Broomfield Options for Improved Broadband Infrastructure

Draft 1.1

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Glossary of Terms

Prior to reading this report, it is important to review broadband-specific related terminology to assist with understanding. There are a myriad of terms specific to broadband networks, the most common include:

Speed

Internet Speed: Broadband speeds – both download and upload – are measured in "megabits per second," or Mbps. Bits are small units of data, with a megabit representing a million of them. The higher the Mbps connection received, the faster the Internet connection is in supporting data transfers. One thousand Mbps equals one Gigabit (Gbps).

Symmetrical Internet Speed: Equal speeds for upload and download (250 Mbps up and 250 Mbps down). Most Internet connections are not symmetrical and offer higher download speeds than upload speeds.

Bandwidth: The maximum data transfer rate of a network or Internet connection. "Bandwidth" refers to how much data can be sent over a specific connection in an amount of time. Often internet connections can appear to slow down at a household, business, or neighborhood level as increased usage (especially video usage) puts a strain on a network's bandwidth capacity.

3G: The term for third generation wireless telecommunications standards usually with network speeds of less than 1 Mbps**.**

4G: Fourth generation wireless telecommunications standards usually with network speeds greater than 1 Mbps.

LTE (Long Term Evolution): A 4G wireless broadband technology that provides speeds up to 100 Mbps download and 30 Mbps upload.

5G: Emerging fifth generation wireless telecommunications standards usually associated with network speeds of up to 1 Gpbs or more.

Infrastructure

Backbone: The "highway" of Internet connectivity delivered via a robust, high-fiber count fiber optic mainline. Backbones are physically connected to central offices, data centers, hubs, etc.

Redundant Backbone: Backbones two-sided fiber connections to ensure the physical network remains available should the fiber connection get cut. Additional redundancies are provided by sourcing multiple Internet service carriers at the central offices, data centers, hubs, etc.

Lateral Connections: With the backbone serving as the highway, lateral connections are the roads/fiber connections that connect homes and businesses to the Internet.

Conduit: The protective "house" of the fiber, conduit is the pipes that carry fiber optic cables.

Fiber: A flexible hair-thin glass or plastic strand that can transmit large amounts of data at high transfer rates as pulses or waves of light.

Dark Fiber: Fiber optic cable that has been installed, is available to use, but is not currently connected to any electronic devices and not transmitting any data. *Also referred to as excess capacity.*

Outside Plant (OSP): The equipment, fiber, conduit, towers, poles, etc. and any associated hardware located between one facility and another.

Gigabit Passive Optical Networks (GPON): This is equipment based at the premise that supports triple-play services, high-bandwidth, long reach, etc.

Dig Once: A dig once policy encourages service providers to work with a municipality or state on joint highway and utility planning and to consider the use of innovative practices and technologies that help to minimize excavation of the roadway.

Network Types

Middle-Mile Network: A "middle-mile" network is a fiber connection that delivers broadband services to community anchor institutions (i.e. schools, libraries, government buildings, public safety agencies, hospitals, etc.). This middle-mile network delivers a community with high speed and high bandwidth service, but it stops at the community anchor institution (CAI) and does not directly serve homes and businesses.

Last-Mile: The "last mile" of a fiber network refers to the connection from either the middle-mile or the backbone that provides services directly to homes and businesses in the community. A last mile network is a comprehensive network that connects everyone - CAIs.

Fiber-to-the-Premise (FTTP): A last-mile network that connects all buildings in a community.

Open-Access Network: A broadband network in which the infrastructure assets (including conduit and fiber) are made available under certain policies and procedures to multiple non-network owners.

Transport Network: Designed for transportation of data. A transport network delivers data from one location to another. These networks do not facilitate Internet connectivity to homes, businesses, community anchor institution (CAIs), but rather from one location to another, short or long distance.

Financing

Sustainable Network: A network that generates enough revenue to offset its costs and expenses. For new network providers, it may take several years before the network reaches sustainability.

Take rates: The percentage of households within a territory that subscribe to a broadband provider's service offering. Typically, take rates (also known as penetration rates) need to be between 40-60% for the provider to break even or be sustainable.

Public-Private Partnerships (P3s): Partners establish a legal partnership that balances and apportions risk, benefit and control of a last-mile network.

Indefeasible Right of Use (IRU): Commonly used in the industry to provide long-term access to assets. Conduit and fiber deployed is leased through an agreement called an IRU.

Public Safety Communications Research (PSCR): A federal program that anticipates awarding up to $30,000,000 in grants and cooperative agreements by May 2017.

E-Rate: A federal program that provides reimbursement funding for telecommunications services to schools and libraries based on free and reduced lunch program percentages within an applying jurisdiction.

Case Examples: Municipal Broadband Networks

Exploring options for a municipal broadband solution starts with examining what some other communities, in Colorado and across the United States, are doing and attempting to ascertain respective success levels. As each community is different, with different assets and incumbent service, it serves Broomfield to look at some of the emerging models.

While we are currently in a time of numerous emerging models and experimentation with municipal network options, very few municipal networks are completed and in full operation.

Colorado Examples

Longmont, Colorado
Model Type: Municipal Electric
Status: Operational citywide

Starting its build out in 2014, Broomfield's neighbor to the north now has a completed, fully-functioning and in service fiber network. Longmont's "NextLight" is a gigabit fiber network owned and operated by the city and its power utility, Longmont Power & Communications (LPC).

In 2013 Longmont supported the network build at a 70% level, approving a $40.3 million bond issuance to cover the startup costs of the Internet service. Even the $40 million price tag would have been significantly higher if not for the existing asset of an 18-mile fiber loop within the City's limits.

Taking an initially conservative approach, early buildout of last mile service was limited to providing service within proximity of the existing fiber loop. With significant take rates, the build continued throughout all of Longmont, with LPC serving as the operator for NextLight.

The "sustainable" network threshold in Longmont was 38%. The first launch area exceeded 40% (and sustainability) while areas that followed reached nearly 60% take rates.

Longmont has 38,000 premises and 92,000 residents within its approximately 30 square miles. NextLight offers symmetrical gigabit service at $50/month for those who signed up early. This $50 rate is for both the lifetime of the home as well as the owner should he/she move within city limits.

Late in 2016 the City voted to increase LPC's budget by $7 million, sourced from the Electric and Broadband Utility Fund balance to hire staff needed to support take rates twice as high as initially

predicted (feasibility study in 2013 predicted 27 percent while take rates average of 56 percent). Take rates will allow a swift payback of both the bonds and the additional appropriation.

Meanwhile NextLight is helping businesses and fostering growth by providing connectivity that's enabling the community to successfully compete with its neighbor to the south, Boulder. Local businesses that were looking to expand outside the city elected to stay and grow in Longmont thanks to the gigabit network. The network is also attracting regional work-from-home Coloradans looking for an ideal place to work and raise their family.

Rio Blanco, Colorado

Model Type: Municipal last-mile
Status: Operational

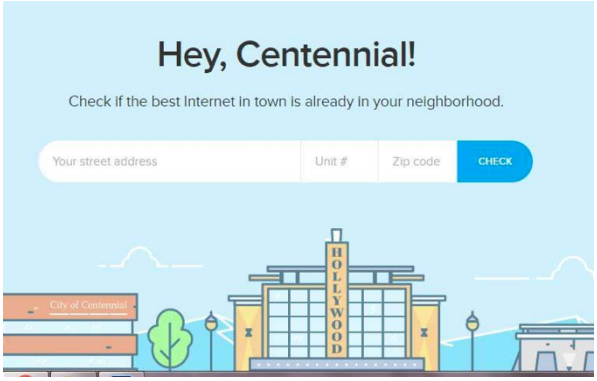
Rio Blanco County utilized county funds and Colorado DOLA grant funds to construct an FTTP network serving its rural community. The technologies deployed are a mix of fiber and wireless. The goal is ubiquitous coverage by 2018. This is one of the few municipal last-mile project that does not involve a municipal electric utility. Ubiquitous coverage means that every house and business within a community is served.

Rio Blanco County is building a fiber to the premises network in its main two population centers (Meeker and Rangley) and a shared fixed wireless solution designed to reach all other addresses. Additionally, Rio Blanco is building middle-mile fiber available for carriers to lease in the county.

Rio Blanco did not go through a feasibility planning stage, due to the large grass roots demand and previous cooperation and planning between community anchor institutions. The county knew it needed to invest in broadband and forged ahead with engineering, building mainline fiber to the heavier population areas and eight towers for wireless service in the more rural areas. The county's goal is ubiquitous coverage by 2018.

Centennial, Colorado

Model Type: Municipal middle-mile with last-mile provider
Status: Municipal middle-mile built, Taking preorders for 2018 last-mile



The City of Centennial (107,000 residents) is in the process of building a fiber backbone. The City is self-funding the middle-mile portion of the network build and will own the assets.

Centennial has selected Ting to be the FTTP service provider, who is currently taking signups for residential service for $89/month range for symmetrical gigabit speeds.

Canada's Ting has recently made a name for itself as a private carrier that will deliver fiber-to-the-premises (FTTP) services over a city-owned network. Already underway in Westminster, MD, Santa Cruz, CA, and Huntsville, AL, just to name a few. It should be noted, that none of these projects are complete and the level of success is to be determined.

While the network is the property of the City and eventually an "open network," Ting partnerships typically feature an "exclusive right to operate network" term of multiple years. While the build is the responsibility of the respective cities, Ting will lease and light the fiber and provide all equipment and Internet access. City's partnering with Ting are mitigating risk and staying out of the challenging ISP business.

Funding the build is a $5.7 million allocation from the general fund. The city council led by the fiber subcommittee looked at this funding as an infrastructure investment removing the expectation that this funding would be directly paid back.

Steamboat Springs, Colorado
Model Type: Municipal middle-mile with network operator vendor
Status: Build in process

Steamboat Springs has teamed with Routt County and 4 other entities to form a nonprofit. These partners are supplying some of the capital for a middle mile network with the bulk of the funds coming from a DOLA grant awarded to the project. The nonprofit hopes to lease dark fiber to attract last-mile providers to build out to homes and business. Construction will be complete in 2017.

National Examples

Westminster, Maryland
Model Type: Municipal middle-mile with last-mile provider
Status: Municipal middle-mile built, building last-mile according to demand/preorders

The City of Westminster is approximately a year or two ahead of Centennial's schedule, using the same city-funded middle-mile build and private operator (Ting) model. This network is often cited as an example of a successful P3 model, but it should be noted that this is still a work in progress as community signup and demand has been slow coming.

Numerous cities across the country are engaging with Ting in this emerging P3 model. Communities funding a middle-mile network then turning it over to a traditional carrier to manage and operate the network. Once the middle-mile network is built, that's where the city's role ends. That typically includes where the city's control ends. After footing the construction bill, the community does indeed ease itself of the burden of managing and operating the network in this model, it also loses control by handing it over to a partner that has an exclusive use contract that's sure to span decades.

Hudson Oaks, Texas
Model Type: Municipal last-mile with private provider operator
Status: In Process

Just outside of Dallas, the rural community of Hudson Oaks is in the process of building an FTTP to less than 2,000 residents. The town is self-funding the infrastructure build and will own the network assets. The town has found a wireless ISP that is going to become the FTTP service provider. The provider will be leasing the assets back from the town. The town has not yet started construction.

Ammon, ID
Model Type: Municipal last-mile
Status: Pilot completed

In the relatively affluent town of Ammon, Idaho the council found itself facing a rate hike as well as a significant ($110K) incumbent charge for connecting a new facility in 2011. It was then that the city decided to build its own middle-mile network which would create cost savings in an amount that it would pay for itself in five years.

Ammon then created a pilot area for households to pay for their own last-mile service through a property assessment of approximately $3,000 which could be paid up front or amortized over twenty years. Even with the $17 amortized fee, the new, more robust service that households received was still less expensive than the incumbent offering. The pilot community saw 60% or 239 homes opt-in to building their own last mile.

Just as interesting and innovative, the Ammon network is an "open access" network meaning multiple providers can lease the town's fiber to provide services. There are four internet service providers currently servicing Ammon with homeowners able to select (and switch to) the carrier of their choice through an online dashboard

Moving forward, Ammon will use an opt-in process to determine where to build first, next, and if at all.

Fairlawn, OH
Model Type: Municipal last-mile
Status: Initial phases completed

The City of Fairlawn didn't let a little thing like not having a utility stop them from offering its community broadband service – they simply started their own utility from scratch. Hiring operations, back office staff, sales staff, etc. Fairlawn established its very own "broadband utility" which is staring to roll out service to the community which has 4,500 households but sees approximately 50,000 visitors on its daily basis as a center of retail and business offices.

Dubbed FairlawnGig, this network delivers gigabit service to a market that previously did not receive more than 50 mbps down and 5 mbps up. FairlawnGig's 100% fiber network has rolled out to two "district areas" with the residential area seeing an 81% take rate while the commercial district had a take rate of 52%. Fairlawn's residential service is at an impressive level give that video/triple play services are not offered – only standalone service. Emboldened, FairlawnGig is working towards expanding its service to other district areas and then expanding to neighboring Akron and North Canton. The completed network will serve a footprint that consists of approximately 100,000 Northeast Ohio residents.

The network was funded through over $10 million dollars of general fund bonding. The vision of Fairlawn and the philosophy of the city is not to recoup the investment, but rather grow the economy, create jobs, and attract businesses to lift the entire community. The network's goal is less about sustainability and much more focused on service fees covering the operation and maintenance costs of the network. Service plans for internet residential service range from $30 for 30Mbps to $75 for a gigabit.

Howard County, Maryland
Model Type: Municipal middle-mile
Status: In service

Howard County, Maryland has a network of over 175 miles that was funded by a combination of County general funds, bonds and federal (ARRA stimulus) grants. The County owns and operates the middle-mile network with the help of outside vendors who handle maintenance and technical needs. The County is now an ISP as the internet provider and E-Rate provider for the entire County school system. The network also leases dark fiber and provides internet service to some commercial businesses. This is one of the most unique and successful municipal middle-mile models in the country.

Chattanooga, TN
Model Type: Municipal last-mile
Status: Completed

Energy ▪ Communications ▪ Community

Chatanooga is often held as a model of a successful municipal network. Deployed through a municipal electric utility, the Chatanooga Electric Power Board (EPB) serves 170,000 households and businesses in the Chattanooga metro area and surrounding communities.

To finance the fiber network, EPB's Electric division issued a bond for $162 million that included costs for construction, $39 million for electric equipment, and $26 million of interest payments. In addition, EPB's Electric division provided a loan of no more than $60 million to finance the Fiber Optics division startup costs.

On September 15, 2009, Chattanooga announced that it would officially start offering broadband internet connections. Shortly after, EPB received a $111 million grant from the Department of Energy that enabled it to roll out its smart grid and complete its 10-year deployment plan in less than three years. EPB initially offered 100 Mbps service but quickly increased its highest capacity package to 150 Mbps. Today Chatanooga offers gigabit internet for $70 dollars a month.

Summary

While these examples provide a starting point and insights, it's important to note that there is no one-size fits all model. The solution right for Broomfield will be dependent on several factors including:

- Anticipated municipal cost savings
- Appetite for risk
- Incumbent efforts to complete with and stop the muni network
- Financial resources in budget
- Ability to raise public funds
- Ability to sustain the network
- Private partners available
- Broomfield's preferred network type (last-mile versus middle-mile)
- Broomfield's preferred operational model (internal versus external)
- Economic development goals
- Residential and commercial demand for better service

Broomfield must determine its hypothetical ideal – what appears to be the best course of action and move forward. Initial decisions need to center on:

- Type of network (middle-mile and/or last-mile);
- Ownership and operating structure;
- Financial, cost and revenue plan.

Network Models

Getting more technical, the following section reviews the various types of network options and models.

Network Types

Other than an exclusive government use network there are two primary kinds of municipal networks, middle-mile and last-mile. For this paper, the term network is inclusive of all technologies. Rural networks are increasingly examining the feasibility of wireless technologies as building fiber is either cost or terrain-prohibitive. The landscape and proximity of building and homes to each other are not an in inhibitor in Broomfield.

Backbone Network

Every network has a backbone, the spine of the network that provides connectivity. Not to be confused with middle-mile, a backbone is merely data transport from a hub to a location, usually built along main corridors. Backbones do not connect to community anchor institutions, businesses, or homes. Often a backbone only network makes its dark fiber available for leasing.

Middle-Mile

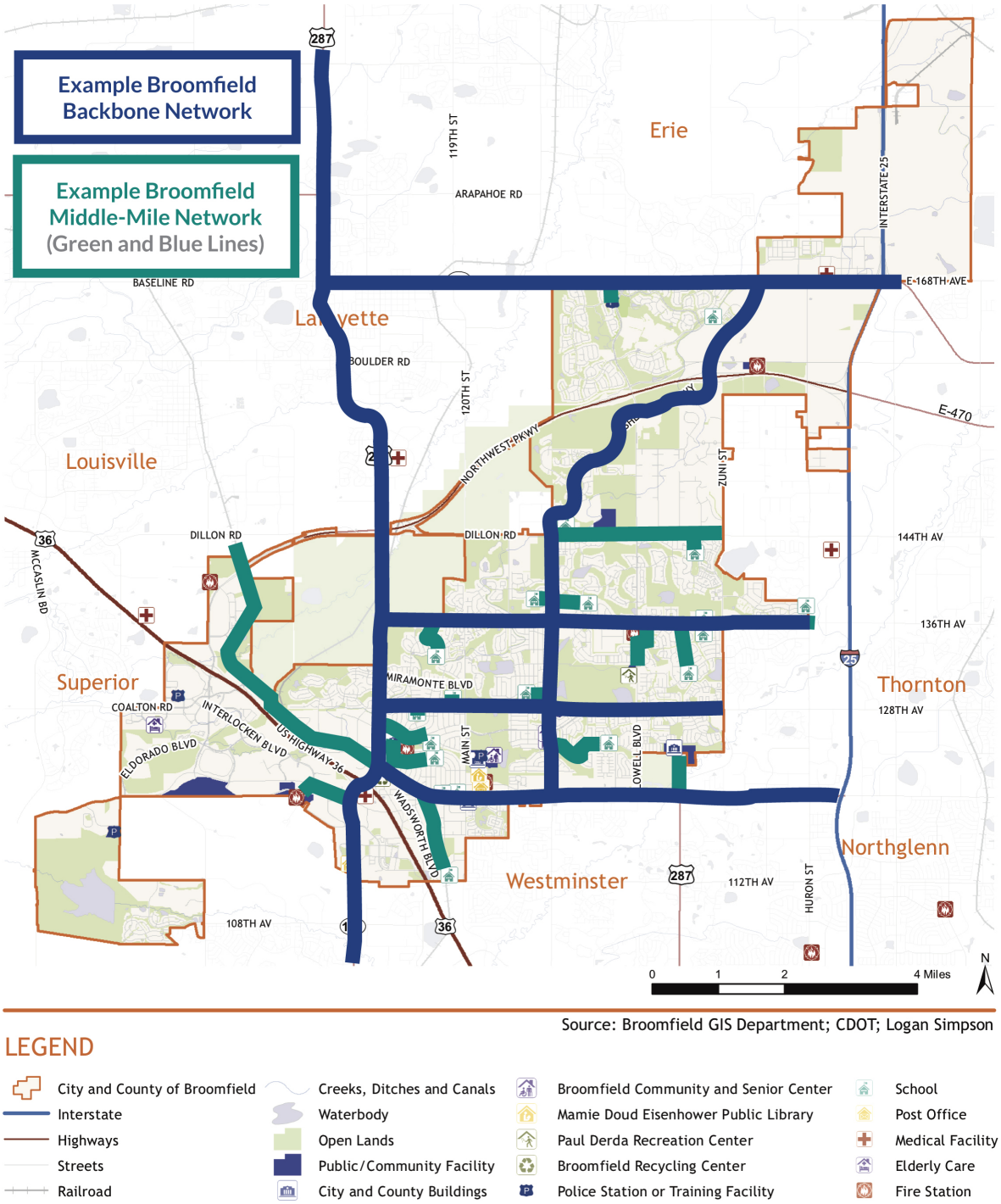
A middle-mile network connects community anchor institutions (i.e. schools, libraries, government buildings, public safety agencies, hospitals, etc.) from its own backbone but does not directly connect homes and businesses. Most municipal middle-mile networks are either directly operated by the municipality or outsourced to a network operator.

The middle-mile benefit to a community is it brings a high fiber count (fiber cables with strand counts of 144 and above) backbone that can be leveraged to provide direct connection to key institutions and enables infrastructure assets to be used by others to service homes and businesses. Third-parties may have an interest in leasing these assets because it helps with reducing their costs of deployment. A provider, then, would only need to invest in the connections to homes and businesses and would not have to build the backbone.

An example of this in Colorado is with the City of Centennial. The network is still under construction; however, it's a middle-mile design that will pass by many of the neighborhoods and apartment complexes within the City. Although the City does not intend to provide any residential services directly through its network, it is actively engaging broadband providers to determine strategic partnerships that

will use the City's network to accelerate broadband providers' fiber to the home deployments in the area.

Middle-mile networks cost less to deploy because they are only designed to reach anchor institutions. Middle-mile networks usually also bring in revenue from the leasing of conduit and fiber.



Source: Broomfield GIS Department; CDOT; Logan Simpson

LEGEND

- City and County of Broomfield
- Interstate
- Highways
- Streets
- Railroad
- Creeks, Ditches and Canals
- Waterbody
- Open Lands
- Public/Community Facility
- City and County Buildings
- Broomfield Community and Senior Center
- Mamie Doud Eisenhower Public Library
- Paul Derda Recreation Center
- Broomfield Recycling Center
- Police Station or Training Facility
- School
- Post Office
- Medical Facility
- Elderly Care
- Fire Station

Last-Mile

A last-mile network (also known as Fiber-to-the-Premises) offers service directly to homes and businesses in the community. Additionally, last-mile networks can serve the community anchor institutions that middle-mile networks do. When a community takes on the last-mile, it is unusual to lease excess fiber or conduit as leasing these assets to another entity creates competition and less likelihood for a community's network to become sustainable.

Requiring fiber to every door, last-mile networks are the most expensive community network to deploy. With this high expense comes great benefits for households, businesses, and organizations. The Fiber Broadband Association estimates that bringing internet fiber service to homes increase home values by 3.2%. Providing businesses fiber creates economic growth opportunities, innovation zones, attracts and retains businesses who need high-capacity Internet. Businesses like ones in Denver and Boulder who may be looking for alternative business locations.

In addition, municipal last-mile networks generally need an operator to partner with the municipality. Most successful municipal last-mile networks are in communities with a municipal electric utility as these communities already have pole infrastructure in place to offset costs, billing systems in place to serve customers, and staff to use and then ramp up. The best example of a municipal last mile at work in Colorado is Longmont, which deployed a fiber-to-the-home network through its municipal electric utility. The Cities of Loveland and Fort Collins are also considering this solution through their municipal electric utility.

For a last-mile network to be sustainable, it must achieve a take-rate between 40-60%, meaning the number of the residential and business accounts signing up for service.

Other options for last-mile networks include establishing a public-private partnership which is discussed later.

Open Access Network

An open access network features infrastructure assets (conduit and fiber) that are available for lease under certain policies and procedures to multiple non-network owners. Usually this occurs in the form of dark fiber leases. Publicly funded grant programs offered by the federal and state government often require networks to be open access. This means multiple internet carriers can lease the same assets to provide competing internet service within a community.

On paper, open access seems like a great idea. Middle-mile networks that lease dark fiber and conduit are by definition open access – otherwise, networks would be limited to one customer. Middle-mile networks need multiple users to be sustainable. Further, allowing multiple providers to access a network should mean increased competition and lower prices. A municipality should benefit from more users on the network.

However, open access is a hotly debated topic particularly as it relates to last-mile networks because the greater the number of providers, the harder it is for a new-entrant provider to meet its take-rate goals and make a profit. Internet Service Provider (ISP) "A" may not appreciate it if the owner of the fiber leases to ISP B, C, D, E, F, etc. In this case, no one may reach the take rates needed to cover their investment as they all compete for the same customers. Perhaps open access can work, but what's most likely is that it only works with a limited number of ISPs. There are exceptions, if the municipality is financing the network (i.e. Fairlawn) then ISP payments for access can be lower and allow more ISPs to succeed in a multiple ISP environment.

Technology

The most expensive part of deploying a broadband network are not the materials (fiber and conduit), but rather the construction. If a community already has conduit then the cost of a fiber buildout will decrease significantly. If there is not conduit in place, an initial build should install extra conduit banks and high-count fiber to cover all current and future needs. Think "dig once."

Excess[1] conduit and fiber deployed by a community is often leased through an agreement called an Indefeasible Right of Use (IRU). IRUs are commonly used in the industry to provide long-term access to assets and typically run 20-30 years. While pricing varies based on regional demand and conduit available, pricing is usually based on a per-foot basis. Below is a chart that provides examples of three different pricing structures for conduit:

Location	Price	IRU Term	Total Cost
Boulder, CO	$5.50 per foot	20 years	$722,271 in a one-time payment
Lincoln, NE	$65,000 per year	20 years	$1.3 million paid monthly over 20 years with an escalation clause not exceed CPI.
Baltimore, MD	$3.00 per foot (appx)	Negotiable	Variable depending on how much leased. City requires any new conduit built by provider to be owned by City

Dark Fiber

Also, referred to as "excess capacity," dark fiber is fiber optic cable that has been installed and is available for use but has not been connected and "lit" to transmit data. Fiber optic cable is available with a wide variety of capacity, with fiber strand counts ranging from 12 strands (low capacity) to 1400+ strands (extremely high capacity). The strands not in use by the owner (or other entity) are considered dark fiber strands that can leased.

[1] Conduit and fiber strands that will not be used by the municipality.

Like conduit, dark fiber pricing varies and includes but is not limited to the following criteria:

a. Availability of dark fiber in the area;
b. Market rate of other dark fiber in the area (sometimes very difficult to ascertain);
c. Number of strands to be leased (minimum of two);
d. Amount of footage to be leased (per mile);
e. Term of years requested;
f. Payment up-front versus over time;
g. Amount of strands remaining that may not be marketable (i.e. if an entity only leases a portion of a route, the corresponding strands on the remainder of the route may not be usable. Often you will see a provider require the entire route to be leased for this reason.)

Dark fiber is priced per-strand, per mile, per month basis. Prices range from $5-$750 per pair of strands with a typical IRU term of 10-20 years. Payment terms vary but one-time payments require less administrative work and book keeping and provides a large infusion of cash. This one-time payment may be cost prohibitive for smaller customers entities may not be able to provide one-time payment. There is also a downside for a community with a one-time payment as fiber market value over the course of twenty years is difficult to ascertain. Ultimately, each should be considered in the negotiating process. Below shows some dark fiber pricing in both urban and rural communities across the country.

Dark Fiber Pricing Examples for a pair of fiber strands. Pricing in large urban areas are more expensive due to demand, the cost of construction in urban concrete areas and lack of available dark fiber.

Urban Area	Up-Front Cost	Maintenace per route mile/per year	Price per month/per mile	Price per year	Term (Years)
Palo Alto	0	0	$355-591	$4.360 - $7,062	Unknown
California Large Urban	0	0	$320 - $600	$2,880 - $7,200	Unknown
Illinois Urban	$3,000	$600	$27.50	$330	20
Virginia Urban	$1,500 - $2,000	0	$100 - $550	$1,200+	20

Rural Community	Rates Per Pair and Per Month	Maintenance	Up-Front Fee per pair	Term
California	$9	$250	$1,000	20
Illinois	$7	$150	$750	20
North Carolina	$7	$250	$750	20-25
Maryland	$90	0	0	20

Maintenance can be included in the cost of the IRU or added as an additional fee. Maintenance fees range from about $200-700 per mile, per year.

The below chart shows what a rate schedule would look like for a price per pair of strands ranging from $10 - $100 exclusive of any up-front or maintenance fees.

Rate Schedule Based on Flat Fee Per Pair of Strands										
Per Pair	**Per Mile**	**Per month**	**Per Year**	**10 Yrs**	**20 Yrs**	**Per Mile**	**Per month**	**Per Year**	**10 Yrs**	**20 Yrs**
$10	1	$10	$120	$1,200	$2,400	10	$100	$1,200	$12,000	$24,000
$20	1	$20	$240	$2,400	$4,800	10	$200	$2,400	$24,000	$48,000
$30	1	$30	$360	$3,600	$7,200	10	$300	$3,600	$36,000	$72,000
$40	1	$40	$480	$4,800	$9,600	10	$400	$4,800	$48,000	$96,000
$50	1	$50	$600	$6,000	$12,000	10	$500	$6,000	$60,000	$120,000
$60	1	$60	$720	$7,200	$14,400	10	$600	$7,200	$72,000	$144,000
$70	1	$70	$840	$8,400	$16,800	10	$700	$8,400	$84,000	$168,000
$80	1	$80	$960	$9,600	$19,200	10	$800	$9,600	$96,000	$192,000
$90	1	$90	$1,080	$10,800	$21,600	10	$900	$10,800	$108,000	$216,000
$100	1	$100	$1,200	$12,000	$24,000	10	$1,000	$12,000	$120,000	$240,000

If Broomfield builds and leases conduit and/or dark fiber, Broomfield must take the following into consideration:

- The map and inventory of all assets leased and available to be leased must be kept current and active;
- Maintenance of the conduit and the fiber generally falls to the network owner and so the owner must have policies and procedures (and staff) in place to meet any service level agreements (SLAs) that the lessees have in place. In other words – the network owner must be able to repair fiber cut within an emergency window to prevent downtime outages to the network customers;
- The network owner must have a plan in place for third-party network access;
- The network owner must have a process in place for interested third-party applications as well as templates for legal agreements and other documents.

It may be too much of a challenge for Broomfield to oversee the above tasks, in which case hiring a third party to manage these activities is perfectly acceptable.

Network Operation Options

Ownership and Operating Structures

There are multiple kinds of ownership and operating structures. The below chart details four basic types:

Type of Operating Structure	Description
Internally Managed	This is a municipal network that is 100% owned and internally managed and operated. There are very few of these around the country. This can be middle-mile or last-mile.
Oversight of Outsourced Management	In this structure, the municipality owns the assets and provides oversight, but outsources the management and operations to a third-party entity that could be a private provider or a nonprofit. This can be middle-mile or last-mile.
Third-Party Owned and Operated	This is a network entirely owned and operated by a third-party but one where the municipality provides some resources (not financial) and benefits from the service. This is usually a last-mile structure and one where the municipality has little control.
Hybrid	Another option is to create a hybrid model that combines one or more of the above options. An example of a hybrid option is a public-private partnership discussed in the financing section.

Internally Managed and Outsourced Operating Structures

While rare, there are municipalities in other parts of the country that have successfully built and internally managed middle-mile networks without private sector investment. In Maryland, there are at least 10 municipalities that own and operate their own networks.[2] These networks are thriving with each jurisdiction continuing to make ongoing investments.

An example of a middle-mile network with outsourced management in Colorado is Northwest Colorado Broadband (NCB). NCB is a nonprofit formed by 6 partner entities including Routt County, City of Steamboat Springs, Steamboat Springs School District, the Steamboat Springs Chamber, Yampa Valley Electric Association, and Yampa Valley Medical Center. In this project, the partners are providing some funds for the initial build but with the bulk of the costs paid for by a grant awarded from Colorado Department of Local Affairs (DOLA). Multiple partners own the assets but an IRU is being granted to Northwest Colorado Broadband for use of the assets. NCB will oversee a contract with a network

[2] Maryland ICBN jurisdictions funded their initial build in large part due to a $115 million dollar federal grant under a Broadband Technology Opportunities Program grant awarded in 2010. However, jurisdictions did contribute more than $20 million dollars in cash and in-kind matching funds. Prior to receiving the grant, each jurisdiction operated its own smaller fiber network.

operator and other vendors. This middle-mile network will be making its assets available to lease to third parties.

Public-Private Partnerships

Hybrid Structure - Public-Private Partnerships

Public-private partnerships (P3s) are a relatively new phenomenon in broadband. A P3 is a legal partnership wherein the partners balance and apportion risk, benefit and control. Recently, more and more municipalities are exploring establishing a P3 for deploying and operating last-mile networks. But what does that mean?

There are many different types of P3s. They include but are not limited to the following:

Public Facilitation, Private Investment

One type of partnership a community/municipality can develop with a carrier requires no cash investment. A community can provide economic incentives and logistic experience to help pave the way for more powerful broadband service. An investment entity steps forward to provide funding for the network in exchange for a long-term payback on their investment. This is a traditional P3. The investment entity usually requires an ownership stake in the assets and sets other conditions such as requiring the municipality to provide a credit backstop to guarantee investments. The municipality generally does not need to provide cash contributions. An investment entity is only likely to be drawn to projects that cost a minimum of $15 million dollars.

This is not a “pay for play” model with tax incentives consisting of the only exchange. New networks can be built on the foundation of your community’s already existing fiber and/or conduit as well as available land – all for low or no-price lease.

This model also relies on a municipality’s ability to encourage private sector investment by removing roadblocks and creating efficiencies (pole rights, etc.) that a private company cannot achieve on its own. This model is, obviously, ideal for municipalities and regions that need to or want to minimize cost – and have no desire to get into the ISP business themselves.

Keep in mind that as there is no specific investment and/or control, a city should tread lightly when entering these relationships to choose a partner with a track record of delivering on promises. Before attracting an outside partner, sit down with your community’s current carriers and offer them the same assistance and tax incentives you will an outside party.

Another risky proposition with this model is that the private sector invests or "cherry picks" the areas where it is most profitable to build. ISPs profit goals diverge with a community's economic development goals.

Public Funding with Private Management

A partnership wherein the municipality provides all funding and owns the network, but does not operate or manage the network.

Toll roads, with private management, are nothing new. A new and emerging trend is communities funding a network and turning it over to a traditional carrier to manage and operate the network.

What makes this model different than the purely municipally funded and operated network is that once the network is built, that's where the city's role ends. With public funds footing the construction bill, this is an expensive option. The private partner does not merely operate and manage the network; often the selected partner takes the lead in design and engineering. While the municipality does not have the burden of managing and operating the network in this model, it also loses control by handing it over.

Shared Public and Private Investment

A partnership wherein both the municipality and provider contribute funding and resources to the project. The two sides share in the capital, operating, and maintenance costs, spreading the risk across the public and private sectors.

Often this partnership takes the form of a community building the fiber network, leasing the network fiber to a private carrier who will in turn pay operating costs operating risk (and potentially share some capital risk).

This model opens more opportunities for rural network builds as the community is putting up capital in areas that may not have the "business case" a private carrier needs to build. With public investment however, that business case comes into focus as an opportunity for the carrier to provide/upgrade services they provide a given community. A community needs to take stock of whether they see broadband as a utility, important enough to spend significant dollars for a disparate population. In this case, a community that invests is acknowledging not only the economic development advantages it may receive, but also the city's obligation to provide adequate service.

Meanwhile the private carrier/partner is required to invest less, allowing it to realize a return on investment in an acceptable frame of time for its business.

The public sector also has access to the network to provide better services and advance public safety, healthcare, education, and economic development opportunities.

The type of P3 Broomfield will choose should depend on several factors, including:

- Whether the provider can make a profit with take rates that justify an investment;
- The sum amount of financial resources the municipality can provide;
- Whether the municipality is willing to be flexible on asset ownership;
- Whether there is a private entity that is interested and viable;
- Whether the municipality and private partner can come to agreement on terms and requirements.

A recent trend by communities interested in exploring P3s is for the municipality to issue a Request for Information (RFI) to invite potential interested partners to submit proposals. It is unclear whether this strategy is entirely effective in ultimately establishing a P3. However, there are instances where the RFI itself has created confusion and significant delay in network planning – particularly where the RFI is issued prematurely, is open ended, vague, or includes too many difficult to meet requirements.[3] In some cases, communities have had to re-issue the RFI with new requirements and/or hold multiple rounds of interviews. Communities thinking of utilizing this RFI approach to finding partners should do so cautiously and should identify potential local partners first.

Even though P3s are widely pursued as options for last-mile municipal broadband networks, a P3 is difficult to establish. This is a larger concern in rural areas than Broomfield as the rural cost of the build is high and the number of potential customers makes it difficult to justify the investment.

Financing

How to finance a municipal network is one of the key questions a community must answer before moving forward with network design. To assist Broomfield understand funding options, this section will provide information that includes the following:

- Capital, revenue bond and self-funding options;
- Grant funding options (governmental and private);
- Other public funds (E-Rate, DOLA);
- Private funding options (P3)

Once a network model and operating structure has been determined, it is recommended to complete a sound business plan that includes costs, revenue projections and a financing plan. While some high-level costs need to be estimated prior to completing a full business plan, it is recommended that the full plan is completed in coordination with any financial contributors or provider-partners.

[3] P3 proposals are time consuming and expensive to develop. Vendors can be hesitant to respond to RFIs where they are unclear on what is expected or they are unsure if it is likely to result in a contract for any vendor.

A key component in developing that business plan is to identify all funding sources and identifying funding gaps. This last section explores network funding options for municipalities separate from any private-sector partners.

Self-funding

Aside from allocating capital project funds as part of the budget process, bond funding is something municipalities can consider assisting with funding network construction, and to support startup and maintenance costs. There are two main types of bonds utilized for capital projects – Revenue Bonds and General Obligation bonds. General Obligation bonds are typically the kind of bond utilized for this kind of funding. However, an option would be to pursue revenue bonds secured with sales tax or other revenues.

Federal Funding

Federal funding opportunities change year to year. With a new Administration, it's difficult to predict what new sources of funding may be available. However, we provide below information on several grant funding opportunities currently available on the federal level. It should be noted that these are available for providers and/or municipal governments that partner with a provider.

Connect America Fund

The FCC created the Connect America Fund (CAF) to help expand access to voice and broadband services to areas where services are currently unavailable. In 2015, through a competitive auction, the FCC awarded carriers nearly $1.7 billion annually for six years to bring broadband to unserved parts of their local service territories. Carriers accepted or declined funding on a state-by-state basis and were required to build out to 95% of the funded areas. Century Link accepted funding for areas in Colorado under this program.

Recently, the FCC announced there would be a second round called the CAF Phase II (CAF II) auction. The FCC has tentatively determined that census block groups or tracts will be the minimum geographic unit for bidding. Bidders will be required to bid on all of the locations within eligible census blocks of a census block group or tracts. The FCC has also released a primary list (final list TBD in late winter/early spring) of eligible census blocks to be up for auction. The Bureau will release the final list of eligible census blocks roughly three months prior to the short-form application deadline. The FCC will also clarify service performance requirements prior to the auction.

This option would only be available for existing providers and for those areas where census blocks are listed. These census blocks are largely located in very rural areas.

E-Rate

E-Rate is a federal program that provides reimbursement funding for telecommunications services to schools and libraries based on free and reduced lunch program percentages within an applying jurisdiction. E-Rate funds are only available to qualifying service providers. This may be an option to pursue for a third-party network provider partner.

Public Safety Communications Research (PSCR)

PSCR is a federal program that anticipates awarding up to $30,000,000 in grants and cooperative agreements by May 2017. The purpose of the program is to rapidly accelerate research and development related to public safety broadband communications.
This funding opportunity focuses on the following six key technology areas that have the potential to transform the future of public safety communications and operations:

- Mission Critical Voice;
- Location Based Services;
- Public Safety Analytics;
- Public Safety Communications Demand Model;
- Research and Prototyping Platforms;
- Resilient Systems.

Applicants may propose projects specific to one or multiple technology areas as well as cross-cutting projects that address objectives within those technology areas.

The funding opportunity is open to all non-federal entities. In addition, applicants are strongly encouraged to partner with public safety organizations to create innovative and impactful proposals. Again, while Fraser and Winter Park could not apply for these funds alone, this could be another source of funding for a potential last-mile provider partner in the region as well as other government entities.

State of Colorado

Over the last few years, the Colorado Department of Local Affairs (DOLA) has awarded broadband grant funding to local governments in Colorado. This has been the sole source of grant funds made available to local governments. Fraser received a DOLA grant to assist with the funding of this Study.

As of the drafting of this report, however, any remaining broadband funds available through DOLA for grant award are frozen. It is unknown when and if more funding will be directly available. There is also a possibility that municipalities will have to compete for broadband funding with other non-broadband related projects.

The bottom line is that this is not a reliable source of potential funding.

Competition

With more and more municipal networks being rolled out we're able to see a pattern of response by incumbents to the "threat" of a municipal network being deployed in their service territory. In the early years of municipal networks (2005-2008), incumbents tried to file lawsuits to stop the deployments. After losing in court multiple times, incumbents developed other countermeasures to try to derail, slow down and stop municipal networks. It was in this time period that Colorado's Senate Bill 152 was passed, forbidding municipalities from offering internet service without an opt-out vote.

Since then incumbent response is mostly with backroom lobbying and offering promotional deals that lock customers into incumbent service when a municipal network coming. The size of a municipality and the number of existing customers will no doubt influence incumbent response. Areas more densely populated like Broomfield have more incumbent subscribers, making an incumbent response extremely likely. A more rural area, with geographical challenges will be sporadically served and less likely to be protected by incumbents.

It also depends which incumbents are in a community. Some incumbents (Time Warner) have been less aggressive than others (AT&T) in fighting municipal networks. Comcast and CenturyLink typically respond with marketing and promotional packages as well as working behind the scenes with elected officials to try and stop efforts.

Some common strategies and tactics employed by incumbents:

- Lobbying elected officials with different messages:
    - The municipal network is not needed because they (the incumbent) are meeting the needs of the community.
    - They will indicate a willingness to work and meet with the municipality to discuss building out to hard to reach areas only for those to be empty promises. This is a stalling tactic to keep scheduling meetings without making firm commitments.
    - Fiber is a "fad" that will go away in a few years.
    - Cry foul over the feasibility process and say that they have not been fairly included.
    - Municipal networks are too expensive and complicated for a local government to deploy effectively.
- Launch public relations campaign to discredit the municipal network, procurement processes and/or the process utilized by the locality to explore the feasibility of a network deployment.
- Offer price reductions in packages that require long-term commitments of subscribers. This undercuts the ability of the municipal network to meet take rates and attract customers. Remember that incumbents do not need to speed capital to compete with a municipal network – they just need to lower prices.

- Actually build/improve their own network to be more competitive – the most rare of tactics.

The longer the process takes – the more time it gives incumbents to respond to the threat. As the network gets closer to becoming a reality, the more active the incumbents become.

Additional Potential Blockers

Google Wireless

Denver, CO

While Google is backing off the fiber business, they're still interested in providing internet service through wireless. This could be significant for Denver and surrounding areas including Broomfield as Google acquired Webpass in June 2016. Webpass is a company focused on building and providing high speed internet connections to residential and commercial locations of up to 1 gigabit per second using point to point wireless technology. At the time of the acquisition, Webpass operated in several large cities across the United States with Denver on the list for expansion as a part of the acquisition and Google's go-forward plans.

Webpass' technology works by wirelessly beaming broadband to roof-top antennas. As such, it is designed to specifically target large multi-dwelling residential and commercial complexes. Cable drops are then constructed to each individual dwelling or commercial unit within a single structure. Users access the line by plugging into a wall ethernet port or use a home router. Webpass charges a flat fee of $60 per unit (regardless of speed) that includes taxes and fees.

While this may appear to be a cost-effective solution - due to the nature of the technology, Webpass will only work in very densely populated areas that contain many high-rise apartments and multi-dwelling units. It is unlikely that Webpass would be deployed to suburban communities such as Broomfield other than multi-dwelling units – and even then, probably not.

Additionally, point to point wireless must connect to a fiber connection at some location. While cost-effective for urban centers, a suburban network would need to carefully consider where to include this kind of wireless technology as part of the network design.

Monticello FiberNet

In most cases, incumbent threats come in the form of a price war or marketing packages (Free HBO, etc.). On the occasion, incumbents match fire with fire – or in the case of Monticello, MN – a fiber build with actual equipment upgrade. Located 40

miles outside of Minneapolis, Monticello was faced with poor service and two incumbents (TDS and Charter) who had no appetite to improve service and in 2008 the community voted (75% yes) for the city to obtain bonds and build its own network. Using the courts to delay the rollout of FiberNet, incumbents were able to stall, upgrade their own infrastructure, and offer prices and services the city found difficult to compete with. By 2013 Monticello was in default and could not pay its bond payments.
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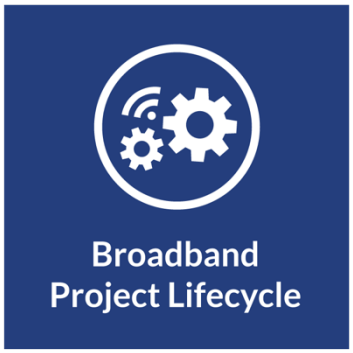
Broadband Projects: The Lifecycle



The lifecycle for a municipality going down the path of exploring options, securing funding, designing and implementing is a long and arduous one. In addition, there are many different things than can cause choke points along the way that will serve to delay or derail a municipal broadband project. Broken down below are some key activities and milestones and the corresponding pitfalls of each.

Feasibility Studies: Most projects begin with a feasibility study. Without debating whether they should, rather let's focus on what a *proper* study should include. Feasibility studies should focus on the critical items that need to be met to move forward, or abandon the project. Too often excessive funds are spent on items that do not provide value and create challenges. These include:

- Using a directional, informal survey process (posting a link on a website or social media, settling for a handful of responses, etc.) in lieu of a scientifically valid market demand survey for residential and business customers. Almost all feasibility studies use this technique which is troubling as informal surveys do not provide critical data points necessary to calculate valid take rates. If the data *from a scientific research study* shows that the potential customer base will not support a new municipal network provider, there is no need to further pursue a FTTP network model. If shortcuts are taken and survey is not scientifically valid, a community will pay a high price when take rates don't match what's anticipated.
- Asking for GIS asset mapping as part of the feasibility study. While it is a good exercise to identify existing assets that may be leveraged such as utility poles and wireless towers, there is only so much information that is publicly available. Carriers will not provide GIS information regarding where their fiber assets are located as it is confidential and proprietary and they will not want the information to be utilized to deploy a network that may compete with them. There are services that do provide reporting on carrier assets in a jurisdiction but this can be very costly. It is unlikely that existing carrier assets would be leveraged as part of a municipal network design and any other existing assets would be identified in the design and engineering phase.
- Prematurely conducting business plans and financial models. These critical components should wait for a model to be selected and/or a potential provider partner to be identified. Conducting a business plan too early may result in reliance on financial models and spreadsheets that aren't accurate. And it wastes time.

P3 Request for Information (RFI): During the past two years, a few dozen jurisdictions or so have released an RFI seeking a P3 provider. To date, this RFI process hasn't resulted in a P3 agreement. Why? The problems with this RFI process include:

- RFIs are too vague and open-ended, making it difficult for vendors to respond. Often the RFI is so vague it ends up being re-issued, creating even more time delays. For example, Grand Junction had to reissue their RFI and after 15 months of discussion – the Council voted down the proposed P3 contract.
- RFIs that include unreasonable requirements. Consultants understand it is unlikely that providers will be able to meet the conditions but the delays and extra interview time benefits these same consultants. The City of Boulder put out an RFI in early 2016 with a long list of requirements. Last summer the City published an update noting that the proposals submitted did not meet all the requirements. Boulder was silent on progress until this week when the City voted to eliminate the option of building a publicly funded network. At the same time, the City indicated plans to continue with discussions with multiple carriers that submitted those RFI proposals, but it has been two years since the City began the broadband feasibility process without selecting a model or provider.
- Issuance of RFIs that dictate price points that may not be workable for the provider making the investment. For example – requiring the provider to charge $70 a month for gigabit service because it's the "industry gold standard" rather basing the price on the provider's business model and what the provider needs to charge to make a profit. (This has also happened when the business plan is prematurely completed in the feasibility phase without the input of the eventual provider).

Issuing out an RFI to see what you get is a strategy. But recognize that this process takes a considerable amount of time and it may very well end up yielding nothing. Most jurisdictions will not be able to establish a P3 because of lack of demand, the size of the community, incumbents, and lack of financing to name a few reasons.

Design, Engineering and Construction: Once a model has been identified and all the approvals, financing and business models are in place, it is time to design and engineer the project. As a rule, design and engineering roughly costs between 10-15% of the total capital cost of the project. Mistakes that can cost time and money in this phase include:

- Accepting engineering proposals where the fee is significantly below the industry average. Chances are there is a good reason why the proposal is so "affordable."
- Accepting Google earth as an acceptable design method. Proper design requires boots on the ground. Generating a design with Google earth will create problems in construction.
- Allowing a design firm to also do the construction. These activities should be done by separate companies to ensure proper quality control, inspection and oversight.

Broomfield SWOT Analysis

- Strengths: characteristics of the project that give it an advantage over others
- Weaknesses: characteristics of the organization that place the project at a disadvantage relative to others
- Opportunities: elements in the environment that the project could exploit to its advantage
- Threats: elements in the environment that could cause trouble for the project

In terms of a network initiative, Broomfield's SWOT follows:

Strengths	Weaknesses
• Civic pride • Local customer service • Strong economic growth from Denver is impacting the area • Tax base on the incline – one of the fastest growing cities in Colorado • Quality of life attracts businesses • Upper middle class/affluent households • Strong millennial population • Tech center • Tech and innovation companies driving • HQ buildings • 6% employment growth • IKEA and hotels coming • Information services (IT) up 16% • Professional business services is the largest business sector • Low unemployment of 2.7% - the lowest since 2000 • Can deliver better access and possibly a complete network • Physical facilities already in place to house equipment • It is recognized that better infrastructure is needed • Population density	• No funding in place • Lack of "adequate" business speed near the mall • No real CAI funding available • Lack of understanding regarding the market or the market demand • Not wanting to partner with an ISP limits options • No electrical utilities – only water and sewer • Not a large appetite for risk • Funding not in place • Very little fiber or conduit • Currently lease fiber through Comcast – giving Broomfield little to no fiber ownership • Inability to operate a network and the lack of widespread support to do so • Broomfield investment is not a given

Opportunities	**Threats**
• Some indicators that there is some unmet demand along the tech area (Mall and 36) • Four school districts available – could tie them together and offer districts services – create a school consortium • Libraries and government buildings served by city/county • Another tech center coming in North Broomfield • City could benefit from better network, leverage services and applications • Increase tax base • Attract and retain businesses • Public Wi-Fi helps quality of life and "tourism" from nearby cities • Smart city – cars, homes, real time sensors • Telemedicne • Use of artificial intelligence (smart city) • Internet of Things opens possibilities • Could partner with mobile companies for middle mile	• Incumbents improving service in Denver • Incumbents would take steps to blunt a Broomfield network and protect its turf • Video is still important – yet difficult to negotiate with municipal networks • 5G can compete with traditional desktop delivery

What-If Scenarios

Included below are three different scenarios and models that Broomfield could consider. However, right now Broomfield has not collected enough data to make an informed decision, so take these for what they are - hypothesis. Before deciding, Broomfield should engage in the following activities to better understand the Broomfield market.

1. Conduct a scientifically valid market demand survey to determine if the Broomfield market can support a new residential provider. In other words – are there enough residential customers to enable the network to obtain a take rate (subscription rate) greater than 40%? If the research shows that there is not enough residential support, then a FTTP network would not be a viable option.

2. Conduct a business survey to determine business needs. Like the residential market – this would enable Broomfield to understand what the business community wants and needs. Broomfield has a substantial number of large and small businesses that would be attractive for a new provider if enough were interested in switching to a new provider.

3. Meet with Adams 12 school system to understand the scope of the $15 million fiber project they are about to launch. There may be ways to work with Adams 12 that could potentially offset network deployment costs in Broomfield.

Once this data has been collected and analyzed, Broomfield will be able to determine if a FTTP network is a viable option. If it is not, then Broomfield must only consider whether to move forward with a backbone-only or middle-mile network model.

It should be noted that once Broomfield decides on a model, a conceptual design and business plan would need to be completed. This will help in determining capital and operating costs, obtaining financing, developing pro-formas, pricing services, etc. If Broomfield would like to obtain high-level capital costs only before deciding, this could be done cost-effectively.

The below options explore all 3 of the potential model options.

Option 1: Develop a FTTP Network either self-financed or possibly with a partner

Benefits of a FTTP network include:

- Bringing gigabit speeds to Broomfield;
- Increasing economic development opportunities;
- Increasing real estate value;
- Deploying infrastructure that will serve Broomfield for the next 30+ years (including WiFi);
- Enabling Broomfield to compete with neighboring communities such as Longmont.

However, there are some significant challenges associated with deploying an FTTP Network and they include:

- While there are some municipal FTTP networks in progress (Fairlawn OH, Hudson Oaks, TX) , there aren't any municipal networks that have successfully completed a FTTP network without having a municipal electric utility deploy the network.
- This option carries the most financial risk;
- The operational costs are high;
- It may not be possible to find a provider-partner who is willing to invest;
- If a provider-partner is not willing to make a financial investment, the burden of financing the network would rest squarely on Broomfield.
- If a provider is willing to invest, the provider may ask for full or partial ownership rights, thus potentially locking Broomfield into a long-term relationship with the provider;
- An open access network would be difficult to sustain with an FTTP model because additional providers would be competing for the same customers and would impact take rates. Thus, it would probably not be feasible for Broomfield to lease the network assets to anyone else.

Option 2 - Deploy a Middle-Mile Network

A middle-mile network in Broomfield could be deployed to connect to Community Anchor institutions such as government buildings, public safety agencies, schools, libraries,
Similar to an FTTP network, a middle-mile network would deploy infrastructure that will serve Broomfield for the next 30+ years. In addition, a middle-mile network could also bring the same benefits IF Broomfield could attract providers that would:

- Bring gigabit speeds to Broomfield;
- Deploy fiber to increase economic development opportunities;
- Connect homes to increase real estate value;
- Enable Broomfield to compete with neighboring communities such as Longmont.

With a middle-mile network there are some additional benefits:

- The middle-mile network model has been effectively deployed by numerous municipalities across the country.
- The investment cost is much smaller and the risk is much less significant;
- Broomfield would own the network and this would be a valuable long term asset;
- This would need to be an open access network to maximize the number of users and Broomfield could lease excess capacity (fiber and/or conduit) to providers and others. The return on the capital investment could be realized much more quickly as Broomfield could generate revenue from leasing dark fiber and conduit space.
- This could significantly increase competition;
- A middle-mile network could develop into a FTTP network later.

Option 3 - Deploy a Backbone Only Network

The purpose of a backbone-only network would be to build core infrastructure that could be leased to private providers. The backbone only model shares the same benefits of a middle-mile network. The costs of building a backbone would be the least expensive option.