CITY AND COUNTY OF SAN FRANCISCO
BOARD OF SUPERVISORS
BUDGET AND LEGISLATIVE ANALYST
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Policy Analysis Report

TO: Supervisor Farrell

FROM: Budget and Legislative Analyst's Office

SUBJECT: Financial Analysis of Options for a Municipal Fiber Optic Network for Citywide Internet Access

DATE: March 15, 2016

Summary of Requested Action

You requested a financial analysis of a municipal fiber network to provide Internet access to all residential, commercial and industrial premises in San Francisco at speeds of a least 1 Gigabit per Second (1 Gbps), with the capacity to increase in the future as the definition of high speed or broadband changes. You specifically requested three approaches to financing and operating the fiber network:

(1) public development and ownership

(2) private development and ownership

(3) public/private partnership development and ownership

You asked that the cost estimates include: 1) hard and soft costs related to construction, including permitting and environmental review, and 2) the cost of operating and maintaining the network. Potential financing sources were to be identified for each option including the City issuing debt, state and federal grants, philanthropic contributions and various private sector funding options.

Finally, you requested that the report provide an analysis of fiber network implementation in other cities and an assessment of the socio-economic benefits of low-cost access to the Internet through fiber networks.

For further information about this report, contact Fred Brousseau at the Budget and Legislative Analyst's Office.

Executive Summary

Fiber optic technology: Converts electrical signals carrying data to light and sends the light through glass fibers. It can transmit data at speeds far exceeding DSL or cable networks, the most common technologies employed by current private sector ISPs.

Fiber to the premises (FTTP): Fiber optic network built out to connect to all premises in a jurisdiction, providing high-speed Internet access. Current networks in residential neighborhoods in San Francisco contain a mix of fiber and copper. Some business in SOMA and downtown have fiber to the premise connections.

Digital divide: the division between those who have high-speed computer-based Internet access at home and those who do not.

- The National Broadband Plan, released by the Federal Communications Commission in 2010, described broadband as "the great infrastructure challenge of the early 21st century" and as "a foundation for economic growth, job creation, global competitiveness and a better way of life".
- In its 2015 report, the national Broadband Opportunity Council called "affordable, reliable access to high-speed broadband" critical to U.S. economic growth and competitiveness. While national in focus, the Council recognized in its report that most broadband investment decisions are made at the local level in partnership with the private sector. The Council included a number of recommendations to facilitate broadband deployment by local governments.
- High-speed, Internet access at speeds of at least 1 Gigabit per second (1 Gbps), the standard in next-generation broadband, is not available to most residential, commercial, and industrial premises in San Francisco.
- Fiber optic networks contain the primary technology capable of delivering such high-speed Internet service and, according to numerous industry experts, will be the baseline speed in the future to allow for full access to and use of the Internet for education, health care, civic engagement, entertainment and other services.
- Except for a municipal network serving some City departments and public housing complexes, Internet service provision in San Francisco is currently provided by private companies that use a combination of some fiber optic, coaxial, copper, and wireless technologies to deliver service at speeds significantly less than a gigabit per second. The City has limited ability to influence service levels, download and upload speeds, and retail prices for services offered by private Internet Service Providers (ISPs).
- While Internet access is available to most premises in San Francisco, 12 percent of City residents, or approximately 100,500 individuals, reported in a 2013 City Controller survey that they did not subscribe to Internet service at home. The price of Internet access service is one of the reasons residents do not have wired Internet access at home.

- According to Ookla, a company that tracks Internet speeds of users who test their Internet access speeds, average download speeds for the top 10 percent of users in San Francisco as of November 2015 ranged from 12 to 279 Mbps, depending on the user's ISP.
- Nationally, the average download speed was 21.2 Mbps in 2014, which ranked 19th in the top 20 national average download speeds in the world. The top three countries with the highest average download speeds were South Korea, Japan, and Sweden. In the top ranked countries, regulatory intervention and funding from local and national governments has fostered high-speed network development.
- While Internet access is available to most residential, commercial and industrial premises in San Francisco, as of June 2014 gigabit per second Internet access speed is only available to 2.6 percent of San Franciscans. Industry experts do not believe that incumbent providers will implement a Citywide fiber to the premise network (FTTP) anytime soon.

Average Download Speeds by Country, 2014

Rank	Country	Average download speed
1	Korea	50.7
2	Japan	41.8
3	Sweden	40.4
4	Netherlands	39.1
5	Switzerland	38.8
	…….	
19	United States	21.2

Bit: basic unit of information in digital communication, with values of either 1 or 0.

Megabit: 1,000,000 bits of data and the standard measurement for download/upload Internet speeds per second (Mbps). Megabits are not the same as megabytes, which measure file or storage space. The average connection speed in the U.S. was 21.2 Mbps in 2014.

Gigabit: 1,000 megabits, a measure of Internet access speed. This is a higher speed than available to most end users in San Francisco and a standard for future-ready broadband.

- Additional ISPs, whether public or private, would increase competition in the ISP marketplace and thus have the potential to increase service levels and decrease retail prices Citywide. However, one of the key barriers to entry for new ISPs is the high cost of network construction.
- There are currently 143 municipally-owned FTTP networks in the United States. No city of comparable size to San Francisco has deployed a ubiquitous FTTP network as of yet. However FTTP network initiatives are underway in cities in California and throughout the U.S.
- Given the still expanding role of the Internet in the economic, education, civic and medical spheres, and given that industry experts do not believe a FTTP Citywide network will be deployed by the private sector absent government intervention, the Board of Supervisors could consider the following three options for making gigabit speed service available via a fiber optic network to all premises in San Francisco.

  1. **The Public Model:** The City would establish a municipal fiber enterprise and assume responsibility for the construction and operations associated with providing gigabit speed Internet service to all premises in San Francisco. Under this model, the City and County of San Francisco (the City) would manage construction of a fiber optic network and establish administrative and retail operations to serve as network administrator and Internet Service Provider.
  2. **The Private Sector Model**: The City would assume no responsibility for deployment of a high-speed network but would rely on the private sector

electing to provide gigabit speed Internet access to all premises. The City could, however, take actions to incent private sector companies to provide such service though there would be no guarantee that such incentives would result in the deployment of a Citywide fiber optic gigabit speed network. City incentives could include relaxing construction regulations and permitting requirements pertaining to network construction, making City property more easily available to ISPs for their network facilities and equipment, and allowing ISPs to use existing public conduit. The City could also provide subsidies and digital literacy education to lower income households to cover the costs of equipment and gigabit speed Internet service, when and where available.

3. **The Public-Private Partnership Model:** The City and one or more private sector partners would share the costs and financial and operational risks associated with constructing and operating a ubiquitous FTTP gigabit speed network. While there are a number of possible configurations for such partnerships, one structure is for the City to retain ownership of the network, but to delegate some or all responsibility for network construction, administration, maintenance, and retail operations to private sector partners under formal agreement and possibly to share in the revenue generated by the new enterprise.

⇨ ***Key decision: demand driven or utility-based buildout for gigabit speed network***

- There are two key buildout approaches to be considered for either the public model or the public-private partnership model: 1) "demand-driven", or 2) "utility-based".
    i. Under a ***demand-driven*** buildout, network connections to individual premises would only be constructed at the time a customer subscribes to the service. This would keep initial construction and operating costs down but would not ensure that all premises are connected to the network with at least a baseline level of Internet access.
    ii. Under a ***utility-based*** buildout, all premises in the City would obtain potential access to the fiber optic network at the time of construction. As a result, network construction, ongoing operating, and capital costs would all be much higher but all premises in San Francisco would benefit from at least baseline access to the network. Access to all premises assumes that all property owners acquiesce to establishing final connections to their property.
- The private sector model is based on a demand-driven buildout. Some incumbent ISPs are beginning to provide or have announced plans to provide

gigabit service in San Francisco in the future. However, affordability and extent of the services to be finally offered are not yet known.

Criteria for evaluating models and buildout approaches to gigabit speed networks

- For this report, each model and approach has been evaluated by the Budget and Legislative Analyst against the following criteria:
  - ✓ Cost to City
  - ✓ Risk to City
  - ✓ Impact on digital divide
  - ✓ Provision of affordable gigabit speed Internet access to all premises

The following discussion addresses the public and public-private partnership models relative to the criteria above. Exhibit A below provides a summary of each model and buildout approach's costs and funding mechanisms. Exhibit B provides a summary graphic of each model and buildout approach relative to the criteria above.

Public Model Costs and Risks

- Assuming a ***demand-driven*** buildout under the public model, the City would incur an estimated $393.7 million in network construction costs, paid for through bonding. It would cover most of its debt service and operating costs from subscriber revenue. However, cost and revenue projections prepared for the Department of Technology (DT) show that, with an assumed market share of 30 percent of all ISP customers and residential and commercial subscriber rates of $70 and $100 per month, respectively, revenues would not be sufficient to cover the $103.2 million in estimated annual debt service, capital and operating costs for twenty years until the initial construction debt is paid off. Unless a larger market share of 40 percent or higher is attained and/or higher subscriber rates charged, a secondary funding source would be needed.
- Construction costs assuming the ***utility-based*** buildout would be $867.3 million, or higher than a demand-driven buildout, because construction would include costly network connections to every premise in San Francisco. Ongoing annual costs would be $231.7 million per year. If the City provided baseline Internet access to all premises and charged a premium for high speed service, subscriber revenue would be $86.3 million per year, using the same market share and pricing assumptions as for the demand-driven buildout above. This would leave an annual deficit of $145.4 million per year that would have to be covered from some other source.
- To cover the higher costs of a utility-based buildout, at least one private sector company promoting fiber optic network public-private partnerships has

proposed charging a utility fee on all premises in exchange for which premise owners would all receive baseline Internet access service with no additional monthly subscriber costs. The City could similarly impose a monthly utility fee on all premises in San Francisco under the public model to ensure sufficient revenue to cover all debt service, operating and ongoing capital costs over a 30 year period. Based on costs estimated by DT's cost consultant, it would require an average monthly fee ranging from $25 per residential premise to $115 on commercial premises.

- An average of $43 for all premises was assumed for public model utility-based buildout estimates in this report. Whatever utility fee amount selected, a utility fee would require two-third voter approval.
- For the utility-based buildout public model, a key risk is that the adopted utility fee would not be sufficient to cover all costs or that a utility fee would not be adopted at all, leaving the City without a funding source to cover the costs of constructing, administering and operating the fiber optic network and serving as an ISP.
- The primary risks associated with the demand-driven public model are that a sufficient number of customers would not subscribe to the City's ISP service and revenues would not be sufficient to cover most of the enterprise's debt service, operating and capital costs.
- Other risks of any public model include incurring network construction delays and/or cost overruns and problems as the City creates and begins operating a new ISP enterprise. Such risks would be heightened by the City's lack of experience starting or operating network administration and Internet Service Provider business enterprises. Public-private partnerships could potentially blunt some of these risks to the City.
- The utility-based buildout would help reduce the digital divide by providing access to a high-speed Internet connection to all premises in San Francisco. However, some households still may be without computer equipment to access the Internet and a utility fee and a monthly subscription rate for high-speed access could pose financial hardships on lower income households. City support through means-based subsidized fees and rates, access to low-cost computers and digital literacy education would likely still be needed to fully close the digital divide.
- Both the demand-driven and utility-based buildouts would help reduce the digital divide by promoting greater ISP competition and, therefore, could reduce prices for Internet access.

Public-Private Partnership Costs and Risk

- The same two buildout approaches assumed for the public model were applied to the public-private partnership (P3) model: 1) utility-based, and 2) demand-driven. The utility-based buildout presented in this report would remove the City from all of the tasks and risks of constructing, administering and operating a fiber optic network by transferring those responsibilities through a long term agreement to a consortium of private sector companies, with the lead firm known as the concessionaire. ISP service would be provided by private sector companies under agreements with the concessionaire. The City would maintain ownership of the fiber optic network assets.
- Due to the high cost of constructing a utility-based fiber optic network connected to all premises in San Francisco, and estimates by DT's consultant that customer subscription revenue would not be sufficient to cover all capital and operating costs. The P3 utility-based buildout presented in this report assumes that the City would impose and collect a utility fee. The fee could range from $10 per month for residential premises to $75 for commercial premises. An average of $25.50 per month collected from all premise owners was assumed for estimating P3 utility-based buildout estimates in this report.
- All premises would be provided with baseline Internet access at lower speeds; those paying a premium on top of the utility fee would be provided gigabit speed service. The utility fee is lower in the P3 utility-based concessionaire model than the utility fee in the public model because the concessionaire would take on less responsibility for operations and therefore have lower costs to be recouped by the fee.
- The average utility fee assumed estimates in this report could be reduced from $25.50 per month for all premises to as low as $10 per month per residential premise, assuming: 1) the City negotiates an arrangement with the consortium in which concessionaire revenue from premium users is used to offset consortium costs, or 2) the utility fee is reduced for residential premises by charging a higher fee for commercial customers in proportion to their use of Internet services. A higher market share than 30 percent or higher subscriber rates for premium gigabit speed service could also allow for lower utility fees.
- A lower cost P3 alternative is presented in this report using a demand-driven "dark fiber" buildout. Though also a concessionaire arrangement, it is distinguished from the utility-based concessionaire approach because the City would assume responsibility for, and the risk of, initial network construction and ongoing maintenance but would not bear responsibility, or the risks, for network administration and provision of ISP services ("lighting" the network). Instead, those functions would be performed by private sector partner(s).

- At $285 million, fiber optic network construction costs would be lower under the demand-driven dark fiber buildout than with the utility-based concessionaire buildout because network connections to individual premises would only be constructed as customers subscribe to the high-speed service. Funding for the City's annual debt service would be from the private partner's network lease payments to the City and any shared subscriber revenues. The City's annual costs would be $56.3 million per year for debt service and network maintenance costs only, which could be covered by the private partner's network lease payments to the City assuming a market share of 30 percent for ISP services provided over the fiber optic network.
- Like the public utility-based model, the P3 utility-based model would better help close the digital divide by providing access to a gigabit speed Internet connection to all premises in San Francisco, though some households without computer equipment still may be without access to the Internet. Further, a utility fee and a monthly subscriber fee for gigabit speed service may prove onerous for low-income households and may require some form of equipment and/or financial subsidy to ensure that all premises had access to the new Internet access service. And, as mentioned above for the public model, property owners may decline a final connection to their premises, limiting the ubiquity of access.
- As with the public model, affordable gigabit speed Internet access to all premises in San Francisco under the P3 model would best be achieved through a utility-based buildout. The demand-driven model would also provide gigabit speed access, but only to premises able to pay for it. Both models would increase ISP competition in San Francisco, which should have the effect of helping keep service affordable.
- A summary of costs and funding mechanisms for the public and public-private partnership models is presented in Exhibit A. As shown, the City would incur the highest construction and ongoing annual costs under the public utility-based model. However, imposition of a monthly utility fee would enable the City to cover those costs while providing fiber optic network gigabit speed Internet access service to all premises in San Francisco.
- The P3 utility-based concessionaire buildout would minimize City costs and related risk by transferring the costs to private sector partners but it would require imposition of a monthly utility fee per premise to cover all private partner costs.
- The demand-driven buildout under either the public or P3 model offers lower City costs by providing network connections only to premises that sign up for service. In the case of the P3 dark fiber demand-driven buildout, the City would

incur even lower costs because it would only be financially responsible for construction and maintenance of the core network. Last mile construction and ongoing operations would be performed by private sector partners.

- The primary risk to the P3 demand-driven dark fiber model is that it would not attract sufficient interest from ISPs and therefore not generate enough lease payments to meet its debt service and ongoing operating costs and would only achieve limited benefits of competition.
- A major risk of the P3 utility-based concessionaire model is that there are no examples yet of this model in the U.S. in which a FTTP network has been built and is operated by a private sector provider in a large urban area as part of a public-private partnership. In addition, assuming the City has a revenue-sharing agreement with its private partners, if the private-partners were not successful at attracting subscribers, the City's share of revenues would be negatively affected. Finally, because it is a utility based buildout that connects to every premise, it is possible that only a fraction of premises will use the new service, leaving much of the new infrastructure, the cost of which will still need to be repaid, unused.

Exhibit A: Comparison of public costs and cost recovery mechanisms for public and public-private partnership models

Model	Public Model		Public-Private Partnership	
Buildout Approach	Demand-driven	Utility-based	Dark fiber, Demand-driven	Concessionaire, Utility-based
City Network Construction Costs	$393.7 mn.	$867.3 mn.	$285.0 mn.	$0
City Ongoing Annual Costs	$103.2 mn.	$231.7 mn.	$56.3 mn.	$0
Cost Recovery Mechanisms:				
Customer Subscription Rates	$70/mo. (res); $100/mo. (com.)	n.a.[1]	n.a.	$70/mo. (res); $100/mo. (com) [2]
Utility Fee per Premise[3]	$0	Average: $43/mo./premise Range: $25/mo. res to $115/mo. commercial	$0	Average: $25.50/mo./premise Range: $10/mo. res to $75/mo. commercial
Fees to City from Private Partner	n.a.	n.a.	Lease revenue based on: $6/premise passed; $30/premise subscribed	Revenue Sharing from Concessionaire; amount to be negotiated

[1] The public model utility-based buildout assumes that all ongoing City costs would be covered by a monthly utility fee imposed on all premises averaging $43 per month, in exchange for which all premises would have access to gigabit speed Internet access. However, if the City wanted to impose a lower monthly utility fee, it could obtain revenue from another source, such as by varying the access speeds provided to all premises, providing a lower speed baseline at no additional cost beyond the utility fee and gigabit speed for an incremental monthly premium amount. The P3 utility-based concessionaire model assumes that the utility fee only covers baseline lower speed service; customers would need to pay an additional fee to access higher speeds.

[2] In the baseline P3 concessionaire model, customer subscriber rate revenue is assumed to be retained by the private sector ISPs with the monthly utility fee imposed on all premises sufficient to cover all the concessionaire's ongoing operating and capital costs for maintaining the wholesale network.

[3] The monthly utility fee amounts presented represent an average maximum fee per premise to cover all ongoing operating, capital and debt service costs. However, as discussed in this report, these fees could be lowered by some combination of imposing fees for higher speed service and utilizing subscriber rate revenue to cover ongoing costs and/or charging higher subscriber rates for commercial customers relative to lower rates for residential customers.

Implementation challenges

- Private contractors, regulated utilities, and City departments that wish to excavate in the public-right-of-way or attach cables to utility poles to construct a FTTP network must first receive numerous certifications and permits, and submit information to the City and, in some instances, the California Public Utilities Commission (CPUC). Cumulatively, the permitting and approval process can take several months.
- Though the regulatory requirements vary for public agencies, private companies and regulated utilities, the amount of time needed to obtain the necessary permits and gain approval to excavate the street and install fiber and conduit should not differ significantly depending on the entity performing the task. Installation of new conduit is expensive and time-consuming and owners of existing conduit may not be inclined or capable of expeditiously granting access to new providers.
- The rules governing access to utility poles also vary depending upon who owns the pole itself, and the type of entity attempting to gain access to the pole. Regulated utilities that own poles are required by the CPUC to provide access to telecommunications and cable TV corporations, but not to municipalities, video companies, or other private companies. Those not granted access by the CPUC must negotiate pole attachment agreements through the Northern California Joint Pole Association. Pole owners may not be inclined or capable of expeditiously granting new service providers access to their poles.

Conclusion

- Exhibit B below compares and summarized each model's strengths and weakness in achieving the City's goals of: (1) minimizing public cost, (2) minimizing risk to the City, (3) reducing the digital divide and (4) ensuring affordable gigabit speed Internet access to all premises in San Francisco. As shown, the various buildout approaches to achieving a ubiquitous gigabit fiber

optic network discussed in this report offer policy makers a range of costs, risks, and benefits to the City.

Exhibit B: Gigabit Speed Fiber Optic Network Models and Buildout Approaches Relative to Evaluation Criteria

Model	Public Model		Public-Private Partnership		Private Model
Build out approach	**Utility - Based**	**Demand-Driven**	**Concessionaire, Utility -Based**	**Dark Fiber, Demand-Driven**	**Demand-Driven**
Cost to City	$$$$	$$$	$$$$	$$	$
Risk to City	↑↑↑↑	↑↑↑	↑↑	↑↑	↑
Reduction in digital divide	🖱🖱🖱	🖱🖱	🖱🖱🖱	🖱🖱	🖱
Gigabit speed to all premises at affordable prices	🐢🐢🐢🐢	🐢🐢	🐢🐢🐢	🐢🐢	🐢

- In general, the higher cost utility-based buildouts would further advance the objectives of reducing the digital divide by providing access to gigabit speed Internet service to all premises in San Francisco. Prices should be more affordable since the new fiber optic network would provide consumers with more ISP choices. Final connections to each premise could be limited to the extent property owners do not approve the final connection to their properties. In addition, City subsidies of lower income households may be needed to assist with the burden of a monthly utility fee and/or subscriber fees.

- The utility-based buildout under either the public or P3 models assumes the imposition of a monthly utility fee on all premises to defray the higher costs of creating and operating a fiber optic gigabit speed network providing access to all premises in San Francisco. The monthly utility fee amount could be lowered for various customer classes by differentiating the amount charged, for example, to residential and commercial customers based on some commercial customers' greater need and use of Internet access and/or by providing lower speed baseline Internet access for free to all premises and gigabit speed access for a higher monthly subscriber rates.

- The public-private partnership model would reduce the costs and risks to the City associated with creating and successfully operating a complex new fiber optic network administration and ISP business enterprises though the City would forego control in areas such as pricing that it would otherwise maintain under the public model. However, the public should benefit under a public-private partnership as more providers would be allowed to use the fiber optic network, thus providing consumers with the benefits of competition.

- The demand-driven model under the public or public-private partnership models is a less costly alternative and would provide consumers with the price and other benefits of increased competition. But it would otherwise not address the digital divide or guarantee provision of fiber network gigabit speed Internet access to all premises in San Francisco.

- The public and public-private partnership models would have to contend with competition from incumbent providers who would continue to operate and compete with any new Internet access provider. In some cities establishment of municipal gigabit networks has resulted in incumbent providers accelerating improvements to their networks and connection speeds and competing with the municipalities on price. Currently, ISPs in San Francisco are offering gigabit speed service in limited areas of the City and some have publicly stated their plans to expand the coverage of these services. One provider, Comcast, has stated that it will offer gigabit services throughout the City within the next two years, though pricing is not yet known.

Project staff: Fred Brousseau, Nicolas Menard and Julia Nagle

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2. Why Broadband and Fiber Optic Networks?

The need for, and benefits of, broadband Internet access, defined by the Federal Communications Commission (FCC) as Internet connections with minimum speeds of 25 Mbps for downloads and 3 Mbps for uploads, have been articulated in a number of analyses and studies. The National Broadband Plan released by the FCC in 2010 described broadband as "the great infrastructure challenge of the early 21st century" and as "a foundation for economic growth, job creation, global competitiveness and a better way of life".

In its 2015 report, the Broadband Opportunity Council, created by Presidential Memorandum, described broadband as a core utility, taking its place alongside water, sewer and electricity as essential infrastructure for communities. It also called "affordable, reliable access to high-speed broadband" critical to U.S. economic growth and competitiveness. While national in focus, the Council recognized in its report that most broadband investment decisions are made at the local level in partnership with the private sector and included a number of recommendations to facilitate broadband deployment by local governments.

Internet service in the U.S. has historically not been conceived of as a utility and has been provided by the private sector, primarily telecommunications and cable television companies that constructed electronic networks to provide homes and businesses with telephone and cable television services. Those networks, generally composed of copper wires, have limitations in providing symmetrical[1] Internet access at high speeds such as 1 gigabit per second (Gbps) which has become a standard for high speed access provided by private and public sector Internet Service Providers (ISPs) serving municipal networks throughout the country. Gbps speed Internet access is much faster than what most Americans have. The average download speed in the U.S. was 21.2 Megabits per second (Mbps) in September 2014, substantially less than the high speed standard of 1,000 Mbps, or 1 Gbps.[2] Many industry analysts consider a Gbps an access speed that will not only allow for extremely fast download and upload speed at present, but will also accommodate future growth in Internet use as new applications and content require increasingly faster access speeds.

A key reason that gigabit per second Internet access speeds are not commonly available in the U.S. is that most existing transmission networks were built for other purposes and are limited in their ability to provide high speed Internet access.

[1] Symmetrical networks have the same download and upload speeds. Because of their network technology, private sector ISPs commonly offer faster download speeds and slower upload speeds. Fast upload can be particularly important for businesses and others that produce content for distribution on the Internet.

[2] Source: OECD Broadband Portal, Figure 2.P30

Digital Subscriber Line (DSL) networks transmit data over copper lines originally designed for telephones and are limited in their ability to provide high-speed Internet access. Cable modem networks use coaxial cables originally designed for cable television transmission. Though cable modem networks offer higher speed access than DSL, they are also limited in providing symmetrical gigabit per second Internet access speed. More details on network transmission types are provided below.

Fiber optic technology, which converts electrical signals carrying data to light and sends the light through glass fibers, can transmit data at speeds far exceeding DSL or cable networks. However, Internet Service Providers (ISPs) serving most communities in the U.S. are limited to either telecommunications or cable television providers that use their existing DSL or cable networks.

A number of industry observers believe that traditional incumbent Internet Service Providers are not likely to upgrade their legacy networks to fiber to provide gigabit speed Internet access to all their customers due to the high cost of such expansion and a lack of competition in the industry. Some incumbent providers have conducted network upgrading, but it has generally been limited to certain geographic areas and offered at higher cost than standard service. Verizon, for example, upgraded limited parts of its networks to fiber with its high-speed FIOS service, but this access was only available in limited areas and the company has since discontinued this program. Between 2006 and 2014, AT&T was offering its higher speed U-Verse service, with speeds up to 24 Megabits per second (Mbps),[3] but it discontinued that service and is now offering GigaPower, but in many cases only in limited markets and at higher rates than its standard service.

A significant change in the private sector ISP industry in recent years that has created more high-speed fiber networks and brought more competition to some cities is Google's creation of Google Fiber. This new enterprise typically constructs and operates new fiber networks in selected cities with speeds up to 1 Gbps.[4] After negotiating terms and conditions with its selected cities, Google Fiber constructs a core fiber network and "hubs," from which connections to individual premises are established. Prior to construction, Google Fiber requires that a certain number of premises in each of its hub areas sign up for service before connections to the premises are established in that area. This allows the company to achieve economies of scale in network construction. But it could also mean that certain neighborhoods, such as lower income neighborhoods or neighborhoods with more renters than homeowners, could end up not being provided gigabit speed service if

[3] Megabits per second refers to the speed of information flow over a given period of time on a telecommunication medium, measured in megabits (or every 1,000,000 bits or 1,000 kilobits) per second.

[4] In February 2016, Google Fiber announced it would offer gigabit service in using existing fiber in Huntsville, AL and in San Francisco. This a change in their business model for FTTP deployments, which until then all involved constructing its own network.

enough customers do not sign up for the service. The traditional incumbents continue to provide service in those cities, though not on fiber networks.

In recent years, 143 municipalities and local governments across the U.S. have constructed and deployed high-speed fiber optic networks, with speeds of up to 1 Gbps, as public or public-private ventures.[5] Known as high-speed fiber to the premise networks (FTTP networks) since premises in these jurisdictions are individually wired to the fiber network, many are in smaller cities or rural areas where private sector service was limited or inadequate. But some are in mid-sized cities and more urbanized areas such as Santa Monica, California and Chattanooga, Tennessee. In many cases, the high-speed service has been offered at rates comparable to those charged by incumbent providers for substantially lower speed service.

Internet access and speeds in San Francisco

While Internet access is available to most residential, commercial and industrial premises in San Francisco, the City is not one of the U.S. jurisdictions with Gigabit per second Internet access speed available to all premises. According to Ookla, a company that tracks Internet speeds of users who elect to test their speeds, the top 10% of users in San Francisco had the following average download speeds as of November 2015 , by ISP: Webpass: 279 Mbps, Comcast: 120 Mbps, Sonic: 32 Mbps, and AT&T: 21 Mbps. These speeds are not indicative of average speeds for all San Francisco users but only those who choose to test their speeds through Ookla.

While some existing Internet Service Providers in San Francisco currently provide or have plans to provide Gigabit per second access speed in limited areas in the future, these services may not be available citywide and/or be affordable. As a result, the "digital divide" in San Francisco could remain or be made worse. In a survey of City residents that responded to a Controller's Office 2013 survey, 12 percent, or approximately 100,493 individuals based on the City's 2013 population of 837,442, reported that they do not have Internet access at home. And six percent of the respondents, or 50,247 residents, when calculated against the 2013 population, reported having slow-speed dial-up access.

3. Why fiber for Internet access: advantages and disadvantages of different types of Internet networks

The Internet relies on a physical communication infrastructure to distribute digital content. As discussed above, the infrastructure is composed largely of telephone and cable networks and fiber optic cable. Digital information is broken into discrete "packets" that are transmitted using either electrical signals (for telephone and cable networks on copper or coaxial copper wires) or light (for fiber

[5] "Number of Community FTTP Networks Reach 143", Broadband Communities, August/September 2014

optic networks). While most networks providing Internet content were originally electrical, designed for telephone and cable television services, many of these legacy networks have been upgraded, or are likely to be upgraded in the future, to contain a combination of fiber and the original copper or coaxial copper wires. However, even with such upgrades, legacy networks cannot provide the advantages of full fiber optic networks: reliable, very high-speed, secure, symmetrical, and upgradable Internet access.

Copper wireline networks (DSL)

Copper wireline legacy telephone networks deliver information embedded in electrical signals over twisted copper wires. Originally designed to make and receive telephone calls, telecommunications companies upgraded their equipment over time to Direct Service Lines (DSL)[6] to enhance the speed at which information is delivered. However, the nature of DSL telephone wire infrastructure sets an upper limit on the maximum delivery speed. Electrical signals quickly degrade over distance, especially at the higher frequencies required for high speed broadband. Equipment upgrades and moving fiber closer to end user premises can boost connection speeds, but signal attenuation and constraints on speed are inherent to the technology.

Cable networks

Cable networks use coaxial copper cables that were originally designed to distribute broadcast television. While cable providers have upgraded their networks to improve their Internet service, their networks still have limitations. Like copper telephone networks, cable transmits information embedded in electric signals over metal wires, which are subject to degradation over distance and thus require regeneration as well as insulation from electromagnetic interference. Like telephone networks, a major drawback of cable networks is that their download and upload speeds are asymmetric by design, usually meaning that upload speeds are much lower than download speeds as their original purpose was to deliver television signals to end users. This is particularly a disadvantage for future Internet use as industry observers expect that businesses and residential end users will be producing greater quantities of content for uploading to the Internet[7] and cable network upgrades to achieve faster Internet download speeds are not likely to have equivalent upload speeds.

Fiber optic networks

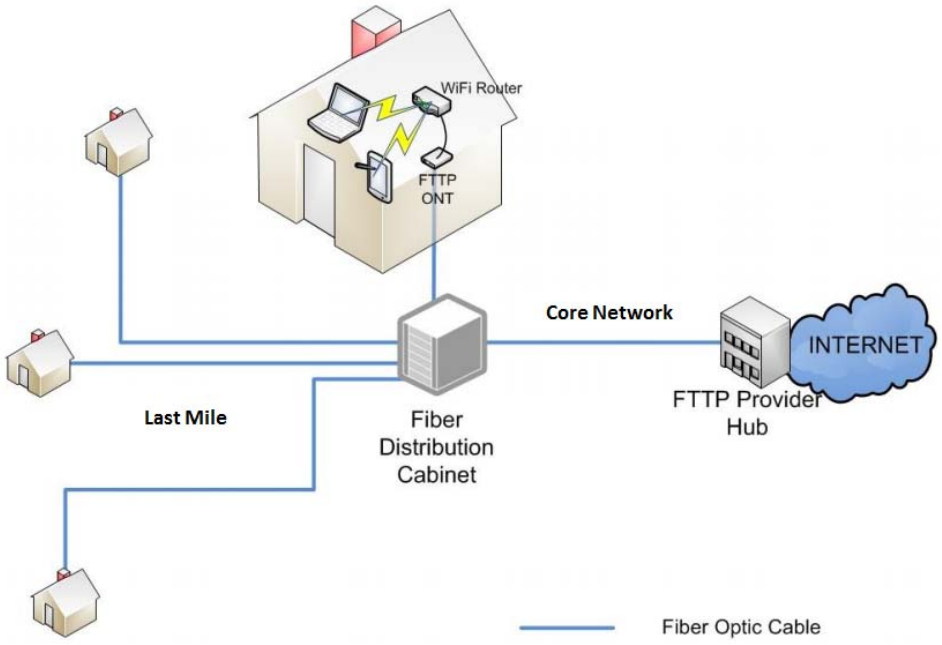
Fiber optic networks use light to transmit information through glass fiber. Fiber can provide much greater speeds in large part because it is not subject to the

[6] The development of Direct Service Line (DSL) allowed for the simultaneous transmission of digital data and wired telephone service on the same telephone line.
[7] Susan Crawford, "Response to Harold Furchtgott-Roth", *Federal Communication Law Journal* , Volume 65.

same signal degradation challenges of copper based networks. Unlike copper, the broadband limitations of fiber-based networks are imposed by the equipment on either end of the network rather than inherent to the transmission medium. It is for this reason that fiber is considered "future proof" with theoretically unlimited capacity.

Regardless of the material used, broadband networks are generally defined as having two components: 1) a core network that transmits digital data signals from a central point of connection to the Internet, and, 2) the "last mile", or the connection from the middle mile to individual premises and end users. The middle mile of the network is generally located underground in conduit but can also be overhead strung on utility poles and the last mile connections may be underground or aerial, such as an overhead wire from a utility pole to end user buildings. Graphic 1 below provides a depiction of a fiber optic network.

Graphic 1: Fiber Optic Network Configuration



Source: CTC Technology and Energy

While construction of a high speed network is a costly undertaking, last mile construction is considered the more costly of the two components since it involves wiring individual premises to the middle mile network. This is why it is not unusual for upgraded legacy telephone and cable networks to include some fiber in their middle mile, but to leave copper wire for last mile connections. As another example of the relative costs of last mile connections, and as mentioned above, one of Google Fiber's business model in the cities where it is providing citywide

Internet access service is not to establish last mile connections in a neighborhood (or a Fiberhood, as the company calls them) until a threshold number of premises have signed up for their service, allowing the company to realize economies of scale when making last mile connections. The high cost of network last mile construction help explain why private sector Internet Service Providers have not, and likely will not, provide ubiquitous fiber to the premises for entire municipalities.

Wireless

Wireless connections offer Internet access to users without the need for wired connection to their premises. However, data distributed within wireless networks ultimately relies on wired networks to connect to the broader Internet (known as "backhaul") and thus wireless is complementary to, rather than a substitute for, wireline networks to the premises. Greater wireless capacity cannot be achieved without an increase in wired capacity. Therefore, investments in wireless networks require a concomitant investment in wired infrastructure for backhaul.

In addition, wireless networks are limited by the physical environment, including geography, weather, buildings, and proximity to the wireless broadcasting device. According to engineers interviewed by the Budget and Legislative Analyst's Office, while wireless transmission is currently being used to provide Internet access to selected individual buildings in the City, the technology could not currently be used to provide last mile connections to every premise in the City and also achieve gigabit services.

Satellite delivery of Internet access is similarly characterized by limited bandwidth and interference imposed by the physical environment, particularly weather. Although connections do not rely on wired infrastructure, the distance between satellite networks and terrestrial premises limit the amount of bandwidth available to a given user.

4. Current Networks and Internet Service Providers in San Francisco

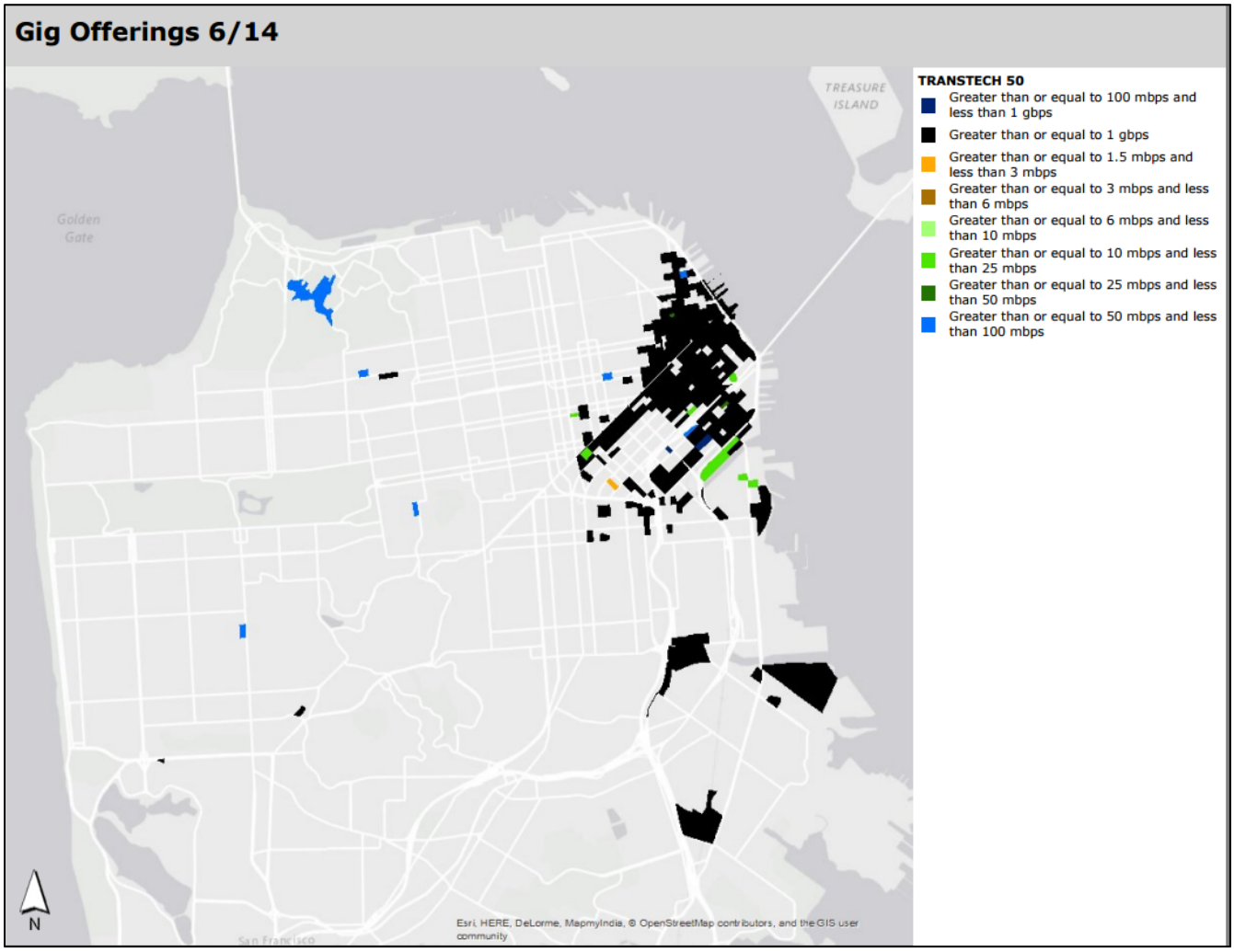
Internet service is available in almost all areas of San Francisco and most households and businesses have a choice of at least two Internet Service Providers (ISPs) and, in some areas of the City, there are three or four options.

While private sector Internet Service Providers offer broadband services throughout most of the City, the availability of gigabit speeds remains very limited. Exhibit 1 below shows the availability of gigabit speed Internet access service in the City as of June 2014. Areas shaded in black show where speeds greater than or equal to a gigabit per second are offered. These offerings are concentrated within the City's business areas. Since the release of this data, both Sonic and AT&T have rolled out gigabit services for residential customers that do not appear on the map below.

While an available download speed of 200 Mbps was reported for San Francisco in a worldwide study of home Internet access speeds, that speed is only available in certain areas of the City served by a smaller ISP. For plans priced between $35 and $50 per month, average download speeds reported in the same study was approximately 40 Mbps. [8]

[8] "The Cost of Connectivity 2014", Open Technology Institute Policy Paper. October 2014.

Exhibit 1: Gigabit Offerings in San Francisco (June 2014)



Source: California Broadband Availability Database (as of June 2014)

The limited availability of gigabit per second Internet access speed is mostly due to: the existing network infrastructures being owned by the two primary Internet Service Providers, AT&T and Comcast, who recently announced plans to upgrade at least some of their networks to gigabit speed (it is unclear when they will be complete); high barriers to entering the market for smaller providers interested in providing higher speed services; and a perceived lack of customer demand for gigabit service by some incumbent service providers.

The Budget and Legislative Analyst has found no evidence of short-term plans by any of the incumbents to invest in affordable gigabit speed fiber-to-the-premises services Citywide.

An overview of each of the main Internet Service Providers offering Internet service to the premises in San Francisco is as follows.

AT&T

One of the primary internet service providers in San Francisco, AT&T, offers service over multiple network technologies - Fiber to the Premise, Fiber to the Node, and DSL copper wire network - with service available to most of the City. The highest speed offered today to consumers is through its fiber based service, Gigapower, which has a maximum speed of 1 Gbps, but is offered in limited areas only.

Following its recent merger with DIRECTV, AT&T agreed to connect at least 12.5 million customers nationwide to the Internet, over fiber, by July 24, 2019. The company has identified 2,000 areas of interest throughout the U.S., including San Francisco, where this new service is currently offered. Initial availability of AT&T GigaPower to homes, apartments and small businesses in San Francisco started in January 2016. AT&T also has stated to the Budget and Legislative Analyst it has plans to offer GigaPower to additional areas within San Francisco. Gigapower has so far been made available in high-income areas in select cities.

In the San Francisco area AT&T GigaPower starts at $90 per month for Internet-only service. Customers who opt-in to receive advertising tailored to their browsing habits may purchase the service for $70 per month. The pricing includes a monthly data allowance of 1,000 gigabytes per month, after which users will be charged $10 for every additional 50 gigabits.

In addition, AT&T has deployed fiber to commercial buildings in San Francisco from 2012 through the present. Businesses in those buildings are able to choose from a variety of services, ranging from complex dedicated services to small business broadband speeds up to 300 Mbps.

AT&T stated it would not currently be interested in leasing space on a municipal network if one were built by the City and County of San Francisco.

To address the digital divide, beginning in April 2016 AT&T will offer a new low-cost Internet access program for households that have at least one participant in the U.S. Supplemental Nutrition Assistance Program (SNAP). Customers can receive speeds up to 10Mbps for $10 per month depending on the speeds available at a customer's location. Additional speeds and offers will also be available.

Comcast

Comcast is the largest Internet Service Provider in San Francisco. It currently offers five different residential speed tiers up to 250 Mbps, at varying costs and those speeds have increased numerous times over the last few years. The company is getting ready to roll out an upgrade to its network, DOCSIS 3.1, later this year which will allow additional tiers and faster speeds (including up to 1Gbps currently) to be deployed to its customers over its existing cable infrastructure. The company expects the DOCSIS 3.1 upgrade to be complete over its entire footprint within the

next two years but has not publicly released the schedule of implementation for the Bay Area or the cost of the gigabit service. In addition, Comcast recently launched Gigabit Pro service which can provide up to 2 Gbps symmetric download/upload in select areas in the San Francisco Bay Area. Gigabit Pro's coverage will not be ubiquitous, however Comcast anticipates that deployment of this product will become more widely available in the next few years. The service is currently priced at $299.95 per month, with a $500 installation fee and up to a $500 activation fee. Customers who sign a three year contract may receive the service at promotional pricing of $159 per month.

In an interview with the Budget and Legislative Analyst's Office, Comcast representatives stated that its network upgrades are market driven; while most customers do not require gigabit speeds for residential usage, service offerings will be available to meet future needs. Comcast provides business services to small, medium and large companies, from simple data services to complex voice, metro-e and fiber data services. Comcast has been installing fiber in increasing portions of its network and expects to continue to do so. Comcast stated it might be interested in leasing space from a municipal dark fiber network if one were built by the City and County of San Francisco.

To address the digital divide, Comcast's Internet Essentials program offers Internet service at 10 Mbps for $9.95, low-cost computers and training to low-income families with children eligible for free and reduced lunches. In August of 2015, Comcast launched a pilot program to expand Internet Essentials to low-income seniors 62 years and older. Via the senior pilot, which was created in partnership with the City and County of San Francisco, Comcast is working with the Department of Aging and Adult Services and local non-profit organizations to connect seniors to home internet and discounted computers, and with SF Connected to provide computer training to seniors throughout the city.

Sonic

Sonic is the fourth largest Internet Service Provider in San Francisco. It is deploying fiber-to-the-premises networks in the Sunset and the Richmond with speeds of up to 1 Gbps, plus bundled nationwide landline home phone service, for $40 per month. In addition to Gigabit Fiber service, Sonic also leases copper lines from the incumbent telecommunications carrier to provide bundled telephone and DSL broadband service throughout most of the City, with speeds of up to 75 Mbps, for $40 per month. Sonic stated it would be interested in leasing space from a municipal dark fiber network in San Francisco if one were built.

Sonic does not have a program to specifically address the digital divide, but Sonic's $40 price for unlimited home phone and broadband is among the lowest in the nation.

Monkey Brains

Monkey Brains, another of the smaller Internet Service Providers in San Francisco, offers wireless residential Internet service with speeds up to 25 Mbps. With the exception of the southwest quadrant, residential service is offered throughout most of the City. Because it provides Internet service wirelessly, connected residential premises must be within range of one Monkey Brains' antennas. Monkey Brains stated it would be interested in leasing dark fiber from a municipal network.

To address the digital divide, Monkey Brains offers installation discounts to lower the cost of connecting a new premise. In addition, Monkey Brains provides free or low-cost Internet access to pedestrians near its offices and to several non-profit organizations, schools, and low-income housing entities within its footprint.

Webpass

Webpass provides Internet service to business customers and to larger residential multi-dwelling unit apartment buildings (MDUs). Webpass offers customers up to 500 Mbps, depending on the internal wiring of the building which impacts the bandwidth available for each unit. The company is planning to expand its fiber network in the SoMA, Potrero Hill, and Mission neighborhoods to provide Internet service to business customers. Webpass stated it would be interested in leasing dark fiber from a municipal network.

Although Webpass offers residential customers high speeds, company representatives reported that there is very limited residential demand for 1 Gbps at this time. Customers do not perceive the difference between 100 Mbps and a gigabit (1,000 Mbps) because consumer Internet content is currently designed for the average user, who uses much lower speeds. In addition, gigabit speeds are limited by currently available wireless routers, many of which offer speeds up to only 150 Mbps.

Webpass does not have a program to address the digital divide.

Wave

Wave offers triple play cable services (television, Internet and telephone) in the eastern and southern portions of the City only, with speeds as high as 110 Mbps. In addition, Wave offers gigabit FTTH service in one MDU building in the Mid-Market area.

Wave does not have a program to address the digital divide.

The City's Current Fiber Networks

With limited use of fiber by private sector Internet Service Providers, and no indications that the private sector will be upgrading existing or constructing new Citywide fiber-to-

the-premises networks in the near future, an option for the City to consider is to expand one or more of its existing municipal networks to provide Internet connectivity to all residents and businesses or, if that is not possible, to construct its own entirely new network.

Currently, the City's Department of Technology (DT) maintains a fiber network, City Fiber, which services some City facilities and San Francisco Housing Authority public Housing developments. In addition, the City's Public Utilities Commission (SFPUC) and Airport own and maintain their own fiber and conduit assets for their Internet access and departmental connectivity. The SFMTA primarily relies on City Fiber, but also maintains a small fiber network that was installed prior to the roll-out of City Fiber.

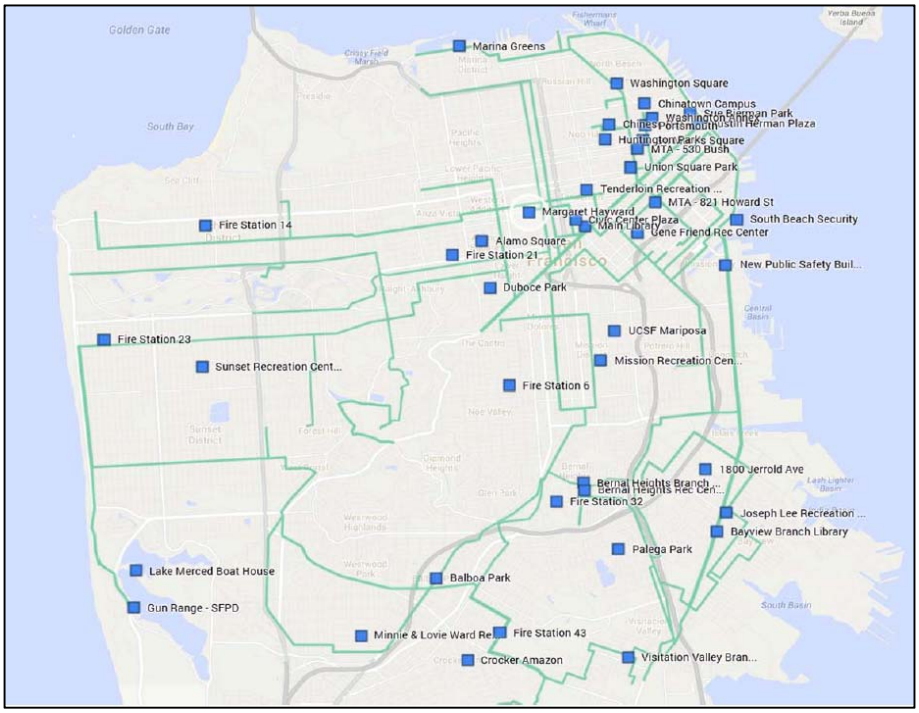
City Fiber

The City has constructed approximately 216 miles of fiber optic network, for municipal purposes, that contribute to the creation of a Citywide municipal network. If there are technical or legal constraints on using the existing network, the City would have to build an entirely new network to provide all residential and business premises with Internet access. The exact number of miles for a Citywide fiber optic network would depend on the type of buildout that is selected: demand-driven, where the network is expanded as customers subscribe to the service, or utility-based, in which the entire network connecting all premises to the City would be constructed at the outset. DT estimates, however, that approximately 1,000 miles of network would be needed. The two buildout approaches to buildout are described further below.

The City's current fiber optic network was originally developed beginning in 2002 when the Department of Emergency Management (then the Emergency Communications Department) issued a bond to construct a fiber- optic network to connect public safety buildings. Since then, the Department of Technology has taken over the management of the network, which has expanded to service 231 City buildings.[9] The map below shows the distribution network and the location of newly connected City buildings as of Fiscal Year 2013-14. The City's 216 mile fiber network has been developed to serve the needs of City functions, which has informed the network's features and geographic distribution.

[9] San Francisco Connectivity Plan, ICT Plan, 2016-2020.

Exhibit 2: San Francisco municipal fiber network, with City buildings connected in FY 2013-14



Source: City and County of San Francisco Committee on Information Technology Meeting Slides: April 7, 2014

The City leases out a small portion of its excess fiber capacity, commonly known as "dark fiber", to private companies and nonprofit organizations. These leases generate $279,000 in annual revenue.

Limits of the City's existing network

The City's Information and Communication Technology Plan (ICT Plan)[10], adopted in 2015, recommends spending $8 million between Fiscal Years 2016-17 and 2019-29 on a "Fix the Network" project to enhance the reliability of the current fiber network. The current network equipment is old and non-standardized, has many single points of failure, and is difficult to monitor. The Department of Technology (DT) is planning to upgrade hardware and software, simplify the network configuration, eliminate single points of failure, and optimize the routing and security of the network as part of the Fix the Network project.

As noted in our December 3, 2015 report, "Fiber Network Assess Management," [11] the Department of Technology has a digital map of the location of its fiber, but information regarding the fiber availability for network expansion or enhancement at a given

[10] Information & Communication Technology Plan, FY 2016-20, City and County of San Francisco. Adopted 2015.
[11] Budget and Legislative Analyst, City and County of San Francisco: "Fiber Network Asset Management". Report to Supervisor Farrell. December 3, 2015.

location and comprehensive data on conduit location and other attributes is not comprehensively collected and digitized by City agencies. Further, the information that is collected of all available fiber and conduit within the City is scattered among City departments (including the Municipal Transportation Agency (SFMTA) and the SFPUC) and private entities such as PG&E, Comcast, and AT&T. In many cases, these records are kept in hard copy, rather than digital form, and thus are difficult to integrate into an expansion plan for City Fiber. Subsequent to issuance of our report, the Board of Supervisors approved an ordinance to require DT to develop a database on all City-owned fiber assets and to determine whether any existing City-owned fiber assets are available to serve Departments' future needs.

Plans for expansion

The City plans to spend $5.45 million over the three fiscal years between FY 2015-16 and FY 2017-18 to expand the existing fiber network, City Fiber, to connect the remaining 178 City buildings that are still using private Internet Service Providers (primarily AT&T) to access the Internet. Of the $5.45 million, $4.3 million was appropriated by the Board of Supervisors for FYs 2015-16 and 2016-17.

DT's expansion plan will be performed by existing staff and contractors, and will need to adhere to the City's Dig Once ordinance adopted in October 2014 (Public Works Code 2.4.4, 2.4.13 – 2.4.14, 2.4.95 – 2.4.97) that allows DT to lay fiber conduit simultaneous with other excavation projects conducted by City departments or the private sector. Exhibit 3 below shows DT's estimate that the cost per mile of installing conduit and fiber would be $174,420 per mile when conducted simultaneous with excavation projects already approved as compared to $633,600 per mile when conducted independently, for a savings of $459,360 per mile.

Exhibit 3: Conduit Installation Costs and Savings per Mile Using Dig Once Policy

Component	Cost per Mile Adhering to Dig Once	Cost per Mile to Excavate without Dig Once	Savings per Mile from Dig Once
Fiber	$79,200	$79,200	$0
Conduit	$95,040	$554,400	$459,360
Fiber + Conduit	$174,240	$633,600	$459,360

Source: City and County of San Francisco Information and Communication Technology Plan 2016-2020

The ICT Plan estimates that the City can expand the current fiber network by 56 to 222 miles over a five year period through coordination with other excavations taking place, for an approximate total savings of between $25.7 and $102 million. The final number of network construction miles that can be coordinated with other already planned excavation projects will depend on a variety of factors such as funding and final project timing.

5. Options for constructing and operating a fiber optic gigabit speed network in San Francisco

Given the low probability of a ubiquitous private sector fiber to the premise gigabit speed network being constructed and made available in San Francisco in the near future, an option for the City to consider to achieve the benefits of a network serving all premises in San Francisco at affordable prices is for the City to construct, manage, and operate its own network or to create partnerships with private sector companies to provide some or all of these functions.

As discussed above, a number of cities throughout the U.S. and the world have constructed and are operating fiber to the premise (FTTP) networks, or have created partnerships with private sector companies that have or are participating in construction and operation of such networks.

The four primary functions to be fulfilled to implement a FTTP gigabit speed network are:

1. *Constructing the network*: excavating streets to install underground conduit containing the fiber which is then connected to residential and business premises. For aboveground portions of the network, the fiber would be strung on utility poles, from which it would be connected to individual premises.
2. *Maintaining the network*: Ensuring that the network is functioning properly and upgraded as needed.
3. *Managing the network*: If the network is leased out to private sector companies, administering those leases to ensure services are provided as agreed upon between the municipality and the private company(ies).
4. *Providing retail Internet services*: Providing Internet connectivity to all premises that choose to use the fiber network, including arranging for service. In some instances, service may be a combination of Internet, voice, and television.

A municipality could assume responsibility for all of these functions or create partnerships and agreements with private sector companies to perform one or more of the four functions.

The following three models can be considered by the Board of Supervisors to implement a Citywide gigabit speed network. All models have been used in other jurisdictions.

- **Public Model**: A public entity such as a municipality performs all four functions listed above. Financing construction of the network would be the responsibility of the public entity and would probably be debt–funded through issuance of municipal bonds.

- **Private Sector Model**: A public entity would not directly or indirectly assume responsibility for any of the four FTTP network functions listed above but would rely on the private sector to elect to create an FTTP gigabit speed network. A municipality might provide some incentives to encourage private sector creation and operation of a FTTP gigabit speed network but because the municipality does not have control over the private entities, this model would not guarantee construction and deployment of a FTTP gigabit speed network serving all premises at affordable prices.
- **Public-Private Partnership**: A public entity such as a municipality establishes partnerships with one or more private companies that perform between one and all four of the network functions listed above. Financial arrangements can vary, such as the municipality generating revenue from private ISPs by leasing space on a fiber optic network that it has constructed and administers; revenue sharing, with the municipality receiving a portion of customer subscriber revenue from the private ISPs that provide Internet service through the municipality's fiber optic network, and other arrangements. Financing could be through traditional municipal bond financing or could be provided by private sector partners in exchange for certain rights or benefits associated with the network.

Criteria for evaluating models and buildout approaches

Each model was analyzed by the Budget and Legislative Analyst and is explained in more detail below. The following criteria were applied to the models:

Cost to City	$$	The City's costs associated with each model and buildout approach are identified in this report. Depending on the model, these costs could cover network construction, debt service, managing and maintaining the network and providing Internet service. Costs could also include lost City revenue such as waived permit fees for Internet Service Providers, rent-free use of City property for Internet Service Provider equipment, and other costs or lost revenue associated with private sector incentives.
Risk to City	↑↑	Risk was measured by the potentially negative impacts of: maintaining the City's Internet service status quo; unforeseen developments and costs associated with undertaking a major capital project to construct the network and establish a new

		City-run Internet Service Provider enterprise; or, a private sector partner in a public-private partnership defaulting on its obligations, going out of business, etc.
Reduction in digital divide		The models and buildout approaches were assessed for the extent to which they could help reduce the number of San Francisco residents that currently do not have Internet access though improved physical access, Internet service pricing, education, and other means.
Gigabit speed to all premises at affordable prices		Each model and buildout approach was assessed for the extent to which it would accomplish the City's policy goal of providing gigabit speed Internet access to all premises in San Francisco at affordable prices.

Methodology

The Budget and Legislative Analyst interviewed City departments to understand rules, regulations, and policies regarding implementation (including construction) and costs, revenues, and financing options for a municipal fiber to the premise gigabit speed network. In particular, we worked collaboratively with staff from the Department of Technology (DT), the Mayor's Office of Innovation, and the Committee on Information Technology (COIT) to gather and interpret information regarding various ownership and financing models to achieve a ubiquitous FTTP network. We also interviewed City staff from San Francisco Public Works, the City Attorney's Office, and the Office of Public Finance.

The Budget and Legislative Analyst conducted interviews with Internet Service Providers, state regulators, PG&E, industry experts (including academics, consultants, and former public officials), public officials and staff in other jurisdictions pursuing public and public-private FTTP models, private sector partners from public-private partnerships in other jurisdictions, and interested constituents from San Francisco to discuss buildout approaches and challenges for the City to facilitate a ubiquitous FTTP network. A complete list of interviewed entities is included in Appendix 1. In addition to these interviews, the Budget and Legislative Analyst reviewed primary and secondary source materials, including official reports and financial documents, and attended a week-long municipal fiber conference to gather information.

DT contracted with CostQuest Associates, a telecommunications consulting firm, to develop an economic model to estimate the costs and revenues associated with

various FTTP models. The Budget and Legislative Analyst collaborated with DT to provide data and test drafts of the CostQuest model so that it accurately represented the geography, demography, and proposed ownership models discussed in this report. The CostQuest model and results available as of the writing of this report incorporated the financial and physical attributes of the models discussed below.

Key Decision: Demand-driven or Utility-based buildout

A municipal fiber optic network could be constructed based on one of two buildout approaches: 1) a demand-driven buildout where the core network is constructed at the outset and connections to individual premises, or "last mile" construction, only occurs as customers subscribe to the service, or 2) a utility-based buildout, with "last mile" fiber connections made to each premise in the City at the time of construction.

Under the utility-based buildout, Internet access is treated as a utility, not unlike water and sewer service, and a minimum, or baseline, level of service would be made available to all premises. The utility-based buildout is more costly since it requires initial construction of a larger network and costly last mile connections to all premises. The utility-based buildout approach estimates assume that all property owners acquiesce to establishing final connections to their properties.

Both buildout approaches have been evaluated for the public and public-private partnership models. They are not evaluated for the private sector model since the decision to execute either buildout approach would be up to the private sector, and not under the control of the City.

Public Model

In the public model, the City would build and operate a fiber to the premises (FTTP) gigabit speed network. To connect all premises would require that the City trench streets and sidewalks to lay new conduit for the underground portion of the fiber network and attach distribution cables to utility poles for the portion of the City where utilities are aerially distributed, or above ground. The City would own all of the network assets and be responsible for all network maintenance, operations, and improvements. [12]

Besides constructing the fiber optic network, the public model requires that the City develop and staff network maintenance, administration and Internet Service

[12] Due to uncertainties about the amount and condition of the City's existing fiber optic network (City Fiber discussed earlier in this report), the estimates below do not assume that any of the existing network could be utilized, or added to, for a Citywide network. To the extent that it could be used, it would lower the costs somewhat by reducing the amount of new conduit and fiber to be installed.

Provider (ISP) enterprises within the City structure, either as part of an existing City department or through creation of one or more new departments. The new enterprise(s) would need to be staffed with network administrators, engineers, technicians, customer service agents, marketing professionals, and managers to maintain the network and provide Internet connectivity, as well as marketing, billing and technical assistance services. Because the City would own all of the network assets, it would have full control over network coverage and operations, including establishing prices for services.

Likely financing for the public model would come from general obligation bonds to cover initial construction costs. However, as discussed more fully in Section 8 below, given the City's current capital plan, a project of this size, whether demand-driven or utility-based, could not be financed by general obligation bonds without raising taxes. This is because the Capital Plan already accounts for all expected proceeds of the City's property tax revenue. General obligation bonds require two-thirds voter approval.

If subscriber revenues prove insufficient to cover network debt service, operating and maintenance and equipment costs, other sources of funds, including the General Fund or proceeds from a utility fee imposed on all premises, would be necessary. According to industry experts, once the City-run enterprise has demonstrated three to five years of positive cash flow, it would be able to issue revenue bonds secured by customer revenue as funds are needed for network upgrades and other capital improvements in the future. See Funding Sources discussion in Section 8 below for more detailed examination of possible funding sources.

Construction of a City FTTP network and deployment of gigabit speed service would face competition from incumbent providers who would continue to operate and compete with the City enterprise. While a number of industry experts report that the incumbents are not likely to provide FTTP gigabit speed service at an affordable price to all premises Citywide.

In some cities establishment of municipal gigabit networks has resulted in incumbent providers accelerating improvements to their networks and connection speeds and competing with the municipalities on price. There are no instances as of the writing of this report of private sector companies deploying ubiquitous FTTP gigabit speed networks in any large municipality in the U.S. Likely competition through price-cutting and related approaches means that a City-run network and Internet Service Provider enterprise would need to be able to withstand competition by offering higher speeds, quality content and service at reasonable prices to maintain a market share sufficient to cover operating costs and debt service.

Cost of the Public Model

The analysis conducted for the City's Department of Technology by CostQuest Associates, discussed above, provides estimates of construction costs for a FTTP gigabit speed network and operating expenses for City network maintenance, administration and a new City-run ISP enterprise.

The two buildout approaches described above were assumed by CostQuest Associates for the public model: (1) a "demand-driven" buildout in which final connections to premises are only made to individual subscribers at the time they sign up for service, and (2) a "utility-based" buildout in which all premises would be connected at the time of construction. For the demand-driven buildout, DT's consultant's analysis found that revenue to cover ongoing operating and capital costs and debt service for initial network construction would be only partially covered by subscriber revenue, assuming the City ISP enterprise achieves a 30 percent market share. This means that an interim funding source, such as a General Fund subsidy, would be needed in the years of operation before the full 30 percent market share is assumed to be achieved. The 30 percent market share is based on subscription estimates provided by the CostQuest model that take into account Internet access preferences of various demographic groups.

The utility-based buildout, so-called because it would establish network connections to every single premise, like a utility, would have the effect of increasing up-front network construction costs compared to the costs of the demand-driven buildout in which only a core network would be initially constructed, with last mile connections to premises made and related costs incurred only at the time customers subscribe. As noted above, last mile connections are a significant driver of buildout costs, so connecting every premise at the time of initial network implementation under the utility-based buildout would increase construction and ongoing operating costs.

The utility-based buildout is rooted in the concept of treating Internet access as a utility service, meaning that access would be available to all premises.[13] The cost and revenue estimates of the utility-based buildout therefore assume that all premises would pay a monthly utility fee to cover operating and capital costs and, in exchange for the fee, be provided Internet download speeds of 1 gigabit per second. According to DT's cost consultants, a monthly fee of $43 per premise would be needed to cover all capital and operating costs for a utility-based network. The utility fee could be adjusted to account for different uses among residents and businesses. For example, total costs could be covered if every residential premise paid $25 per month and businesses paid $115 per month to reflect average greater needs for business customers. Under this buildout, all

[13] Premises refer to residential households and places of business.

premise occupants would have access to a gigabit level of Internet access service though they would not be required to use the municipal ISP service; they could continue to pay market rates using a competing provider.

The utility fee is rooted in the concept of treating Internet access as essential infrastructure, like water or electricity, which is made available to all residents and businesses. Because of the relatively higher upfront costs of a utility-based municipal networks and the uncertainty about developing a sufficient market share to cover all capital and operating costs in the early years of operations, the establishment of a monthly utility fee, paid by each premise owner, ensures a revenue source available to cover all costs.

The utility fee is also contemplated in one of the public-private partnerships discussed below. However, since a utility fee could be implemented by a municipality without a public-private partnership to ensure sufficient revenue to cover all fiber optic network costs, the Budget and Legislative Analyst used the model prepared by DT's consultant to estimate the costs and revenues of a municipal ISP if such a fee were established under the public model utility-based buildout approach.

If the Board of Supervisors does not choose to impose a utility fee on all premises to cover costs but still deploys a network in which every premise is connected at implementation, another funding source would need to be used to cover total annual costs of $231.7 million shown in Exhibit 4 below. Charging $70 per month for residents and $100 per month for businesses for premium gigabit speed service and making a slower speed available to all other premises paying only the utility fee would be one option but, based on the assumed market share of 30 percent, only approximately $86.3 million in annual revenues on average over the first ten years would be generated, leaving a gap of approximately $145.4 million in average annual operating and capital costs.

At $393.7 million, construction costs would be lower for the demand-driven buildout than for the utility-based buildout, with estimated construction costs of $867.3 million, since the costs of last mile connections between the central network and individual premises in the demand-driven model would occur as individual premises subscribe. The demand-driven model thus does not assume that a utility fee or parcel tax would need to be imposed to generate revenue to meet initial network construction and ongoing operating expenses.

As shown in Exhibit 4, the demand-driven buildout to the public model assumes that subscriber revenue generated by a 30 percent market share would be the sole source of funds to cover network construction debt service as well as ongoing operating and maintenance costs for a City-run ISP. However, as presented in Exhibit 4, average annual subscriber revenue of approximately $86.3 million

would be short of the approximately $103.2 million in estimated average annual costs by $16.9 million per year for the first ten years of operation

The utility-based buildout is more expensive but is assumed to recover capital and operating costs through a utility assessment or fee on all residential and business premises. Given the cost of the enterprise, an estimated $43 monthly utility fee per premise would be required to cover costs. See the Public-Private Partnership discussion below for how the utility fee could vary based on using other sources of revenue to offset network costs intended to be covered by the utility fee.

Baseline cost estimates for the public model are presented in Exhibit 4 below. The demand-driven buildout figures assume that the City's ISP enterprise achieves a 30 percent market share and charges $70 per month for residents and $100 per month for businesses. In addition, a one-time $300 installation fee is assumed for all users in the demand-driven model, which would be waived if customers sign a two-year contract. The model assumes that a small portion of users would be eligible for a free, basic Internet access service, for which they would only have to pay the $300 installation fee and not any ongoing monthly costs.

The utility-based buildout assumes that owners of all premises in San Francisco would pay a $43 per month utility fee to cover capital and operating costs, in exchange for which they would all have access to download speed of one gigabit per second (1 Gbps).

As can be calculated from the numbers presented in Exhibit 4, the network construction cost difference between the demand-driven and utility-based buildout is $473.6 million.

The financial viability of the demand-driven public model enterprise is sensitive to different assumptions about the City ISP enterprise's market share and retail prices for service. If the enterprise achieved a market share of 40 percent or more and/or charged higher monthly rates for services, the DT consultant's model predicts it could be financially self-sufficient. Because the utility fee is designed to cover operating, capital, and debt service costs, the enterprise would be financially self-sufficient over the thirty year life of the project.[14]

[14] Although, the utility fee revenue covers all costs of the network over a thirty year period, the enterprise is projected to experience deficits during some years. However, these deficits are covered by surpluses in other years, such that the project is cost-neutral over a thirty year period. As with the demand-driven model, other sources of funds would have to be identified to cover any annual deficits.

Exhibit 4: Costs and Revenues of Public Model Gigabit Speed Fiber optic Network

	Demand-Driven Buildout	Utility-Based Buildout
Assumed market share for City enterprise ISP services	30%	100%
Total fiber network construction costs	$393,716,583	$867,310,678
Average annual operating costs, for first 10 years of City-run ISP enterprise*	$58,403,867	$159,469,521
Average annual capital costs for first 10 years of City-run ISP enterprise*	$19,993,406	$32,066,541
Average annual debt service for construction costs**	$24,812,569	$40,148,397
Total average annual costs for first 10 years*	$103,209,842	$231,684,459
Average total annual subscriber/utility fee revenue for first 10 years*	$86,276,317	$231,684,459
Average annual revenue surplus/deficit for first 10 years	($16,933,525)	$0
Average monthly utility fee assessed on all premises	$0	$43/month

Source: CostQuest Associates: analysis prepared for Department of Technology, February 2016

* Averages refer to first ten years of operations.

** Debt service assumes a twenty year bond, four year deferment of principal repayment, four percent cost of capital, one percent cost of issuance, and a five percent debt service reserve.

As discussed above, the demand-driven buildout network construction cost estimate assumes that construction of the core network would be completed before the first year of operations and that connections to premises, or "last mile" construction, would take place over seven years, as households and businesses sign up for service until the City-run ISP achieves a market share of 30 percent. This means that last mile network construction costs would be gradually spread over seven years, with decreasing amounts incurred each year.

The utility-based buildout cost estimate assumes that last mile connections to all premises in San Francisco would take place as part of initial construction, resulting in higher construction and ongoing operating, capital and debt service costs. However, because the network would connect to all premises in the City, as though it were a utility, the Budget and Legislative Analyst has assumed that these

costs would be offset by a utility fee imposed on all residential and commercial premise owners. If the City were to charge customers for subscribing to the new gigabit speed service, DT's consultant's model shows that subscriber revenue at baseline rates would not be sufficient to cover the annual costs under the utility-based buildout.

Risks: Public Model

The major risk with the demand-driven public model is that the City would not generate sufficient revenue from its new Internet Service Provider enterprise to service its debt and cover ongoing operating and capital expenses beyond the deficit already assumed with a 30 percent market share. Although the City could offer gigabit speed service at a reasonable price under this model, since it would not be trying to maximize revenues and shareholder value like a private sector enterprise, the extent to which customers choose to subscribe to the City service as compared to continuing Internet service from their incumbent providers could affect the long-term financial feasibility of a City network. As discussed above, even with a 30 percent market share, it would take twenty years (until the debt for the initial construction is paid down) for the demand-driven enterprise to generate sufficient revenue to cover its costs.

Further, as discussed above, in the event a public fiber optic network is deployed, the incumbent providers could potentially lower their prices and improve their services in the interest of maintaining their customer bases. Because their infrastructure is already installed, and to a large extent paid off, incumbent providers have a cost advantage when competing with market entrants and thus could lower their prices to protect their market share. This is particularly true for Comcast, which is upgrading its network to offer gigabit download speeds for the entire City within the next two years. Pricing for this service is not available at this time.

The incumbent providers' responses to Google Fiber's expansion in other cities may foreshadow their responses to a municipal network in San Francisco. After Google Fiber came to Kansas City, incumbent providers Comcast and Time Warner upgraded their networks to double residential speeds, which lowered the dollar per megabit cost of bandwidth for their customers. Industry experts interviewed by the Budget and Legislative Analyst estimate that these upgrades cost very little for incumbent providers and occurred because of the competitive threat Google Fiber posed. Similarly, AT&T deployed its high speed Gigapower network in Austin shortly after Google Fiber announced its intention to build in that City. AT&T is charging $50 less per month for Gigapower in Austin, where it competes with Google Fiber, than in other cities where it does not. Similarly, Comcast upgraded residential speeds at no additional cost to customers after the City of Santa Cruz announced its intention to form a public-private partnership to deploy a FTTP

network. Besides price differentials, some customers might be reticent to sign up for service from a new City-run enterprise due to concern about it being able to provide efficient high quality service.

These factors could affect the City's ability to achieve the market share needed to cover debt service and ongoing operating costs. Using the baseline assumptions discussed above for the demand-driven model, if market share of the City's ISP service is not greater than 40 percent, then the cash flows over a thirty year period would be less than the cost of the buildout. In addition, if the enterprise could not cover its costs with customer revenues (as is the case in the baseline model assuming a 30 percent market share), it would have to charge higher prices for services or use another source of funds, such as the General Fund, which would need to be appropriated to cover the new enterprise's costs. However, the Board of Supervisors may not be inclined to obligate General Fund resources for this purpose given that an enterprise City department should be assumed to generate sufficient revenue to cover costs.

In addition, the City would have to create a new function for a City department or create a new City department to organize the activities of the public Internet Service Provider, including constructing the network, marketing, customer service, network maintenance, and customer billing. Depending on the number of customers, the new enterprise could require dozens of additional City employees. The City enterprise would have to operate effectively to compete with the private sector for customers.

Funding the network's construction and operations through a utility fee under the utility-based buildout would require two-thirds voter approval. If such a fee were not adopted, the City would need to identify another funding source to cover capital and operating costs of the new enterprise. As discussed above, even charging a $70/month rate for residents and $100/month for businesses for gigabit speed service would generate only approximately $86.3 million per year on average for the first ten years, assuming a 30 percent market share. This would leave a deficit of approximately $145.4 million per year needed to cover total enterprise capital and operating costs of $231.7 million per year under the utility-based buildout. Similarly, the utility-based buildout, which connects to every premise, runs the risk that only a fraction of premises will use the new service leaving much of the new infrastructure unused. The cost of the new citywide network will have to be repaid regardless of how much is used.

An additional risk of the utility-based buildout, some industry experts believe that the utility fee obligation could be considered public debt by regulators, auditors,

ratings agencies, and municipal bond investors.[15] Thus, the utility fee buildout could raise the City's cost of debt and/or crowd out spending on other capital projects, even though the debt would be held by the private sector.

In addition, property owners would have to agree to establish final connections to their property, which could limit the ubiquity of access to the new network to the extent property owners do not agree to have a final connection installed. Property owners who opt out of construction would still be subject to the utility fee, which may diminish support for the utility-based buildout approach.

Public Model impact on digital divide

Because they promote competition in the broadband market and thus would likely lower retail prices for Internet access, both buildout approaches could help mitigate the digital divide by making Internet access more affordable. The utility-based buildout would help to reduce the digital divide further by providing gigabit speed access to the Internet to every single premise in the City, including those households that currently do not have wireline service. Additional efforts to promote computer literacy and subsidizing low-income households' purchase of computers and payment of the utility fee would need to be undertaken to fully address the digital divide, but the lack of the potential for physical connection to gigabit speed Internet service would be overcome. In this respect, a demand-driven buildout would do less to address the digital divide because customers would only be connected as they sign up for service (though sign-ups for low-income households could also be subsidized).

Public Model impact on affordable gigabit speed service to all premises

As stated above, the public model would introduce more competition in the local broadband market, which would likely reduce retail prices for Internet access as ISPs compete for customers. However the effect on prices of one additional ISP (the City) on competition may not be as great as if multiple new ISPs enter the market, which would be the likely outcome of the public-private partnership models discussed below.

Private Sector Model

In this model, the City would rely on the private sector to provide a Citywide FTTP gigabit speed network. However, the City does not have regulatory authority over Internet Service Providers and thus has no basis for requiring particular types of services or speeds, where service is provided, or prices. The City does have regulatory authority over rights-of-way and authorizes any work by private sector

[15] *See:* Dan Hughes and William Jones,"P3s, Bond Ratings, and Debt Calculation", *Government Finance Review*, December 2015. http://www.gfoa.org/sites/default/files/1215GFR08.pdf *and:* Joanne Hovis, Marc Schulhof, Kim Baller, and Ashley Stelfox, "The Emerging World of Broadband Public-Private Partnerships", The Benton Foundation, February 2016.

companies on their underground networks, as well as compliance with related regulations in areas such as traffic control and sidewalk repair requirements related to excavation and construction work under City streets.

The City also has approval authority over locations such as City sidewalks for utility boxes that contain electronic components that serve the underground networks. The City has authority over a limited number of utility poles and could potentially enable use of them by private sector ISPs for above ground fiber optic network connections. However, most utility poles in the City are owned by PG&E, over which the City does not have authority.

Incumbent telecommunications providers and other companies regulated by the California Public Utilities Commission (CPUC) that have installed underground conduit and networks are required to lease out excess capacity in their facilities to ISPs that have met certain requirements of the CPUC. While this requirement is intended to facilitate entry in to the marketplace for companies such as ISPs without incurring the costs of constructing new networks, a number of ISPs have reported to the Budget and Legislative Analyst that it can be difficult and costly to make such arrangements with incumbent providers and that there is no source of information, other than from the incumbent companies themselves, on the extent to which their conduit has excess capacity.

While the City does not presently have regulatory authority over the incumbent providers, it could adopt regulations that require the companies to disclose the location and status of their conduit constructed in the City's public right-of-way, under the City's streets. This could help foster more companies entering the ISP market in San Francisco. To encourage private sector outcomes consistent with City goals for a ubiquitous FTTP gigabit speed network, the City could also adjust its regulations to incent more rapid and comprehensive private sector deployment of fiber networks to service San Francisco residents and businesses. Such incentives could include permit expediting for network installation and upgrade work, arrangements with private sector companies to enable their use of City property (including assets such as City-owned fiber and conduit) for network components, and streamlining of construction-related regulations to allow for more efficient and less costly network improvements for the private sector providers.

In the private sector model, the City would not own or control any fiber network assets and thus there would be no guarantee that the City would achieve its goals for coverage, price, service levels, network materials and Internet access speeds provided to City residents and businesses. However, the City would avoid financial and operational risk under a private sector model as it would not incur long-term debt service obligations, operating expenses or capital costs for constructing and operating a network. A private sector model could include the City subsidizing

low-income users or creating an office of digital permitting to streamline private ISPs' movement through the City's permitting process.

The City has numerous regulations that some ISPs have indicated have reduced their willingness to invest in fiber infrastructure in San Francisco. The Budget and Legislative Analyst interviewed six ISPs (Google, Comcast, AT&T, Sonic, Monkey Brains, and Webpass) to identify potential policy changes the City could make to incent greater private sector investment in fiber. The ISPs identified the following regulations, summarized in Exhibit 5 below. In addition, several ISPs noted AT&T's seven year effort to upgrade its network to include more fiber. The upgrade requires installation of approximately 700-800 fiber "cabinets" on sidewalks around San Francisco. The effort was subject to litigation among the City, AT&T, and neighborhood groups.

Exhibit 5: Summary of Potential Policy Changes Suggested by ISPs Operating in San Francisco

Current Regulation	Code	Change Suggested by ISPs
Five Year Excavation Moratorium	SF Public Works Code 2.4.21	Grant mass waivers to all streets or recently restored streets
Re-pavement Requirements	SF Public Works Code 2.4.55(a)	Grant mass waivers or modify requirements
Surface Mounted Utility Ordinance	SF Public Works Code 27	Reduce or eliminate public art, landscaping, public input, and noticing requirements
Antennae Fees	SF Public Works Code 25	Streamline process; reduce requirements and fees

Source: Budget and Legislative Analyst interviews with Internet Service Providers

In addition, ISPs have proposed other legislation/changes to City policy that they state would enhance private deployment of fiber. These are summarized in Exhibit 6 below.

Exhibit 6: Changes in City Regulation / Policies Proposed by ISPs

Proposed Regulation / Policies
1. Require housing developers to build conduit with new construction
2. Streamline permitting process required to excavate public right of way
3. Identify and make available City property to install network equipment
4. Make available information about the existing fiber network assets and prioritize leasing them to private providers.
5. Notify ISPs of equipment decommissions

Source: Budget and Legislative Analyst interviews with Internet Service Providers

Cost of Private Sector Solutions

The CostQuest analysis prepared for DT did not include an estimate for private sector firms constructing or upgrading to a fiber to the premise gigabit speed network since such costs, if any, would be borne by those enterprises and the City would not have any financial obligation for the upgrades, new construction, or ongoing operations. The City might incur some costs if it created incentives for private sector upgrading or new construction of a fiber optic network such as waiving certain permit fees, making City property available for free for use by ISPs for their equipment, and staff time spent collecting information to facilitate ISP construction such as City conduit location data, pavement condition inventory, and others.

Risks of Private Sector Solutions

The major risk associated with relying on the private sector to upgrade or construct a ubiquitous FTTP gigabit speed network and offer reasonably priced Internet service to all premises is that none of these objectives will be achieved. As stated earlier in this report, major incumbent telecommunications providers have begun to offer gigabit service in limited areas and have announced plans to add more fiber to their networks to provide higher access speeds, at least in some areas of the City. In addition, Comcast has announced it will be able to offer gigabit speed download service over its existing cable infrastructure within the next two years. Only Comcast has stated that they will be making such networks and service available Citywide and pricing for that service and its ultimate coverage area remain unknown. Like all businesses, an initiative such as deployment of this level of gigabit service is subject to change in business conditions and plans.

As discussed above, industry experts interviewed by the Budget and Legislative Analyst's Office indicated that they believe it is unlikely that incumbent ISPs will create Citywide fiber optic networks and provide gigabit speed service to all premises due to the high capital costs and the lack of perceived market for this level of service.[16] As discussed above, Comcast, the City's major cable provider, has announced plans to upgrade its network between 2016 and 2018 so that it can provide gigabit speeds over its existing cable infrastructure, but it has not released details on its upgrade's coverage and prices. Similarly, AT&T has announced a nationwide plan to upgrade its networks in selected jurisdictions and has started to provide gigabit speed service via an FTTP network in some large apartment buildings in San Francisco. Even if these upgrades are ubiquitous, gigabit or higher speeds offered by the incumbents still may not be affordable and, at least for Comcast, upload speeds would be bound by the technical limitations of their respective technologies, discussed above. Further, like any business enterprise, future plans are subject to change as business conditions change.

Changes in City regulations may not be enough to incent private sector deployment/operation of a fiber network. The Budget and Legislative Analyst attended a municipal fiber conference and interviewed an array of industry experts (detailed in Appendix 1), none of whom believed that changes to municipal regulations would by themselves provide sufficient incentive for incumbent providers to deploy ubiquitous fiber to the premise networks in the short term. This is because the local regulations and processes that would be subject to change under this model would only reduce the cost to the private sector of deploying an FTTP network by an estimated 8 percent, which is significant but may not be enough to change the economic incentives of incumbent providers or lower the barriers to entry for smaller ISPs.[17]

The one potential exception to the impact of the City providing incentives to private sector providers could be Google Fiber, which, in the cities where it installs fiber optic networks, requires that they provide specific information on existing network infrastructure and waivers on certain regulations to ease construction.[18]

Private Sector Model impact on digital divide

The private sector model would have limited impact, if any, on the digital divide. It would rely on existing digital divide programs, which are voluntary and over which

[16] Susan Crawford, "Big Cable Owns Internet Access. Here's How to Change That." http://tinyurl.com/jk7gve2 *and* Blair Levin and Denise Linn, "The Next Generation Network Connectivity Handbook", Vol. 1, July 2015.
[17] Hovis *et al.*
[18] Google Fiber's announcement in February 2016 that they intend to provide service in San Francisco did not require detailed information about the existing infrastructure or changing regulatory requirements because the service will be provided over existing fiber installations.

the City would have minimal influence. Current programs aimed at reducing the digital divide such as Comcast's Internet Essentials may be continued or even expanded but the City would not have control over this or any other private sector programs. The City could offer financial assistance and/or digital literacy programs to assist more residents without home-based wireline Internet access to make use of services offered by the private sector.

Private Sector Model impact on affordable gigabit speed service to all premises

Because this model has a low probability of increasing competition in the local broadband market, prices for services would likely not change and therefore affordability levels would remain the same. The City has virtually no influence over prices and service levels in the Private Sector model. There is no indication with information currently available that the private sector model would lead to the provision of Internet access to all premises in San Francisco.

Public-Private Partnerships (P3 Model)

A public-private partnership is a model in which the City and one or more private partners would share financial and operational risks associated with constructing and operating a FTTP gigabit speed network serving all premises in San Francisco. While there are a number of possible configurations for such partnerships, a key requirement for the City to achieve its policy goals pertaining to Internet access would be for it to retain ownership of the network, but to delegate some or all responsibility for network construction, administration and maintenance, and retail operations to private sector partners under formal agreement. Under a public-private partnership, the City and private sector partners would share in the revenues generated by the new enterprise.

The City could still undertake many of the incentive actions outlined in the private sector model; the difference between the private and public-private partnership models is that, in the latter, the City would make an investment that would result in ownership of fiber network assets, thereby maintaining greater control of the way in which Internet service is delivered to San Francisco residents and businesses.

Using the public-private partnership models (P3), construction of a FTTP gigabit speed network could be financed by the City issuing debt or it could be provided by a third party financier. While there are many examples of public-private partnerships for public sector capital projects in the U.S. and internationally, there are no large-scale public-private partnership FTTP networks yet in the United States. Many smaller municipalities have experimented with variations on public-private partnerships, with varying success, and a number of larger jurisdictions are planning or developing networks using this model.

Risk sharing arrangements are specific to each community, however all partnerships must make decisions concerning the following variables:

- **Ownership:** Who owns the fiber assets and for how long.
- **Financing:** Whether the build-out of the network is publicly or privately financed.
- **Coverage:** Whether the network connects to every single premise as part of initial construction in the utility-based model or deployment is demand-driven (fiber connections to the premises are not made until the owner or tenant subscribes to network services).
- **Customer Base:** Whether the network is intended to primarily serve residents, businesses, or both.
- **Social Goals:** How the parties bridge the digital divide.
- **Open Access:** Whether network operations will be awarded to a single company or whether competition among ISPs will be allowed, and how ISPs will be selected to provide service.
- **Principal – Agent Conflicting Goals:** How to align the financial and operational incentives of both the City and its private partner(s).
- **Service:** How parties define service requirements such as average speed per user and duration of network outages.
- **Performance Monitoring:** How the parties define compliance procedures and monitoring systems to ensure that service requirements are met.
- **Network Design and Maintenance:** How the parties share responsibility for network planning and design and how maintenance responsibilities are allocated.
- **Price:** How prices for services are set.
- **Wholesale/Retail Service:** whether ISPs provide wholesale or retail services, or both, and how to ensure that firms that provide both wholesale and retail services offer non-discriminatory access to other retail providers.
- **Catastrophes:** how elements of the agreement, including ownership of assets and provision of services, would continue if the private partner was acquired, went bankrupt, or decided to terminate the agreement.

Costs of the P3 Models

The cost estimates for a public-private partnership model (P3 model) prepared for DT by CostQuest Associates replicated the two buildout approaches used for the public sector model discussed above: 1) utility-based, and 2) demand-driven . Both

buildout approaches assume that the City would establish a relationship with a private sector partner, or consortium of partners, who would assume responsibility for one or more of the functions associated with gigabit speed FTTP network construction and operations for all residential and business premises in San Francisco.

The first of the P3 models is the utility-based concessionaire buildout, in which a private sector partner, or concessionaire, would receive authority to construct and operate the fiber optic network by organizing a consortium of firms to provide all network functions, including construction, network operations and maintenance. ISP services would be provided by other companies under contract to the concessionaire.

The buildout approach for this model is utility-based: it would connect all premises in San Francisco and provide them with a free, lower speed baseline level of service. Gigabit speed service would be available at a monthly subscriber rate. Cost estimates for this model assumes that all property owners acquiesce to establishing final connections to their property. This approach assumes imposition of a monthly utility fee on all premises to cover all costs since customer subscriptions were projected to be insufficient to cover all construction and operating costs by DT's cost consultant, as detailed further below.[19]

The second P3 model analyzed by CostQuest assumes a dark fiber demand-driven buildout, in which the City finances, builds, owns and maintains the physical network infrastructure (such as fiber, conduit, and other hard assets) as "dark fiber" and partners with one or more private providers to "light" the network and provide Internet connectivity to subscribed premises within the City. This is distinguished from the utility-based concessionaire buildout because the dark fiber model analyzed by CostQuest assumes a demand-driven buildout with the City responsible for construction and maintenance of the fiber optic network. The City would thus maintain greater control over the asset but would incur higher costs.

- ***Utility-based Concessionaire P3 Model***

Under the P3 utility-based concessionaire buildout, the City would maintain ownership of the network but the concessionaire, or lead firm, would administer subsidiary agreements with one or more firms that would construct the network and serve as network administrators. The consortium would then partner with ISPs who would lease access to the new network to provide retail Internet access

[19] This model is based on an approach proposed by Macquarie Capital, an Australian financial services firm that has been promoting this utility-based approach to state and local governments in the U.S. and abroad in recent years.

services. Lease revenue paid to the concessionaire by the ISPs would be subject to revenue sharing with the City.

Network retail service would be open access, meaning that multiple ISPs could offer their services on the network, and consumers would benefit from such competition. Prices would be a function of competition on the new network and from incumbent providers, who are assumed to be continuing to operate on their own networks. A free, baseline level of service is assumed to be available to all premises in this model as a benefit for paying a monthly utility fee. While the baseline level of service would be subject to negotiation between the City and its private sector partners, the Budget and Legislative Analyst believes that this free service should at least be equivalent to the FCC definition of broadband, 25 Mbps downstream and 3 Mbps upstream.

Though the City would not issue debt nor incur debt service obligations under the utility-based concessionaire model, this model assumes that the City would make regular payments to the concessionaire in exchange for constructing and providing new infrastructure to the City and for providing ongoing wholesale service. The model assumes that at least some if not all of the concessionaire's costs be funded by a utility fee or user charge imposed on each premise. The City's fee payments to the concessionaire would be contingent on the private sector partners meeting and sustaining predetermined performance goals regarding network construction timelines and costs as well as ongoing ISP operations.

The utility fee is intended to cover all of the private partner's capital and operating costs over a thirty year period. As in the utility-based buildout for the public model, all premises would have access to Internet service on the fiber optic network, the costs of which would be covered by the utility fee. However, unlike the public model, only a baseline level of service would be provided to all premises; customers that want gigabit speed connectivity would pay an additional fee on top of the utility fee for these services. Customer revenue from premium subscribers would not be critical to the concessionaire's success since the entire cost of doing business would be covered by the utility fee. Additional revenues from gigabit service subscribers would be split among the City, the concessionaire, and the retail ISP(s), the details of which would be subject to negotiation. This revenue stream could be used to offset the need for a utility fee set at a level to recover all costs.

Baseline cost estimates for a P3 model utility-based concessionaire buildout are presented in Exhibit 7. The estimates show that a utility fee of $25.50 per premise per month would be required over the 30 year concession to cover all capital and operating costs, which were estimated to average $138 million per year by DT's consultant. The model assumes that the concessionaire's ISP(s) achieve a 30 percent market share and that the ISP partner(s) pay the concessionaire $15 per

month per residential customer that subscribes to gigabit service to residents and $20 per month for businesses that subscribe to gigabit service. Prices for retail services would be independently set by ISPs and would be a function of competition on the new network and from incumbent providers. Retail subscriber rates for gigabit speed Internet access would be in addition to the monthly utility fee for those customers.

As modeled, the revenue to the concessionaire would consist of the utility fee assessed on all premises and an additional $15 per residential customer and $20 per business customer per month paid by the ISPs for those subscribing to gigabit service. The revenue from gigabit subscribers could be shared with the City, subject to negotiation between the City and the private sector concessionaire and/or used to offset the utility fee amount. A monthly utility fee of $25.50 is estimated to be needed to cover all concessionaire costs. Use of a portion of the premium subscriber rate revenue to cover concessionaire costs would allow for a lower monthly utility fee, as discussed further below. Alternatively, the City could potentially negotiate an arrangement where only a utility fee would be charged, with all premises eligible for high-speed service without additional premium subscriber rates.

Because the City would not incur debt, capital or operating costs but would instead allow the concessionaire and its consortium to bear financial and operational risks of building and constructing the network, the figures in Exhibit 7 only show how publically collected revenue, or the monthly utility fee, would be used under the utility-based concessionaire public-private partnership.

Exhibit 7: Residential, Business, and City Costs and Revenues of Concessionaire Utility-based Public-Private Partnership Gigabit Speed Network Model

Assumed P3 market share for premium ISP services (for gigabit services)	30%
Utility fee assessed on all premises	$25.50
City annual costs	$0
Concessionaire annual costs*	$138,065,298
Average annual revenue from $25.50 monthly utility fee on all premises*	$138,217,466
Average annual revenue from premium subscribers (amount subject to revenue sharing with City)*	$20,605,521
Average total annual customer revenue*	$158,822,946
Average annual revenue from utility fees from non-subscribers*	$105,420,672

Source: CostQuest Associates: analysis prepared for Department of Technology, February 2016

* Averages refer to first ten years of operations.

Utility Fee Options

As noted above, the $25.50 per month utility fee on all premises in the baseline model is intended to cover all operating, capital, and debt service costs associated with the 30 year concession. These costs have been applied evenly across all residential and business premises in the baseline model. However, utilizing different sources of funds to offset network costs could reduce the amount of the utility fee. Exhibit 8 below shows two scenarios that could lower the utility fee for residential premises.

The concessionaire's revenue from the ISPs for premium subscribers, which, as mentioned, could be subject to revenue sharing with the City, is estimated to average $20.6 million annually over the first ten years of the project but is not assumed to be used in DT's consultant's estimates to cover the concessionaire's annual costs. By using a portion of premium subscriber revenue to cover the concessionaire's annual costs, the monthly utility fee could be lower than the $25.50 estimated to cover all concessionaire costs.

In Scenario 1 shown in Exhibit 8 below, the City is assumed to receive 80 percent of the revenue from premium subscribers as part of its revenue sharing agreement with the concessionaire. This revenue would be used to cover a portion of the total costs of the network, which reduces the utility fee that needs to be collected from all premises from $25.50 to $22.50. Scenario 2 assumes the same revenue sharing agreement as Scenario 1 but also charges business

premises a higher premium service rate and a higher utility fee. These changes reduce the utility fee for residential premises to $10 per month in Scenario 2.

The higher rates for business premises are founded upon the idea that businesses have higher data needs, a higher ability to pay, and often have larger premises to be served. The rates are averages across all businesses; the fee could be adjusted so that different types and sizes of businesses pay higher or lower utility fees, such as fees based on the square footage of a business's facilities or some other measure of Internet use. The figures in Exhibit 8 are meant to be illustrative of how the utility fee may be adjusted for different users by obtaining revenue from other sources, in this case premium revenue sharing and differential rates for businesses.

Exhibit 8: Utility Fee Options

	Baseline P3 Utility Fee to cover costs	**Scenario 1: Use 80% of Premium Revenue to Offset Utility Fee**	**Scenario 2: Use 80% of Premium Revenue to Offset Utility Fee & Differentiate Business and Residential Fees**
Residential Utility Fee (Monthly)	$25.50	$22.50	$10.00
Business Utility Fee (Monthly)	$25.50	$22.50	$75.00

Source: Budget and Legislative Analyst

As an alternative approach, the City could attempt to negotiate an arrangement with the concessionaire where no subscriber rates are charged, and all premises paying a utility fee would be eligible for high-speed service.

The Demand-Driven Dark Fiber P3 Model

This dark fiber model is different than the utility-based concessionaire P3 described above because the City would be responsible for construction and maintenance of physical network infrastructure (such as fiber, conduit, and other hard assets) as "dark fiber" and partners with one or more private providers to "light" the network and provide Internet connectivity to subscribed premises within the City. This could allow for greater amount of service diversity relative to the utility-based concessionaire model because it allows lessees to customize the use of the fiber network.

The dark fiber model analyzed for this report is assumed to be demand-driven, with final connections to individual premises made when customers subscribe to the service rather than connecting all premises to the fiber optic network at the outset, as would be the approach under the utility-based concessionaire buildout. It is further distinguished from the P3 utility-based concessionaire model in that the asset provided by the City is dark fiber

Unlike the utility-based models discussed above in which residents and businesses would pay for buildout of the network to all premises through the payment of a utility fee, under the demand-based dark fiber model, the private sector would fund the City's network buildout through network lease payments to the City and, possibly, a customer revenue sharing arrangement with the ISPs providing service on the network. If lease revenues and any customer revenue sharing were not sufficient to meet the City's debt service, capital and operating costs, other public funds would have to be identified and appropriated. If customer revenues were insufficient to meet private ISP capital and operating costs, it would be the responsibility of the partner(s) to cover their costs from some other source.

CostQuest's demand-driven dark fiber model projections prepared for DT assumes a risk-sharing arrangement similar to the one between the City of Westminster, Maryland and Ting, Inc., a telecommunications provider selected as private sector partner in that city's public-private partnership. The recently executed Westminster/Ting arrangement is discussed in more detail in a case study in Appendix 2 of this report.

Under the dark fiber model, the City's costs would be limited to initial construction of the physical network and certain maintenance responsibilities for network assets as defined by the contract with the private provider. For modeling purposes, it is assumed the City would generate revenue to meet its debt service by leasing out the network assets to a private provider or set of providers in addition to a revenue sharing agreement with the private company(ies). The private partner would be responsible for last mile network construction as customers subscribe to the service. Several San Francisco ISPs (including Comcast, Sonic, Monkey Brains, and Webpass) interviewed by the Budget and Legislative Analyst stated their interest in leasing dark fiber from the City if it were to construct a dark fiber network.

Under the demand-driven dark fiber model, the City would have some influence over service levels, coverage and price through its ownership of network assets and lease terms and conditions on those assets. As with the utility-based concessionaire model, retail prices for service would be a function of competition on the new fiber network and from incumbent broadband providers.

The revenue estimates presented in Exhibit 9 below assume that ISPs pay the City $6 per month per premise passed by the network and $30 per subscribed

customer per month, a structure similar to the arrangement in Westminster, MD. As in the other cost estimates, the new network is assumed to achieve a 30 percent market share over the first ten years of operations.

Exhibit 9: City Costs and Revenues of Demand-based Dark Fiber Public-Private Partnership Gigabit Speed Network Model

Assumed P3 enterprise market share for ISP services	30%
Total fiber network construction costs	$285,075,753
Average annual City operating costs for dark fiber network*	$25,298,481
Average annual City capital costs for dark fiber network*	$12,317,035
Average annual City debt service for construction costs**	$18,768,619
Total average annual City costs*	$56,298,804
Average total annual revenue from lease payments*	$59,110,477

Source: CostQuest Associates: analysis prepared for Department of Technology, February 2016

* Averages refer to first ten years of operations.

** Debt service assumes a twenty year bond, four year deferment of principal repayment, four percent cost of capital, one percent cost of issuance, and a five percent debt service reserve.

Risks to the P3 Models

In both P3 models, the City would have limited control over rates for retail services, which would be determined by competition among ISPs on the new network and with incumbent providers. Prices for services on the new FTTP network could therefore potentially be unaffordable to some residents and businesses.

The risk of not attracting enough subscribers and revenue to cover debt service would not be in place under the utility-based concessionaire P3 model since all network construction costs would be borne by a private partner. Similarly, the risk of an unsuccessful Internet Service Provider enterprise would fall on the private partner although, as discussed above, depending on the amount of the assumed utility fee on all premise owners, the private sector partners may not be completely dependent on subscriber revenues to cover their costs either. However, assuming the City has a revenue-sharing agreement with its private partners, if the private partners were not successful in attracting subscribers, the City's share of revenues could be negatively affected.

As with the utility-based buildout in the public model, some industry experts believe that the utility fee obligation could be considered public debt by

regulators, auditors, ratings agencies, and municipal bond investors. Thus, the utility fee buildout could raise the City's cost of debt and/or crowd out spending on other capital projects, even though the debt would be held by the private sector. In addition, multi-dwelling unit property owners would have to agree to establish final connections to all units on their properties, which could limit the ubiquity of access of the new network.

The chief risk associated with the demand-driven dark fiber buildout is that the City might not generate enough network lease revenue or collect sufficient subscriber revenue–sharing proceeds to cover its debt service, in which case other public funds would need to be appropriated to cover costs. In addition, the City would have to expand or create a City function, or partner with a private contractor, to maintain the Citywide dark fiber network.

In both P3 models, network and operating performance deficiencies as a result of poor performance by the private partner(s) could cause customer dissatisfaction with the City's decision to establish the gigabit speed fiber optic network, particularly if all residents and businesses are paying a utility fee for it as assumed under the utility-based buildout. Defaults or bankruptcies by private partners would put the City in the difficult position of having to find new partners for a complex business relationship.

Industry experts interviewed by the Budget and Legislative Analyst believe that there is limited private capital available to fund FTTP networks and ISPs. This limits the size and quantity of non-incumbent ISPs and the number and size of projects in which they can participate. Thus, the mere existence of a new network (either dark fiber provided by the City or network assets provided by a concessionaire's consortium) may not be sufficient to attract high quality ISPs to provide retail service. However, because they involve publicly funded new and open network infrastructure, all models would lower the cost of entering the local ISP market and would have the potential to drive greater competition and therefore enhance service levels and lower prices. In addition, in the case of a concessionaire agreement, the City could include a provision that requires the concessionaire to provide connectivity services in the event that no qualified ISPs use the new network.

Retail prices would not be controlled by the City under the P3 models outlined above so there is a risk that the Internet access services provided would not be affordable to some City residents and businesses if there are not enough ISP lessees using the City network to foster sufficient competition to maintain reasonable prices.

With respect to the utility-based concessionaire model, although there are numerous examples of these arrangements in other types of public sector capital

project construction, there are no examples yet of this model in which a FTTP network has been built and is operated by a private sector provider in a large urban area as part of a public-private partnership. There are, however, some examples of early stage concessionaire agreements currently being negotiated in the United States to build FTTP networks.

Macquarie Capital, a financial services firm, is negotiating concessionaire agreements to finance FTTP networks in Connecticut and in suburban Salt Lake City. In Utah the firm recently acquired the twice bankrupt UTOPIA network, covering 11,000 premises in five cities in Utah, and hopes to expand it to cover over 110,000 premises across fifteen localities. According to a recent analysis of public private partnerships, some of the localities that had been exploring working with Macquarie to provide network services have withdrawn from negotiations due to a lack of support for the utility fee on all premises.[20]

In September 2015, Macquarie Capital was awarded a contract to build out a statewide wholesale fiber network to provide high speed Internet infrastructure across all of Kentucky. The network will allow retail ISPs faster connection with the Internet, which in turn will allow them to offer faster services to their customers. The new network will also serve government facilities. The buildout will prioritize the least served areas in eastern Kentucky and is expected to take two years. Macquarie Capital and its technical partners will design, develop, and operate the network for 30 years.

The projects in Connecticut, Utah, and Kentucky are in very early phases so their success cannot yet be determined. Because there is almost no track record at this time, the risks of the utility-based concessionaire model may not be identifiable in advance. The success of the concessionaire model is dependent on the strength of the contract and the ability of each party to adequately anticipate and provide guidance for all potential conflicts.

The differences between the P3 models discussed in this section are summarized in Exhibit 10 below.

[20] Joanne Hovis, Marc Schulhof, Kim Baller, and Ashley Stelfox, "The Emerging World of Broadband Public-Private Partnerships", The Benton Foundation, February 2016.

Exhibit 10: Summary of responsibilities in two P3 models

	Public funds	Physical buildout	Maintenance: Hard Assets[21]	Maintenance: Network Electronics	Wholesale Service (e.g., leasing network)	Retail Service
Dark Fiber	General Fund, Bonding	City/City Contractor	City/City Contractor	Private	Private	Private
Concessionaire	Utility fee (or parcel tax)	Private	Private	Private	Private	Private

Source: Budget and Legislative Analyst interviews with ISPs and industry experts

Impact on Digital Divide

Because they promote competition in the broadband market and thus would likely lower or keep retail prices stable for Internet access, both the utility-based and demand-driven P3 models mitigate the digital divide by making Internet access more affordable. The utility-based model would help to reduce the digital divide further by providing gigabit speed access to the Internet to every single premise in the City, including those households that currently do not have wireline service. Additional efforts to promote computer literacy and subsidizing low-income households' purchase of computers and payment of the utility would need to be undertaken to fully address the digital divide, but the lack of physical connection to the Internet would be overcome. In this respect, the demand-driven model would do less to address the digital divide because customers are only connected as they sign up (though sign-ups for low-income households could also be subsidized).

Impact on affordable gigabit speed service to all premises

As stated above, both P3 models would increase competition in the local broadband market by providing Citywide FTTP infrastructure, potentially allowing multiple ISPs to compete for customers by offering gigabit services. The utility buildout, because it connects to every single premise, may attract more ISPs than the dark fiber buildout, and therefore may have a greater effect on Citywide prices for Internet access.

[21] Hard assets include fiber strands, conduit, surface mounted hubs, and generators.

Other Risks for all Models

Technology Risk

There is a risk that the City's ultimate design of the network and equipment that supports it will be supplanted by future technologies. Technological innovation can be rapid and impossible to predict, thus any technology choices made by the City could be rendered obsolete over the useful life of the project's assets. For example, changes to wireless technology may in the future allow for increased data transmission with speeds similar to those now only achievable on fiber-based networks, thus rendering that infrastructure obsolete. In the worst case scenario, the City would be obligated to pay off network construction costs while facing competition from ISPs using new technology that can deliver similar quality service at a lower price. However, at this time, wireless transmission cannot provide the same quality and speed, particularly for uploading data or engaging in any real time online activities as fiber.

Political risk

Most of the experts consulted by the Budget and Legislative Analyst, including policymakers and Internet Service Providers, emphasized that political unity is the necessary starting point for proceeding with a network deployment. Even if financial projections indicate positive returns from the project, ISPs would be less likely to enter a market in which the project is politically contentious, as this would likely delay deployment and raise costs. In order for the City to attract private investment and to be an effective partner in a network buildout, the buildout approach and details of the ultimate FTTP gigabit speed network plan should ideally address any concerns of the Board of Supervisors and other City officials to ensure their support.

There is also some risk at the community level if members of the community believe the project would be financially or environmentally detrimental to the community. In some communities that have deployed municipal fiber, extensive community outreach and education have taken place to develop community support (see Chattanooga case study below).

The California Environmental Quality Act (CEQA) requires that public agencies review potentially adverse environmental effects of their actions, including granting approval of private sector activity, if such actions meet the statute's definition of a "project." A public agency may determine a project is exempt from CEQA review or, if not, conduct an initial study of the project's effects. If the initial study determines that the project might produce significant negative effects unless mitigated, then the relevant public agencies must prepare an environmental impact report to analyze significant adverse environmental effects and provide mitigation measures. CEQA grants standing to any organization or

member of the public to challenge any public agency's findings during the CEQA process. This means that small but dedicated groups of residents can use CEQA to delay projects. Thus, political consensus at the community level regarding the importance of any fiber project is critical to smooth implementation and thus its success.

In testimony before the U.S. House of Representatives, representatives from Google Fiber cited CEQA as a major reason the company had chosen not to invest in California cities at that time[22] (since that testimony, Google Fiber announced it was exploring expanding to Los Angeles, San Jose, Irvine, San Diego, and will offer service over existing fiber within a limited area of San Francisco). As CEQA is state law, the City does not have the authority to alter the CEQA process, but it can play a role in addressing community opposition to potential projects.

Access to Multi-Dwelling Unit Buildings

This report and associated model assume that a new network would have access to all premises in San Francisco, including multi-dwelling unit buildings (MDUs), that is, buildings with multiple housing units. As noted in the discussion of the models that have utility-based buildouts, property owners must acquiesce to final connection to their premises. While any property owner could potentially refuse to allow a final connection to the fiber optic network, large MDUs present an additional set of challenges because they may have exclusive agreements with existing providers or may need to be re-wired in order distribute high-speed Internet access to all housing units. Some MDUs are already served by high-speed providers, such as Webpass and Wave, and Google Fiber recently announced it would begin to serve MDUs. These hurdles could make customer acquisition for any new network difficult and slower than forecasted.

6. Implementation Challenges

Private contractors, regulated utilities, and City departments that wish to excavate in the public-right-of-way or attach cables to utility poles to construct a fiber-to-the-premises (FTTP) gigabit speed network must first receive numerous certifications and permits, and submit information to the City that, cumulatively, can take several months to process. Once a contractor or City department has received approval to excavate, there are numerous City and state specifications regarding when a project can be conducted, how the street may be excavated, how the public is to be notified, and how violations are to be dealt with.

Though the regulatory requirements vary for public agencies, private companies and regulated utilities, the amount of time needed to obtain the necessary

[22] Testimony of Milo Medin, Vice President of Access Services, Google Inc. House Committee on Oversight and Government Reform Field, Hearing On Innovation and Regulation, April 18, 2011

permits and gain approval to excavate the street and install fiber and conduit should not differ significantly depending on the entity performing the task.

The rules governing access to utility poles also vary depending upon who owns the pole itself, and the type of entity attempting to gain access to the pole. Regulated utilities that own poles are required by the California Public Utilities Commission (CPUC) to provide access to telecommunications and cable TV corporations, but not to municipalities, video companies, or other private companies such as ISPs that are not also a cable or telecommunications company. Those not granted access by the CPUC must negotiate pole attachment agreements through the Northern California Joint Pole Association. For this reason, it would be easier for the City to partner with a telecommunications or cable television corporation for the attachment of fiber broadband to above ground utility poles than to conduct the installation itself or to create a partnership with a private company without access rights. However, if the City conducts the project itself or partners with another type of company, it would still be possible to obtain access to utility poles, but more steps would need to be taken to accomplish this.

If the City conducts the project itself or partners with a company not granted utility pole access under CPUC regulations, it would still be possible to obtain access to utility poles, but more steps would need to be taken to accomplish this. Besides negotiating with the Northern California Joint Pole Association for access, the City's private partner could apply to the Federal Communications Commission (FCC) to be granted status as a company with access rights.

Obtaining Permission to Install Conduit and Fiber below Ground

Certificate of Public Convenience and Necessity

Companies regulated by the CPUC seeking the right to excavate under the public right-of-way to install conduit and fiber below ground must have a Certificate of Public Convenience and Necessity (or its equivalent, depending on the type of company) issued by the California Public Utilities Commission (CPUC). This is required for incumbent and competitive local exchange carriers (ILECs and CLECs)[23], cable TV corporations, long-distance carriers, wireless providers, and video service providers.[24] Private contractors that are not regulated utilities, such as Internet Service Providers that do not also provide telephone or cable television service, do not need to obtain the Certificate, nor do municipal departments.

[23] Competitive local exchange carriers (CLECs) are telecommunications providers that now compete with each other and the incumbent local exchange carrier. Incumbent local exchange carriers were the original sole telephone companies serving a region prior to deregulation and the breakup of the Bell telephone system.
[24] Video service provider (VSP) registration is required under the 2006 Digital Infrastructure and Video Competition Act (DIVCA). Prior to DIVCA, cable franchises were issued by cities and counties. DIVCA replaces that system with one in which video franchises are now issued by the CPUC, rather than local entities.

Since some of the companies that the City might partner with in constructing and deploying a FTTP gigabit speed network might possibly already have this Certificate for providing service in the City and County of San Francisco or not be required to have one, this requirement may not have much impact on the City deploying a fiber optic network. According to Senior Counsel at the CPUC, it can be safely assumed that the majority of regulated utilities have already registered and received their Certificate for operations in the City and County, which does not expire so long as the entity files an annual report and pays user fees and surcharges.

If a potential partner company for the City needed to obtain a Certificate of Public Convenience and Necessity, such as a CLEC that had not previously obtained a Certificate for network construction or extension in San Francisco, it would add between three months and one year to the process. The company would be required to file an application and answer questions such as whether any sanctions have been filed against it. The goal of this process is to prove that the company is generally fit to be in business. Receiving the Certificate is dependent upon Commission approval.[25]

Possession of a CPCN does not grant holders additional rights or privileges over non-holders when it comes to obtaining permits and other authorizations from the City. Rather, it is a requirement to access the public right of way for entities that are regulated by the CPUC and gives approved companies interconnection rights (e.g., right to lease spare capacity, to the extent available, in other companies' conduit) and certain utility pole access rights. Such rights could facilitate construction of a City fiber optic network but there are alternative means of obtaining access to available conduit and utility poles, discussed further below, but rights to such access is only available to companies with CPCNs.

Utility Conditions Permit

Certified telephone and wireless services companies wishing to excavate in the City must obtain a Utility Conditions Permit (UCP) from San Francisco Public Works[26]. The UCP authorizes the permittee to construct, install, maintain, locate, move, occupy, operate, place, protect, reconstruct, reinstall, relocate, remove, and replace, facilities within the public right-of-way for the sole purpose of providing telecommunications services on a common carrier basis.[27] The City does not have to obtain a UCP but a private company in a public-private partnership with the City would need to obtain this permit.

[25] CPUC Senior Staff provided the information contained in this paragraph.
[26] According to Ms. Lynn Fong, Permit Manager, at San Francisco Public Works. Formerly known as the Department of Public Works, the department has been renamed San Francisco Public Works.
[27] The federal Telecommunications Act of 1996 defines common carriers as any provider of telecommunications services.

The UCP is valid for two years and costs $2,000. The application for a UCP is reviewed by the City Attorney. It can take between two weeks and several months to issue the permit. No hearing is required to obtain a UCP. If a private contractor on behalf of a City department such as the Department of Technology (DT) were to install conduit and fiber itself, it would not be required to obtain a UCP.

Dig Once Project Review

Before excavation permits can be issued, private sector applicants must submit details of their excavation project to the Department of Technology (DT) for review, as part of the City's Dig Once program. City departments will also be required to undergo this review process once it is fully implemented.

Adopted in November of 2014, the purpose of the Dig Once program is to allow DT to determine whether it can implement public communications infrastructure at the same time that utilities and private companies open the street for other projects.[28]

DT must be notified by permit applicants of all excavation projects measuring greater than 900 linear feet at least 14 days in advance of excavation permit applications being submitted to San Francisco Public Works so DT can exercise the option of participating in the project by simultaneously constructing conduit under the right-of-way to expand the City's fiber network.

DT's policy is to respond within seven days of receiving notice and indicate whether it intends to participate in the project or not; the applicant either receives an approval or refusal that it then submits to San Francisco Public Works to indicate that DT has reviewed the project and made a decision as to its participation. When deciding whether to participate, DT determines whether adding to the City's network simultaneous with the planned excavation project is financially feasible and consistent with the City's long-term goals of adding communications infrastructure. DT also examines whether the project plans are consistent with standard technical specifications for City communications infrastructure.[29]

Registration with San Francisco Public Works

Both private companies and City departments planning to apply for excavation permits must register with San Francisco Public Works, and provide or have on record with the department the following information:

- A copy of any legal documents (such as a Certificate for Public Convenience and Necessity) that the applicant may have authorizing it to occupy and

[28] Department of Technology Order No. 1, Regulations Implementing San Francisco's "Dig Once" Ordinance.
[29] Department of Technology Order No. 1: Regulations Implementing San Francisco's "Dig Once," Ordinance.

use the public right-of-way for the purpose stated in the Excavation Permit application*;

- A current City Business Tax Registration Certificate*;
- Current evidence of insurance;
- A $25,000 deposit;
- A 24-hour phone number and name of a person who will respond to emergencies;
- The name, telephone, and facsimile numbers and the mailing and email addresses of the person who will receive official correspondence from the Department;
- Written acknowledgement that all materials necessary for construction will be on hand and ready for use so as not to delay the excavation and the prompt restoration of the public right-of-way;
- Written acknowledgement that the applicant and owner are in compliance with all Excavation Code requirements, rules, Departmental Orders, Standard Plans and Specifications, and are not subject to any outstanding DPW fees or penalties; and
- Written acknowledgement that the owner of the facility to be installed is a member of Underground Service Alert.

*Does not apply to the City.

The time needed to register with Public Works prior to completing an excavation project varies depending on the size of the project. It typically takes five days for small projects of less than 1,000 square feet, and up to 25 days for large projects greater than 1,000 square feet.

Excavation permits

After a company has obtained a Utility Conditions Permit, completed the Dig Once project review and registered with San Francisco Public Works, it can apply for excavation permits. Even if a company holds a franchise under Article 11 of the Administrative Code, they must still obtain excavation permits. The City may also obtain excavation permits after the applicant department has registered with San Francisco Public Works, as described above.

Excavation permit applications require the following details about the project:

- Location, purpose, and method of the excavation;
- Dimensions of the excavation;
- Purpose of the facilities to be installed, maintained or repaired;

- Proposed start and end dates of the excavation; and
- Square footage of asphalt wearing surface and concrete to be excavated in each block.

It can take between three and 30 days for San Francisco Public Works to approve and issue an excavation permit, depending on the size of the excavation. For major excavation projects, or those lasting more than 15 calendar days, a pre-application meeting is required to coordinate approval of all necessary permits and to minimize the impact of construction on the public.

Excavation permits are voided if the excavation has not begun within 30 calendar days of the start date specified in the permit; if the work permitted is not conducted diligently to its conclusion, or if the excavation, including restoration, has not been completed within the specified duration.

Although there are no specified limits on the size of the excavation permit, it would not be feasible to create a blanket permit extending citywide for all projects due to the fact that the permit would become hundreds of pages long and the contractor would not be able to include all of the specific requirements for a certain street or area. Issuing a permit for excavation for even half of the city would be infeasible. As a result, the city or a private partner would need to apply for potentially dozens of permits to install fiber underground.

Coordinating Excavations and Street Repaving

In conjunction with applying for excavation permits, utility and municipal agency excavators must submit five-year plans to San Francisco Public Works, on the first day of April and October of each year, showing all of the facilities they expect to install in the City within five years of the excavation permit application date. The department currently utilizes Accela Right of Way Management (formerly Envista), a mapping system to upload all planned work within the next five years, and to create a consolidated five-year repaving plan. Private companies are only required to coordinate their construction with the city's five-year repaving plan if they are implementing a capital project that will impact more than one street segment. Public Works instantaneously uploads the five-year plans and utilizes the information to create a consolidated five-year repaving plan.

Applicants that do not propose major work in the five year period must submit a statement to that extent and are required to immediately report any major work to the Department as soon as it does become planned. Prior to the issuance of excavation permits, applications are checked against existing five-year paving plans and a permit might be conditioned to coordinate work with scheduled paving and so that the work can be completed before the paving start date. This review is conducted separately from the Dig Once project review.

SF Public Works' consolidated five-year repaving plan also identifies streets that have been repaved within the previous five-year period, and labels them "moratorium" streets. According to the Permit Manager for San Francisco Public Works, it is unlikely that the department would deny a permit for an excavation planned on a moratorium street. Instead, the department would add additional paving restoration requirements before allowing a company to dig into the recently paved street. Similarly, a private company would also not be denied access but would be required to perform additional and costly restoration if they propose to excavate in a moratorium street.

Exhibit 11 below illustrates the certifications and permits that a private company, public utility or a City department would need to obtain prior to being able to install conduit and fiber underground and demonstrates the amount of time required to obtain each.

Exhibit 11: **Steps Required to Implement Conduit and Fiber Broadband below Ground**

Required Authorization	Issuing Department	Time to Complete	Who Obtains?		
			Private Contractor	Regulated Utility	City Department
1) Certificate of Public Convenience and Necessity*	California Public Utilities Commission (CPUC)	Three months to one year		X	
2) Utility Conditions Permit	San Francisco Public Works	Two weeks to three months		X	
3) Dig Once Project Review	Department of Technology	Two weeks	X	X	X
4) Five Year Repaving Plans	San Francisco Public Works	Departments upload this information twice a year. Completion occurs instantaneously.		X	X
5) Registration with Public Works	San Francisco Public Works	Five days for small projects (less than 1,000 sq. ft.), up to 25 days for larger projects (more than 1,000 sq. ft.)	X	X	X
6) Excavation Permits	San Francisco Public Works	Three days to one month per permit	X	X	X

Source: Department of Public Works; Department of Technology; California Public Utilities Commission (CPUC)

* The majority of regulated utilities have already registered with the CPUC and obtained the Certificate for their networks in the City and County of San Francisco, thus eliminating the additional time needed to obtain this approval.

Once an applicant has received a permit to excavate, the private company, utility, or City department must follow requirements regarding public noticing, protection of the street, excavation materials to be used, paving specifications, street restoration, and the identification and marking of subsurface facilities. An excavation site may not exceed 1,200 linear feet at any time. Failure to follow specified requirements can result in fines and/or the loss of the excavation permit.

Exhibit 12 below, from SF Public Works, indicates the types of violations and fines that might be incurred for failure to follow excavation specifications, and the remedies to address the infractions.

Exhibit 12: Types of Violations and Fines that can be Incurred during Street Excavations

Violation	Fine/Remedy
Excavating without permits (Excavation permit, special traffic permit, USA ticket number)	$10,000/day, stop work and get permit
Excavating without providing public notice	$1,000/day, stop work until corrected
Beginning a "Major Project," without having a pre-construction meeting	$500 per occurrence, and stop work until a pre-construction meeting has occurred
Violation of permit conditions	$500 per occurrence per day
Improper site protection (improper plating, path of travel, barricading, etc.)	$500 per occurrence per day
No permit on site	$250 per occurrence, correct immediately
Improper trimming of trench	$100 per block, per day stop excavation until correct
Trench length over 1,200 linear feet	$100 per days over until restoration of trench to satisfy 1,200 linear feet and excessive work
Improper public notice (No project sign, wrong information on sign/notice, etc.)	$100 per block, per day stop work until Public Notice is provided and validated
Non-compliance with 120 hour trench restoration requirements	$100 per block, per day until trench is restored per requirement stop additional work
Improper housekeeping (failure to remove spoil, dirty site, no sweeping, etc.)	$100 per block, per day, correct immediately
Other Excavation Code violations	$100 per block, per day

Source: San Francisco Public Works

The amount of time needed to obtain plan approval and permits from the City to excavate the street is likely not to vary significantly based on the type of entity that wishes to conduct the excavation though, based on the time estimates presented above, the private sector permitting would take somewhat longer than the City obtaining approvals. If the City were constructing its own network, it would avoid the two weeks to three months required to obtain a Utility Conditions Permit from SF Public Works, since that permit is only required of private companies, but not City departments.

In choosing a partner to complete the FTTP gigabit speed network, the restrictions placed on utility pole access explained below would present greater challenges.

Aerial Distribution of Fiber

Roughly half of the City's telecommunications and other utility wires are overhead in San Francisco, spread over 470 miles. In areas with overhead wires, fiber network cable would also likely be installed above ground. There are numerous state and federal specifications governing how new wires are to be installed on existing utility poles; this section highlights the most important ones.

The Federal Communications Commission (FCC) regulates the rates, terms, and conditions for pole attachments to ensure that such terms are just and reasonable, and to adopt procedures to hear and resolve complaints regarding rates. However, a state may supersede the FCC's regulation of pole attachments if it can certify to the FCC that it has enacted regulations governing the rates, terms and conditions of pole attachments, and that it has the authority to govern the rates and terms in the interests of subscribers.[30] The State of California has made the required certification and has its own rules in place regarding pole attachments that would apply in the event that the City, or a private company on behalf of the City, was to construct a Citywide FTTP gigabit speed network.

California Public Utilities Code Section 767 delegates the State's Public Utilities Commission (CPUC) the authority to require that regulated utilities grant each other access to their utility poles. The CPUC sets the rates, terms, and conditions for this access, which is known as Mandatory Access.

In its 1998 Rights-of-Way (ROW) Order,[31] the CPUC found that access to poles by communications providers' was necessary to ensure competition in the local telecommunications market, and it required that investor-owned utilities and Incumbent Local Exchange Carriers (ILECs)[32] also provide facilities-based telecommunications[33] and cable TV providers with access to their utility poles.[34]

[30] *See generally* 47 U.S.C. §§ 224, 224 (c).
[31] CPUC Decision (D.) 98-10-058.
[32] An incumbent local exchange carrier (ILEC) is a local telephone company that held the regional monopoly on landline service before the market was opened to competitive local exchange carriers. After the 1996 Telecommunications Act was enacted, competitive local exchange carriers (CLECs) emerged. ILECs still provide most of the residential voice services in California, rivalled only by cable companies which bundle voice service with cable broadband.
[33] A facilities-based telecommunications service provider (e.g., the traditional ILEC) owns its own network, while non-facilities based competitors purchase "unbundled network elements" from the ILECs, or simply resell ILEC service (under the terms of the 1996 Telecommunications Act, 47 U.S.C. §§ 251-252). In reality, telecommunications networks today may be cobbled together from a mixture of facilities ownership, long-term leases, and purchase of UNE services from incumbents. Facilities-based ILECs and cable companies own or control the majority of last-mile lines to homes and residences in California.

As a result of these actions, CPUC regulation of pole attachments and rights-of-way have superseded FCC regulation in California.[35]

Commission Rules Governing Access to Regulated Utility Infrastructure

In the CPUC's1998 ROW Order, the Commission directs utilities to negotiate with CLECS and cable TV corporations (CATVs) regarding the fees and charges for access to utility infrastructure. If the parties cannot agree, the ROW Order authorizes parties to bring their dispute to the Commission which can apply a default price rule consisting of the following three components:

1) A standardized make-ready[36] charge that consists of the actual costs incurred by a utility to make its support structures ready for attachments;

2) An annual fee for the use of support structures other than poles (e.g. conduits)[37]; and

3) An annual fee for pole attachments that is equal to the greater of $2.50 or 7.4% of the utility's annual cost-of-ownership for the pole and supporting anchor.[38]

The CPUC specifies regulations in General Orders (GO) 95 and 128 for the design, construction, and maintenance of all overhead electric and communications facilities within its jurisdiction, including facilities belonging to co-ops, municipalities and investor-owned utilities. The General Orders also regulate the placement of lines, circuits, and other equipment on the poles themselves.

Pole Access for Municipalities and Other Parties

As a result of the policies established by the State's Public Utilities Code Section 767 and the Commission ROW Order, various parties, such as telecommunications companies and cable TV providers, have a right to place attachments on utility poles in California.

Other entities such as municipalities, private companies that are not subject to CPUC regulation (i.e., companies other than CLECs, ILECs or cable TV corporations) and water companies may seek to attach facilities to utility poles despite not being covered by the access rules. Such parties wishing to obtain pole access may become joint owners or tenants, if the pole owners agree to make space

[34] Similar to accessing the public right of way, entities regulated by the CPUC must obtain a CPCN to access utility poles.
[35] *See* ROW Decision, D.98-10-058, Conclusions of Law 1-4.
[36] Ibid.
[37] This fee is equal to the percentage of the support structure that is used by the attachment multiplied by the utility's annual cost-of-ownership for the support structure.
[38] The 7.4% pole-attachment fee includes all of the utility's pole-related costs, such as administrative and general costs, operations and maintenance costs, straight-line depreciation, cost of capital, franchise fees and taxes, and offsetting credits for contributed capital and deferred income taxes.

accessible, and allow the party to purchase an interest in a pole through the Northern California Joint Pole Association (NCJPA).[39] The NCJPA tracks ownership of and activity on jointly owned poles and invoices members for their activities. Many utility poles in California are subject to joint ownership arrangements; the NCJPA has 40 members, including the City and County of San Francisco.

Besides handling billing issues, the NCJPA has established procedures and protocols for aspects of joint pole ownership not addressed by GO 95, such as joint pole planning practice, pole replacement and removal, identification of poles and attachments for record-keeping purposes.

Legislation Governing Access to Local, Publicly Owned Utility Poles

In 2012, the California State Legislature passed AB 1027 that requires local, publicly-owned electric utilities, including irrigation districts that own or control utility poles and support structures such as ducts and conduits, to make available appropriate space and capacity on or in those structures to cable television corporations, video service providers and telephone corporations under reasonable rates, terms and conditions.

As San Francisco does not have a municipal electric utility, and the majority of the poles in the city are owned by PG&E, this legislation is less relevant in this context.

Exhibit 13 below illustrates the legal frameworks that govern access to telephone poles and the conditions under which attachments are made based on the ownership of the pole and which party is attempting to access the pole. General Orders 95 and 128 govern safety standards and the actual placement of lines and conduit on the poles themselves, regardless of who owns the poles and which party is attempting to access them.

[39] *See* ROW Decision, D.98-10-058, at Section X ("Membership [in joint pole associations] is comprised of ILECs, CLECs, wireless providers, municipalities, and electric and water utilities. Pursuant to such joint pole associations, third parties have acquired access to jointly owned poles as tenants of one of the owners"). Elsewhere, the ROW Decision anticipates municipal networks: "The statewide interest in promoting competition and the removal of barriers to entry and nondiscrimination are equally important with respect to both investor-owned utilities and municipally-owned ROW access rights. This is particularly true to the extent that many municipalities are themselves offering, or intending to offer, communications and cable television services, and thus, are or will become competitors to other providers of those services" (at Section G.2).

Exhibit 13: Laws, Regulations and Entities Governing Pole Access based on Pole Ownership and Accessing Party

		Accessing Party			
Pole Owned By		**Telecommunications Provider**	**Cable TV Corporations**	**Video Service Provider**	**Municipality (or its contractor)**
	Regulated Utility	CPUC's Right-of-Way Order (1998)	CPUC's Right-of-Way Order (1998)	Joint Pole Association	Joint Pole Association
	Municipal Utility	California Public Utilities Code, Division 4.8, Sections 9500 and 9510	California Public Utilities Code, Division 4.8, Sections 9500 and 9510	California Public Utilities Code, Division 4.8, Sections 9500 and 9510	City policy

Source: Budget and Legislative Analyst

Expanding the Scope of Mandatory Access Policies to Allow More Entities to Use Utility Poles

In 2006, the California State Legislature passed the Digital Infrastructure and Video Competition Act (DIVCA), which directed the CPUC to "establish and administer a new state franchise authorization process for" video service providers (VSPs), pursuant to which the CPUC became the state's sole franchising authority for video franchises. In passing the DIVCA Order, however, the CPUC determined that its authority over VSPs was limited because VSPs are not "public utilities," under California law.[40] The CPUC ultimately concluded that it lacked the authority to enforce its safety rules, such as General Order 95, with respect to VSPs.[41]

Google Fiber Inc. was recognized as a VSP in 2011 by the State of California. When the company sought to offer commercial video service through broadband infrastructure, it raised the concern that, as a VSP, it lacked mandatory access rights to poles and other utility infrastructure because the DIVCA Order does not grant such rights to VSPs. Google Fiber claimed that as a result, some public utilities have refused to negotiate pole attachment agreements or to provide access to their poles and, therefore, Google Fiber might not be able to construct broadband infrastructure.

Google Fiber, Inc. filed a petition in 2014 that sought to have the CPUC modify the DIVCA Order so that VSPs could take advantage of the ROW Rules and gain Mandatory Access rights to utility poles, thus leveling the playing field between VSPs and cable TV corporations. The petition was denied on February 20, 2015, on the basis that the Commission lacks explicit statutory authority under the Public

[40] D.07-0P3-014, Conclusions of Law 6-7 ("the Commission may not impose any requirement on any holder of a state video franchise, except as expressly provided by DIVCA").
[41] "Decision Denying Google Fiber Inc.'s Petition to Modify Decision 07-0P3-014," D.15-05-002, at Conclusion of Law 1.

Utilities Code to: 1) grant state-franchised VSPs the right to access public utility infrastructure, and 2) promulgate and enforce safety regulations with respect to VSPs.[42]

However, the CPUC did note that while all VSPs are not cable TV corporations under federal law, as interpreted by State law, some VSPs may be considered cable TV corporations and would thus be covered by the ROW rules which requires that investor-owned utilities and Incumbent Local Exchange Carriers (legacy telephone companies, or ILECs) provide facilities-based telecommunications and cable TV providers with access to their poles.[43] Google Fiber Inc. and other VSPs could thus register with the FCC as cable operators and then obtain pole access under the ROW Order. To date, Google Fiber has not pursued this action at the federal level, or its equivalent at the state level. VSPs and other entities not covered under the ROW Order regulations could also partner with an entity that is covered, such as a CLEC, to gain non-discriminatory access to utility poles.

Relatedly, on October 30, 2015, the California Public Utilities Commission issued a Proposed Decision in response to a petition filed by AT&T that would amend the ROW Rules to allow wireless carriers (i.e. commercial mobile radio service or CMRS providers)[44] to have the same rights of non-discriminatory access to utility poles and other infrastructure that are currently granted to public utilities.

The City appears to be limited in the type of companies it could partner with to construct an FTTP gigabit speed network using utility poles in the City for the above ground segments of the network. The City would need to partner with either a competitive local exchange carrier (CLEC), cable TV (CATV) corporation or a Video Service Provider (to the extent that it also qualifies as a cable television corporation or cable operator under the *Google Petition* decision) to ensure that it can install its FTTP network on existing poles that are owned by regulated utilities, as only these entities are granted access rights by the CPUC's ROW decision, and the attachment rates, terms, and conditions are clearly enumerated.

If the City (or its contractor) wanted to install fiber itself or if a private company not granted mandatory access rights to utility poles by the California Public Utilities Commission wished to install aerial fiber, it could enter joint pole agreements through the Northern California Joint Pole Association, although there is no guarantee that the pole owners would agree to provide access. According to

[42] Valenstein, Jill. "Google's Pole Attachment Rights in California on Hold for Now." Broadband Deployment Law Advisory. March 6, 2015. http://www.broadbandlawadvisor.com/2015/0P3/articles/pole-attachments-2/googles-pole-attachment-rights-in-california-on-hold-for-now/

[43] D.15-05-002, at note P31: "There is nothing mutually exclusive about being a state-franchised VSP and a cable TV corporation."

[44] Commissioner Randolph. "Decision Regarding the Applicability of the Commission's Right-of-Way Rules to Commercial Mobile Radio Service Carriers." California Public Utilities Commission, October 30, 2015.

the Department of Technology, the majority of the poles in San Francisco are jointly owned by PG&E and AT&T.[45]

Summary of implementation challenges

- In order to implement an FTTP network, the City and/or its private partners must have access to conduit to lay fiber underground, and to utility poles to distribute fiber aerially. Since it does not own enough conduit or utility poles to support a citywide FTTP network, the City or its private partner will need to either (a) work with the conduit and pole owners to gain access to their assets or (b) construct its conduit and poles for the network.
- Gaining access to existing conduit requires understanding what is currently installed within the City's streets and to what extent it is available for use for a new network. For City owned conduit, this information is scattered among City departments and not centralized and therefore difficult to incorporate into any planning process. In any case there is not enough City-owned conduit to support a FTTP network without the need for additional conduit installation. Private owners of conduit have not made information regarding the location, availability and other attributes of their conduit publically available. Additionally, owners of conduit may not be inclined or capable of expeditiously granting access to new providers.
- Therefore, this report assumes that the City will need to install new conduit in areas where utilities have been undergrounded.
- Installation of new conduit would require obtaining various permits and certifications from the City, and, in many cases, obtaining permission from the CPUC. It can several months to meet all regulatory requirements before installation of conduit can begin. In addition, it would require compliance with numerous City and state specifications regarding when a project can be conducted, how the street may be excavated, how the public is to be notified, and how violations are to be dealt with. Though the regulatory requirements vary for public agencies, private companies and regulated utilities, the amount of time needed to obtain the necessary permits and gain approval to excavate the street and install fiber and conduit should not differ significantly depending on the entity performing the task.

[45] Davis Wright Tremaine, LLP. "CPUC Proposed Decision Extends Pole Attachment Rights to CMRS Providers." Broadband Deployment Law Advisory. November P3, 2015. http://www.broadbandlawadvisor.com/2015/11/articles/pole-attachments-2/cpuc-proposed-decision-extends-pole-attachment-rights-to-cmrs-providers/

- This report has furthered assumed that the City or its private partner will seek to access existing utility poles rather than install new ones. Accessing existing utility poles is time consuming, expensive, and complicated. Pole owners may not be inclined or capable of expeditiously granting access to their poles to new providers.
- The rules governing access to utility poles also vary depending upon who owns the pole itself, and the type of entity attempting to gain access to the pole. Regulated utilities that own poles are required by the CPUC to provide access to telecommunications and cable TV corporations, but not to municipalities, video companies, or other private companies such as ISPs that are not also a cable or telecommunications company. Those not granted access by the CPUC may negotiate pole attachment agreements through the Northern California Joint Pole Association or apply to the FCC to be granted status as a company with access rights, though access rights are not guaranteed.

7. California fiber initiatives

Of the 1,015 private and public entities that have deployed FTTP networks in the U.S, 160 are cities (143 municipally owned), including at least six in California. Across California, cities are pursuing various paths to enhance their internet infrastructure for their businesses and residents. As shown in Exhibit 14 below, larger networks are operated by private entities and tend to serve businesses and anchor institutions.[46] Cities that only serve residents tend to be smaller in area and population.

No city of comparable size to San Francisco has deployed a ubiquitous fiber-to-the-premise network as of yet. However, as shown in Exhibit 14, FTTP network initiatives are underway in the largest cities in the state: Los Angeles, San Diego, Long Beach, and San Jose. Outside California, the City of Chicago is now on the Google Fiber potential expansion list and the City of New Haven, together with other localities in Connecticut, is developing a fiber network plan for implementation. Google Fiber reports that it has received over 1,000 applications for its fiber network enterprise.

Exhibit 14: Sample of fiber initiatives in California municipalities

Municipality	Short description of status	Customers	Initial Funding	Operator
Atherton	Financed by residents, Atherton will connect any home that opts in to the network with a fiber line. Needs 20% take rate to be viable.	Residential (expected)	Private investment by residents (expected)	Private (expected)

[46] Anchor institutions are public institutions such as schools, hospitals, libraries, colleges, public safety facilities, and other government facilities. These generally serve and are open to the community, are distributed across jurisdictions, and have high bandwidth needs.

Municipality	Short description of status	Customers	Initial Funding	Operator
Berkeley	Recently completed a broadband needs assessment	N/A	N/A	N/A
Brentwood	P3 with Sonic to use City conduit to pull fiber and provide FTTH service for residents and free to schools, if certain customer thresholds achieved.	Residential / Businesses	Private	Private
Irvine	On Google Fiber potential expansion list	Residential and Businesses (expected)	Private (expected)	Private (expected)
Loma Linda	City offers FTTP services for residents and businesses. New development must include fiber interface and compatible copper wiring within. The network is open access.	Businesses and Residents	Public	Public
Long Beach	RFP in Feb. 2016 to install fiber network to connect city buildings	Government (expected)	Public (expected)	Public (expected)
Los Angeles	Issued RFP in June 2015 seeking proposals for ubiquitous FTTP network and public WiFi. Response to proposals expected Nov. 2015. Since RFP issued, city added to Google Fiber potential expansion list.	Residential and Businesses (expected)	Private (expected)	Private (expected)
Mountain View	On Google Fiber potential expansion list	Residential and Businesses (expected)	Private (expected)	Private (expected)
Palo Alto	City has Master Plan to assess options for FTTP network, but no model selected yet. Also on Google Fiber potential expansion list.	N/A	N/A	N/A
San Diego	On Google Fiber potential expansion list	Residential and Businesses (expected)	Private (expected)	Private (expected)
San Jose	On Google Fiber potential expansion list, draft Mitigated Negative Declaration published in Oct. 2015	Residential and Businesses (expected)	Private (expected)	Private (expected)
San Leandro	City leases conduit and other fiber assets to private entity, Lit San Leandro, which serves business customers in downtown San Leandro.	Businesses	Private	Private
Santa Clara	Electric utility offers dark fiber to businesses. The City is also on the Google Fiber potential list.	Businesses / Anchor Institutions / Telecom carriers		Public utility
Santa Cruz	P3 citywide FTTP network. City owns fiber. Internet only service (no voice/video)	Businesses / Anchor	Public (expected)	Private

Municipality	Short description of status	Customers	Initial Funding	Operator
		Institutions / Residents (expected)		
Santa Monica	Municipal fiber network that serves local government agencies and business customers in downtown Santa Monica. Recently announced intention to build out network to serve residents.	Businesses / Government / Anchor Institutions / Residential (expected)	Avoided costs, lease/service revenue	Public (but also leases dark fiber to customers)
Sunnyvale	On Google Fiber potential expansion list	Residential and Businesses (expected)	Private (expected)	Private (expected)
Vallejo	Developing a Master Plan to set connectivity goals. Interested in developing an economic development network.	Businesses / Anchor Institutions (expected)	Public (expected) / Private (expected)	Private (expected)

Source: Budget and Legislative Analyst survey

Why haven't large cities implemented municipal networks to serve residents?

Exhibit 14 above is notable for the absence of cities of San Francisco's size or larger that have completed implementation of a citywide municipal fiber network. The same is true for the rest of the country; Chattanooga, TN is the largest municipality of the 1,015 private companies and municipalities that have deployed FTTP networks in the United States. Existing FTTP networks tend to have been built in rural areas, which are historically underserved by incumbents, or in cities much smaller than San Francisco.

Municipal FTTP builds face a common set of challenges. FTTP projects are expensive and have to compete with other municipal priorities. Many municipalities have experienced fiscal tightening since the financial crisis of 2008. In addition, Internet service provision is seen by some as a private good, rather than a utility, or basic infrastructure, and thus outside the ambit of municipal services. Cases of municipal network failures such as the City of Alameda and the multi-city UTOPIA network in Utah, may have garnered more media attention than the success of other municipal networks.

Large cities face additional challenges to deploying FTTP networks:

1. Large cities tend to be well-covered by incumbent providers, so there may be less perceived need among residents and policy makers for FTTP infrastructure. Unlike rural areas, the digital divide in cities is generally an issue of affordability, literacy, and preferences rather than physical access.
2. FTTP projects have high risk, with large capital expenditures and uncertain outcomes.

3. Construction of a citywide network in a larger city would take one to three years at best, and financial models generally show positive cash flow only at least four to five years after construction. Changes in city leadership during a time span such as this could compromise the viability of the project and support from the community.
4. Incumbent Internet Service Providers are more likely to try to stop, undermine, or aggressively maintain their market share in large cities that are considering municipal FTTP networks. Large cities constitute a significant portion of incumbent providers' customer bases.
5. Large cities are often more dense and have more congested right of way and poles as well as complex geographies and requirements for construction, all of which increases buildout costs relative to rural areas.

8. Funding Sources

There are several sources of government funding available for deploying a municipal fiber-to-the-premises (FTTP) gigabit speed network in San Francisco, including funds to support planning and building a new network, or expanding an existing network. Most funding is directed to "underserved" and "high cost" areas, the definitions of which generally encompass rural areas with limited or no Internet service provision. The Budget and Legislative Analyst surveyed government funding opportunities that could potentially be available for San Francisco to offset the cost of the municipal network buildout, summarized below.

State and Federal Funding Opportunities

Exhibit 15 below summarizes the federal funding opportunities that might be available to help pay for a network deployment in San Francisco. As with rural funding opportunities, these funds may only be used to offset project costs in economically distressed areas. Although the definition of economically distressed varies by program, such areas are generally low-income and/or have high unemployment. In addition, application processes, eligibility, and funding priorities vary by program and are subject to change over time. The Broadband Opportunity Council, a federal interagency task force, recently recommended clarifying eligibility guidelines for these funding programs to explicitly include broadband infrastructure and streamlining information access and application processes. The report also made funding recommendations, which are subject to the federal appropriation process and therefore uncertain.[47]

The Budget and Legislative Analyst surveyed State of California funding opportunities and interviewed State officials but did not identify any State funding that would be available for a network deployment in San Francisco at this time.

[47] In addition, The U.S. House of Representatives is considering legislation to streamline permitting and access to federal land as well as dig once policies for highway projects.

Like federal government programs, State funding programs identified are mostly directed to underserve rural areas.

There may be funding state/federal opportunities to enhance specific government functions that are not explicitly targeted for broadband deployment but could nonetheless be used to offset connection costs. An example would be a grant to upgrade emergency management communications that could be used to offset network buildout costs among emergency management facilities. However, specific funding sources of this type were not identified in the Budget and Legislative Analyst's survey of State funding sources.

Exhibit 15: Federal fiber optic network funding opportunities for San Francisco*

Agency	Program	Possible Uses	Typical Size	Eligibility
Department of Commerce, Economic Development Administration	Public Works	Connecting anchor institutions or industrial parks to fiber optic networks; telecommunication facilities	$100,000 - $3,000,000 one-time grants	Must be in an economically distressed area, defined as higher than average unemployment or lower than average per capita income or an area designated as "special need" by the EDA.
Department of Commerce, Economic Development Administration	Economic Adjustment	Site acquisition, site preparation, rehabbing/equipping existing facilities, construction	$100,000 - $3,000,000 one- time grants	Must be in an economically distressed area, defined as higher than average unemployment or lower than average per capita income or an area designated as "special need" by the EDA.
Department of Housing and Urban Development	Community Development Block Grant	Connecting public or private facilities that create/retain jobs, infrastructure deployment	City received $16.5m in FY 2014-15; grantees typically receive $50,000 - $150,000. Use for FTTP would require reallocation from currently funded initiatives	Must benefit low-income communities, prevent/eliminate slums/blight, or address community health and safety
Department of Housing and Urban Development	Section 108 Loan Guarantee	Financing for large scale infrastructure projects. Amount limited to 5x CDBG allocation and existing Section 108 Loans for the City.	As much as $82.5m, based on FY 2014-15 CDBG data and assuming no outstanding 108 Loans	Must benefit low-income communities, prevent/eliminate slums/blight, or address community health and safety

Agency	Program	Possible Uses	Typical Size	Eligibility
Department of the Treasury	New Market Tax Credit	Private investments in broadband infrastructure projects in low-incomes areas	Up to 39% credit for federal taxes for private sector companies	Low-income communities may receive tax credits through Community Development Entities, which are corporations or partnerships authorized by the U.S. Treasury to provide financing for program purposes.

Source: Broadband Opportunity Council Report and Recommendations Report, 08/20/15

*There are funding opportunities for expanding broadband to public schools and libraries.

The Mayor's Office of Housing and Community Development (MOHCD) administers the Community Development Block Grant (CDBG) and Section 108 loans. MOHCD has developed a plan through FY 2018-19 for the use of CDBG funds, prioritizing affordable housing and economic development. Redirection of CDBG funds would require canceling planned grants to community-based organizations providing service in these areas.

The City has a liability of approximately $5.5 million in outstanding Section 108 loans, thus leaving an estimated $77 million in borrowing capacity.[48] Section 108 loans could be used to pay for portions of the network rollout that directly benefit low-income communities in San Francisco. To secure Section 108 loans, the City would need to go through an application process with HUD. Section 108 loans are secured by future CDBG disbursements, thus default on these loans could compromise funding to community-based organizations receiving CDBG funds. Section 108 loans are low interest: depending on the type of Section 108 loan, the interest rate is either 3 month LIBOR + 0.2% or pegged to Treasury Bills with similar maturity.

Philanthropy

The Budget and Legislative Analyst surveyed fiber-based network deployments across the country and interviewed industry experts and did not identify any instances where philanthropy was a significant source of funding for a network buildout.

An exception is the One Community network in Northern Ohio, which serves community anchor institutions in 23 counties in the Cleveland area. In 2010, One Community received $44 million in federal stimulus funds, which was matched with $15 million of privately donated funds and in-kind contributions to fund an expansion of its fiber to the premise network. In addition, the CEO believes that philanthropic revenue has accounted for 10% - 25% of One Community's revenues for the past three fiscal years.

[48] The City may not be able to use its entire Section 108 borrowing capacity; the total appropriation for that program in the most recent fiscal years was $500 million.

In an interview with the Budget and Legislative Analyst, the CEO of One Community stated that philanthropy is not a scalable model with which to build a fiber network meaning that (1) private donations are more likely to be directed to universities and other non-profit entities, and (2) it is unlikely that a city could acquire sufficient private donations to fund a network buildout. In addition, One Community's philanthropic funding is specific to the timing of its origins (2003) and the fact that is a non-profit entity, rather than a municipality. One Community is transferring its fiber assets to its for-profit subsidiary, Everstream, which will then continue to serve anchor institutions and other business customers with dark fiber, gigabit speed internet connections, and access to data centers.

Debt

As shown in Exhibit 16 below, the City has various debt instruments available with a range of interest rates. The interest rate on revenue bonds depends on the quality of revenue. This would be particularly true for a City FTTP gigabit speed enterprise that had yet to demonstrate sustained, positive cash flow and would therefore most likely not be able to be used for the initial network deployment. For both revenue and capital leases, the perceived risk and interest rate would depend on how and whether the City shared financial and operational risk with the private sector and how the use of back-up funding (including the General Fund) would be triggered and appropriated. General obligation bonds, because they are secured by property taxes, would be less sensitive to how a fiber project is structured and would have lower interest rates.

Exhibit 16: Bonding options to finance network buildout

Bond type	Security	Interest rate	Allowable Uses
Revenue[1]	Enterprise revenue; General Fund	Medium	Acquisition, improvement, or construction of real property
Capital Leases	Equipment	Medium	Acquisition, improvement, or construction of real property or equipment
Certificate of Participation (COP)	City property	Medium	Acquisition, improvement, or construction of real property or equipment
Mello-Roos	Special property taxes	High	Facilities, equipment, services, other debt
General obligation	All SF property	Low	Acquisition, improvement, or construction of real property

Source: Controller's Office of Public Finance

[1] Currently, the only City departments that may issue revenue bonds are the PUC, MTA, Port, and the Airport.

Section 9.106 of the City Charter states that the total value of the City's general obligation bonds may not exceed 3 percent of the assessed value of taxable real property; however, the City's current general obligation bonding are approximately 1.04% of taxable assessed value, leaving room for additional borrowing. According to the Controller's Office of Public Finance, based on the City's current Capital Plan, a project the size of a FTTP gigabit speed City network could not be financed by general obligation bonds without raising the City's property tax rate or deferring planned projects. General obligation bonds are subject to 2/3 voter approval.

The City as a whole or portions of it may form a Community Facilities District (CFD) and issue Mello-Roos bonds. Similar to general obligation bonds, Mello-Roos bonds require 2/3 voter approval within the CFD. The bond payments are secured by special property taxes within the CFD. These taxes may not be *ad valorem* but are otherwise flexible in how they are distributed among the properties within the CFD.

Limitations of bonding

State law places restrictions on the uses of bond revenue. Bonds may only be used to improve or construct new property, not for operating expenses. General obligation bonds may only be used to finance construction of real property. Equipment must be financed with other types of bonds. Thus, in the fiber optic network public model option, the City would have to appropriate a different funding source to cover operational costs until the enterprise became self-sustaining. Revenue bonds may be limited by Proposition 218, which established cost-based rules for setting utility fees. Certificates of Participation (COPs) are paid through the general fund and therefore compete with other general fund needs.

New taxes, fees, and dedicated government revenue

In addition to the General Fund, the City may seek to raise revenue to offset the construction, operational, and capital costs of the network, such as through a parcel tax, utility fee or other new taxes. New taxes must generally be approved by 2/3 of voters, unless the revenue has no specified use, in which case it only requires majority voter approval. Dedicated, rather than unspecified, use of revenue would generally lower the City's cost of borrowing.

Avoided costs

The City currently spends $680,000 per month, on average, for Internet and telephone service from AT&T. If City implements a new or expands the existing municipal network to additional City facilities, it could redirect its expenditures from private ISPs to financing the network buildout or operations. This has been

the method of financing for several government-backed fiber network rollouts, including Santa Monica and the middle-mile network in Kentucky. Migrating off the AT&T contract would require capital expenditures to upgrade and maintain new infrastructure to replace the services AT&T is currently providing.

Funding Sources Summary

- There are several potential sources of funding available to fund a Citywide FTTP network, including federal grants and loans, local government revenue (such as the General Fund and/or new taxes/fees), and debt. However, no single revenue source is likely to cover the full cost of the project and some are only be available in limited areas such as neighborhoods defined as economically disadvantaged.
- The City will likely have to identify revenue to fund the network in its early years. It is unlikely that subscriber revenue will cover operating and capital costs in the initial years after network deployment. Because State law restricts bond revenue from being used to cover operating costs and equipment purchases, other public sources of funds will need to be identified and appropriated for this project until it becomes self-sustaining.
- The City cannot take advantage of federal grants without disrupting existing plans to fund community-based organizations that provide affordable housing and economic development but may be able to take advantage of low-cost federal loans to fund portions of the network buildout in low-income areas.
- The City may redirect its current spending on AT&T telephone and network services, which total approximately $680,000 per month ($8,160,000 per year), but doing so will require one-time spending to install a new network and ongoing spending to maintain telephone and network services to replace services that AT&T is currently providing. As a result, the full $680,000 per month will not be available to fund any future municipal FTTP network.
- Combining several sources of funds, such as revenue from premium services, general fund monies, utility fees, and other new taxes could allow the new enterprise to achieve financial self-sustainability more easily. These funds could also subsidize low-income users' access to the network.

9. Conclusion

- Exhibit 17 below compares and summarizes each model's strengths and weakness in achieving the City's goals of: (1) minimizing public cost, (2) minimizing risk to the City, (3) reducing the digital divide and (4) ensuring affordable gigabit speed Internet access to all premises in San Francisco. As

shown, the various buildout approaches to achieving a ubiquitous gigabit fiber optic network discussed in this report offer policy makers a range of costs, risks, and benefits to the City.

Exhibit 17: Gigabit Speed Fiber Optic Network Models and Buildout Approaches Relative to Evaluation Criteria

Model	Public Model		Public-Private Partnership		Private Model
Buildout Approach	**Utility - Based**	**Demand-Driven**	**Concessionaire, Utility -Based**	**Dark Fiber, Demand-Driven**	
Cost to City	$$$$	$$$	$$$$	$$	$
Risk to City	↑↑↑↑	↑↑↑	↑↑	↑↑	↑
Reduction in digital divide					
Gigabit speed to all premises at affordable prices					

- In general, the higher cost utility-based buildouts would further advance the objectives of reducing the digital divide by providing access to gigabit speed Internet service to all premises in San Francisco. Prices should be more affordable since the new fiber optic network would provide consumers with more ISP choices. Final connections to each premise could be limited to the extent property owners do not approve the final connection to their properties. In addition, City subsidies of lower income households may be needed to assist with the burden of a monthly utility fee and/or subscriber fees.

- The utility-based buildout under either the public or P3 models assumes the imposition of a monthly utility fee on all premises to defray the higher costs of creating and operating a fiber optic gigabit speed network providing access to all premises in San Francisco. The monthly utility fee amount could be lowered for various customer classes by differentiating the amount charged, for example, to residential and commercial customers based on some commercial customers' greater need and use of Internet access and/or by providing lower speed baseline Internet access for free to all premises and gigabit speed access for a higher monthly subscriber rates.

- The public-private partnership model would reduce the costs and risks to the City associated with creating and successfully operating a complex new fiber optic network administration and ISP business enterprises though the City would forego control in areas such as pricing that it would otherwise maintain under the public model. However, the public should benefit under a public-private partnership as more providers would be allowed to use the fiber optic network, thus providing consumers with the benefits of competition.

- The demand-driven model under the public or public-private partnership models is a less costly alternative and would provide consumers with the price and other benefits of increased competition. But it would otherwise not address the digital divide or guarantee provision of fiber network gigabit speed Internet access to all premises in San Francisco.

- The public and public-private partnership models would have to contend with competition from incumbent providers who would continue to operate and compete with any new Internet access provider. In some cities establishment of municipal gigabit networks has resulted in incumbent providers accelerating improvements to their networks and connection speeds and competing with the municipalities on price. Currently, ISPs in San Francisco are offering gigabit speed service in limited areas of the City and some have publicly stated their plans to expand the coverage of these services. One provider, Comcast, has stated that it will offer gigabit services throughout the City within the next two years, though pricing is not yet known.

Appendix 1: List of interviews

Internet Service Providers

- Google Fiber
- Comcast
- AT&T
- Sonic
- Monkey Brains
- Ting
- Webpass
- Lit San Leandro

Regulators

- California Public Utilities Commission
    - Dr. William Johnston, Telecommunication Advisor to Catherine Sandoval, Commissioner, California Public Utilities Commission
    - Christopher Witteman, Senior Counsel, Telecommunications & Consumer Protection, California Public Utilities Commission

Thought Leaders

- Susan Crawford, Harvard Law School
- Blair Levin, Fellow at Brookings Institution, Former Director of National Broadband Plan at the Federal Communication Commission
- Joanne Hovis, CTC Technology and Energy
- Lev Gonick, One Community

SF City Agencies

- Department of Technology
    - Miguel Gamino, Chief Information Officer
    - Brian Roberts, Policy Analyst
- Public Works
    - Patrick Rivera, Design & Engineering Division Manager
    - Mindy Linetzky, Government Relations
- Mayor's Office of Civic Innovation
    - Jay Nath, Chief Innovation Officer
    - Denise Cheng, Innovation Fellow
- Committee on Information Technology
    - Matthias Jaime, Policy Analyst
- City Attorney

    - William Sanders, Deputy City Attorney
- Controller's Office of Public Finance
    - Nadia Sesay, Director, Office of Public Finance

Other Public Officials

- New Haven, CT and State of Connecticut
    - Elin Katz, Connecticut Office of Consumer Counsel
    - William Vallee, Connecticut Office of Consumer Counsel
    - Daryl Jones, Controller for City of New Haven, Connecticut
- Vallejo, CA
    - Will Morat, Administrative Analyst
- Santa Monica, CA
    - Jory Wolf, Chief Information Officer
- Santa Cruz, CA
    - J. Guevara, Economic Development Manager
- Westminster, MD
    - Dr. Robert Wack, City Council

Utilities

- Pacific Gas & Electric
    - Ontario Smith, Government Relations
- Huntsville Utilities
    - Jay Stowe, CEO

Financial entities

- Macquarie Group
- CostQuest Associates
- MoffetNathanson

Constituents

- Daniel Goldman
- Niels Erich

Appendix 2: Model Case Studies

Case Study: Public Model - Chattanooga

Overview

Chattanooga, Tennessee has the largest publicly owned and operated fiber optic network in the United States. Since 2010, the city's electric utility, EPB, has offered broadband internet to its residential and business customers within the city limits. The city-owned EPB planned, financed, constructed, and now operates a fiber enterprise. As an enterprise, EPB is responsible for all network maintenance, customer service, and billing for its fiber services.

Service offered

EPB offers two tiers of fiber service for its residential customers: (1) 100 Mbps for $57.99 per month and (2) 1 Gigabit per second (or 1,000 Mbps) for $69.99 per month. Fiber services may be paired with television ($118 per month) and with television and phone ($133 per month).[49] EPB also offers video on demand for its television subscribers and free anti-virus protection. Prices for business customers differ.

EPB offers a low cost Digital Divide program to low-income families, similar to Comcast's Internet Essentials program. For low-income families, EPB charges $26.99 per month for 100 Mbps and Comcast charges $9.99 per month for 10 Mbps.

Customers

According to EPB's 2014 financial statement, it had 58,000 residential customers and 4,600 business customers, for a total of 62,600 fiber customers.[50] Based on Census data from 2010, these customers represent 73% of the residential market.[51] However, the New York *Times* reported in 2014 that of 48,000 residential fiber customers EPB had at that time, only 3,640 residents, or 7.5% of total residential customers, subscribed to the EPB's 1 Gbps service. Similarly, only 55 businesses subscribed to EPB's 1 GB service. The remaining EPB fiber customers purchased lower tier broadband service, which offers customers 100 Mbps.[52] As noted above, 100 Mbps is still substantially higher than the national

[49] Television rates refer to "gold" package, which is roughly equivalent to standard cable television lineup. Premium channels such as HBO may be purchased at additional cost.
[50] EPB 2014 Financial Statement, pg. 13.
[51] Census Data shows that Chattanooga had 79,607 total housing units in 2010. See: http://quickfacts.census.gov/qfd/states/47/4714000.html.
[52] Edward Wyatt, "Fast Internet is Chattanooga's New Locomotive", New York *Times*, Feb. 3, 2014.

average (38.5 Mpbs) and the San Francisco average download speed (45.5 Mpbs).[53]

Financing

The cost to deploy Chattanooga's network cost $330 million and took three years to build the network such that it passed, or became available to all residents and businesses in the 143 square mile city. The network construction was funded in three ways: (1) $111 million federal stimulus grant offered as part of the American Recovery and Reinvestment Act ($52 million of which was used for the fiber enterprise), (2) $219 million in revenue bonds, and (3) $60 million in an interdivision loan from EPB's electric division. Fiber revenue now covers all ISP operating and maintenance costs. According to EPB's FY 2014 financial statement, its fiber enterprise had operating revenue of $99.8 million and achieved a net income of $17.5 million.[54]

Challenges faced

EPB faced several challenges that delayed the deployment of its FTTP network by several years, including obtaining approval from the Tennessee State Comptroller and the Tennessee Valley Authority, public comment, four votes by the EPB board and two by the city council regarding the overall plan and the bond issuance, and obtaining a franchise agreement from the City of Chattanooga.

EPB conducted extensive community outreach about the network technology and benefits of fiber. Officials attended hundreds of community meetings with local organizations and members of the public, which ultimately resulted in between 80% and 90 percent public support for deployment of the public network according to various polls taken on the issue.[55] EPB also needed to resolve several lawsuits brought against it by Comcast and an ISP trade association before it could deploy its network. The lawsuits challenged EPB's interdivision loan between its electric and fiber enterprises and were ultimately resolved in EPB's favor after a year of litigation in state court.

Analysis

There are many potentially unique contributors to EPB's success that may not apply to San Francisco. Most importantly, EPB had a pre-existing utility enterprise with residential service and so had a network infrastructure in place providing physical access to all of its potential customers. It also had a preexisting billing and customer service apparatus and had been providing Internet access service to businesses since 2003.

[53] Average download speeds as cited by Ookla.
[54] EPB 2014 Financial Statement, pg. 56.
[55] Christopher Mitchell, "How Three Communities Built Next-Generation Networks", Institute for Local Self-Reliance, pg. 35-36.

EPB had a high degree of public trust in its effectiveness as a service provider. As mentioned above, there was extensive public outreach, and hundreds of meetings with the public in the lead-up to network deployment. There was a strong public commitment from EPB management to deploy fiber to the premises, as evidenced by the three year planning process between 2003 and 2006, and three years of regulatory and private sector challenges to the plan between 2006 and 2009, before the network finally debuted in 2010.

On financing, EPB had access to federal stimulus grants that are no longer available and was able to finance a portion of the fiber enterprise's startup costs secured by enterprise revenue from its electric utility. San Francisco will need to identify sources of funding other than those that were available to the city of Chattanooga.

Case Study: Private Model - Kansas City

Overview

This case study is one example of how a municipality created incentives for the private sector to assume the costs and risks of constructing and deploying a FTTP network for gigabit Internet service. In this case, the city entered into an agreement with Google Fiber, which constructed a fiber network to serve the entire city, and is now providing Internet services in many areas of that jurisdiction.

Kansas City was the first city in the United States to win a Google Fiber build out. In 2011, Kansas City, Kansas and Kansas City, Missouri (from here on referred to as "Kansas City") were selected from a group of cities that applied to the company to have a fiber network built by Google Fiber. In selecting cities, the company, which is now constructing and deploying its services in other cities in the U.S., considers market conditions and the degree to which the municipality can meet certain conditions that the company requests to facilitate their construction work and minimize their costs. To date, San Francisco has not applied for or been considered as a candidate city by Google Fiber for deployment of one of its privately financed fiber networks.

The tradeoff for Kansas City transferring the costs and risks of constructing and operating its own fiber network to Google Fiber is that the city does not own the network assets, cannot control factors such as which neighborhoods are provided gigabit speed service, prices charged, and does not participate in any financial benefits of the enterprise's success.

While there are other providers besides Google Fiber that might be motivated by City incentives to construct or upgrade their networks to fiber Citywide in San Francisco, at this time Google Fiber is the major company establishing itself in this business, with the municipalities bearing no costs and little risk other that complying with the company's requirements for cities to facilitate deployment of a Google Fiber network, described further below.

Kansas City reached agreements with Google Fiber that made it easier and less expensive for the company to build a fiber network in the cities. In particular, Kansas City waived all project-related permit and inspection fees, created City positions to coordinate all City activity and marketing for the project, and granted free access to City property, rights of way, and other public assets. The agreements also required Kansas City to respond to all permits within five days. The development agreements provided that Google Fiber build a fiber-to--the home network that allowed for gigabit service to be provided citywide, and to activate such service neighborhood by neighborhood, "based upon demand by

City residents and availability of necessary infrastructure."[56] The agreements did not set prices for services. Google is now expanding the network to serve residents in suburban areas near Kansas City.

Service offered

Google Fiber offers 1 Gbps symmetrical Internet connection to residents and businesses in Kansas City. The deployment of the network is based on a demand-driven model. Google Fiber builds out its last mile fiber network to areas only when they have passed a certain threshold of customer signups in a contiguous area. Within these "Fiberhoods," connections to multiunit dwellings require a critical mass of a building's residents to subscribe. The cost for residential services is $70 per month for Internet only and $130 per month for Internet and television. Google also offers free basic internet (5 Mbps down / 1 Mbps up) in its Fiberhoods after a one-time $300 installation fee. Fiber services for businesses start at $100 per month.

Customers/Financing

There is little publicly available information on Google Fiber's finances or number of customers in Kansas City. In fact, the development agreements between Google Fiber and Kansa City rendered the information confidential. According to a recent news report, Google Fiber had 27,000 customers in Kansas City that opted for the Internet/video package, constituting 11% of the video market.[57] Based on the $130/month charge for the Internet/video package, these customers in Kansas City would generate approximately $42,120,000 in revenue annually. Additional Google Fiber revenue generated by Internet-only subscribers is not known.

Challenges faced

To address the digital divide, Google offers digital literacy programs and free gigabit speed connection to schools and government buildings within the Fiberhoods where services are being provided.[58] As mentioned above, Google Fiber also offers its free lower speed Internet for residents and businesses in its Fiberhoods after a one-time installation fee. However, the deployment of Google Fiber is demand-driven, which to date has meant that while the network was offered throughout Kansas City, the final connection to premises, or last mile connections, only partially cover the city. According to a 2012 study, Google Fiber

[56] Development agreements between Google and Kansas City, KS and Kansas, MO.
[57] Scott Moritz and Gerry Smith, "Google Fiber Threat to Cable Is 'Like Ebola,' Analyst Says", *Bloomberg*, March 12, 2015. This number does not include internet only subscribers.
[58] "Advancing digital literacy in Kansas City", Google Fiber Blog. April 1, 2015.

is available in 75%of medium to high-income Kansas City homes but only 30% of low-income homes.[59]

Approximately 20% of Kansas City residents may not be able to obtain Google Fiber services because they live in apartment buildings, where owners and renters are less likely to pay installation fees. Nevertheless, according to a survey commissioned by the *Wall Street Journal*, 9% of Google Fiber subscribers did not have Internet at home previously and 24% had only accessed the Internet through their mobile phones.[60]

According to a review by the State of Connecticut when it was considering statewide options for implementing gigabit speed Internet access, deployment of the Google Fiber network in Kansas City was stalled by disputes over material and installation costs, pole and rights-of-way access, and other regulations.[61] In 2014, Google Fiber withdrew its intention to build out Leawood, Kansas, one of the suburbs of Kansas City that was supposed to have received Google Fiber service as it expanded beyond the central city, reportedly because of a local regulation that required all new utilities to be undergrounded, which is typically more expensive than the aerial connections Google Fiber relied on for the "last mile" connection in other parts of the Kansas City metropolitan area.[62] This suggests that relying solely on the private sector to provide gigabit service may sacrifice network ubiquity.

Analysis

The challenges of the private sector model are (1) the difficulty of bridging the digital divide, both in terms of network coverage and affordability and (2) the extent to which local regulations inhibits the private sector deployment of fiber.

After its deployment in Kansas City, Google published a guide of policy changes local governments could make in order to incent private sector deployment of fiber. [63] The recommendations have three broad goals: (1) gather detailed records of existing infrastructure, including fiber assets and right of way data, (2) ease access to existing infrastructure, and (3) make construction swift and predictable. Exhibit 18 below summarizes the items. In addition to the items listed below, private sector providers and industry experts interviewed for this analysis stressed to the Budget and Legislative Analyst's Office that localities where leadership demonstrates strong commitment to fiber network projects help create certainty among the private sector participants considering investments in fiber infrastructure.

[59] "Why Would CT Want Gig Service?", Connecticut State Broadband Initiative Nov. 30. 2014; Alistair Barr, "Google Fiber Leaves a Digital Divide", *Wall Street Journal*, Oct. 2, 2014.
[60] Alistair Barr, "If Google Builds It, Many Still Won't Subscribe to Fiber Service", *Wall Street Journal*, Oct. 3, 2014.
[61] Why Would CT Want Gig Service?", Connecticut State Broadband Initiative Nov. 30. 2014
[62] Michael Grass, "Why a Google Fiber Deal Fell Apart in Kansas", *Government Executive*, Nov. 7, 2014.
[63] "Google Fiber City Checklist", Google Fiber Inc., November, 2014. Available at: http://tinyurl.com/q2zzxeo

Exhibit 18: Google Fiber Checklist for Cities to Facilitate Construction of Fiber Networks

Goal	Items
Provide information about existing infrastructure	City to gather and provide detailed geospatial data on: * public and private fiber network assets, including fiber, conduit, utility poles, and networking facilities * streets, street lights, and pavement conditions * parcels, right of way, easements, and overhead strands * underground utility routes * zoning regulations and requirements * building footprint and addresses
Help ensure access to existing infrastructure	* make available for lease assets such as fiber, conduit, and real estate * streamline utility pole access
Make construction speedy and predictable	* ideally allow for citywide permit application * electronic permitting process and 10 day turnaround * acceptance of Google's construction standards * city to provide permit application communication through single point of contact

Source: Google Fiber City Checklist

San Francisco would currently have a challenge providing some of the items in the Google Fiber Checklist. As noted above and in our December 2015 report, "Fiber Network Asset Management", the City does not have complete centralized records of the conduit it has utilized for its fiber networks. Records of the City's network assets, including the location and availability of City fiber and conduit are incomplete and scattered among various City agencies. In addition, the City has occupied privately owned conduit, the commercialization of which is subject to legal uncertainty. Subsequent to issuance of our report, the Board of Supervisors approved an ordinance to require DT to develop a database on all City-owned fiber assets and to determine whether any existing City-owned fiber assets are available to serve Departments' future needs.

Case Study: P3 Model - Westminster, MD

Westminster, Maryland is a suburb of 18,000 in the Washington/Baltimore metropolitan areas. Due to dissatisfaction with the incumbent providers, the City Council approved a plan for a comprehensive FTTP network. After a successful pilot and a competitive process, in February 2015 the City of Westminster reached an agreement with Ting, a Canadian ISP, to build and manage Westminster's citywide fiber network. Westminster will issue debt to cover its construction costs and will thereafter maintain a dark fiber network (i.e., owned but not operated by the city) that it will lease to Ting to administer to provide retail services to customers. Ting began providing service in Westminster in June 2015 and has since been expanding the network to serve additional residents.

Services Offered

As of September 2015, Ting announced it will offer symmetrical gigabit Internet for $89 per month and a one-time installation fee of $399. Business packages will be $139 per month and have an installation fee of $599. For low income customers, Ting will offer a symmetrical 5 Mbps connection for $19 per month after a $399 installation fee.

Ting will be the exclusive ISP for the network for two years, after which the network will be open to other ISPs that wish to compete with Ting to provide service. Ting is obligated under the contract to sell wholesale Internet access to retail ISPs on the Westminster network.[64]

Financing

The City of Westminster will issue a total of $20 million in general obligation bonds over the next four years to fund construction of the dark fiber network.[65] The network will also be partially funded by a General Fund subsidy ranging from $200,000 to $546,396 annually, depending on the year.[66] Ting will provide the City of Westminster with leasing fees which the city expects will cover its debt service after two years of operations.[67] Under the contract, if the fees Ting pays to the City are insufficient to cover debt service, Ting must pay a portion of the debt service.[68]

The fee schedule for Ting is performance-based in order to align the incentives of the City (which wants a ubiquitous, reliable network) and Ting, a profit-seeking

[64] Ting/Westminster Dark Fiber Lease and Network Operation Agreement, Section 7. Ting may charge for these services but cannot do so on a discriminatory basis.
[65] City of Westminster, MD FY16 budget, pg. 10, 40, and 52.
[66] City of Westminster, MD FY16 budget, pg. 16, 52
[67] City of Westminster, MD FY16 budget, pg. 174
[68] Ting/ City of Westminster Dark Fiber Lease and Network Operation Agreement, Section 9.2.

ISP. As Ting enrolls subscribers and expands its customer base and revenues in Westminster, the city will also benefit since Ting will pay the city a fixed fee for every premise connected to the network and an additional fee for each customer. These fees may be adjusted upwards, based on Ting's average revenue per customer. Thus Ting will be incentivized to market and reliably service every customer within the City's network buildout. In addition, if the network is unreliable, the agreement calls for Ting to refund a portion of its customer service charges.[69]

Deployment

Deployment of the network will occur in phases and neighborhood roll-outs will be prioritized according to market demand, as assessed jointly by the City of Westminster and Ting.[70] As stated above, Westminster's goal is to have a ubiquitous network available to all residents and businesses. As the entity building the network, the City of Westminster will deploy the network in phases (detailed in the contract with Ting), starting in the City's business zone and a residential zone identified in the contract. The City may choose not to continue with the deployment if its market share in the initial build out area is less than 20% and will prioritize deployment to areas with high expected market share.

Analysis

In the Westminster model, the City will build and maintain a dark fiber network. Ting, a private telecommunications company, will provide wholesale (administer and maintain the network) and retail service (Internet access services for residents and businesses) to network customers. To manage the conflict of interest of being both a wholesale and retail provider, Westminster's partnership with Ting is conditioned on open access to the network such that Ting, after an exclusivity period of two years, is required by contract to lease network space at non-discriminatory prices to any potential retail competitors. Ting's lease fees to be paid to the City will consist of a fee for every premise passed by the network and an additional fee for every customer receiving service.

Although the City of Westminster will retain control of its fiber assets, it will not have any direct influence or control over retail prices and only requires that Ting set wholesale prices on a non-discriminatory basis. The City is relying on the network's open access model to ensure prices remain competitive due to multiple ISPs on the network. However, there is no guarantee that other ISPs will enter the Westminster market, leaving Ting as the sole fiber provider (with incumbent cable and telephone providers as competitors). The network may fail due to low market

[69] Ting/City of Westminster Dark Fiber Lease and Network Operation Agreement, Exhibit D.
[70] Ting/ City of Westminster Dark Fiber Lease and Network Operation Agreement, Section 6.

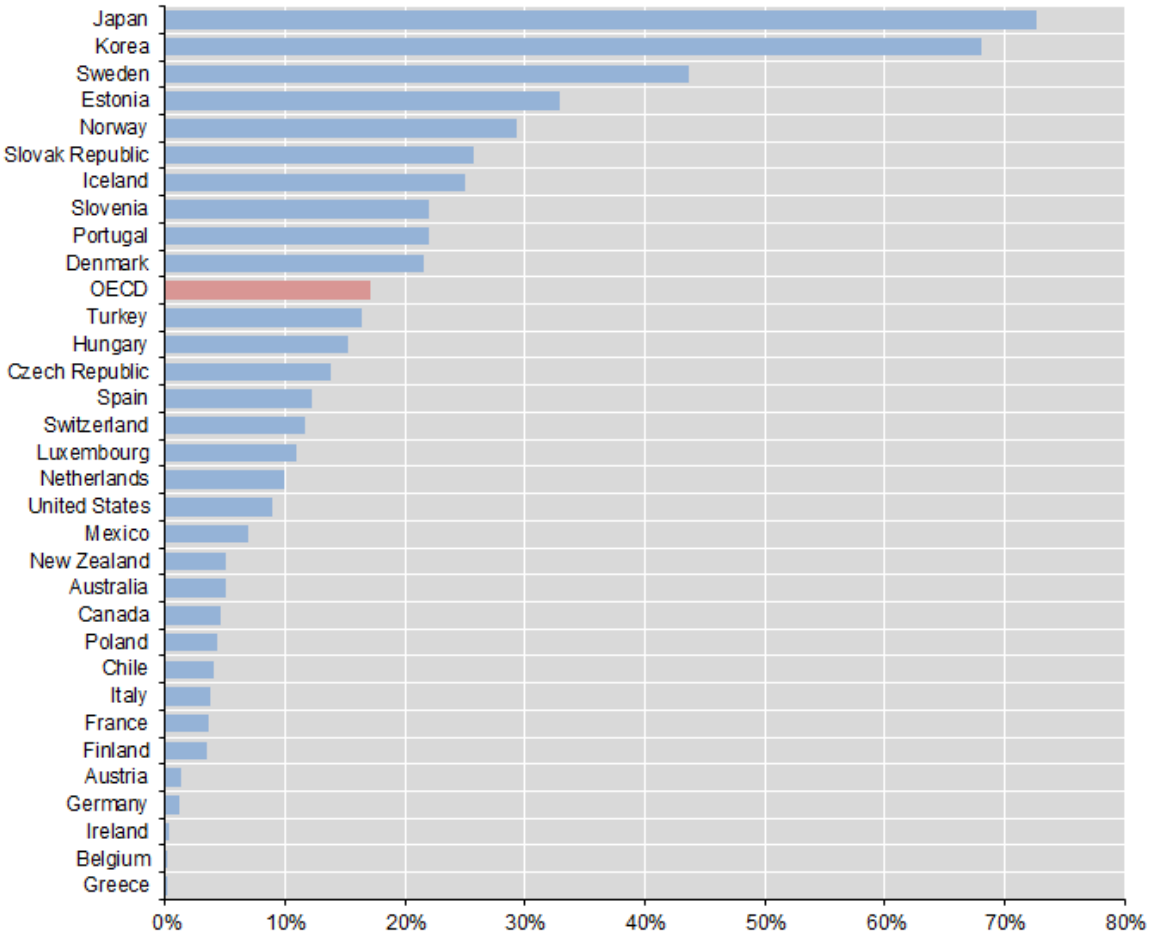
share or lack of reliable service and the City would still be obligated to repay debt associated with the network buildout and maintenance.

Appendix 3: International Comparisons

The United States ranks poorly in international comparisons of average Internet connection speed, price, and use of fiber. The Budget and Legislative Analyst conducted research on cities in the top three countries with the fastest Internet connections: Sweden, Korea, and Japan, and compared their experience to the United States. Individual case studies follow below in this section.

The Budget and Legislative Analyst consulted data from the Organization for Economic Cooperation and Development (OECD) to compare broadband outcomes in the United States to peer countries. The OECD is an intergovernmental organization that produces economic data and research for policy makers. As part of that effort, the OECD collects broadband data from national regulators and publishes the compiled and analyzed data at its online Broadband Portal. Data from the OECD's Broadband Portal is shown below in Exhibit 19. As can be seen, fiber-to-the-premises connections accounted for only 8.9 percent of subscriptions in the United States, well below the world wide average of 17.1 percent. Fiber networks accounted for a greater share of total subscriptions in Sweden (43.7%), South Korea (68%), and Japan (72.7%).

Exhibit 19: Percentage of fiber connections relative to total broadband subscriptions (Dec. 2014)

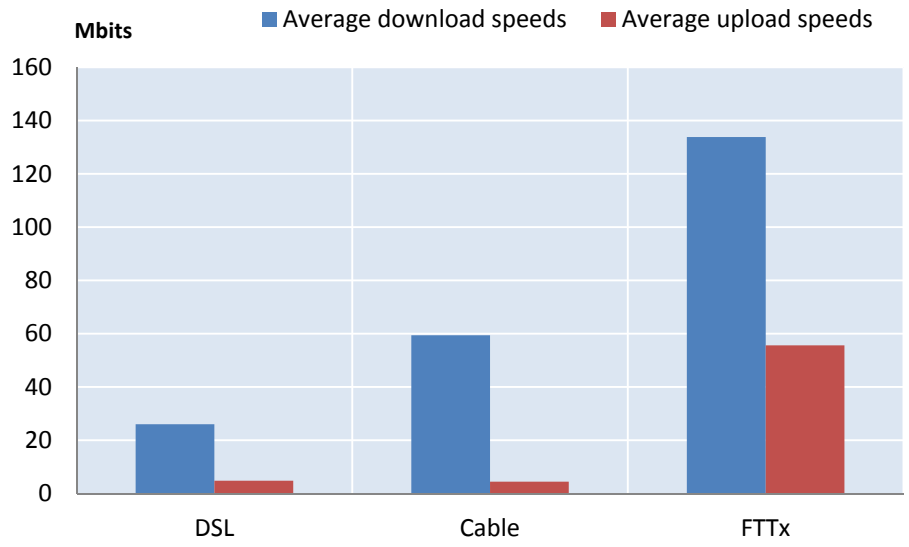


Source: OECD Broadband Portal, Figure 1.10

As shown below in Exhibit 20, the average connection speed for fiber-based networks (FFTx)[71] at 133 Mbps is substantially higher than DSL (26 Mbps) or cable networks (59 Mbps).

[71] FTTx refers to a range of fiber-based networks from fiber all the way to the premise or fiber to a local node with copper wires making the final connection to the premise. Networks can achieve greater speeds the closer fiber is to the premise. FTTx figures refer to an average of FTTP (fiber to the premise), FTTB (fiber to the building), FTTC (fiber to the curb), and FTTN (fiber to the node) networks.

Exhibit 20: Average advertised download/upload speeds for fixed broadband technology



Source: OECD Broadband Portal, Figure 2.28

Note: FFTx represents a wide range of fiber optic network configurations including FTTP (fiber to the premise), FTTB (fiber to the building), FTTC (fiber to the curb), and FTTN (fiber to the node) networks.

The mix of broadband network technologies impacts a country's average download speed. Countries with more fiber networks and subscribers have higher average download speeds. According to Ookla, a website for self-testing Internet service speeds, as of December 2014, the United States ranked 19th in average download speed at 21.23 Mbps. As shown below in Exhibit 21, this is slightly less than half the average download speed of 44.3 of the top three countries with the highest connection speeds. These countries also have the greatest proportion of fiber subscribers relative to total broadband users.

Exhibit 21: Average Internet download speeds (Dec. 2014)

Rank	Country	Average download speed
1	Korea	50.67
2	Japan	41.77
3	Sweden	40.38
4	Netherlands	39.13
5	Switzerland	38.79
6	Denmark	34.99
7	Iceland	32.96
8	Luxembourg	32.44
9	Belgium	28.51
10	France	26.56
11	Norway	26.30
12	Finland	26.15
13	Portugal	24.76
14	Germany	24.65
15	Estonia	24.22
16	United Kingdom	23.89
17	Hungary	23.74
18	Czech Republic	23.37
19	United States	21.23
20	Israel	21.22

Source: OECD Broadband Portal, Figure 2.30

There are common elements to the Swedish, Japanese, and Korean path to widespread deployment of fiber networks that contributed to deployment of fiber networks in cities in those countries. The government of each country enabled competition for broadband service provision through some version of an open access/unbundling policy[72], promulgated either by a national regulator (Japan, Korea) or local government (Sweden). These policies lowered barriers to entry for ISPs which fostered a competitive market for internet service provision, leading to improved service levels. These countries also had an engaged government entity (beyond the regulator) that either built the networks, provided low cost financing to build networks, aggregated demand, or some combination of all three. Although the private sector was key to delivering retail services, in all three cases, government played an active role in restructuring the ISP market.

[72] Unbundling refers to regulations allow discrete access and use of existing incumbent telecommunication infrastructure.

Case studies are presented on the following pages describing deployment of FTTP networks in Stockholm, Sweden, Seoul, South Korea and Tokyo, Japan. The high rate of FTTP high speed network deployment in Seoul and Tokyo are tied to national government policies and actions, so may have limited applicability to San Francisco initiating a FTTP gigabit speed network. The United States experimented with unbundling policy starting with the Telecommunications Act of 1996, however those rules were weakened (relative to international comparisons) through a series of court challenges and changes in national regulatory policy. Industry experts interviewed by the Budget and Legislative Analyst do not believe further unbundling regulations will occur in the medium term.

Stockholm's fiber network was more the result of municipal policy maker action and therefore may have more applicability to San Francisco. Development of the Stockholm network commenced over 20 years ago and grew incrementally to eventually cover most residences and businesses in the city. The network was mostly paid for with City funding. The Stockholm approach has resulted in a very successful fiber network, measured in the price and speed of services as well as the diversity of services offered on the network.

9. Stockholm

Stockholm, Sweden is world-renowned for its open access fiber network, operated by Stokab, a publicly owned corporation. Stockholm began its fiber roll-out in 1994 in response to concerns by city officials over the sufficiency of the existing telecommunications copper infrastructure and that multiple ISPs would seek to deploy next generation telecommunication infrastructure, leading to constant street excavation. The original network, financed by a general obligation bond, focused on anchor institutions[73] in the downtown area. Over time, the network has expanded to meet residential and business demand. The expansion of the network was slow and therefore mostly funded from customer revenue, with the exception of a debt write-down in 2003.

Stokab is a dark fiber network, which means the city owns the network, but does not play a role in managing the network or providing retail Internet service to Stockholm's residents and businesses. Under Stockholm's structure, multiple ISPs lease space on the network and users are allowed to customize their network use. End users can set up their own networks or are served by third parties that compete to provide wholesale and retail services.

The Stokab network has over 800 customers, or content providers serving end user customers, only half of which are ISPs, mobile operators, and communication companies. The rest of Stokab's providers include public entities and large businesses who purchased dark fiber to run their own enterprise networks (rather than purchasing network services from an ISP) and real estate companies that purchase dark fiber directly from Stokab to connect residential buildings. Stokab is currently used by 90 percent of households and 100 percent of businesses in Stockholm at a cost of $25.50 per month for symmetrical 1 Gbps.

[73] Anchor institutions are public institutions such as schools, hospitals, libraries, colleges, public safety facilities, and other government facilities. These generally serve and are open to the community, are distributed across jurisdictions, and have high bandwidth needs.

10. Seoul

As discussed above, South Korea is an international leader in broadband connectivity. According to Akami, a company that tracks Internet speeds by country, South Korea has the highest average download speed of any other country.[74] The country was able to deploy widespread broadband networks in part because of its high population density; over 80% of the population lives in multiple dwelling units, reducing last mile construction costs.[75]

In addition, the South Korean government played a very active role in incentivizing the private sector to bring fiber closer to customers with enhanced speeds. It forced incumbent operators to "unbundle", that is, open up their networks to competitors, with wholesale rates regulated by the national government.[76] The central government promoted broadband competition through loans, tax incentives for operators, rent reductions, and formation of industry standards. On the demand side, the government aggregated demand of public entities to feed the nascent broadband market, promoted the shift to e-commerce and online delivery of government services, and implemented programs to close the digital divide, such as subsidies for computers to low-income residents, loans for rural networks, and online education. The result, according to the World Bank, was that 43% of South Korean homes were connected to FTTH networks at the end of 2008.[77] According to the OECD, FTTP connections accounted for 68% of all Korean broadband connections as of December 2014.[78]

South Korea's broadband infrastructure allows for commercialization of services that require a large amount of bandwidth per user. A June 2015 New York *Times* article discussed how a South Korean mobile application developer had to remove features when adapting the application to the American market because the broadband infrastructure in this country was inadequate to support them.[79]

[74] Akami's Q2 2015 State of the Internet Report, Akami.
[75] Yochai Benkler *et al.,* "Next Generation Connectivity", The Berkman Center for Internet & Society at Harvard University, Feb 2010.
[76] A similar provision in the 1996 Telecom Act was litigated and greatly limited by the FCC in 2004. In its *Open Internet Order* from earlier this year, the FCC reiterated it retains the authority to require broadband providers to allow unbundled access to their networks, but chose to "forbear" on exercising that authority. *P30 FCC Rcd 5601*, paragraph 51P3.
[77] Yongsoo Kim, Tim Kelly, and Siddhartha Raja, "Building Broadband: Strategies and policies for the developing world", World Bank, Jan. 2010, pg. 25-27.
[78] OECD Broadband Portal, Figure 1.10
[79] Jenna Wortham, "What Silicon Valley Can Learn from Seoul", New York *Times*, June 2, 2015.

11. Tokyo

Fiber networks were deployed in Japan as the result of facilities-based competition, or competition of broadband providers that use different technologies (e.g. cable vs. telephone infrastructure). This competition was stimulated by unbundling regulations requiring owners of telephone networks to allow competitors access to their networks at regulated prices. As the DSL market grew over existing telephone infrastructure, cable companies began offering Internet service over coaxial networks, followed by power companies that offered Internet service through their fiber networks. This competition drove telephone and cable companies to enhance the fiber in their networks and increase Internet access speeds for their customers. Network upgrades and deployments were financed in part by low cost government loans.[80] By June 2008, fiber-based subscriptions exceed the amount of DSL and cable subscriptions nationwide[81] and, according to OECD data as of December 2014, fiber constituted over 72% of total broadband subscriptions, compared to 8.9% in the United States.[82]

[80] Yochai Benkler *et al.,* "Next Generation Connectivity", The Berkman Center for Internet & Society at Harvard University, Feb 2010., pg. 140, 28P3
[81] Berkman report, pg. 284
[82] OECD Broadband Portal, Table 1.10

Appendix 4: Microtrenching

Microtrenching is a technique to lay cables in the ground without a complete excavation. In lieu of digging up the street, saw-like machines cut trenches in sidewalks or roads that are typically 1" – 2" wide and 4" – 6" deep. By avoiding excavation, microtrenching could substantially lower the cost of building a citywide fiber network. At the present time San Francisco Public Works has concerns about the feasibility of microtrenching in San Francisco, stating: (1) the proposed microtrench depth is shallower than the Department's and the California Public Utilities Commission's recommended depth for underground utilities, (2) the shallow placement of the cables could leave them susceptible to damage in future excavations, and (3) most streets in the City have a thin layer of asphalt followed by a concrete layer underneath. In DPW's analysis, cutting deeper past the concrete layer or hardening the cables to protect them from future street excavations would negate any cost savings. None of the ISPs interviewed by the Budget and Legislative Analyst were enthusiastic about microtrenching or had used it extensively, given similar opposition to microtrenching for their project buildouts in other cities.

San Francisco Public Works' most recent analysis of microtrenching was in 2009. The Board of Supervisors is currently working with the Department to re-assess the feasibility of microtrenching in San Francisco.

The City of Santa Cruz is in the final stages of negotiating a public-private partnership with a local ISP to implement a ubiquitous FTTP network. City of Santa Cruz officials interviewed by the Budget and Legislative Analyst stated that they expect to use microtrenching for as much as 80 percent of the project, which would substantially lower the estimated $40 - $45 million implementation cost to a lesser amount. However, streets in the City of Santa Cruz are primarily asphalt and therefore any success in using microtrenching there may not be applicable to San Francisco.