



TILSON

Summary Network Designs and Business Models

City of Cambridge, Massachusetts

Prepared by:

Tilson

245 Commercial Street

Portland, ME 04101

Phone: 207-591-6427

E-mail: info@tilsontech.com

DRAFT

Table of Contents

Executive Summary.....	1
Business Models.....	2
Capital Cost Strategies	2
Funding and Financing Models	4
Operating Models	5
Other Municipal Broadband Projects: Case Studies	9
Mass-Market Broadband Examples	9
Targeted Examples: Low-Income Housing.....	14
Fiber Designs.....	17
General Design Parameters	17
Small Network: Fiber to Cambridge Housing Authority Locations	17
Medium Network: Multi-Neighborhood Dark Fiber	19
Large Network: Fiber to All Premises in Cambridge	20

DRAFT

Executive Summary

The City of Cambridge engaged Tilson to support a Phase I broadband planning effort undertaken with the Cambridge Broadband Task Force. Part of the work of this phase is to produce a high level network design for a potential expansion of the existing municipal fiber network, with an eye to improving broadband service in underserved areas and population segments.

In this report, Tilson will also discuss the business models of other community broadband initiatives around the United States. This will include an overview of the communities, the networks they built, how they are funded and operated, and by whom. Tilson will also provide a similar discussion for other municipal broadband networks in the United States that specifically serve low-income residents.

This report provides the analysis for these components of the broadband planning effort, which will also be incorporated into Tilson's final report to the City.

DRAFT

Business Models

This section provides a discussion of various business model aspects to consider in developing a citywide broadband network. The three main points of consideration are:

- **Capital Cost Strategies.** How will the developer select the breadth of network to be built? Will the network service all premises in the city, or will it only serve a subset of premises? If the latter, will there be a way to easily add more connectivity in the future?
- **Funding and Financing Models.** As with any large, capital-intensive project, it is important to determine how the project will be funded.
- **Operating Models.** There are several possibilities, depending on who owns the network and who provides service on it.

Capital Cost Strategies

Full Network Builds

In a full network build-out, the City would take on the full capital costs of building out a network on a broad (or universal) scale throughout the city. These costs include the *pass*, the *drop*, and the electronics. Briefly, the *pass* is the fiber optic cable that runs by the premises to be connected, usually along a road on a pole, or buried underground, and connects to a central aggregation point through which services can be provided. The *drop* is the fiber that is spliced into the *pass* and connected to the individual premises. Electronics that enable the passing of data on the network are installed at individual customer premises and at the central aggregation point, or node.

Opportunities

For a city looking to address broadband needs of its residents, businesses, and institutions, this level of commitment allows the city to ensure that a complete and fully integrated network is deployed. Uncertainty about the type of services that will be available, and where they will be available, is reduced. This type of network also has the greatest opportunities for producing revenues from users.

Operating Implications

This option produces a network with the greatest level of operating responsibility. It requires maintenance and management not only of the physical infrastructure, but also of the data network that rides on it. It is the largest scale and most complex operation to manage, relatively speaking.

Risks

This option has the greatest capital and operating cost requirements. Its greater level of complexity can produce greater levels of execution risk at the construction and operating stages.

Partial Network Builds

The city may elect to develop only part of the network infrastructure to deliver improved broadband, and offer access to it on favorable terms. The objective is to make it easier for more or alternative broadband service providers to enter the market than if they had to construct an entire network themselves.

“Partial” as used here refers not to building only to a small subset of users (see “Targeted” Network Builds, below), but constructing a network consisting of some network elements, and not others. For example, a dark fiber network consisting only of the fiber *pass* (either along all city routes, or only key routes) would

be an example of a partial network. Such a network would rely on service providers to invest capital in constructing drops (and perhaps lateral routes off of the key routes), as well as network electronics in order to provide a complete “lit” broadband service. A partial network can include a greater or lesser number of elements. For example, a dark fiber network that delivers a fiber drop to every premise would still be a partial network (but a more expensive one). A partial network might also involve no fiber at all, but only some of the supporting infrastructure for deploying fiber, such as underground conduit.

Opportunities

Partial networks can be constructed at a fraction of the cost of a full network build-out, and therefore may present a lower fiscal hurdle for the city to clear. They also lend themselves more readily to building relationships with multiple service providers. Because a partial network by itself does not deliver broadband services to retail customers, it is less likely to be in direct competition with broadband service providers. However, this does not mean that no incumbent providers will see such a network deployment as a competitive threat.

Operating Implications

By the very nature of building only parts of a solution, this requires that the city develop relationships with one or more broadband service providers who are willing to use the city’s infrastructure and invest their own additional capital. Turning these relationships into improved services is key to realizing benefits from this type of build-out. Partial networks are also operationally less complex to manage. They involve far fewer direct customer relationships for the city to manage, and the city would not be required to manage the network electronics that light the network.

Risks

Partial network build-outs run a greater risk that geographic coverage and broadband service objectives will not be fully realized, and the more partial the network, the greater the risk. Simply put, the city cedes a degree of direct control over how (or whether) the direct network elements it does not control will be developed and operated, and the services that will be offered. This risk can be mitigated by negotiating for requirements or offering more favorable terms for those companies that use the city’s network elements to deliver the types of additional investments and services that the city is seeking.

Targeted Network Build

A targeted build out delivers service to a small geographic area or a certain class of users. Examples of user classes could include low income users or neighborhoods, small businesses, families with school-age children, households with a resident over the age of 55, or any other group identified as in need of network access.

To a large extent, the City of Cambridge already has a targeted network, as it has over time developed its own fiber facilities connecting city buildings. Extensions of this network would be additional targeted network builds.

Opportunities

Targeted build-outs provide a lower capital and operating cost than larger network builds. In some cases they have a built-in business case, as existing spending on telecommunications networks can be re-directed to support the cost of building out a network that the city owns. Some cities have used targeted network builds as an early-stage way of developing a core network and developing operational expertise on small scale before later expanding to serve a broader base of users.

Operating Implications

Targeted network build-outs are more likely to be successfully managed internally by a small IT or network services department. Their smaller number of users makes them less complex to manage.

Risks

One of the biggest risks of this type of approach is that the demand from the targeted users becomes “siloed” and does not contribute to the overall business case of a wider network. This is not inevitable, but can happen unless explicitly guarded against. In particular, new fiber network facilities built to serve targeted users must be engineered and built in a manner that allows additional users along or off the route served to be added with a modest incremental investment. This will raise the cost of a project compared to one that only serves the targeted users, but will be lower than the cost of constructing additional fiber routes on top of the initial investment.

Funding and Financing Models

There are several options for funding and financing the business model of a municipal broadband network. Common funding sources include:

- **User Fees.** Revenue is generated by charging the user for service, typically on a voluntary subscription basis.
- **Re-purposed Municipal Telecom Expenditures.** The municipality redirects funds that would have been incurred for leased circuits to municipal facilities and instead spends them on the amortized cost of the municipality building its own network. This funding model is generally most useful in the early stages of developing a network, but would be insufficient for the full expenditure.
- **Special or Enterprise Funds.** The excess funds from some source other than general tax revenue, such as revenue generated by an existing electric utility, or franchise fees.
- **Grants.** Municipalities in some cases are able to fund a portion of network development through state or federal grant funding. However, grant funding specifically for general broadband infrastructure development is often not available for areas that do not have large gaps in broadband service availability compared to state or national norms. In some cases, municipalities are able to use grant funds available for a specific purpose to develop communications infrastructure with a dual use at a lower incremental cost than if a general use-network were used.
- **Taxes.** Municipalities may use general tax revenue from residents and businesses to help build and/or operate a municipal network. This can be a controversial revenue source, especially in some jurisdictions that have existing networks and competitors offering broadband service.

There are a number of municipal networks whose construction was funded by revenue-backed bonds. Networks built by revenue bonds are susceptible to financial pressure if these municipalities fail to gain enough subscribers. Failure to make debt payments resulting from undersubscription is a leading cause of failure among municipally owned networks.

Since broadband networks are capital-intensive, it is common to pay for their costs over time. Again, there are a variety of options. Common strategies include:

- **General Obligation Borrowing.** The municipality borrows against general tax revenue.
- **Revenue Borrowing.** The municipality borrows against future revenues of the network, such as those generated by user fees. Although this has the advantage of not impacting tax revenues

directly, it is important to think through the degree to which revenues are assured. If revenues from voluntary sources such as user fees do not materialize at forecasted levels, there can be a mismatch between funding and financing models

- **Pay As You Go.** The municipality makes incremental payments out of current revenues or cost savings realized by offsetting existing telecom spending. This approach is best suited for a targeted or incremental approach to building out a network.

Partnering with one or more private parties can be part of the capital cost strategy, as described in the prior section, and part of the operating model, as described in the next section. It can also be part of the financing strategy.

For example, infrastructure funds like Macquarie Capital invest in networks and can act as both developer and financier. Macquarie developed a 3,200 mile fiber network in Kentucky to connect schools and government buildings, and raised municipal bonds to finance the network. In return, the state makes availability payments to Macquarie over a 30 year period. The network is operated by Fujitsu. Typically, funds like this seek underserved areas and larger projects of at least \$50 million.

Operating Models

Following is an overview of operating models. Each approach comes with its own operating costs, varying risks, and level of control. The three models discussed are:

- Municipally owned and operated networks
- Outsourced network developer or operator
- Dark fiber and other infrastructure platforms

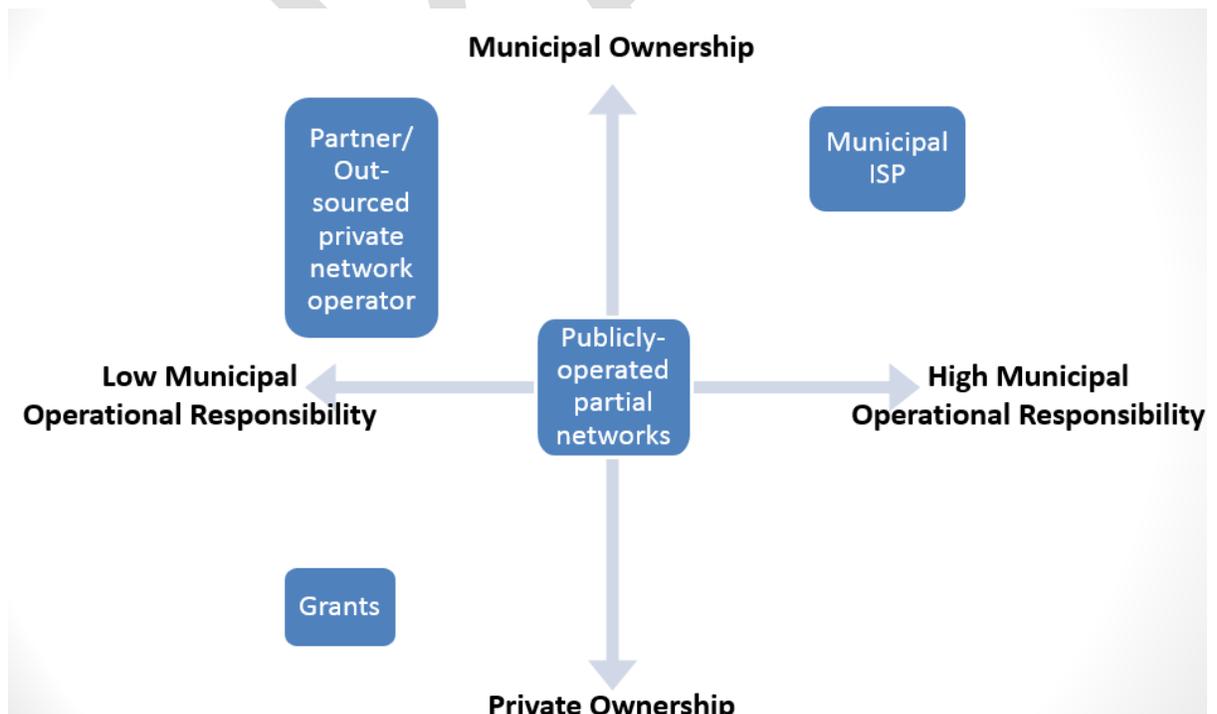


Figure 1 – Operating Responsibility and Ownership

The basic relationships between operational responsibility and ownership are summarized in graphic above and discussed further in this section.

Municipally Owned and Operated Utilities

Operating Costs

The municipality assumes the fixed costs of operating the network. This model involves the highest level of operating costs and responsibility, where physical maintenance and operation of the fiber, as well as customer-facing operations are present. However, user subscription fees can decrease, or even offset these costs.

Risks

The greatest risk a municipality faces stems from the fact that cities are often not in the broadband business. Depending on how the project is financed, the city runs a very real risk of not being able to pay its costs from user fees if an insufficient number of customers sign up for service. Also, most cities are inexperienced in being internet service providers to the general public and may have significant problems suddenly becoming competitors in the marketplace. Lastly, incumbent providers are aggressively raising the stakes: in 2015 every major incumbent – covering over 80 percent of the U.S. population – announced plans to deliver mass-market gigabit service within the next few years.¹

Control

The municipality assumes 100% control of the network, allowing for a greater sense of community accountability and focused customer service than that of an incumbent provider.

Public-Private Partnerships and Other Blended Operating Models

Network Operating Partners

In this scenario, the city partners with an existing service provider, who then becomes the exclusive provider of network services.

- **Operating Costs.** Partnering with a private firm as the network operator, the municipality eliminates or limits its assumption of operating costs.
- **Risks.** Once the contract is in place between the municipality and the network operator, the private entity accepts most of the risk in running the business in exchange for increased control. Risk and control are highly correlated in this type of partnership. A municipality can mitigate their risk of a partner's non-performance by structuring the contract so that frequent renegotiations take place, contingent on the network operator's successes or failures of particular provisions or requirements previously agreed to.
- **Control.** As previously stated, risk and control are highly correlated in this type of partnership. A municipality who relinquishes control and transfers risk generally stands to benefit from the network operator's business acumen. Network provisioning, maintenance, customer support, and billing are key activities that a municipality does not have the experience or reputation on, whereby relinquishing control to the private entity allows for the opportunity to earn and sustain revenues.

¹ (The Brookings Institution, 2015)

Outsourced Network Developer/Operator

There are several benefits associated with outsourcing some or all tasks in network development and operations. Should a municipality decide early on that network development and/or operations will not be part of its core business, outsourcing these tasks allow it to provide a greater focus on their customers. This strategy tradeoff creates an opportunity to provide a reliable, affordable, and best-in-class customer service experience. In addition, the outsourced network developer and/or operator may create synergies across activities that provide immense value to both parties from a cost advantage perspective.

- **Operating Costs.** Based on the agreed level of outsourcing, the private entity assumes partial or full responsibility for network operations costs.
- **Risks.** This operating model structure has a relatively low amount of risk centered on the municipality's dependence on the network developer/operator. As in the Network Operating Partner Model above, the municipality lowers its own execution risk by hiring a firm of specialized expertise. However, some risk associated with the performance of the partner remains, and management of that relationship is required. It is desirable for the municipality to position itself where the network operator is interchangeable in the long-term. Based on the agreed level of outsourcing, the private entity assumes partial or full risk associated with network development and/or operations.
- **Control.** The municipality relinquishes a certain level of control in exchange for the private entity providing advantages on network development and operations. For example, outsourcing the design and deployment of the network allows the operator's expertise to be leveraged and ultimately decrease the total cost of ownership, and creating the ideal environment for managing capacity and scaling the network.

Dark Fiber and Other Broadband Infrastructure Platforms

A dark fiber or "infrastructure platform" approach involves the city building the physical fiber routes and having one or more service providers pay the city to offer service on the fiber. Service providers are responsible for all aspects of lighting the network, customer service, billing, and general operational expenses to provide service to end users. The city would be responsible for maintenance of the physical network to the extent it does not outsource this, potentially to a service provider lighting the network.

- **Operating Costs.** Where a municipality is building the platform for providing broadband, whether it be dark fiber, conduit infrastructure, or the like, its operating cost is the maintenance and management of this shared resource. The municipality would also incur costs for general administration and for marketing the network to potential service provider customers. While these are relatively small expenses compared to the operation of a lit network, they are not negligible.
- **Risks.** Upfront capital costs associated with providing the platform is the greatest risk to a municipality. It is a sunk cost. Additionally, there is a level of risk incurred with the uncertainty of service providers wanting to deliver the utility within the community. It is highly recommended that a municipality explore potential interest amongst ISPs prior to funding the capital investment on the platform.
- **Control.** As the owner of the infrastructure providing the platform, the municipality has 100% control in this type of operating model, but limited control over the services riding on it.

Open vs. Closed Access Models

There are two main models for allowing service providers to access the network: open access and closed access. The municipality owns the network and enters into wholesale transport, dark fiber lease, or indefeasible right of use (IRU) agreements with service providers to offer broadband services over the network.

Open Access Model

In an open access model, the network owner provides nondiscriminatory, transparent pricing for service providers to access the network, with an ultimate goal of market competition. In a pure open access model, the network owner does not compete with retail providers on the network for end user customers. However, some open access models can involve a network operator that offers both retail service and wholesale access to the network.

Open access networks fall into two major types: dark networks and lit networks. Dark Fiber Open Access Networks sell or lease dark fiber capacity to service providers. In this model, service providers must provide the electronics to light the network and transmit data across the fiber. There is substantial overlap between the concepts of a Dark Fiber Open Access Network and a Partial Network Build Capital Costs Strategy. In Lit Fiber Open Access Networks, a network operator lights the fiber to transmit data across the route (referred to as transport or layer 2 connections) and the service provider offers enhanced services such as internet access over the operator-provided connections.

- **Benefits.** An open access network more readily facilitates migration of users from one less successful service provider to another, more successful one. An open network can be better suited to attracting service providers who specialize or excel in supporting a particular niche in the market (for example, small businesses, enterprise users, or cellular carriers). Depending on who the operator is, some of these niches may be difficult for a single service provider in a closed access model to capitalize on.
- **Risks.** On an open access network that depends exclusively on fees from broadband service providers for financial support, there can be two levels of execution risk for the owner of the underlying network:
 - (i) Risk that the owner will be successful in attracting one or more service providers as paying customers
 - (ii) Risk that those service providers will be successful in attracting the retail customers necessary to support the lease payments to the underlying network operator

Service providers using an underlying network on an open access basis may be less deeply committed to investing in the success of a network than if they have a degree of exclusivity, especially for the least attractive segments of the market. On the other hand, exclusivity makes the owner of an underlying network much more dependent on the success and performance of the exclusive partner.

Closed Access Model

In a closed access model, the network owner chooses which service provider or providers to allow on the network. Often, the owner will choose an exclusive provider for the network, who may then market services under its own name.

- **Benefits.** The owner of the physical network has the ability to choose which internet service provider, or providers, can make a connection and begin offering services to the end users, and it can use exclusivity as leverage to obtain service commitments (or it can be the sole provider). In the case of a sole provider, that provider is well-positioned to capture the greatest share of the revenue stream generated by the network.
- **Risks.** This model allows the owner of the physical network to dominate the market for network services as a service provider, thus limiting competition. A closed model provides less potential for different businesses to expand the number of market niches served by the network. For example, a company that orients itself to providing local residential broadband may or may not be the best oriented company to sell services to large cellular companies or enterprise customers requiring specialized services and customer care. A company that tries to be all things to all users may not succeed in doing so, even with a network that is technologically advanced.

Other Municipal Broadband Projects: Case Studies

Mass-Market Broadband Examples

Leverett, MA

The town owns a town-wide fiber-to-the-home (FTTH) network using Active Ethernet technology, called LeverettNet. All premises in town are connected, but not all subscribe to the service. The town-created Municipal Light Plant (MLP) entity (with a separate budget) is the custodian of the network. Crocker Communications, a local ISP based in western Massachusetts, provides data and voice services with a single one gigabit internet service tier. Holyoke Gas & Electric Telecom provides network operation services.

The Leverett network's construction was financed by tax-backed municipal bonds. Operational expenses are funded solely via revenue from broadband and telecom services. Users of the network pay a monthly network operations charge to cover the fixed operating costs of the network. The more users on the network, the lower that portion of their bill. The Leverett network relies on subscriber revenue, but only to offset ongoing maintenance costs.

The town-created Master Limited Partnership, which has a separate budget, is responsible for overall network operations (outsourced to HG&E Telecom) and assumes the financial risk of operations. Leverett does not have an open access network. The Town has partnered with one ISP, Crocker, to provide the services to subscribers on the network.

Key Drivers of Success

- Financing the capital cost of the network via tax-backed bonds instead of revenue-backed bonds resulted in guaranteed ability to repay the debt. The town's ability to repay a revenue-backed bond issue would depend entirely on getting enough subscriptions for service.
- Leverett connected all premises in town to the network as part of the initial capital outlay and network construction, whether or not those premise owners had signed up for service. This resulted in significant economies of scale and let the town spread the high fixed costs over a wider group of premises.
- Active political leadership in the town convinced residents to approve a property tax increase in order to pay for the network.

Chattanooga, TN

Chattanooga's FTTH broadband fiber network is a model of a successful municipally owned and operated fiber network, with the Chattanooga Electric Power Board (EPB) performing the range of network operations responsibilities, and assuming the financial risk of operations. The citywide FTTH network was originally conceived to provide network connectivity for the EPB's smart meter deployment and is currently operated as a closed network.

The city of Chattanooga, Tennessee undertook the goal of improving broadband access for its citizens through its municipally-owned power utility, the Chattanooga Electric Power Board (EPB). One of the primary advantages of this structure for Chattanooga was that it significantly reduced the cost of constructing the network through lower make ready expenditures. Chattanooga used municipal bonds to provide funding for constructing its 170,000 service location, 8,000 mile network. The total project cost of the EPB network was approximately \$340 million, with \$111 million funded through a federal American Recovery and Reinvestment Act (ARRA) grant from the Department of Energy. The remaining cost of the network was funded through the City's passing of a \$229 million municipal bond to provide matching funds. The structure of the loan involved EPB's electric division lending EPB's cable/internet division sufficient funds, with the loan being repaid using revenue generated from network subscriptions.² Operating cost and risk are assumed by the EPB, as it is the network internet service provider.

Key Drivers of Success

- Like LeverettNet, the Chattanooga network was financed via debt whose repayment is not dependent on the number of people subscribing to internet or phone services. In addition, Chattanooga EPB funded a significant portion of the capital cost with grants, which do not need to be repaid.
- Since the EPB network is owned by the local electric utility, it was able to better manage make-ready costs on utility poles.

Lafayette, LA

Ownership/Operation

LUSFiber is a closed network and wholly owned subsidiary of the municipal Lafayette Utilities System (LUS), which provides electric and water service to the city of Lafayette. LUSFiber is a FTTH provider of internet, cable TV, and phone service with connectivity to all premises in the city. Internet speed tiers range from 3-2000Mbps symmetric. Prices vary depending on specific services and bundles. The main network was originally built for electric substation management. In 2002, LUS formed LUSFiber and connected area hospitals and schools to dark fiber strands on the main network. Residential services began in 2009, following several years of legal battles around the city competing with Cox and AT&T/BellSouth.

The city issued \$110 million in bonds to finance the construction of the network. The project became cash flow positive in 2012 on operating revenues and expenses, but still has upwards of \$100 million in debt. Legally, LUSFiber is a nonprofit entity. It recovers its costs via project revenue only.

² Information regarding EPB's network was obtained in a phone interview with Danna Bailey, EPB's Vice President of Corporate Communications (baileydk@epb.net).

Key Drivers of Success

- The core network was already built for utility operations. LUSFiber runs on dark fiber strands that were put in the original core network, and thus did not incur a significant part of the capital cost of the initial buildout.
- LUSFiber received anchor tenancy from local institutions prior to offering residential service. This enabled it to gain ISP experience and an initial revenue stream.

Burlington Telecom

Burlington Telecom is a department of the City of Burlington, Vermont and is 100% municipally owned and operated. However, the City is in a multi-year process to seek a buyer for the system.

Originally funded through a capital lease, this network was refinanced in an effort to expand the money available. While the original intent of the City was for network operations to be funded not by general revenue (taxpayer dollars) but instead by project revenue, Burlington Telecom ran out of money and used \$17 million from the City Treasury department to support network operations.

Burlington Telecom shouldered the operating risk associated with the network, and then failed to repay the loan from the city treasury. It has settled a suit levied against it by its commercial lender, Citi Leasing. Burlington Telecom assumed additional debt to retire the settlement liability. The telco is still making payments against this loan.

The Burlington Telecom network is nominally an open access network, but the city directly provides most of the services delivered over the network.

Key Causes of Failure

Political infighting and operational mismanagement have been the biggest sources of trouble for the BT network. A former mayor prohibited the network from offering service outside Burlington city limits until all premises in the city were connected to it, despite the fact that the network was designed with excess capacity to serve outlying areas. In addition, the city experienced significant cost overruns on the project over the course of several years, which that previous mayor's administration hid from the public.

CityNet (Santa Monica, CA)

CityNet is currently a 10Gbps network in the city of Santa Monica, California, spawned by the City's need to reduce its data access costs.³ After forming a task force evaluating several different approaches, Santa Monica decided to pursue an institutional fiber network in 1998. The first step in developing its fiber network was for Santa Monica to lease an institutional fiber network from the local cable TV operator. That network connected 43 city buildings as well as school and college facilities.

When it leased the institutional network, the City funded the network construction but shared the operations and maintenance costs with the local school district and college. The operational cost savings derived from this shared cost approach reduced the combined telecom costs by \$500,000 per year shortly after the network went live in 2002. From here, the City utilized the savings to build its own 10 Gbps municipal fiber network, from which it began leasing its excess dark fiber to local businesses. Because of low monthly fees, these businesses were willing to fund the cost of building fiber from the backbone to

³ <http://www.bbpmag.com/MuniPortal/EditorsChoice/0511editorschoice.php>

their buildings. In this manner, Santa Monica's network was extended at no cost to the city. In 2009, the city made an additional investment in the network in an effort to provide lower cost bandwidth to small businesses in the area. It did this by leasing a fiber connection to a major colocation center in Los Angeles, 15 miles away, and getting transport from a service provider.

City Net's revenue is \$300,000 per year, which is adequate to fund network operations and maintenance while also supporting a network of 27 Wi-Fi hot spots throughout Santa Monica. The city uses its nearly \$200,000 in remaining capital funds as a revolving capital improvement project account. This account funds construction for network expansion, which is repaid by customers as the network continues to expand to their premises.

CityNet's requirement that customers pay for their own connections slows the growth of the network, but short of receiving a stimulus grant, CityNet will continue a policy of expanding based on demand alone. While the city provides internet access directly, it also makes the network available to third-party providers on an open-access basis.

Key Drivers of Success

- Capital costs were largely paid through telecom savings, allowing the city to fund the initial network backbone at little to no additional cost.
- The city uses excess funds for capital improvement and funds network growth directly via new subscribers.

Utopia – UT

The Utah Telecommunication Open Infrastructure Agency (UTOPIA) is a consortium of 16 municipalities in the Salt Lake City area that builds and owns a FTTP network using active Ethernet. The network is open access, with multiple ISPs operating on the network. UTOPIA also provides public Wi-Fi service in parks and public buildings within its member cities. Each premises to be connected to the UTOPIA network must pay a \$2,750 installation fee. Available speeds range from 100-1000 Mbps.

UTOPIA conducted its initial financing round with a \$185 million bond issue in 2004. In 2006, UTOPIA received an additional loan of \$66 million from the USDA's Rural Utilities Service to complete the network buildout. After paying only \$21 million of the additional loan, the USDA suspended further payments in 2008, citing materially adverse circumstances in UTOPIA's operations. The network is currently seeking funds to complete the buildout, which was to be completed by 2007. UTOPIA has been in discussion with Macquarie Capital regarding a possible buyout.

The UTOPIA network member cities sought the initial bond funds as a unit, in order to pool their collective bond ratings and tax authority. Cities pledged sales tax revenues as collateral for the bonds. Debt service was to be satisfied by project revenues, with sales taxes making up any shortfall.

The constituent towns have borne all operating risk for the network. According to UTOPIA's website, annual operating costs are approximately \$215,000. Constituent towns have attempted to make up the shortfall by raising property taxes or levying a mandatory utility fee on all homeowners (regardless of whether they are connected to the network). Taxpayers have generally voted down these proposals. UTOPIA is often held as an example of a failed attempt at constructing a viable municipal broadband network.

At least some of the network's insolvency is due to a far lower take rate than planned: the network currently has only about 11,000 subscribers versus the 50,000 anticipated. FY 2014 revenues totaled \$6.9 million, against expenses of \$26.8 million and outstanding debt of \$241.2 million.

Individual subscribers have a variety of options for funding the \$2,750 installation fee:

- Lump sum payment
- 6% financing: \$300 up front and \$30/month for 10 years
- 7.9% financing: No money down and \$25/month for 20 years

The installation fee is for the physical network connection and hardware, and is in addition to service fees that the ISPs charge.

UTOPIA is an open access model, and currently has 20 ISPs active on the network. It is worth noting that the incumbent providers (Comcast, CenturyLink, and Frontier) have refused UTOPIA's offer to use the network.

Key Causes of Failure

- UTOPIA based its revenue projections on take rate assumptions that, in hindsight, turned out to be wildly optimistic. The network took on debt based on these faulty assumptions that it cannot repay.
- The UTOPIA network intended to cover a very large geographic footprint from the start, thus incurring very large capital expenses up front, and without guaranteed anchor customers.

New Hampshire FastRoads: Rindge, NH

The Rindge fiber optic network is part of the larger New Hampshire FastRoads project, an open-access middle and last mile network spanning 22 towns and 220 anchor institutions in western New Hampshire. FastRoads is owned by the New Hampshire Community Development Finance Authority, the Monadnock Economic Development Corporation, WCNH.net, and towns in the Monadnock region.

The towns of Rindge and Enfield are the locations of the initial FTTH pilot project, with initial speed tiers of 10-1000 Mbps.

The project has been funded primarily from a NTIA/BroadbandUSA grant of \$44 million under the American Recovery & Reinvestment Act of 2009. FastRoads is a sub-project of the broader Network New Hampshire project. Total construction capital was \$7.6 million.

FastRoads operations are outsourced to a third party network operator. Costs and risks are borne by the participating communities and the Monadnock Economic Development Corporation. Participating ISPs pay FastRoads a percent of their revenue, based on their network utilization. It is worth noting, however, that currently only one service provider offers residential service on the network, while three providers offer small business services.

Key Issues

- The Rindge network has a variety of anchor customers, thus providing guaranteed revenue for operating expenses

- The project received a grant from the NTIA for the bulk of its construction costs, and thus has no debt to pay off.
- The project has struggled to expand and achieve scale.

Targeted Examples: Low-Income Housing

Should the City of Cambridge elect to build only a small network serving Cambridge Housing Authority properties, the following examples will be pertinent.

Austin, TX

Overview

The City of Austin has partnered with Google Fiber to receive its symmetric gigabit broadband internet service through a State of Texas franchise. Speeds of 5 mbps download and 1 mbps upload will be free of charge to 100 community anchor institutions, including the Housing Authority of the City of Austin's (HACA's) properties. The initial plan was for Google Fiber to install broadband internet access for residents at the computer labs of these developments. But the HACA looked to Google Fiber and key community partners to help achieve its two year strategic plan: bringing basic broadband internet into each low-income household. By Google responding favorably and entering into a partnership with HACA, along with HACA receiving a grant from the Community Connections Program, the "Unlocking the Connection" program was rolled out to provide free, basic in-home broadband access for 4,300 public housing residents at 18 HACA properties. HACA's nonprofit subsidiary, Austin Pathways, is the entity charged with seeking funding and implementing the Unlocking the Connection initiatives. The City's project with Google Fiber is divided into three phases, with each phase connecting 6 out of the 18 HACA properties.

Funding

Funding for the initiative is provided in part by the Ford Foundation, the Open Society Foundation, and by key gifts from the following in-kind partners: Austin Community College (ACC), IBM, Freescale, Rackspace, The University of Texas Moody College of Communication, and EveryoneOn.

Capital Costs

The first phase of the Unlocking the Connection initiative is expected to cost \$1.4 million. While Google has not disclosed the total cost of its Austin network, industry analysts estimate the per-premises capital cost for its Kansas City network at approximately \$560.

Operating Costs

As the network operator and internet service provider, the operating costs are borne by Google Fiber. Additionally, Google Fiber has waived the \$300 connection fee per household for all HACA residents. Per the terms of the contract between HACA and Google Fiber, basic internet access will be provided to residents free of charge for ten years.

Risks

HACA and the City of Austin are in a public-private partnership with Google Fiber. In this specific business model, the risks to HACA and the City of Austin are limited, with the primary tradeoff being no control of the network. The other risk – and potential barrier for low-income Austin residents – is the \$10 pre-registration fee that HACA or its residents must pay to Google Fiber in exchange for its services. Otherwise,

Google Fiber constructs, operates and maintains 100% of the network at its expense in exchange for access to Austin's municipal assets and existing network infrastructure free of charge.

Key Drivers of Success

- A large amount of political support was received early on, with a strong commitment to improve broadband availability. There was strong collaboration among stakeholders, and a thorough planning process was put in place.
- City-wide fiber access is being rolled out in phases by Google Fiber, an experienced developer. Phased development allows for a more orderly project execution, and makes it easier for Google Fiber to scale the network.
- The city allowed Google Fiber to utilize its existing infrastructure in lieu of Google Fiber needing to build its own facilities and pass those costs onto the customers.

Fremont, CA

Overview

Eden Housing, an affordable housing developer, opened Cottonwood Place in Fremont, California in 2012. It is a mixed-use development that combines housing and health care services for low-income seniors age 62 and older, and comprises a partnership between Eden Housing, the City of Fremont, and On Lok Lifeways, a senior health services organization. In each of the 98 units at Cottonwood Place, broadband internet access is offered free of charge, with Eden Housing paying the full cost of wired broadband access and providing a free modem to each unit.

Funding

Broadband internet deployment at Cottonwood Place was 100% financed by Eden Housing. However, Eden Housing was able to receive tax credits through California's Qualified Allocation Plan (QAP) application for Low Income Housing Tax Credit (LIHTC), which awards additional points to applicants who offer in-unit broadband access to residents.⁴

Operating Costs

The total cost of service incurred by Eden Housing, Inc. is \$190 per month for the entire housing development. Service is provided to all residents free of charge.⁵

Risks

Eden Housing's ISP may raise prices or go out of business.

Key Drivers of Success

- The funding for the project was readily available by Eden Housing, Inc., and they seized the opportunity of taking the California Low Income Housing Tax Credit in the process.
- All operating expenses incurred by Eden Housing at Cottonwood Place are accounted for in their general operating budget.

⁴ (Ault, Eden Housing's Cottonwood Place, 2015)

⁵ Ibid.

Madison, WI

Overview

The city of Madison is in the process of building a pilot FTTH project in four low-income neighborhoods. Its initial RFP, released in mid-2015, received three proposals; two were for wireless solutions. The RFP specified that the city would prefer a wireless or LTE solution, so there was some surprise that it opted for the sole non-wireless proposal. Madison's mayor, Paul Soglin, has long been a vocal proponent of FTTH, so the move was not entirely surprising. The city will own the network, and ResTech, a local ISP, will be the network operator and internet service provider.

ResTech is building the pilot network and connecting it to Madison's existing municipal fiber backbone, the Metropolitan Unified Fiber Network (MUFN), a 132-mile fiber backbone built with a \$5.1 million grant from the American Recovery and Reinvestment Act of 2009. MUFN currently serves hospitals, municipal buildings, and other community institutions.

Funding and Service Tier

The city passed a budget amendment to its initial \$150,000 allocation allowing it to pay for the entire project, currently estimated at \$512,000. ResTech will provide a single tier of service: 10Mbps symmetric for \$9.99/month.

Risks

The city has not analyzed demand for the service in the four neighborhoods, or what the probable take rate will be. Indeed, in a show on the local community radio station, it was said that this is the single largest unknown in the network's development.⁶

Under Wisconsin law, cities that wish to offer municipal broadband must perform a cost-benefit analysis and hold a public hearing, as well as obtain Competitive Local Exchange Carrier (CLEC) certification. Madison states that it will conduct the cost-benefit analysis one year into the network's operation. If the analysis is promising, the city will consider expanding the network to all city premises.

More troublesome for the project, under state law, municipal broadband networks may not offer phone or TV services; they can only provide Internet service. Being unable to offer additional services cuts off municipal providers in Wisconsin from potentially important alternative revenue streams, making it more difficult to develop a profitable network. The Federal Communications Commission is currently debating new rules that would make it illegal to restrict the types of services municipal broadband networks can offer.

Other Low-Income Broadband Initiatives

ConnectHome

While not a specific network, an overview of ConnectHome is in order. ConnectHome⁷ is a US government program unveiled in July 2015 by President Obama to expand broadband access to low-income households in 28 communities around the country, including one tribal nation. Under the program, the federal Department of Housing and Urban Development has partnered with eight national and local ISPs, including Google Fiber, CenturyLink, and Cox Communications, to provide low-cost broadband service to low-income Americans, with initial focus on households with children. The program also pays for

⁶ <http://www.wortfm.org/explaining-the-city-of-madisons-broadband-initiatives/>

⁷ <https://goo.gl/9FGtLM>

computer literacy training via a partnership with Best Buy and for reduced-cost computers and tablets via grants from private donors, as well as online course materials including SAT prep.

Existing ISP Programs for Low-Income Customers

Several ISPs offer unpublicized tiers of service for low-income customers. In the City of Cambridge, Comcast currently offers their *Internet Essentials Program*. Details of selected providers' programs are in the below table.

Provider	Details
CenturyLink	InternetBasics program provides 1.5Mbps service for \$9.95/month with a 12 month contract. Qualifications vary by state, but generally require some kind of participation in benefits.
Comcast	Internet Essentials program provides 10Mbps download speeds for \$9.95/month to families with at least one child in the National School Lunch Program and who have no outstanding debt to Comcast within the last year. The program requires no credit checks or contracts, and includes a free Wi-Fi modem.
Cox	Connect2Compete program provides up to 10Mbps download speeds for \$9.95/month for families with at least one child in the National School Lunch Program and who have no outstanding debt to Cox within the last year. The program requires no credit checks or contracts, and includes a free Wi-Fi modem.
Google Fiber	Basic Internet Plan provides free 5Mbps service but users must pay a \$300 setup fee, which can also be spread into 12 monthly payments of \$25.

Fiber Designs

General Design Parameters

Tilson has laid out and analyzed of three separate alternative fiber designs, termed Small, Medium, and Large. The parameters for each of the designs were chosen in consultation with the Broadband Task Force and City staff. Each of the three designs illustrates one of the Capital Cost Strategies discussed earlier in the report. The estimates in this section assume that any given design is built from scratch, not based on a smaller initial buildout.

The two lit network designs presented, the Small and Large Designs, use a Gigabit Passive Optical Network (GPON) architecture, the most common fiber-to-the-premise network architecture deployed in the United States today. In a passive network, fibers are split so that multiple premises share a single beam of light. While it is possible to split fiber cables so that up to 64 premises share one beam of light, Tilson has designed a 1:32 split ratio as the best balance between cost and performance.

Small Network: Fiber to Cambridge Housing Authority Locations

Key Assumptions

The Small network option is a Targeted Network build-out. This design envisions building fiber to Cambridge Housing Authority locations only. Each building will have fiber brought to it. Distributing connectivity via inside wiring or via wireless within multi-tenant buildings is not within the scope of this

study, but would be a very important part of delivering service to residents, and depending on the condition and availability of existing wiring, could increase capital costs significantly.

Network Design

As can be seen from the below map, the proposed small buildout connects Cambridge Housing Authority properties to the existing City of Cambridge fiber network.

The Small network design totals 4.4 miles of fiber, approximately 2.7 miles of which are routed underground. The aboveground portion is carried on utility poles. This network connects to Cambridge's existing municipal fiber network.

It also assumes this project would be built in a manner that could be used later as one part of a larger build-out to reach a broader audience. Therefore, it also assumes that the fiber is built in manner that is consistent with providing premises along the route access to the fiber in the future.

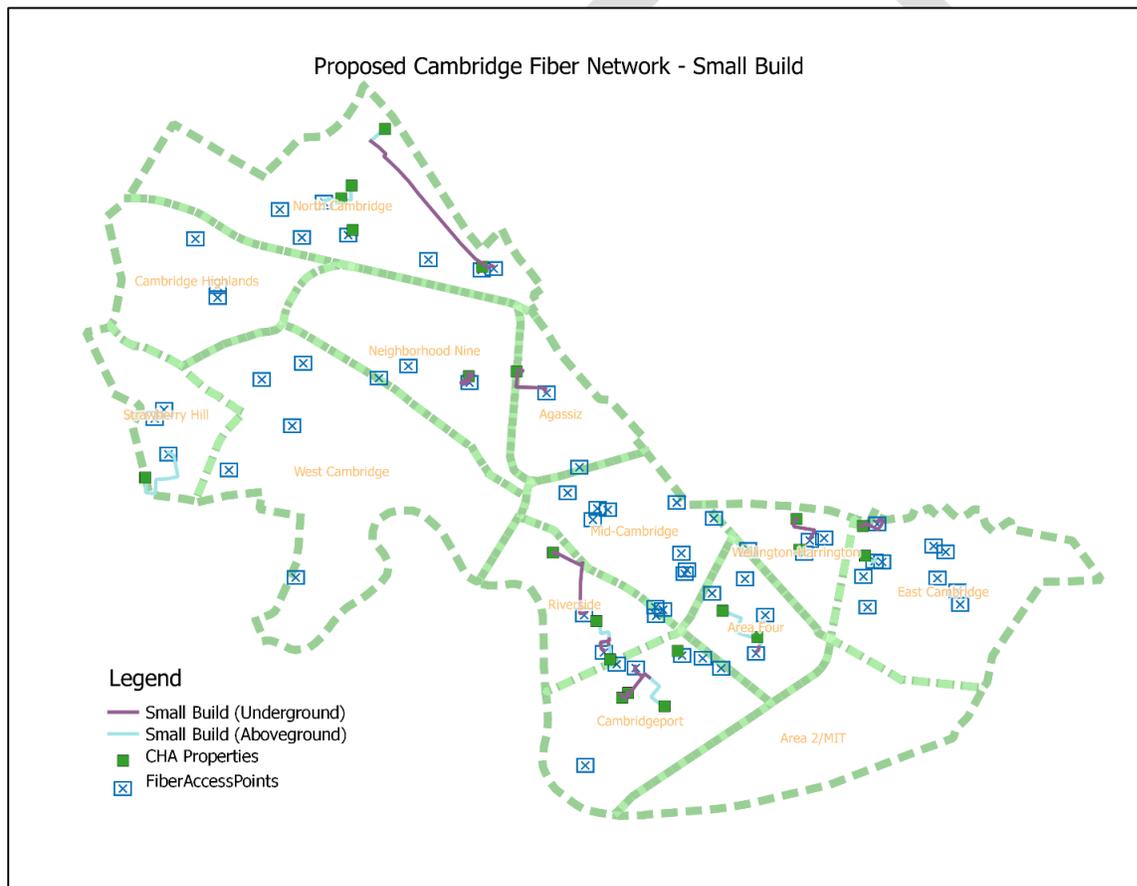


Figure 2 – Small Network Buildout

Operating Expenses

The City could choose to operate the network as an extension of the existing municipal fiber network. As such, operating expenses will include the same types of operation and maintenance on the actual fiber plant that the city is already accustomed to doing. This model assumes that service is to provide an

amenity to residents in CHA properties at little or no cost to them, avoiding the need to provide for extensive billing and payment systems.

Medium Network: Multi-Neighborhood Dark Fiber

Key Assumptions

The Medium design is a partial network build-out intended to provide a dark fiber pass along routes that pass through city neighborhoods. The general approach of the Medium buildout is to provide fiber to multiple key neighborhoods in the city. Private internet service providers would then be invited to connect to the fiber in each neighborhood, run service to individual premises, and provide full Fiber to the Home service.

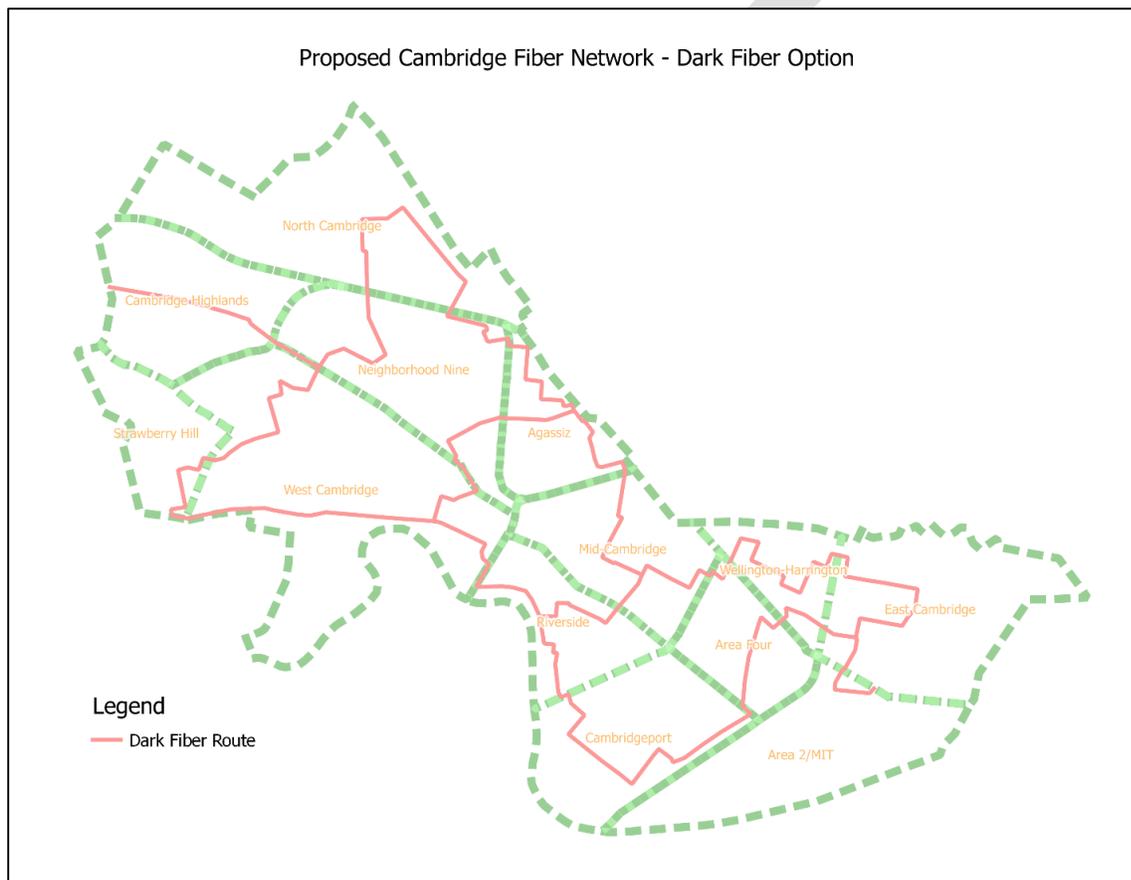


Figure 3 – Dark Fiber Network Map

Network Design

The dark fiber network consists of 17 miles and extends to all city neighborhoods. Approximately 88% of the fiber is run on existing poles aboveground in order to minimize costs; in fact, routing along roads with poles where possible was a design criterion for this option. This design includes installation of a Point of Presence where service providers will connect with other networks. Note that this does not include any network equipment, as service providers will install and maintain the equipment they need in order to provide service. Below is a map of the proposed network buildout.

Operating Expenses

Operating expenses for the city will include maintenance and upkeep of the fiber strands and associated buildings, as well as marketing and management costs.

Large Network: Fiber to All Premises in Cambridge

Key Assumptions

The Large design is a Full Network build-out for fiber to the home at all premises in the city limits—approximately 148 miles of fiber. The model assumes approximately 29% of the cable will be run underground via new trenches dug to minimize impact to existing city facilities. For this design, Tilson has assumed that existing underground conduits will not be available to the project. To the extent that the project can use existing underground facilities, the project's cost will decrease.

Network Design

The network extends to all premises in the city, as shown in the map below. The City might choose to implement a city-wide design at a number of levels that would ultimately affect the total capital costs. Specifically, the City might choose pass all premises, but only provide drops and electronics to premise that subscribe to service. Therefore the total capital cost would be greater or lower depending on the take-rate.⁸ In addition, if the city constructed only the fiber pass and drop, this would also result in a lower capital cost, with the important caveat that a private partner would need to make these investments to result in a network that delivered broadband services to users in the City.

Operating Expenses

Operating a city-wide lit fiber network would require substantially more operating capabilities than the other options. It would require call centers for customer service and technical support, as well as investment in billing systems. The city would also likely need to scale up existing operations, such as its network operations center and fleet of bucket trucks, or contract with an entity that can provide these.

⁸ Obviously, despite a higher capital cost, a scenario with a higher take rate tends to have better business case because of the opportunity to spread out the fixed cost of constructing the fiber pass over a larger number of users.

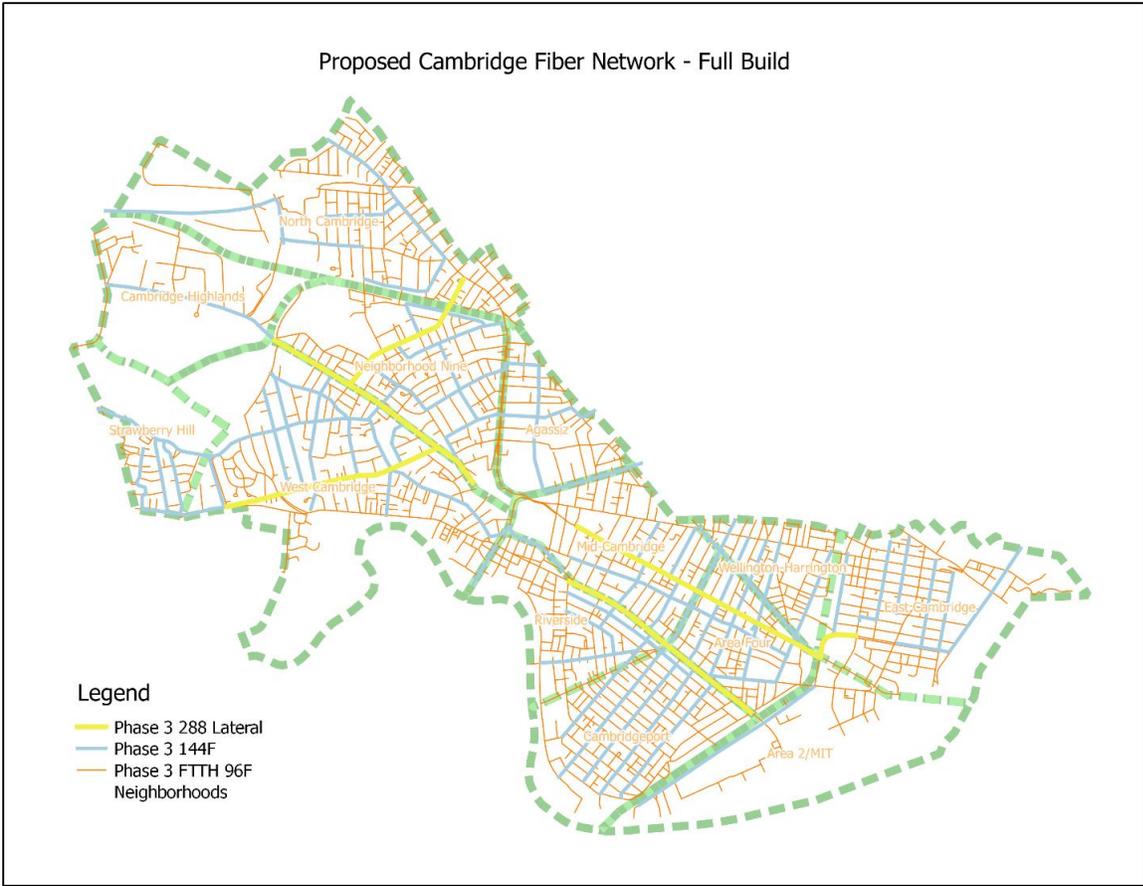


Figure 4 – Large Network Buildout Map