

**CITY AND COUNTY OF SAN FRANCISCO
BOARD OF SUPERVISORS
BUDGET AND LEGISLATIVE ANALYST**

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Policy Analysis Report

To: Board of Supervisors
From: Budget and Legislative Analyst's Office
Re: Potential Economic Benefits of the City
Deploying a Ubiquitous Gigabit Speed Network
Date: May 9, 2018



Summary of Requested Action

Your office requested that the Budget and Legislative Analyst: (1) survey City departments to understand their fiber-optic related expenses and (2) identify potential economic impacts and revenue opportunities in San Francisco if the City were to deploy a ubiquitous gigabit speed network to all residents and businesses.

For further information about this report, contact Fred Brousseau, Director of Policy Analysis, at the Budget and Legislative Analyst's Office at 415-553-4627 or fbrousseau@sfgov.org.

Executive Summary

- The City and County of San Francisco is considering constructing a Citywide fiber-optic network to provide gigabit speed Internet service to all premises in the City (“fiber-to-the-premises”). Objectives of this undertaking are to enable affordable, high speed internet access to prepare all San Francisco residents and businesses for the future and to close the digital divide.
- A high-speed municipal fiber-to-the-premises network feasibility study conducted by a consultant to the Department of Technology and released in October 2017 recommended that the City pursue a public-private partnership to build and operate the network, which it estimated would cost between approximately \$1.2 and \$1.8 billion in one-time construction and implementation costs and between \$69 and \$121 million in annual costs, depending on assumptions about the network configuration, maintenance requirements, and other factors. The City would own the network assets but would contract with private sector entities for network services.
- This report presents possible social and economic benefits of having a ubiquitous, fiber-to-the-premises high-speed network. These benefits include fiscal savings and revenues, improved service delivery, job growth, and property value appreciation.
- We surveyed City departments to understand their planned or aspirational projects and initiatives that would benefit from a high-speed fiber network as well as possible service improvements made possible by the proposed network. The City has an

estimated \$153,489,279 of one-time costs in planned or aspirational projects through FY 2021-22, at least some of which could be offset if the City deployed the proposed network. Further, the network could generate up to \$1,297,000 in ongoing savings and avoided costs as well as an unquantified amount of additional property tax and real estate transfer taxes for the City. City departments are already contemplating how to leverage such a network to improve their services, including increasing access to medical care and traffic management.

- In addition, the network has the potential to generate significant economic returns, including higher property valuations, lower prices for broadband service, increased business development, more efficient energy consumption, and job growth. In addition to selling internet connectivity, the network could be leased to other customers, such as wireless providers or advertisers, generating additional revenue. It could also enable new types of government services and private industry that enhance the well-being of San Franciscans.

Project staff: Fred Brousseau and Nicolas Menard

Background

The City and County of San Francisco is considering constructing a Citywide fiber-optic network to provide gigabit speed Internet service to all premises in the City. The objectives of this undertaking are to enable affordable, high speed internet access to prepare all San Francisco residents and businesses for the future and to close the digital divide. A report on this topic prepared by our office cited a Controller's survey finding that 12 percent of San Franciscans, or approximately 100,000 residents, did not have wired access to the Internet at home.¹

A municipal Citywide fiber-to-the-premises network feasibility study prepared by a consultant and released in October 2017 recommended that the City pursue a public-private partnership to build and operate the gigabit-speed fiber-optic network, for which it estimated one-time costs of between approximately \$1.2 and \$1.8 billion and between \$69 and \$121 million in annual costs depending on specifics of the network

¹ San Francisco Budget and Legislative Analyst, "Digital Divide in San Francisco", April 15, 2015.

configuration, maintenance requirements, and other factors. The City would own the network assets but would contract with private sector entities for network services.²

This report presents possible social and economic benefits of having a ubiquitous, high-speed network in San Francisco. These benefits include fiscal savings and revenues, improved service delivery, job growth, and property value appreciation. We surveyed City departments to understand their planned or desired projects and initiatives that would benefit from a high-speed fiber network as well as possible service improvements made possible by the proposed network. In addition, we consulted academic literature as well as the experience of other cities that have deployed similar networks to understand some of the other possible benefits of such a network for San Francisco.

Planned City Projects and Potential Savings

City Fiber Expansion

The City has several planned and aspirational projects that require or would benefit from the deployment of a gigabit speed network. At the beginning of Fiscal Year 2017-18, the City had connected 387 public facilities to its municipal fiber network, City Fiber, which provides internet connectivity. The Department of Technology (DT) estimated the cost to connect the remaining 120 City facilities that are not yet connected to City Fiber in the 2017 Connectivity Plan.³ As shown below in Exhibit 1, the total cost to connect these facilities is approximately \$7.3 million. The Connectivity Plan establishes a schedule to connect the remaining facilities between FYs 2018-19 and 2021-22, assuming all requested funding is made available.

Exhibit 1: Costs of expanding City Fiber

FY	2018-19	2019-20	2020-21	2021-22	Total
Costs	\$1,250,000	\$2,750,000	\$2,450,000	\$850,000	\$7,300,000

Source: 2017 Connectivity Plan

Although the proposed municipal network may not be deployed for several years, expansion of City Fiber has historically been underfunded and behind schedule. Once the City commits to the development of the proposed ubiquitous gigabit-speed network, the cost of connecting the remaining City facilities could be avoided. If the City wanted to fully realize the \$7,300,000 of avoided connection costs, it would have

² The Potential for Ubiquitous, Open, Fiber-to-the-Premises in San Francisco, CTC Technology and Energy and IMG Rebel, October 2017. URL: <http://sfbos.org/sites/default/files/CTC-Deliverable22-final-20171017.pdf>

³ San Francisco 2017 Connectivity Plan, Department of Technology. <https://tinyurl.com/y8fk53sk>

to pause the currently scheduled expansion of City Fiber to City facilities until the proposed municipal network is in place.

As noted in the 2017 Connectivity Plan, expanding City Fiber will allow the City to reduce its reliance on private internet service providers. Exhibit 2 below summarizes the estimated savings from migrating off of redundant internet service providers, as departments connect to City Fiber.

Exhibit 2: Citywide savings from reducing use of private internet service providers due to expanded City Fiber

FY	2018-19	2019-20	2020-21	2021-22	Ongoing savings
Costs	\$448,000	\$747,000	\$896,000	\$1,297,000	\$1,297,000

Source: 2017 Connectivity Plan

The 2017 Connectivity Plan recommends that these savings be directed towards maintaining City Fiber.

SFMTA

The MTA is in the process of upgrading its traffic signal communications technology by replacing the legacy communication technology with fiber optic cables and wireless radios where applicable. Such infrastructure allows traffic signals to provide signal priority to transit emergency vehicles, consistent with the City's Transit First policy. According to the MTA, bringing fiber to traffic signals also enables the agency to install cameras and variable message signs, provide real-time street conditions, and disseminate real-time garage parking and special event information.

Because installation of fiber is costly, the MTA has coordinated the upgrades with other street capital improvement projects and upgraded only a portion of its signal system with fiber. MTA has so far connected approximately 285 of the 1,300 total traffic lights in the City using fiber optic cable and will connect approximately 75 more according to current and planned capital improvement projects, leaving an estimated 940 signals to be connected (1,300 less 285 connected less 75 already planned for connection). According to the MTA, the cost of connecting each traffic signal to fiber is approximately \$150,000 if implemented independently. If the proposed network is deployed, MTA could avoid potentially up to \$141 million in construction costs (\$150,000 per signal x 940 remaining signals). Such savings would be offset to some extent by the costs of connecting the signals to the municipal network.

Public Health

The Department of Public Health identified several potential savings in our survey. According to DPH, having a truly ubiquitous network that is affordable for all San

Franciscans, (12 percent of which did not have wired broadband connections at home, as reported in our April 2015 report on the City's digital divide) could produce potential operating savings for the Department. The network would allow the Department to monitor and treat patients remotely, commonly referred to as telehealth. The Center for Medicare and Medicaid Services (CMS), which monitors funding and compliance of the MediCal insurance program for low-income Californians, may withhold up to 2 percent of a hospital's annual Medicare revenues for excessive hospital readmissions (within thirty days of initial treatment). According to DPH, home-based monitoring has the potential to decrease the rate of initial admission and re-admissions, especially for conditions for which DPH can intervene remotely by looking at a patient via video, and listening to their lungs and heart via remote audio technology to prevent an initial or repeat hospitalization. According to DPH performance data, CMS withheld \$71,000 from DPH's Medicare revenues in FY 2015-16 due to excessive readmissions. If 50 percent of all readmissions could be avoided through video-based health services provided over the City network, an estimated \$35,000 per year in DPH annual operating costs would be avoided. Some initial costs would be incurred for DPH to obtain needed equipment to provide telehealth services.

In addition, although difficult to quantify, a robust telehealth program would allow DPH to collect objective data about patients (e.g., taking temperatures, visual inspection of faces/rashes/infections, listening to lungs and hearts), so that patients can be accurately triaged, potentially avoiding costly emergency room visits. Such a telehealth solution that is available to all San Franciscans would also allow home-bound patients to minimize hospital visits. Home-bound patients include geriatrics, those receiving palliative care, recovering from surgery, or with severe mental illness. DPH provides care in many non-traditional settings (such as streets, shelters, homeless outreach vans, and schools), and although not traditionally thought of as telehealth, giving providers easier remote access to DPH information systems will also favorably impact the health of the City's population.

Because DPH operates the City's public hospital, it provides health services to inmates in San Francisco's jails. When inmates require medical care beyond what jail medical facilities are capable of, they are escorted by Sheriff's deputies to Zuckerberg General Hospital. According to a DPH analysis in 2009, there were 1,622 clinic visits and 640 emergency room visits by inmates that year. DPH estimated the costs of deputies' time to facilitate custody transports were \$811,000 for clinic visits and \$384,000 for emergency visits, for a total of annual cost \$1,195,000. These costs only include Sheriff's deputy hours for custody transport and do not include any overhead costs

or other indirect costs. A portion of these costs could be avoided if inmates could receive medical care without being transported to the Zuckerberg General Hospital.

Finally, DPH has planned investments in fiber optic infrastructure over the next several years. According to the DPH Chief Information Officer, these investments total \$936,279 between FY 2016-17 and 2018-19. Such investments include bringing fiber to clinics and supportive housing. DPH further anticipates \$240,000 in fiber investments in FY 2019-20 and \$65,000 in FY 2020-21 to enhance its bandwidth with its cloud service provider, for a total planned fiber investment of \$1,124,279 between now and FY 2020-21. If the proposed network were deployed, DPH could avoid some or all of these infrastructure costs.

Department of Elections

In response to our survey of City departments, the Department of Elections reported that it plans to relocate its warehouse from Pier 48 to Pier 31 in 2019. However, the new warehouse location does not have fiber-optic infrastructure and is not included in the planned expansion of City Fiber detailed in the 2017 Connectivity Plan. According to the Department, extending fiber to its new warehouse was estimated by an internet service provider in 2016 to cost \$560,000. The Department states that it would benefit from having fiber at its new warehouse. If the proposed network is deployed, the Department could avoid the \$560,000 connection cost.

Summary

Exhibit 3 bellows summarizes the potential maximum cost savings described above.

Exhibit 3: Potential Departmental Savings and Avoided Costs

Department	One-time	Ongoing Annual
DT (City Fiber)	\$7,300,000	\$0
DT (ISP Savings)	\$3,388,000	\$1,297,000 ^a
Elections	\$560,000	\$0
MTA	\$141,000,000	\$0
Public Health	\$1,241,279	\$0
Total	\$153,489,279	\$1,297,000

Source: Budget and Legislative Analyst survey of City departments

^a Based on estimated savings in FY 2021-22 of complete rollout of City Fiber to all municipal facilities that currently purchase connectivity from private providers.

The costs in Exhibit 3 represent a high-end estimate of departmental savings and avoided costs. Some costs, such as inmate transport costs to DPH, would not be fully offset by the deployment of the proposed network. In addition, the deployment of

the Citywide network may not fully offset the MTA's \$141,000,000 cost of bringing fiber to all traffic signals.

Improved Service Delivery

Our survey of City departments also asked departments to identify potential service improvements if the City were to deploy a ubiquitous gigabit speed network.

Mayor's Office of Housing and Community Development (MOHCD)

MOHCD noted that most public housing developments, including those administered by the San Francisco Housing Authority or MOHCD, the HOPE VI developments, as well as properties recently transferred to private ownership under the Rental Assistance Demonstration Program (RAD), do not have access to affordable high speed internet connectivity. While most households in affordable housing would be eligible for income-based subsidies, such as Comcast's Internet Essentials which costs \$9.99 per month for a 15 Mbps download / 2 Mbps upload connection, this is far less than the 1,000 Mbps (one gigabit per second) download and upload speeds in the proposed Citywide network.

According to MOHCD, there are approximately 52 public housing sites in the City, 29 of which are already slated for high-speed fiber connection in the City's 2017 Connectivity Plan. Taking the fiber connection costs of \$40,000 per facility plus a 25 percent construction reserve noted in the 2017 Connectivity Plan, we estimate that connecting the remaining 23 facilities would cost at least approximately \$1,150,000.⁴

In addition, to the extent the proposed network would lower the cost of high-speed broadband, residents in the City's inclusionary housing, who are low-income households, would benefit as well. Currently, MOHCD does not have a plan in place to provide high speed internet access to all of the City's inclusionary housing units.

Public Safety

Although not under consideration by the Police Department, it could benefit from additional smart cameras and lights, linked by a Citywide fiber-optic network, that could be activated by police officers on their way to a crime scene. Such devices could also be linked to the City's ShotSpotter technology, which automatically notifies of the department of the location of gun fire. Such technology would help police develop

⁴ The 2017 Connectivity Plan includes 29 San Francisco Housing Authority facilities, leaving 23 remaining public housing developments to be connected times \$50,000 per connection = \$1,150,000. Additional costs may be incurred for re-wiring old buildings to provide final connections to residents.

situational awareness immediately after crimes are reported as well as identify and track suspects.

The City of Anyang, Korea, has deployed an intelligent crime prevention solution similar to the one described above. In Anyang, a city of approximately 600,000 people, CCTV cameras are activated when citizens report crimes and footage is beamed directly to surrounding patrol cars as well as to the City's operations center. Suspects may be tracked and recorded and information about them can be available to police in real-time before they are on site.

According to a case study⁵ by the Inter-American Development Bank, Anyang has seen an 18 percent decrease in violent crime. Some violent crime subcategories, such as assaults, decreased by 28 percent. The study notes that the number of crimes in public places decreased by a wider margin than crimes committed indoors, suggesting that the decrease in crime was strongly linked to the increased surveillance.

According to the San Francisco Police Department's Year End Crime Statistics Report for 2016, there were 6,240 violent crimes in 2016, including 2,616 assaults. Applying the 18 percent decrease experienced in Anyang, if San Francisco were to experience an effect similar to that of Anyang, it would have experienced 1,111 fewer violent crimes overall in 2016 and 466 fewer aggravated assaults. If such a surveillance system were to be deployed in San Francisco, it would have to conform to Chapter 19 of the Administrative Code, which governs use and installation of City safety cameras.

Economic Impacts

Deployment of ubiquitous gigabit speed fiber network that is affordable and connected to all residents and businesses could stimulate the local economy and generate significant economic returns. We consulted academic literature regarding the economic benefits of high-speed networks as well as the anecdotal experience of other cities that have deployed similar networks. As described more fully below, benefits cited included higher property valuations, lower prices for broadband service, business development, and job growth.

Property Values

Two recent studies examined the impact of fiber to the home networks on property valuations. A 2014 survey⁶ of multi-dwelling unit (MDU) residents⁷ concluded that

⁵ International Case Studies of Smart Cities: Anyang, Korea. Inter-American Development Bank. June 2016.

⁶ Steve Ross, "Consumer Survey: FTTH Adds Value to MDUS", <http://www.bbpmag.com/Features/0714feature-ConsumerSurvey.php>, accessed September 27, 2017.

⁷ Those that live in apartment buildings.

sales of MDU units with fiber installed were 2.8 percent higher than non-fiber units. Similarly, in June 2016 academics from the University of Colorado Boulder and Carnegie Mellon University examined Federal Communications Commission broadband data and real estate transactions occurring between 2011 and 2013. The researchers found that the combination of access to a fiber network and gigabit speed per second internet access adds 3.1 percent to the value of single family homes compared to properties without those attributes.

San Francisco property taxes are collected against the assessed valuations of property. These revenues are split between the City's General Fund, the San Francisco Unified School District, and the San Francisco Community College District. According to the City's 2016 Comprehensive Annual Financial Report, property tax revenue contributed \$1.157 billion to the City's General Fund and \$605.2 million to the School District, Community College, and other public education.

The benefit of the increased value of San Francisco real estate due to connection to a high speed fiber network would include increased revenue to the City's General Fund through increases in property tax and real estate transfer tax revenues. While the value of all real estate may increase with a ubiquitous Citywide fiber network, increases in property tax revenue would only occur as real estate is sold which is when State law allows for increases in valuations greater than 2 percent. As properties change hands over time, the City would experience such increases. Additional revenue would be generated in succeeding years as other properties are reassessed upon turnover which would account for the impact of the fiber connection.

Broadband Competition

A November 2016 report⁸ by two researchers at Analysis Group, an economic consultancy, found that when a broadband provider begins providing gigabit speed services, competitors tend to lower prices of their current services and increase speeds to retain customers. In particular, the researchers found that the presence of gigabit services providers is associated with a 25 percent per month decrease in the average monthly price of broadband plans with speeds greater than 100 Mbps and less than 1 Gbps. Rates for lower speed services decreased by 14 to 19 percent. The researchers found that areas with more broadband providers have lower prices for the same speeds offered in areas with fewer providers and that the availability of high-speed plans increases the chance the broadband incumbents will upgrade their current service speeds.

⁸ Dan Mahoney and Greg Rafert, Broadband Competition Helps to Drive Lower Prices and Faster Download Speeds for U.S. Residential Consumers, November 2016.

Similar effects on broadband competition have been observed by other researchers. In a study published in 2015, two researchers from Creighton University in Omaha, Nebraska reviewed Federal Communication Commission broadband data as well as Census data to understand the effects of broadband competition. They found that the presence of gigabit service providers caused cable providers to increase their average service speeds.

In January 2015, an analysis by the Executive Office of the President of the United States⁹ noted instances in the United States where broadband competition increased when Google Fiber, a gigabit service provider, began offering services. The report stated that when Google announced it would provide service in Kansas City, “speeds on existing networks surged 97 percent—the largest year-over-year jump in bandwidth observed in any state, ever.” When Google announced it would provide service in Austin, Texas, AT&T announced it would provide its own gigabit network. Similarly, when the City of Chattanooga’s electric utility began providing high speed service to its customers in 2008, Comcast invested \$15 million to deploy its own high speed network, Xfinity. The report notes that Comcast deployed Xfinity in Chattanooga, TN before it did so in Atlanta, GA, a larger and more developed nearby broadband market.

Based on the studies cited above, if San Francisco were to deploy the proposed network with a standard service of 1 Gbps, it is likely that sub-gigabit speed services would become less expensive and existing providers would upgrade their service speeds. These effects would not only benefit residential consumers of broadband but also businesses. AT&T and Comcast have both announced several times over the past five years that they are upgrading their network to provide gigabit speed services in San Francisco, but have yet to deploy those services ubiquitously or affordably. For example, according to the 2017 CTC report for the City, Comcast currently offers San Francisco residents gigabit speeds at a cost of \$160 per month and charges more for businesses. With a 25 percent average reduction in these rates, the monthly charges would be \$120 per month for residential customers. The proposed network’s effect on connectivity prices and services will depend on the current level of competition in a given neighborhood. According to the Department of Technology, one private ISP, Sonic, offers gigabit service in 25 percent of the City for \$50 - \$60 per month as of the writing of this report.

⁹ Community Based Broadband Solutions, Executive Office of the President of the United States, January 2015.

Business Development and Jobs

Several analyses have reported that broadband is essential for business development. A 2014 report¹⁰ conducted by CTC and the New America Foundation, a think tank, stated that most businesses consider broadband affordability and availability as significant factors in their location decision making, equivalent to transportation infrastructure and local talent. An earlier CTC study¹¹ from 2010 for the Small Business Administration reached a similar conclusion. CTC surveyed businesses across the country to assess the importance of broadband to their business. The survey found that broadband was an "essential" service, required for businesses objectives, required by customers, and for long-term value creation. The study also found that broadband provides "production efficiencies and allows the creation of new markets and firms." Affordable fiber-based broadband would be especially helpful for businesses since fiber, unlike cable technology, allows for symmetrical download and upload speeds. This is important for businesses, as they are both producers and consumers of data that is transmitted over information networks.

Given these findings, it not surprising that other cities have experienced strong economic development after the deployment of municipal networks that serve businesses. The website Community Networks, maintained by the Institute of Local Self Reliance, a community development advocacy organization, maintains a list¹² of 58 examples from across the United States of economic development spurred by municipal networks.

Two examples noted by Community Networks were in California. In 2014, the *San Jose Mercury News* reported¹³ that the City of San Leandro was experiencing a business boom after deploying a municipal fiber network to serve local businesses. The network was the result of a public-private partnership between the City and a local business owner. At the time of the article, the City of San Leandro reportedly had the greatest number of 3-D printing businesses, a nascent industry that relies on high-speed internet connections.

The other California city noted by Community Networks is Santa Monica, which also deployed a municipal network to serve businesses. According to a case study by the

¹⁰ The Art of the Possible, The New America Foundation Open Technology Institute and CTC Technology and Energy, 2014.

¹¹ The Impact of Broadband Speed and Price on Small Business, Small Business Administration Office of Advocacy, November 2010.

¹² See here: <https://tinyurl.com/y8rd4n8s>. Accessed October 26, 2017.

¹³ Rebecca Parr, "San Leandro entice tech startups, entrepreneurs", San Mercury News, August 5, 2014.

Institute of Local Self Reliance, the expansion of the City of Santa Monica’s network was driven by business demand for affordable, gigabit speed connectivity.¹⁴

Because high-speed, affordable broadband is essential for businesses, cities that ensure such services are likely to see job growth. A 2010 study by the Public Policy Institute of California (PPIC) found that between 1999 and 2006, zip codes that moved from having no broadband providers to multiple broadband providers had 6.4 percent more employment than zip codes that continued to not have broadband providers.¹⁵ Such employment growth was concentrated in broadband dependent industries, such as business management, scientific and technical services, finance, and information services. Since San Francisco already has multiple broadband providers, it is not likely to experience job growth as identified in the PPIC study. However, the point remains that industries and jobs appear to thrive in areas that are served by multiple providers. A Citywide fiber-optic network would foster more competition and be of benefit to businesses in San Francisco.

Energy Consumption

According to the Federal Communications Commission, in addition to being used for connectivity, broadband infrastructure may be used to monitor energy consumption.¹⁶ Such “smart grids” are expensive to build but industry experts believe that they will make energy distribution networks more reliable, more open to renewable sources of energy, and allow for more efficient consumption of energy.¹⁷

An analysis of Chattanooga, Tennessee’s smart grid (which is also used to provide internet connectivity to residents and businesses) found that its smart grid allowed for a reduction in peak power consumption, reduced operating costs, reduced electricity theft, and reduced outage times.¹⁸ It is in part for these reasons that PG&E, San Francisco’s electricity provider, began upgrading its California grid in 2013.¹⁹ It is possible that the City’s fiber investments could be merged with PG&E’s ongoing smart

¹⁴ Eric Lampland and Christopher Mitchell, “Santa Monica City Net: An Incremental Approach to Building a Fiber Optic Network”, Institute of Local Self Reliance, March 2014.

¹⁵ Jed Kolko, “Does Broadband Boost Local Economic Development?”, Public Policy Institute of California, 2010.

¹⁶ “Energy and the Environment Highlights”, Federal Communications Commission, URL: <http://www.broadband.gov/issues/energy-and-the-environment.html>, accessed January 4, 2018.

¹⁷ Peter Behr, “Smart Grid Costs Are Massive, but Benefits Will Be Larger, Industry Study Says”, *New York Times*, May 25, 2011. URL: <https://tinyurl.com/42emw39>, accessed January 4, 2018.

¹⁸ David Talbot and Mara Paz-Canales, “Smart Grid Paybacks: The Chattanooga Example”, The Berkman Klein Center, February 2017. URL: <http://nrs.harvard.edu/urn-3:HUL.InstRepos:30201056>, accessed September 11, 2017.

¹⁹ PG&E 2017 Smart Grid Annual Report. September 29, 2017.

grid investments, leading to a more rapid smart grid upgrade and therefore more rapid realization of the above mentioned benefits.

Other Revenue Opportunities

As noted above, affordable high speed internet connectivity is essential to businesses development and job growth. A 2017 report by Deloitte, a management consultancy, estimated that the United States requires \$130 billion to \$150 billion of fiber investment over the next five to seven years in order to meet business needs.²⁰ The report states that the business will need to either build their fiber infrastructure or lease it from others, including assets owned by municipalities.

Wireless

Any wireless service ultimately relies on fiber or other wired infrastructure in order to transmit data. The 2017 Deloitte report estimated that wireless carriers need to invest \$15 billion to \$20 billion in fiber in order to support user growth and faster wireless speeds over next generation “5G” wireless networks.²¹ The Deloitte study stated that, given the current fiber shortage, wireless providers would be willing to lease municipally owned fiber assets. In doing so, wireless providers are expected to become revenue generating customers of municipal networks, in addition to, and separate from, residential and business customers that pay for the network to provide internet connectivity. Such demand would not be novel; a 2012 report²² by CTC stated that wireless carriers and tower owners were customers of municipally owned dark fiber. A high speed Citywide municipal fiber network should thus be able to generate revenue of an unknown amount by leasing space on the network to wireless providers.

The Stockholm experience

For over two decades, the city of Stockholm, Sweden, has had a municipally-owned dark fiber network, Stokab. The city does not provide connectivity directly to residents and businesses but instead leases its fiber assets to businesses for a variety of purposes, including internet service and other network service providers, wireless carriers, and large private businesses that use the fiber to connect their facilities to

²⁰ “Communications infrastructure upgrade: The need for deep fiber”, Deloitte, July 2017.

²¹ “5G” wireless networks refer to next-generation wireless networks that are expected to be able to provide high-speed connections wirelessly, similar from the increase in speed in cellular networks from 3G to LTE.

²² Dark Fiber Lease Considerations, CTC Technology and Energy

each other.²³ The city had over 800 customers in 2012.²⁴ This broad customer base has allowed Stokab to remain financially viable. With a municipally owned dark fiber network, the City and County of San Francisco should also be able to generate customers above and beyond standard internet service providers.

The SF Public Utilities Commission is piloting a revenue generating program that relies on fiber

The SFPUC is currently converting streetlights to use emitting diode (LED) lights, a low energy, cost effective replacement for the department's current lighting technology. As it does so, it is piloting a program in which radio-like devices are attached to the streetlights so that PUC staff can monitor and control them. The devices can also be used to provide WiFi or leased out to cellular providers to help manage congestion on their networks. Ultimately, the devices must connect to fiber to transmit data. The PUC is planning to rely on City Fiber for its pilot, but will need additional fiber connections if the program is to expand. If deployed prior to the PUC's expansion of the pilot, a Citywide municipal fiber network would provide a means for the PUC to expand this program and generate additional revenue.

Advertising

Widespread high-speed connectivity could enable new forms of targeted advertising and thus another source of revenue for fiber asset owners. A 2017 article in City Lab, an online urban affairs journal, reported that Kansas City may finance a roadway construction project by allowing advertisers to install sensors in the roadway that connects to passing cars.²⁵ This will allow local businesses, such as gas stations or restaurants, to target passers-by based on the fuel-level of their cars or time of day. Having a ubiquitous affordable high-speed network would allow San Francisco to explore similar revenue generating advertising partnerships that could finance public projects while avoiding any breaches of individual privacy rights.

Smart City Applications

As noted above, adoption of broadband technology can enable governments to improve their service provision. The ubiquity of reliable connectivity, sensors, and innovation in service delivery may enable so-called "smart cities." According to one

²³ Benoit Felton, "Stockholm's Stokab: A Blueprint for Ubiquitous Fiber Connectivity?", Diffraction Analysis, July 2012.

²⁴ Felton.

²⁵ Linda Poon, "What Makes a Smart City Truly Smart?", City Lab, September 5, 2017. URL: <https://tinyurl.com/y9mcsvzf>, accessed January 4, 2018.

industry estimate, by 2020 there will be five million “smart” sensors deployed, transmitting 507.5 zettabytes of data (approximately 472 trillion gigabytes).²⁶ According to a 2016 report by the National League of Cities, “a smart city is a city that has developed some technological infrastructure that enables it to collect, aggregate, and analyze real-time data and has made a concerted effort to use that data to improve the lives of its residents.”²⁷ That report identified a variety of potential smart city applications, including:

- Water and wastewater monitoring systems
- Parking systems that provide real-time data on parking availability
- Bridge inspection systems
- Waste management monitoring systems
- Lighting control systems
- Fire detection systems
- Energy monitoring and titration systems
- Vehicle fleet communication and monitoring systems
- Surveillance systems
- Body camera systems

A ubiquitous high-speed network would enable deployment of these “smart” systems by providing the bandwidth and speed necessary to allow users to monitor each system’s real-time conditions and respond accordingly. This has the potential to improve service delivery, save money, and allow for new types of government services.

Toronto

Sidewalk Labs, an Alphabet, Inc. subsidiary, is partnering with the city of Toronto, Canada to develop a portion of Toronto’s waterfront. The new neighborhood is expected to be filled with robots, sensors, and other digital infrastructure to gather data about neighborhood activities, such as movements of people, pollution, trash, and noise.²⁸ The project will attempt to use this data to better understand neighborhood needs and improve delivery of government services. According to

²⁶ Mary Shacklet, “Edge computing: The smart person’s guide”, Tech Republic. July 21, 2017. URL: <https://www.techrepublic.com/article/edge-computing-the-smart-persons-guide/>, accessed January 4, 2018.

²⁷ Trends in Smart City Development, National League of Cities, 2016.

²⁸ Ian Austen, “City of the Future? Humans, Not Technology, Are the Challenge in Toronto”, *New York Times*, December 29, 2017. URL: <https://www.nytimes.com/2017/12/29/world/canada/google-toronto-city-future.html>, accessed January 4, 2018.

Sidewalk's Feedback Report of a community meeting it held to solicit citizen input, questions about data privacy and ownership were among several concerns raised by the media and during the community input process. As of this writing, Sidewalk Labs and the City of Toronto have not yet finalized the project development agreement, which will ultimately address the privacy and intellectual property questions.

Autonomous Vehicles and Road Sensors

Automobile makers and other transportation companies are currently testing autonomous vehicles (also known as "self-driving cars") in California and other parts of the United States. Rather than relying on human drivers, autonomous vehicles use a combination of onboard and roadside sensors and driving software to navigate vehicles with minimal human effort. Although the technology is still in the testing phase, some industry experts believe that autonomous vehicles will rely on roadside sensors for navigation and will therefore require fiber-based networks to ensure rapid transmission of data between these sensors and the autonomous vehicles.²⁹ The CEO of Intel, a computer manufacturer, reportedly stated that autonomous vehicles will require 4,000 gigabytes of data for every eight hours of driving.³⁰ According to the Fiber Broadband Association, an advocacy organization, the transmission of such amounts of data, even if it occurs wirelessly, will require deployment of dense fiber networks.³¹

In addition to supporting autonomous vehicles, roadside sensors may also be used in a variety of applications to improve government services. According to a September 2015 U.S. Government Accountability Office report, such sensors "could provide safety, mobility, environmental, and operational benefits, for example, by: (1) alerting drivers to potential dangers, (2) allowing agencies to monitor and address congestion, and (3) providing driving and route advice."³² Roadside sensors also have the potential to increase parking space occupancy and meter commercial loading times.³³

²⁹ CCG Consulting, "Two Visions for Self-Driving Cars," April 21, 2017. URL: <https://potsandpansbyccg.com/2017/04/21/two-visions-for-self-driving-cars/>, accessed January 4, 2017.

³⁰ *Ibid.*

See also: Patrick Nelson, "Just one autonomous car will use 4,000 GB of data/day", Network World, December 7, 2016. URL: <https://tinyurl.com/y76e48xx>, accessed January 4, 2018.

³¹ "The Road to 5G is Paved with Fiber", Fiber Broadband Association, December 2017.

³² "Intelligent Transportation Systems (GAO-15-775)". U.S. Government Accountability Office, September 2015.

³³ Brent Skorup, "Driverless Cars Need Just One Thing: Futuristic Roads", *Wired*, October 10, 2016. URL: <https://www.wired.com/2016/10/driverless-cars-need-just-one-thing-futuristic-roads/>, accessed January 4, 2017.

Conclusion

The City has an estimated \$153,489,279 in planned or aspirational projects through FY 2021-22, some of which could be offset if the City constructed its own Citywide gigabit-speed fiber-optic network connected to all residents and businesses. Further, the network could generate up to \$1,297,000 in ongoing savings and avoided costs as well as an unquantified amount of additional property tax and real estate transfer tax revenues for the City. City departments are already contemplating how to leverage such a network to improve their services, including increasing access to medical care and traffic management.

The network has the potential to generate significant economic returns, including higher property valuations, lower prices for broadband service, business development, and job growth. In addition to selling internet connectivity, the network could be leased to other customers, such as wireless providers or advertisers, generating additional revenue. It could also enable new types of government services and private industry that enhance the well-being of San Franciscans.