unique requirements and design solutions identified in the manual, is mandatory. Requests to deviate from the industry standards and design solutions prescribed in these guidelines may be submitted, on a case-by-case basis, to the <INSERT NAME> Engineer for review and approval. No deviation from the requirements of the National Electrical Code will be allowed.

B. Architects, Consultants, and Contractors shall always reference the most recent standards available. Most references listed below can be purchased directly from the individual standards organization, or from:

Global Engineering Documents
15 Inverness Way East
Englewood, CO 80112-5776
Telephone: (800) 854-7179 (303) 397-7956
Fax: (303) 397-2740
http://www.global.ihs.com

Codes, Standards, References, and Applicability

Design, Build Firm to follow all standards, references and technical special provisions referenced below.

A. NATIONAL ELECTRICAL CODE, NFPA 70
The National Fire Protection Association has acted as the sponsor of the National Electrical Code (NEC) since 1911. The original Code was developed in 1897 as a result of the united efforts of various insurance, electrical, architectural, and allied interests. The purpose of the NEC is the practical safeguarding of persons and property from hazards arising from the use of electricity. The NEC provides the minimum code requirements for electrical safety. In telecommunications distribution design, the NEC must be used in concert with the ANSI/EIA/TIA standards identified below, which are intended to insure the performance of the telecommunications infrastructure.

B. ANSI/TIA/EIA STANDARDS

The Telecommunications Industry Association/Electronics Industry Association (TIA/EIA) engineering standards and publications are designed to serve the public interest through eliminating misunderstandings between manufacturers and purchasers. The standards facilitate interchangeability and improvement of products and assist the purchaser in selecting and obtaining the proper product for his or her particular need.

The TIA/EIA Standards are updated every five years. Due to the rapid changes in the telecommunications and electronics industries, TIA/EIA publishes periodic Telecommunications Systems Bulletins (TSB), which provides additional guidance on certain technical issues that must be addressed prior to the next scheduled revision of the standards. The information contained in TSBs is usually incorporated into the applicable standard during the next standards revision. Standards and publications are adopted by TIA/EIA in accordance with American National Standards Institute (ANSI) patent policy. The TIA web site is: http://www.tiaonline.org/

C. FIBER OPTIC TEST STANDARDS, TIA/EIA-526

The TIA/EIA-455 series, together with its addenda, provides uniform test procedures for testing the fiber optic components intended for, or forming a part of, optical communications and data transmission systems. This series contains standard test procedures for optical fibers, cables, transducers, and connecting and terminating devices.

D. CABLING STANDARD, ANSI/TIA/EIA-568

The ANSI/TIA/EIA-568-A series, together with its addenda is the Commercial Building Telecommunications Cabling Standard. This standard defines a generic telecommunications wiring system for commercial buildings that will support a multiproduct, multivendor environment. It also provides direction for the design of telecommunications products for commercial enterprise.

The purpose of the standard is to enable planning and installation of building wiring with little knowledge of the telecommunications products that subsequently will be installed. Installation of wiring systems during building construction or renovation is significantly less expensive and less disruptive than after the building is occupied. TIA/EIA-568-A series establishes performance and technical criteria for various wiring system configurations for interfacing and connecting their respective elements.

E. GROUNDING AND BONDING, ANSI/TIA/EIA-607

The ANSI/TIA/EIA-606 (series) is the Commercial Building, Grounding and Bonding Requirements for Telecommunications. The National Electrical Code (NEC) provides grounding, bonding, and electrical protection requirements to ensure life safety. Modern telecommunications systems require an effective grounding infrastructure to insure optimum performance of the wide variety of

electronic information transport systems that may be used throughout the life of a building. The grounding and bonding requirements of this standard are additional technical requirements for telecommunications that are beyond the scope of the NEC. These standards are intended to work in concert with the cabling topology specified in ANSI/TIA/EIA-568-A series, and installed in the pathways and spaces designed in accordance with ANSI/TIA/EIA-569-A.

F. CUSTOMER OWNED OUTSIDE PLANT (OSP), ANSI/TIA/EIA-758
The ANSI/TIA/EIA-758 provides industry standards for the design and construction of customer owned OSP infrastructure. Unless specified otherwise in the <INSERT NAME>, standard OSP designed and constructed at all <INSERT NAME> facilities will be in compliance with ANSI/TIA/EIA-758.

G. TRANSMISSION PERFORMANCE SPECIFICATIONS, TIA/EIA BULLETIN TSB67
TSB67 is the Transmission Performance Specification for Field Testing of Unshielded Twisted- Pair (UTP) Cabling Systems. This bulletin specifies the electrical characteristics and performance requirements of field test instruments, test methods, and the minimum transmission requirements for UTP cabling. All testing of horizontal distribution cabling at <INSERT NAME> facilities will be performed with a TSB67 Level II test instrument.

H. ADDITIONAL HORIZONTAL CABLING PRACTICES FOR OPEN OFFICES, TIA/EIA BULLETIN TSB75
This document specifies optional practices for open office environments, for any horizontal telecommunications cabling recognized in TIA/EIA-568. It specifies optional cabling schemes and topologies for horizontal cabling routed through modular office furniture or movable partitions, which are frequently reconfigured

I. LOCAL AREA NETWORK ETHERNET STANDARD, IEEE 802.3 (SERIES)
<INSERT NAME> utilizes the Ethernet LAN protocol at all facilities. All <INSERT NAME> infrastructures must be designed to support the Institute of Electrical and Electronic Engineers (IEEE) Ethernet 802.3 standards, which define protocols and signaling technologies. All newly installed cabling must support 1000BaseX Gigabit Ethernet protocol based on the IEEE 802.3z standard.

J. THE BICSI TELECOMMUNICATIONS DISTRIBUTION METHODS MANUAL
The Building Industry Consulting Service International, Inc. (BICSI) is a Telecommunications Association whose mission is to provide state-of-the-art telecommunications knowledge to the industry, resulting in good service to the end user. BICSI develops and publishes the Telecommunications Distribution Methods Manual (TDMM). The TDMM is not a code or standard. The TDMM is an extensive volume of information on the various aspects of telecommunications systems and telecommunications distribution. The TDMM provides discussions and examples of various engineering methods and design solutions that can be selected and employed in order to meet the requirements of the NEC and

ANSI/TIA/EIA standards. Designers and installers are encouraged to use the TDMM as an engineering tool, within the constraints of the unique requirements of the <INSERT NAME> Infrastructure Standards.

K. THE CALIFORNIA DEPARTMENT OF TRANSPORTATION (CALTRANS) Refer to the current standard for CALTRANS Intelligent Transportation Systems, Technical Special Provisions for Fiber Optic Cable and Interconnect;

L. INTERNATIONAL TELECOMMUNICATIONS UNION – (ITU-T 652 Categories A, B, C, D) Refer to the international standard on Fiber Optic Cable covering "reduced-water-peak", "low-water-peak" and "full spectrum fiber". Material deployed in the project shall be ITU-T 652.D full spectrum compliant such as Corning SMF-28e for full compatibility and interoperability with legacy fiber, while providing low Polarization Mode Dispersion (PMD).

Definitions

Fiber Optic Cable: A cable that contains individual glass fibers, designed for the transmission of digital information, using light pulses.

All Dielectric Self Support (ADSS) Cable: A cable designed and constructed with non-metallic components, that is designed for aerial applications and does not require a separate cable messenger.

Loose Tube Cable: A cable designed and constructed with non-metallic components, which is designed for underground applications. These are "dry" cables using water swellable powders to protect against water penetration.

OTDR: Optical Time Domain Reflectometer. A device used for characterizing a fiber, wherein an optical pulse is transmitted through the fiber and the resulting backscatter and reflections are measured as a function of time.

Single-mode Fiber: An optical fiber with a small core diameter, in which only a single mode of light is capable of propagation. All Single-mode glass employed on project shall meet or exceed .35/.25dB/km optical attenuation and Polarization Mode Dispersion: $\leq$0.5 ps / km

Multi-mode Fiber: An optical fiber whose core diameter is large compared with the optical wavelength and which, consequently, a large number of light modes are capable of propagation.

Splicing: A permanent junction between optical fiber splices. May be thermally fused or mechanically applied.

Minimum Bend Radius: The minimum radius a fiber may be bent before optical losses are induced.

Guidelines for Designing Underground Fiber Optic Cable Routes

Governing Caltrans Indexes and regulations should be used as well as all applicable codes in force.

Conduit Placement

The conduit shall be placed at an offset from the roadway that meets the governing MDT regulations and indexes while still staying within the ROW. If this cannot be accomplished please raise issue to the <INSERT NAME> Project Engineer or liaison.

Depth (Minimum / Maximum)

The conduit used as the primary carrier of the fiber optic cable should be buried no greater than 42." and no less than 36." beneath grade except where code requires otherwise or directed in writing by the Project Engineer on behalf of the <INSERT NAME>.

Grade away from Buildings/Structures

The conduit shall be placed in such a way to as to maintain a gradual grade down away from buildings and other major structures.

Conduit type/ Inner Duct type

Standard placement shall be of quantity (2), 2" ID HDPE conduit direct buried/trenched/bored as appropriate to the construction needs (Color Orange and Blue). If specified an outer conduit shall be of the HDPE type, of suitable strength per the governing MDT indexes for the location of work. Conduit shall be 6" I.D. in size with quantity (2), 2" ID HDPE conduits (Color Orange and Blue)

All conduits and inner ducts should be cleared and cleaned prior to capping.

Conduit Turns & Transitions

All conduit turns shall be made with 45-degree bends or sweeps. At no time shall 90-degree bends be utilized in the outside plant arena, unless it is an already existing conduit, and approved by the <INSERT NAME>.

Exceptions may be made to this rule for work inside of buildings.

Trace Wire

A minimum #12 AWG trace wire should be placed along with all conduits put in place. This trace wire should maintain continuity from end station to end station. Where possible it is okay to use vaults/hand holes for joining the trace wire, while keeping these joints visible and out of the way of the fiber cable. Where not possible please use the small hand hole for joining the trace wire.

Marker Poles

Easily visible, marked, 6' fiber optic marker poles should be placed above the conduit at all major transitions to said conduit (turns greater than 25 degrees, etc.), where applicable. Please get marking poles approved by the <INSERT NAME> prior to installation/purchase.

Conduit Entering Hand Holes/Man Holes

All conduits should be stubbed up underneath the bottom of each manhole/hand hole leaving at least 8" but no more than 12" of visible conduit exposed. Conduit and inner ducts should be capped until use, after use they should be plugged appropriately to maintain the integrity of the conduit/inner duct from dirt and water.

Locate Information

As an as-built information gathering job, all splice points, vaults/hand hole/manhole/conduit turns of 45 degrees or greater should receive a GPS coordinate that is marked and labeled back onto the as-built drawings.

Building Entrances

All building entrances should be checked and approved with the <INSERT NAME> Project Engineer or liaison. Preference is given in the following order (but dictated by the facility itself) utilizing existing conduit to enter the building, core drilling and bringing conduit up through the floor, bringing conduit up the outside of a facility, attaching a pull box to the exterior of said building and entering through the wall of the building.

Box Sizing

Please confirm with the <INSERT NAME> your selection of boxes and box sizes PRIOR to utilization of said boxes in quote or design. All boxes utilized MUST meet the MDT applicable indexes and be on the MDT approved equipment list. The following sizes are to be used wherever possible:

16x22x18." (straight wall)
16x22x30." (flared wall)
17x30x18." (flared wall)
24x36x30." (flared wall)
30x60x36." (flared wall)

Please get all boxes approved during the design phase and prior to purchasing/installation of said boxes. All box lids shall have a Logo embedded on them. This logo is to be provided by the <INSERT NAME>.

Guidelines for Installing Conduit

Depth (Minimum / Maximum)

The conduit used as the primary carrier of the fiber optic cable should be buried no greater than 42" and no less than 36" beneath grade except where code requires otherwise or directed in writing by the Project Engineer on behalf of the <INSERT NAME>.

Reel Placement

Have the reel set adjacent to the manhole and use a fiber optic manhole pulling block assembly.

Conduit type/ Inner Duct type

Standard placement shall be of quantity (2), 2" ID HDPE conduits (Color Orange and Blue), direct buried/trenched/bored as appropriate to the construction needs.

If specified an outer conduit shall be of the HDPE type, of suitable strength per the governing MDT indexes for the location of work. Conduit shall be 6" I.D. in size with quantity (2), 2" ID HDPE conduits (Color Orange and Blue).

All conduits and inner ducts should be cleared and cleaned prior to capping.

Guidelines for Installing/Pulling Underground Fiber Optic Cable

Bend Radius

The main risk of damage to the fiber optic cable is by overlooking the minimum-bending radius. It is important to know that the damage occurs more easily when the cable is bent under tension, so when the installation is in process be sure to allow for at least the minimum bending radius. The number of 90-degree turns on a pull shall not exceed four (4).

Reel Placement

Have the reel set adjacent to the manhole and use a fiber optic manhole pulling block assembly from Sherman & Reilly (or similar).

Cable Slack

Please coil 150 feet of cable at transition points, termination points, and every 1500 feet.

Splices

All splice locations will be designated by the <INSERT NAME>.

Strength

The fibers in the cable will shatter under considerable impact, pressure or if pulling tensions exceed 600 LB, although from the outside of the cable this will not be apparent. With fiber optic cable the jacket of the cable and the Kevlar layer directly beneath give the cable its strength so please be sure to note and repair all nicks and cuts.

Installation

When installing use a swivel eye for pulling the fiber optic cable and conduit system.

Precautions

Please review the manufacturer's installation instructions prior to commencing with the installation. If any questions arise during installation please refer to the manufacturer's installation instructions, or notify the Project Engineer.

Testing

Perform OTDR test on each fiber in the installed cable, to verify the parameters of each fiber meet the system design criteria. Power meter tests should also be performed. All test results should be provided to the <INSERT NAME> Project Engineer in PDF format.

Safety

Contractor to provide proper work zone safety through an approved site-specific MOT (Maintenance of Traffic) plan.

Contractor to ensure that all personnel working in the field adhere to all PPE (Personnel Protection Equipment) requirements needed for the particular job location at all times.

Contractor to conduct pre-work safety briefings with workers prior to starting work each day/shift in the field. This briefing should be conducted by supervisor/manager in the field. All safety briefings should be logged in paper and this log easily accessible by <INSERT NAME> personnel in the field.

Locating Fiber Optic Cables

Aiding the locators, please install a #12 gauge wire. Pull #12 gauge wire in with the fiber cable for the underground conduit systems.

Terminate the ends of the #12 gauge wire in a handhold box. This box can be used by the locating contractor.