Enhanced Communications in San Francisco:
Phase II Fiber Optics Feasibility Report

Prepared for the City and County of San Francisco

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1 Executive Summary

Broadband networks rank among the most important infrastructure assets of our time—for purposes of economic development and competitiveness, innovation, workforce preparedness, healthcare, education, and environmental sustainability. In the short decade or so since the advent of the commercial Internet, broadband access has become a necessity – not a luxury. The City and County of San Francisco recognizes the need for essential broadband services in the City and is considering how to facilitate development of such services. The citizens and businesses of San Francisco agree with the City about the importance of broadband; 61 percent of San Francisco business and 59 percent of San Francisco residents believe that Internet access is an essential service.[1]

This Report presents the results of market research of San Francisco's businesses and residents with respect to use and needs for high-speed communications, as well as an evaluation of the feasibility of a municipal Fiber-to-the-Premises (FTTP) network in San Francisco under a range of business models. This Report was prepared by Columbia Telecommunications Corporation (CTC) in the summer and fall of 2008 at the request of the San Francisco Department of Technology (DT).

1.1 Project Background

This Report summarizes San Francisco's Phase II analysis of the feasibility of municipal fiber networking. It serves as a complement and update to the 2007 report, "Fiber Optics for Government and Public Broadband: A Feasibility Study" (hereinafter, "the 2007 Report"). The 2007 Report demonstrates the need in San Francisco for affordable, high-end connectivity for a range of purposes, including competition, telemedicine, small business attraction and growth, and incubation of key economic sectors such as digital media. But none of the City's incumbent wired providers (AT&T, Astound, and Comcast) has indicated any plans to deploy FTTP facilities throughout San Francisco.

To fill that gap, the 2007 Report preliminarily recommends a wholesale, "open access" FTTP network and estimates deployment costs ranging from approximately $500 to $750 million, depending on the business model adopted. The Report assumes that the City would recoup its costs (including financing costs) if the network were able to attract a 36 percent market share (an approximate blended rate of voice, video, and data revenues), based on extremely conservative assumptions with no accounting for indirect benefits such as economic development, education, digital inclusion, and environment protection.

The 2007 Report notes that all estimates of market share were based on assumptions, not on empirical or market data. Reliable empirical data are almost non-existent given that no American city of the size or stature of San Francisco has engaged in a project of this scope. The

[1] These numbers are based on CTC market research of summer 2008, summarized in detail below.

2007 Report recommends that the market share assumptions (and the resulting business models) be tested through statistically-reliable market research of the business and residential markets in San Francisco.

This Report offers the market research and updated business analysis recommended by the 2007 Report. To prepare this Report, during the summer of 2008 CTC conducted extensive market research and then analyzed a range of fiber business models in light of the results of that research. Specifically, CTC's staff of engineers and analysts undertook the following tasks:

- Conduct market research of San Francisco residents and businesses to:
    - Analyze satisfaction levels with existing services—and determine importance of services to consumers
    - Analyze and quantify the potential market for new services
    - Gauge public interest in City facilitation of FTTP deployment
    - Explore feasibility of new models for fiber ownership
- Meet with City officials and stakeholders
- Evaluate the functional differences between FTTP technology and the existing broadband technologies offered by incumbent providers in the San Francisco market.
- Inventory and evaluate the current communications offerings available to both residential and business markets
- Evaluate the various models by which the City could advance the availability of high-speed Internet access
- Identify and quantify the risk of the key strategies, particularly in light of the results of the market analysis
- Consider the business case for the City for each of the identified strategies
- Determine and document the risk as well as the business benefits for the City of various levels of involvement in a broadband initiative
- Summarize potential ancillary benefits that may be served by a FTTP network

1.2 Industry Background

Fiber optics are increasingly recognized as the ultimate platform for communications networks—a theoretically-infinitely scalable and adaptable medium that enables development and use of the communications applications of today and the future.

High-bandwidth broadband is widely-recognized as a key driver of future economic competitiveness,[2] and is also regarded as a facilitator of political discourse and activity – the

[2] According to a 2005 study by the Massachusetts Institute of Technology and Carnegie-Mellon University, "broadband access does matter to the economy… between 1998 and 2002, communities in which mass-market broadband was available by December 1999 experienced more rapid growth in employment, the number of businesses overall, and businesses in IT-intensive sectors." William Lehr, Carlos Osorio, Sharon Gillett, Marvin Sirbu, "Measuring Broadband's Economic Impact," Broadband Properties, December 2005, http://www.broadbandproperties.com/2005issues/dec05issues/Measuring%20Broadband%20Eco%20Impact,%20Le

most important medium for communication and expression of political ideas since the advent of television.

America's competitor nations in Europe and Asia are increasingly adopting FTTP as the inevitable, essential broadband medium. Significant initiatives for FTTP are underway throughout the Pacific Rim and Western Europe, most of them undertaken by the private sector with significant government incentives and/or mandates. Asia currently represents more than 80 percent of FTTP subscribers in the world, primarily in Japan and South Korea. China is aggressively building FTTP and plans to have up to 20 million subscribers connected by the end of 2009.[3]

In addition, variations of municipal FTTP projects are underway or under consideration in many major European and Asian cities including Paris, Vienna, Amsterdam, Stockholm, Zurich, Milan, Singapore, and Hong Kong.[4]

In the United States, the Federal Government has left fiber deployment to an unregulated private sector, but this approach is generally considered to have enabled very limited investment in FTTP, most of it by Verizon in relatively small parts of the country, and small deployments by AT&T and Qwest in areas of new development.

In the absence of Federal action comparable to that in Europe and Asia, many local governments have attempted to meet their communities' needs for fiber technology. A significant handful of municipalities and municipal electric utilities have deployed FTTP in rural and small town areas. And in recent years, a number of larger cities such as Portland, OR, Seattle, and Palo Alto have begun evaluating whether municipal, open access[5] fiber is advisable and feasible for their

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hr,%20Gilett,%20Sirbu.pdf. High-speed communications are not only an engine for commerce, but also for integration of the many, diverse areas of the U.S. into an increasingly-global economy. High-bandwidth broadband is widely-recognized a key driver of a city's future economic competitiveness because it (1) enables small business creation and growth; (2) enables job creation and the enhanced, multiplied economic activity that accompanies it; (3) supports businesses with very high bandwidth needs, such as digital media and software; (4) attracts and retains businesses of all sizes; (5) enables workforce education; (6) enables telework and distributed work; and (7) promotes major development initiatives such as revitalization zones or event bids. Even as there is growing consensus nationally that broadband is a key driver of economic competitiveness, the United States is simultaneously falling behind our competitor nations in broadband infrastructure, competition, and availability. The economic consequences of falling behind in broadband could be profound. For example, small and medium businesses cannot compete without affordable, high-speed access—and large businesses increasingly refuse to locate in areas without very high-speed access. Home-based businesses fail to emerge or grow because of slow Internet speeds. Lack of very high-speed broadband also precludes development of the collaborative, distributed work that is a hallmark of the emerging global economy.

[3] Lynn Hutcheson, "Is China poised to take the lead in FTTx subscribers?," Ovum Telecoms and Software News, November 24, 2008, http://www.ovum.com/news/euronews.asp?id=7525.

[4] These projects span a wide variety of models, ranging from municipal ownership to public/private partnership to municipal attempts to stimulate private fiber builds.

[5] In open-access networks, the network owner leases capacity to retail providers, who deliver voice, video, and data products to consumers. This Report uses the term "wholesale model" and "open access" to refer to networks that allow competing service providers to compete over network infrastructure at non-discriminatory prices and on non-discriminatory terms. Open access fiber has attracted many municipalities because it opens the door to dramatic innovation and competition of countless companies and individuals—all over the big pipe of fiber. In this way, the

respective communities. These communities are focusing on the economic and social needs for higher speed connectivity and greater consumer choice.

This Report addresses three key areas: (1) the market for the network contemplated by the City; (2) the feasibility of various emerging business models for that network; and (3) key technical considerations in evaluation of whether to undertake a fiber project.

The findings with respect to each of those areas are summarized here.

1.3 Summary of Market Findings: San Francisco Needs More, Better Broadband

1.3.1. San Francisco's Market Does Not Currently Deliver World Class Communications

San Francisco's residents and businesses have a relatively broad range of services available, as compared to other urban areas. However, as compared to FTTP areas (such as Verizon FiOS build areas and the FTTP networks in major cities in Europe and the Pacific Rim), San Francisco is at a great disadvantage with respect to affordability, access, speed, and ubiquity of broadband.

None of the City's incumbent wired providers (AT&T, Astound, and Comcast) has indicated any plans to deploy FTTP facilities throughout San Francisco.

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network replicates over big-bandwidth the creativity of the early Internet era that has been reduced by the closing of the incumbents' networks. In the formative days of the commercial Internet, dial-up modems were used to access the Internet over copper telephone wires. Subscribers had open access to any Internet Service Provider simply by dialing their chosen ISP over their computer's modem. Under common carrier rules, the telephone companies (who owned the access network -- the telephone wires and equipment in their offices) could not legally control or limit their competitors' traffic, nor could they block or limit access to the phone lines of a particular Internet Service Provider. This dynamic enabled the Internet to grow into the indispensable information storehouse and innovation engine it is now, because both content creators and users were allowed unhindered connectivity.

Today, however, bandwidth requirements far exceed the capabilities of a dial-up modem connection. As a result, consumers use the higher capacity service offerings of a limited number of broadband networks. However, incumbent broadband networks are generally proprietary, or closed to competitive providers – a deviation from the common carrier rules under which the telephone networks have long operated and under which numerous ISPs competed over dial-up modems. As a result, many of these ISPs have gone out of business—because they cannot access the distribution networks, at any price. The dynamic ISP competition of the early commercial Internet era has ceased to exist.

However, advanced networks can allow access to multiple providers of services -- in the same way that all companies have non-discriminatory access to roadways, over which they can compete commercially. Government can facilitate this process by laying the foundation for competition in the form of communications infrastructure, and allowing the free market to drive innovative service development and competitive pricing.

Verizon offers FiOS in parts of Southern California (see Figure 95 below) but has not indicated any plans of extending the service to San Francisco.

San Francisco's incumbent providers are taking certain steps to deploy some new technologies, but they are constrained in their investment choices by a number of key factors including (1) the need to satisfy capital markets that reward short-term profits and punish long-term investments; (2) the high cost of the required infrastructure investment—existing regulations require that each new competitor build its own fiber network—and impracticality akin to forcing competing delivery services to build their own road and highway systems; and (3) higher bandwidth threatens incumbents' existing revenue streams by enabling consumers to use free or cheap web-based services rather than buying the incumbents' phone and video services.[6]

Existing regulatory and market structures therefore facilitate the scarcity of bandwidth, which is likely to continue. But scarcity does not deliver the big pipe for innovation and creativity; new capabilities; opportunities for competitive and innovative service providers; enhanced customer alternatives; or consumer choice.

1.3.2. San Franciscans Want Higher Speeds and Greater Choice

The market research conducted for this Report indicates that San Francisco businesses and residences are not satisfied with the status quo in the telephone, cable television, and Internet markets. The research also demonstrates that a majority of San Franciscans believes the City should play a role in addressing the shortcomings of the market structure: limited choices of providers and lack of availability (and affordability) of innovative products and services.

With the rise of Internet-based voice and video services, such as VoIP and video streaming, consumers are looking for larger bandwidth Internet services from providers. San Francisco businesses and consumers are limited to what the cable and phone companies can provide -- speeds that are not comparable to those FTTP can offer and that San Francisco residents and businesses have demonstrated they need.

Most significantly, the market research demonstrates that competing for traditional voice and video market-share would be very difficult for a new entrant such as an FTTP operator. However, a significant, unmet market exists for high-speed, high-capability Internet/data services—a market that the existing providers are not meeting and cannot meet, given the technical limits of their existing networks.

In summary, the following are the key findings of the market research:

[6] For example, Internet-based Voice over Internet Protocol (VoIP) is a threat to incumbent voice revenues. VoIP, combined with high-speed Internet access, transforms voice communication from a service to an application. Consumers can get VoIP over their data connection as a free or cheap service. Similarly, video multicasting and video streaming is a threat to incumbent video revenues.

- **Consumers value choice more important than bundling or purported "convenience.":** Both the residents[7] and businesses[8] surveyed consider the ability to choose services from a variety of providers more important than the "convenience" of bundled telephone, cable television, and Internet services. Incumbent cable and phone companies have, in recent years, strongly promoted the convenience benefits of bundling (specifically, they claim that consumers want to deal with one bill and one provider only for communications services), but the market research demonstrates that San Franciscans do not prioritize bundling and are more interested in choice of providers and choice of evolving Internet-based voice and video alternatives.

- **A majority of respondents believe there is a role for the City to play in addressing the shortcomings of the broadband market:** The market research demonstrates that 74 percent of San Francisco residents believe the City should have some role in the development of a broadband communications network. Fifty percent believe that the City should itself build and operate a network and 24 percent believe the City should encourage a private firm to build a network. Over 50 percent of businesses indicate the City should build and operate a network.

- **New providers can compete in the shrinking market for traditional voice services only with lower prices:** Telephone/voice has become a commodity product—in a market that is shrinking annually. Businesses and residents are motivated to select voice providers on the basis of price rather than user features. This is quite common in mature markets such that, for example, service attributes such as voice mail are a competitive necessity -- not a distinguishing feature. As a result, the fundamental way to compete for voice market-share is by offering lower prices. Compounding the weakness of the voice market, the market analysis demonstrates that the size of the residential landline market is shrinking; a substantial share of residential consumers is using wireless alternatives as their only or primary telephone connection.

- **Residential consumers are frustrated with cable television options and pricing—but these are not areas where new providers are likely to be able to offer change:** The market research demonstrates that rising prices and forced bundling/tiering of channels have resulted in significant consumer dissatisfaction with cable television choices. Consumers demonstrate a clear interest in lower prices and the choice of paying only for the channels they watch. But new entrants to the traditional cable television market have limited (if any) flexibility to meet these consumer demands. Content-owners (such as Comcast, ESPN, and other programmers) charge cable television providers for the right to broadcast their programs. These payments have historically increased substantially each year -- and are the main cause of rising subscriber costs. Further, the content-owners generally can set terms with respect to (1) bundling of their channel with others, (2) what channel and tier the program is on, and (3) the percentage of all subscribers that

[7] Among the residential respondents, 68 percent indicated a need for greater provider choice, while 27 percent indicated bundling was of paramount importance.
[8] Among business respondents, 59 percent indicated a need for greater provider choice, while 39 percent indicated bundling was of paramount importance.

receive the program. These requirements have the effect of precluding cable providers from offering "a la carte" programming and limit the ability to hold down consumer costs.

- **The greatest market opportunity for a new entrant is Internet and data services:** The market research demonstrates that residential consumers are dissatisfied with the value of current Internet services. Consumers are looking for higher reliability, greater capacity, and faster speeds. Residential respondents to the surveys demonstrate a clear desire for symmetrical (up and downstream) 100 Mbps, high capacity, high reliability, unfettered Internet offerings in a price-range of $35 to $40 per month.[9] The market is currently not meeting these needs—not only with respect to price, but also with respect to symmetry, speed, reliability, and openness. Frankly, it is unlikely that these market deficiencies will be addressed absent City action, in light of the existing market structure, the legacy copper and coaxial networks operated by AT&T, Astound, and Comcast - and the incumbents' political efforts to protect old business models. The incumbent carriers around the country benefit from lower, asymmetric Internet speeds, which prolong the lives of their cable television and telephone networks by limiting the ability of Internet-based applications to meet consumer video and data needs.

1.3.3. Some San Franciscans Would Pay an Advance Fee for Their Own Fiber Connection

The market research demonstrates an important interest among San Francisco businesses and residents in paying for individual fiber connections to their home, particularly if that fiber affords them choice among companies providing services over the fiber and long-term reductions in service costs. From the City's standpoint, this model could provide a source of capital as well as direct citizen engagement and investment in the fiber initiative.

To determine whether there is interest in this model, during the summer the market surveys queried businesses and residents regarding their interest and willingness to pay a one-time, up-front fee for a direct fiber optic connection, under a range of cost scenarios, so as to obtain a higher-speed connection and to be able to purchase competitive services from competing providers over the fiber.[10]

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[9] Such residential offerings may seem like wishful thinking to many Americans, but in major European and Pacific Rim cities, such prices and service attributes are standard. Indeed, in Tokyo, approximately $45 per month buys a reliable, symmetrical one gigabit per second product—10 times the speed discussed in this Section and 500 to 1,000 times the speed of many broadband services in the U.S. China is considering deploying services of 10 gigabits per second—approximately 10,000 times the speed of many US broadband services.

[10] To our knowledge, this series of questions is the first time this model has been market-surveyed in the United States. The model has never been trialed in the U.S. and is virtually unknown among American businesses and consumers, although it has apparently seen some success and discussion in limited deployments in Europe. That relative lack in the U.S. is, however, changing. In the past few months, we have seen significant discussion and interest in the model. The model and its variations are currently attracting significant attention from cities, technologists, and advocates that are focused on attempting to address the U.S. broadband deficit. For example, like San Francisco, Seattle has also recently conducted market research regarding interest in up-front payment for direct fiber connections. The UTOPIA consortium in Utah is considering adoption of this model to further build out its open access, inter-community fiber infrastructure. The New America Foundation recently released a paper by

The market research data demonstrate that consumer and business interest in the model increase with knowledge of the costs and benefits associated with it. Absent knowledge of the value proposition for a direct fiber connection, there is some limited willingness to invest the up-front payment for the direct connection. We conclude that these respondents represent the early adopter community—those who are interested in having the extraordinary capacity of fiber and for whom cost is not a sole determining factor.

However, the survey respondents demonstrate greater interest in paying an up-front fee when the successive questions include assumptions of some of the presumed benefits—that communications service fees could be lower on an ongoing basis, and that there would be a choice of providers of voice, video, and data services over the fiber connection.

Put another way, there is limited interest in this model in an environment where it is unknown and its benefits are not apparent. As the value proposition becomes apparent, interest in the model spikes.

Among businesses, even without further detail or discussion of the details of the long-range cost benefits of a direct fiber connection, 11.5 percent of respondents indicate willingness to pay a $1,000 fee for a fiber optic connection. 5.3 percent indicate willingness to pay a $2,000 for the connection (Figure 15 below).

The data demonstrate a correlation between the number of employees a business has and its interest in paying up-front for a fiber connection. Nearly 40 percent of business respondents with 50 or more employees indicate willingness to spend $1,000 for fiber connections. More than 20 percent of business respondents with 20 or more employees indicate the same willingness (Figure 16).

The financial, insurance, and real estate industries show the greatest willingness to pay $1,000 for a fiber optic connection (Figure 17). Not surprisingly, given the interest among these industries, those businesses willing to pay for a fiber connection are concentrated in the Downtown area and Financial District (Figure 19 and Figure 20).

The survey follows these initial questions by adding assumptions about the benefits of a fiber connection. If a $2,000 hook-up fee would result in lower monthly costs for communications services, 21.2 percent indicate they would be somewhat or very willing to switch for a 20 percent price reduction while 41.0 percent are willing to switch for a 40 percent price reduction.

Professor Tim Wu of Columbia Law School and Derek Slater of Google, Inc. that proposes and describes a condominium variation of this model in which customers would own their fiber connections as personal property attached to their homes, and would share a collective ownership interest in the trunk fiber leading from the curb or sidewalk of their homes through the neighborhood to a Point of Presence at which the fiber would connect to service providers. That ownership model is currently being piloted in Ottawa, Canada in an innovative model that seeks to reduce energy consumption through fiber use.

For property owners, if their property resale value were to increase by $2,000 because of the fiber connection, 26.1 percent of respondents are somewhat or very willing to pay a $1,000 fee; 15 percent are willing to pay a $2,000 hook-up fee. In contrast, 51.6 percent are somewhat or very unwilling to pay a $1,000 hook-up fee and 69.3 percent are somewhat or very unwilling to pay a $2,000 hook-up fee (Figure 22).

Nearly one-third of respondents are willing to pay more for a business property with a fiber connection or to pay higher rent for a property with a fiber connection (Figures 23).

It does, however, demonstrate a relationship between willingness to pay more and the type of business. The financial, insurance, and real estate businesses recognize more value in a fiber connection than do other kinds of businesses. More than 60 percent of business respondents from those industries signal a willingness to pay more in purchasing a property (Figure 25) while nearly 40 percent of manufacturing businesses are willing to pay higher rent for a property with fiber (Figure 27).

Service-based businesses and financial, insurance, and real estate businesses also indicate a high rate of interest (more than one-third) in paying higher rents for properties with fiber connections (Figure 27).

1.3.4. Telework over Broadband Could Reduce Carbon Emissions and Save Costs

The market research demonstrates that San Francisco has the potential to benefit from the direct and indirect outcomes of high-speed networking.[11] For example, the market surveys included innovative new questions designed to enable projection of the potential increase in telework if San Francisco workers had access to Internet connections with capabilities greater than that offered over DSL or cable modem.[12] CTC then analyzed the resulting data to determine potential reduction of vehicle operating expenses and commuting time. Using extremely conservative assumptions, we conclude that:

- San Francisco commuters can potentially eliminate 151 million miles driven[13] and 10.2 million hours spent[14] commuting per year. Assuming the cost of operating a vehicle is

[11] Though this Report focuses primarily on the potential for a City network to cash flow, it is important to note that the business case for FTTP is not limited to such easily-quantified matters as costs, revenues, and rate of return. Rather, the business case for FTTP investment includes the less quantifiable financial factors, including economic development, small business empowerment, job creation, livability, environment protection, education, increased sales tax and real estate tax revenues, increased property values, and other factors that measure the overall benefit of a next generation communications infrastructure such as FTTP. In this way, FTTP is a tool of economic and community development in much the same way as other infrastructure projects. Cities do not require bridges and roads to pay for themselves entirely through toll revenues; the business case for the road is based on the benefits it delivers to the community.

[12] FTTP can easily support connections speeds of 100 Mbps or greater today- far beyond cable modem or DSL capabilities. In contrast, a WiFi network is not capable of delivering speeds beyond cable modem or DSL capabilities.

[13] Based on respondents that drive alone when they commute to work.

[14] Based on respondents that use public transportation or drive alone when they commute to work.

the IRS-approved rate of 55 cents per mile and that each hour of time saved can be valued at $10, these reductions represent an annual cost savings to the community of $171 million.

- San Francisco commuters would potentially emit nearly 146.6 million pounds LESS carbon dioxide per year through this increased rate of telework, assuming EPA figures for carbon dioxide emissions per gallon. This savings could represent not only an environmental benefit but also a financial revenue source: if a verifiable measurement of this reduction potential is developed and certified under the relevant ISO standard, the savings may be salable as carbon credits.

1.4 Summary of Business Plan Findings: All Business Models are Feasible But Entail Risk

The market and other research in this Report suggest that a business case exists for the City to build FTTP and that enormous social and economic goals will be realized through that project. It is important to note, however, that both the core business models entail financial risk for the City -- at the same time as enabling enormous direct and indirect benefits for the City and consumers.

The 2007 Report preliminarily recommended an open access model based on a series of assumptions about market size[15] and market share[16] rates for voice video and data services, as well as on all the policy reasons that motivate this project—competition, innovation, digital inclusion, sustainability, and other benefits.

The 2008 market research demonstrates that the consumer market size for voice and video services is declining faster than anyone in the industry[17] has anticipated. Voice and video consumers shop for deep price discounts; data consumers expect higher capacity and higher reliability at lower or static prices. The San Francisco market research (which is likely a harbinger for what to expect nationally) demonstrates that a new, competing provider can expect to attract the following market shares:

- voice: 22 percent
- video: 28 percent
- data: 55 percent.[18]

[15] Market size is the number of potential consumers (households) acquiring a service from any provider.
[16] Market share is the percentage of the market (consumers acquiring a service) that a given provider captures.
[17] In the past few years the market size for residential telephone has declined to 80 percent of households (from nearly 100 percent a few years ago). The market size for telephone is declining by approximately five percent per year. Cable television market size has dropped to 51 percent and is anticipated to slowly decline as Internet options evolve. The 2007 study used market size estimates of 95 percent, 85 percent, and 80 percent, for voice, video, and data service respectfully.
[18] The 2007 study used market share assumptions of 42 percent, 34 percent, and 34 percent for voce, video, and data services respectfully.

Given these market shares and other reasonable assumptions, neither the open access nor the retail model is likely to pay for itself in its entirety; or, at a minimum, there exists considerable risk. This risk is a constant for any overbuilder in this industry, whether public or private.

It is important to note that the financial projections by themselves do not tell the entire story of potential risks (or potential success) of each of the models. The assumptions used in the open access projections are highly subjective because very little empirical data exist. Further, even a slight variation in an assumption can greatly change the outcome. For example, just a slight increase in the access fee paid to the City by the retail provider results in a positive projected cash balance throughout the project life.

Despite the risks, however, the reasons for building the network are unchanged: the massive consumer and community benefits that flow from open fiber infrastructure, including the savings to the community from increased telework, enhanced education, greater competition, innovation, economic development, and non-quantifiable benefits.

For these reasons, and in light of the goals that motivated Mayor Newsom and the Board of Supervisors to initiate the San Francisco broadband projects, we continue to recommend consideration of the open access model.

Further, in light of the breadth of the potential benefits of this project, San Francisco (like its peers around the country) can reasonably consider funding sources beyond anticipated subscriber revenues. Most municipal FTTP ventures are funded through a combination of revenues from subscribers, internal use of fiber assets, enhanced interaction with taxpayers, and support of economic development efforts. The demonstrable benefits of FTTP make it a tool of economic and community development in much the same way as other infrastructure projects. Cities do not require bridges and roads to pay for themselves entirely through toll revenues; the business case for the road is based on the benefits it delivers to the community.

Market timing and local conditions are crucial to the potential success of a given business model. Municipalities that were the first to introduce a high-speed cable modem connection in the community had a greater chance of stand-alone business success than if similar connection alternatives were available. For San Francisco, the business model with the greatest potential of success is one that:

1. Addresses the performance and capabilities shortcomings of cable modem and DSL offerings (in other words, offers a different, better product than those currently available)
2. Meets the growing consumer desire for choice of a wide range of providers and options
3. Realizes the enormous economic development and other community benefits enabled by FTTP

To address the needs identified by the market research and the goals set forth by the City, this Report investigates the costs and potential revenues associated with six different business models for the City's consideration. That analysis primarily addresses the quantifiable, direct financial factors that are relevant to the potential internal business plan for the models under consideration, but is not intended to suggest that cash flow is the only factor of significance. Rather, as noted above, the business case for municipal communications networking extends far beyond the pro forma income statements—such projects are undertaken not to realize revenues but rather to realize the economic and community development benefits of next generation broadband infrastructure

The following is a brief summary of the Report's analysis and conclusions with respect primarily to the direct cost and revenue aspects for each of the alternative business models. The financial[19] aspects of each model below are analyzed in detail Section 8 below.

1.4.1. Debt Financing/Retail Overbuild: City Deploys FTTP & Provides Services

In this model, the City builds FTTP infrastructure and offers retail telephone, television, and Internet services to businesses and residences. Financing of this network is through bonding secured through identified City funds or other revenue source. To increase the chances of initial success, the City could outsource a portion of the management and operations.[20]

With respect to direct financial factors, CTC advises caution with respect to a "pure" retail FTTP network operated by the City. Although the market research indicates a potential for the City to obtain the market penetration necessary to support cash flow[21] for a retail model, sustaining the market penetration is likely daunting. Further, the addition of one more facilities-based competitor does not fully address San Franciscans' demonstrated need wide choices of providers and service offerings.

Our analysis indicates the required initial financing for a retail FTTP model is approximately $580 million. The financial analysis projects a year 20 cash balance shortage of $30.1 million (this cash balance does not consider the range of external benefits discussed above). In addition, the financial model[22] includes funds to replenish consumer and network hardware. If these costs are capitalized and financed with debt rather than expensed and financed with cash, the model approaches a break even cash flow projection.

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[19] The projections used in this analysis were prepared to assist the City to assess the financial feasibility of establishing a broadband utility to offer connectivity services to residents and businesses in San Francisco. Where appropriate, the analysis includes projected operating revenues, expenses, and cash flows for the life of the system based on estimated construction costs and various market penetration rates. This analysis should not be used for any other purpose. There will usually be differences between the projected and actual results, because events and circumstances frequently do not occur as expected, and those differences may be material. CTC has no responsibility to update or certify this projection for events and circumstances occurring after the date of this Report.

[20] For example, Bristol Virginia Utilities (BVU), an early entrant in the municipal FTTP retail market, has expanded its services to include operations support. Its first customer is MI Connection, a municipal cable television and Internet operation that serves Mooresville, Davidson, and Cornelius, North Carolina. BVU manages day-to-day operations and MI Connection employs staff recruited and hired by BVU.

[21] Based on a potential cash flow objective for the retail model to remain a self-supporting enterprise which generates sufficient revenue to cover operation expenses and debt service.

[22] The equipment replenishment expenses are included in of the business models presented in this report. The replenishment expenses are often overlooked or not included.

1.4.2. Debt Financing/Open Access: City Deploys FTTP & Sells Capacity to Competitors

In this model, the City builds, owns, and operates fiber optics all the way to the home and business. Retail providers lease access to the infrastructure which they use to deliver phone, cable, and Internet services to consumers. Financing of this network is through bonding secured through identified City funds or other revenue source.

This involves significant risk with respect to recovery of project costs through network revenues. A number of factors outside the control of the City (such as (1) the interest of retail providers to offer services over the network and (2) the retail providers' marketing success)[23] have the potential to reduce revenues below break-even cash flow needs.

Our analysis indicates the required initial financing for an open access FTTP model is approximately $570 million. The financial analysis projects a year 20 cash shortage of $53.9 million.

1.4.3. Equity Participation/Open Access: Subscribers Finance "Last Mile" of City Network

In this model, as in the case of the open access model, the City builds FTTP infrastructure. Retail providers then lease access to deliver retail services. In addition to debt financing secured by the City, one-time connection fees[24] are collected from the property owners who request that their premises be connected to the network.

This model has some potential to stimulate private efforts to offer diverse, cost-competitive services to residents and businesses.

This is a model that has met with some success in Europe and that is under consideration for the UTOPIA network of 16 communities in Utah.

Assuming the same market shares as used in the retail model, our analysis indicates the required initial financing of the equity model is approximately $320 million. The financial analysis projects a year 20 cash balance of $69.3 million. The market research suggests that interest in the equity model is substantially lower than would be required to make this model work, in part because the model is new, unfamiliar, and not well understood. As a result, the City faces the challenge of demonstrating the benefit of fiber ownership and convincing residents to pay for their fiber connections on the basis of long-term reduced service fees and potential increases in property value.

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[23] The well-known UTOPIA (Utah Telecommunications Open Infrastructure Agency, a joint project of 16 communities in suburban and rural Utah) network encountered exactly these problems—difficulty finding providers to offer services over the network, and uneven marketing efforts by those providers that did offer services.
[24] The financial analysis assumes a one-time fiber purchase/connection fee of $2,500.

1.4.4. Essential Service/Open Access: Property Assessments Finance FTTP Deployments

In this model, as in the case of the open access model, the City builds FTTP infrastructure. Retail providers then lease access to deliver retail services. In addition to debt financing secured by the City, one-time assessments are collected from all property owners.

This model has potential to stimulate private efforts to offer diverse, cost-competitive services to residents and businesses.

Assuming the same market shares as used in the retail model, our analysis indicates the required non-assessment financing is approximately $160 million. The financial analysis projects a year 20 cash balance of $102.7 million. Lowering access fees over time will draw down this projected balance, however cash balances in the early years of operation are negative.

1.4.5. Infrastructure Participation/Open Access: The City Encourages Private Investment

The City owns assets in key locations that could reduce FTTP deployment costs for a new City enterprise or a private sector communications provider. Construction costs could be reduced through use of such assets as fiber optics, communications conduit, and facilities.

In this model, the City makes available to a private sector entity, for lease, selected assets that will enable the private entity to more efficiently and expeditiously build and operate a network. This is the model that is under consideration in Portland, OR and Palo Alto, CA.

Extending fiber into business parks and selected neighborhoods could provide some attraction to a private sector investor or operator. The City of Palo Alto is currently negotiating with a consortium of companies for FTTP financing, construction, and operations. According to information available as of this writing, the City will be required to provide substantial fiber assets but not financing, although it may be asked to guarantee the private Consortium's investment.

To attract an investment, City financing guarantees may be required—entailing City risk but with limited control. Given current market and economic conditions, we believe it will be challenging for most communities to encourage a private sector FTTP deployment, but San Francisco may be an exception, given the high demand and sophisticated data use in the community.

1.4.6. Key Account Model: The City Builds and Leases a Modest Fiber Backbone

In this model, the City seeks to offer dark fiber[25] connections, through a lease, to institutions and businesses in San Francisco. The City can lease the excess fiber to recover incremental costs, so long as the leased fiber contract is structured so it does not violate internal, state, and federal

[25] Dark fiber refers to the lease of point-to-point fiber strands. The lessee of dark fiber is responsible for adding electronics to "light" the fiber.

safety requirements. Under the lease, the City would receive a revenue stream with very little risk associated. This model requires less involvement in operations than does a retail model because it does not require the City to go into the business of providing communications services itself. At the same time, the model leverages the electric and other departments' considerable right-of-way knowledge and utility maintenance capabilities.

CTC's experience suggests that this is the business and technical model with the highest possibility of financial success and with the lowest risk for the City. This model can facilitate a modest portion of the goals of the City while still minimizing risk. This model requires a smaller capital investment than does more extensive fiber deployment and the available data suggest that the City could realize a modest revenue stream from this model—at the same time as meeting its own communications needs and reducing the cost of leasing circuits.

This model for fiber construction and leasing has been successfully implemented by another large city municipal electric utility for nearly a decade. A case study of this utility's fiber leasing experience is provided below.

Although some dark fiber exists in San Francisco, the existing providers are generally unwilling to lease to new, competing providers or to themselves offer dark fiber as an alternative to their lucrative provisioned circuits such as Ethernet.

Significantly, though this model will fill a market vacuum for selected business customers, it will not address the needs of residents and small businesses throughout the City. The Key Account model does offer some incentives for a private provider to construct FTTP infrastructure, but is unlikely to be enough to attract private sector investment in FTTP because it does not significantly lower the costs of market entry.

1.5 Summary of Technical Findings: Fiber is Superior to Alternatives for Capacity, Security, and Long-Term Cost

The market research identified three core issues related to connectivity services in San Francisco; speed,[26] price, and choice of providers. To address the speed issues identified, a FTTP network is required. Wireless alternatives do add a layer of mobility, but do not advance capabilities beyond cable modem and DSL alternatives. Further, addition of another Hybrid Fiber/Coax (HFC)[27] or Fiber-to-the-Curb (essentially, hybrid fiber/copper)[28] network does little to address San Franciscans' growing needs for network performance.

1.5.1. Existing Networks are Not Technically Capable of Speeds Enabled by Fiber

[26] Includes speed (Mbps) and capacity (Bytes per day).
[27] Used by Comcast and Astound to support cable modem service.
[28] AT&T uses this architecture in its U-Verse DSL offering.

Fiber technology offers speeds and capacity that are several orders of magnitude removed from the other technologies that are considered to "compete" with it—as a technical matter and as a matter of physics, those technologies cannot compete with fiber:

- Copper networks, operated by the phone companies, including AT&T, with some fiber in the core of the network, but with much of the "last mile" copper dating back many decades and, in some cases, a century
- Coaxial networks, operated by the cable companies, including Comcast and Astound, also with fiber in the core of the network, but with coaxial cable in the last mile that was deployed in the 1970s and 1980s
- Wireless networks, which offer tremendous benefits with respect to mobility and convenience, but which are limited in speeds and therefore serve as complements—not alternatives—to high-bandwidth wired connections like fiber

All of these networks deliver products defined as "broadband" under the FCC's definition, but it is important to put that definition in perspective: the FCC's 2008 definition of "basic broadband" is downstream (not symmetrical) speeds between 768Kbps and 1.5Mbps -- higher than the previous definition of 200 Kbps but still laughably low. As one observer has noted, it would take 8.16 hours to download under the old broadband definition; at the new definition, an American with basic broadband will need 2.12 hours to download a movie.[29]

A service or product that meets even the ceiling of this definition (1.5Mbps) will deliver one 600th of the speed that fiber can deliver using existing, affordable, off-the-shelf technologies (Gigabit Ethernet, 1,000 times one megabit). These speeds will grow dramatically as new technologies become available. The speeds possible over copper, coax, and wireless speeds will also grow, but as a matter of physics, cannot keep up with fiber's ability to scale.

Gigabit over fiber offers more than 25 times the maximum capacity of advanced cable networks,[30] more than 75 times the capacity of advanced copper/phone networks,[31] and 250 times the capacity of the fastest, most sophisticated commercial wireless services currently available to consumers on PDAs and laptops.[32]

Gigabit speeds represent the norm for consumer-grade connections in such cities as Tokyo and are being deployed in Singapore, Amsterdam, Stockholm, and elsewhere. China is aggressively

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[29] "FCC Definition for Broadband Now 786 Kbps," http://elliottback.com/wp/archives/2008/03/22/fcc-definition-for-broadband-now-768kbps/.

[30] Based on maximum possible downstream speeds on a DOCSIS 1.1/2.0 network of approximately 38 Mbps. Note that cable modem networks are usually engineered to enable far slower upstream speeds.

[31] Based on maximum downstream speeds on a VDSL network of approximately 13 Mbps with a maximum distance of 5,000 feet between the customer premise and provider Central Office. Note that DSL networks are usually engineered to enable far slower upstream speeds.

[32] Based on advertised maximum downstream speeds of 4 Mbps for Sprint's WiMAX-based XOHM service, currently available only in limited markets. Note that wireless networks are usually engineered to enable far slower upstream speeds.

moving to deploy fiber networks, and is considering technologies that will deliver 10 Gbps (gigabits per second)[33]—more than 10,000 times the speed the FCC considers to be broadband.

Put another way, while the Chinese and Japanese are contemplating deploying two-way (both up and down-stream) 10 Gbps, the U.S. cable industry is considering shared, one-way (downstream-only) speeds of 150 Mbps and U.S. phone companies (excluding Verizon with respect to its limited FiOS deployments) are discussing migrating to one-way (downstream-only) speeds of 25 Mbps.

1.5.2. Fiber Holds Advantage over Copper/Coaxial Technologies

Copper wire has been widely used for carrying voice, video, and data since the days of the telegraph. Progress in telecommunications technology and the growth in popularity of the Internet was characterized by a transition to digital modes of communications and higher demands for communications capacity. As a result, copper telecommunications networks were retrofitted for transferring data as well, with an ongoing shift in the network architectures to support the growing demands.

Copper cabling is predominantly found in two forms: coaxial (coax) cables and twisted-pair cables. Coax cables were originally used for carrying video signals within cable television systems and radio frequency (RF) signals to and from antennas within wireless systems. Twisted-pair copper wire was developed from the invention of the telegraph, and was later used in the traditional telephone industry. Due to rising demands for Internet connectivity, cable TV companies and traditional phone companies adapted their infrastructure with new technologies, including cable modems and digital subscriber line (DSL), to begin offering higher speed data services than simple telephone lines could support.

Coax cables, on the other hand, have one central conductor surrounded by a conductive shield that blocks interference electromagnetic interference (EMI) from outside sources. Insulating layers separates and protects each conductive component.

All copper cables use electrical signals to transfer information between users. Optical fibers use light rays to transfer the same information through their glass cores. The core is usually made out of specialized glass with low optical attenuation. The cladding, coating, and housing serve to protect the optical core and minimize the optical loss of the core.

Optical fibers and copper cables have different physical compositions, which give the optical fibers inherent advantages over their copper counterparts. For a given expenditure in communications hardware, fiber optics can reliably carry many times more capacity over many times greater distances than copper wires of any type – far superior in both regards.

[33] Lynn Hutcheson, "Is China poised to take the lead in FTTx subscribers?," Ovum Telecoms and Software News, November 24, 2008, http://www.ovum.com/news/euronews.asp?id=7525.

The biggest advantage that fiber has over copper is the theoretically unlimited bandwidth that it can provide. This bandwidth is only restricted by the electronics at either end of the cable; modern fiber equipment is capable of speeds on the order of terabits per second over a single "strand." In addition, not only do fibers provide more bandwidth, they are able to do so over longer distances as compared to copper cables without necessitating regeneration or amplification, both of which can reduce signal reliability and capacity while increasing costs.

Bandwidth limits on copper cables are directly related to the underlying physical properties of copper. Copper conducts electrical signals at various frequencies, and higher data rates over copper require higher frequencies of operation. Twisted pair wire is limited to a few hundred megahertz in usable bandwidth (at most), with dramatic signal loss increasing with distance at higher frequencies. This physical limitation is why DSL service is only available within a close proximity to the telephone central office. Coaxial cable has a frequency bandwidth of approximately one gigahertz, or more; therefore its capacity is greater than that of twisted pair. Despite its higher capacity, coaxial cable does experience signal attenuation at higher frequencies similar to twisted pair. In other words, coaxial cable is incrementally more capable than twisted-pair wire, though it is still not comparable to the exponentially greater upper limits of fiber. In fact, fiber optics cables have a theoretically unlimited bandwidth, and today can support data rates of hundreds of gigabits per second in a practical sense.

Within a fiber optic strand, an optical communications signal (essentially a ray of light) behaves according to a principle referred to as "Total Internal Reflection" that guides it through the optical cable. Optical cables do not use electrical conduction, and thus do not require a metallic conductor, such as copper, as their propagation medium. Hence, optical communications signals do not experience the significantly increased losses as a function of higher frequency transmission experienced by electrical signals over copper cables. Further, technological innovations have allowed for the manufacturing of very high quality, low impurity glass that can provide extremely low losses within a wide range of frequencies, or wavelengths, of transmitted optical signals, enabling long range transmissions. Compared to a signal loss on the order of tens of decibels (dB) over hundreds of feet of coaxial cable, a fiber optic cable can carry a signal of equivalent capacity over several miles with only a few tenths of a dB in signal loss.

Even with technological advances, copper cables will not be able to live up to customer requirements. This is why communications carriers and cable operators are deploying fiber to replace large portions of their copper networks, and on an increasingly larger scale. Fiber optics is one of the few technologies that can legitimately be referred to as "future-proof," meaning that they will be able to provide customers with larger, better and faster service offerings as demand grows.

Fiber is able to provide better signals over longer distances. This does not hold true for copper cables since copper is susceptible to cross talk, signal attenuation, and interference that degrade the signal quality. The length of the cable plays an important role in this, because longer cables result in greater losses at any bandwidth or frequency of operation. To compensate for this, electrical signal needs to be amplified or regenerated every few thousand feet using repeaters and amplifiers, whereas fiber optic signals can travel hundreds of miles without regeneration. This reduces the complexity and expense of operation and maintenance of networks comprised of fiber.

Optical fibers do not conduct electricity and are immune to other electromagnetic interferences. These properties allow optical fibers to be deployed where conductive materials would be prohibitive, such as near power lines or within electric substations. Moreover, the cables do not corrode in the way that metallic components can over time, due to weather and environmental conditions, further reducing maintenance costs.

Copper cables transfer data in form of electrical signals. This makes the data less secure, since it is possible to physically "tap" in to the cables, especially twisted pair, and observe the data. Optical fibers are much more difficult to tap without breaking the connection, making the data they carry more secure.

1.5.3. Fiber Holds Advantage over Wireless Technologies

Fiber and wireless are frequently posited as competing technologies, a common — but inaccurate — perception. Neither can supplant nor compete with the other; rather, ***these technologies inherently enhance and complement each other***. Wireless delivers mobility and fiber delivers capacity and speed. In addition, wireless needs fiber: for purposes of reliability and speed, a wireless network requires a robust fiber optic core backbone that connects it to core resources, to the Internet, and to other public networks. High wireless performance depends on backhaul over a core fiber network and, correspondingly, a wireless network will deliver poor performance if backhaul is inadequate, regardless of the quality of the wireless network itself.[34]

Each network technology has its own distinct advantages and challenges, but CTC finds that fiber is a more flexible, future-proof, and capable technology for purposes of the goals of this project—and a far less risky investment.

Wireless networks provide mobility and flexibility. Wireless holds a benefit with respect to speed to deployment and flexibility. However, there are significant challenges in providing effective wireless service. Design limitations such as power levels, spectrum availability, and required data capacity require that individual antennas or base stations serve limited areas, such as one mile or less. The challenge of deploying and managing wireless is also complicated if unlicensed frequencies are used for such technologies as WiFi. Further, when a wireless provider needs to migrate to a more advanced technology platform, it may need to re-engineer and redesign its entire system.

Fiber networks hold the advantage in capacity, robustness, and security. Fiber provides almost unlimited capacity. Each single fiber optic strand is theoretically able to duplicate the entire electromagnetic spectrum available to all wireless users. In a practical sense, the capacity limit is imposed by the capability of the electronics connected to the fiber. Further, capacity is

[34] In our analysis, the unsuccessful attempt to use (supposedly) lower-cost wireless backhaul was one of the key reasons for the technical failure of many of the high-profile municipal wireless initiatives of recent years.

constantly increasing as technology improves. Fiber has a life of decades, assuming adequate maintenance, and it can cost-effectively and simply be scaled to dramatically higher speeds as new electronics become available.

There are significant challenges in fiber optic network technology, especially in the high cost of initial construction—particularly for underground installation or where extensive make-ready is required for aerial installation.

2 Results of Market Research

This Section of the Report describes the results of the market research conducted by CTC's market research team during the summer of 2008.[35] In total, we completed and analyzed telephone surveys of 500 randomly-selected businesses and written surveys of 868 randomly-selected residences.[36] The surveys provide market information about Internet, telephone, and cable television services and gauge interest in a Citywide high-speed broadband network.

The market research has a number of key uses including:

1. Enables the City to determine the support among San Francisco residents and businesses in San Francisco playing a role to facilitate deployment of broadband networking resources.
2. Identifies the areas where the existing private market is failing to meet the needs of San Francisco's businesses and residents.
3. Provides data regarding the potential market in San Francisco for a new entrant into the broadband space—with respect to voice, video, and a range of data services. To this end, this Report uses the survey results to provide inputs (particularly with respect to potential revenues) for each potential business model's financial and feasibility analysis.
4. Provides background data to project how higher-speed broadband might increase telework, and thereby realize efficiency benefits for the San Francisco community by reducing commute times, gas costs, vehicle use costs, and carbon emissions.[37]

Key findings of the market research study include:

1. Internet use is high in San Francisco. Approximately 93 percent of San Francisco businesses and 90 percent of residents have Internet access. Over 95 percent of all Internet subscribers[38] have high-speed (DSL, cable modem, wireless) connections.

2. Public support for municipal broadband is high. Almost one-half of businesses and residents agree that the City should build a publicly-financed network for private firms to provide Internet, phone, and television services.

3. The City's name and brand are no detriment to the potential project. There is no statistical difference between consumer support for a City broadband network versus one that is unaffiliated with the City—suggesting that the City has a neutral brand image with regard to provision of broadband services—the City's name and/or sponsorship would be

[35] This Section simply summarizes and reports the data; the data is then analyzed and applied to various business plans in the Sections below.

[36] CTC's market research team includes CTC (designing the survey and analyzing results); WS Live of Cedar Rapids, IA (conducting phone surveys); and Clearspring Energy Advisors of Madison, WI (conducting survey statistical analysis, managing written survey distribution, and providing data entry for written survey results).

[37] These potential efficiency benefits are analyzed in some detail later in this Report.

[38] 97 percent of business and 95.5 percent of residential Internet users.

neither a benefit nor a detriment for marketing a network or endorsing one provided by a private investor.

Summary of Findings Regarding Business Market

4. San Francisco business are comfortable with telework and would allow more telework if more bandwidth were available. The number of businesses supporting teleworkers is very high, and the potential for growth is apparent. Business responses also indicate a concern about the capacity of existing infrastructure as the teleworker market and file sizes grow. More than one-third of all businesses indicated that they would encourage more telework if employees had faster home Internet connections that could support video teleconferencing and large data transfers.

5. The connection speed and price present the largest gap between satisfaction and importance, although 70 percent of respondents indicate they are very or somewhat satisfied with connection speed. Today's businesses have a need for speed beyond those supported with cable modem and DSL, and are with the early adopters in the financial and service industries. The gap that exists between importance and the satisfaction with price is not surprising. While it does present a minor opportunity, a new market entrant will need to price access services significantly below the competition to take advantage of it. Furthermore, the competition will drop their prices. Fifty-seven percent of business respondents indicated they are very or somewhat satisfied with the price they pay for Internet while only 25 percent indicate the market is structured to deliver affordable services.

6. The high-end business market is risk-averse. The businesses leasing high capacity circuits (T3 and above) are more risk averse and are more satisfied with existing services.

7. Telephone service is clearly a commodity. Purchase decisions are driven primarily by price and any new entrant to this market would have to offer extremely low prices to attain market share.

8. Cable television service is not in demand in the business market. Unless support of a cable television service for business can be added to a residential offering at a low or no incremental cost, it will likely be difficult to support from a cash flow perspective.

Summary of Findings Regarding Residential Market

9. San Francisco residents demonstrate an interest in telework and a need for greater bandwidth to facilitate telework. More than 56 percent of respondents indicate an interest in telework. Almost 67 percent indicate a need for speeds greater than DSL or cable modems to effectively work from home.

10. Connection speed, price, and wireless access present the largest gap between satisfaction and importance. For example, less than 40 percent of respondents indicated they are very

satisfied or satisfied with connection speed, while 90 percent indicated speed was very important or important. Less than 27 percent of respondents indicated they are very satisfied or satisfied with price paid, while 83 percent indicated price was very important or important.

11. Residential telephone service has become a commodity product. A significant volume of voice service is moving to wireless and Internet-based providers, and the market share of traditional landline telephone services is rapidly shrinking.

    a. Over 45 percent of respondents consider their wireless phone as their primary number and only 52 percent of respondents consider their landline telephone to be their primary telephone number. This percentage is highly dependant upon age -- only 27 percent of respondents under the age of 35 reports using a landline as their primary number, while 93 percent of respondents over the age of 65 indicate that the landline is their primary number.
    b. Only 84 percent of respondents maintain a landline telephone -- 70 percent from AT&T and 14 percent from their cable television provider.
    c. Almost nine percent of respondents use an Internet-based telephone service from online providers, such as Skype or Vonage.

12. Residential video subscription rates are lower in San Francisco than many comparable markets. Slightly over 62 percent of respondents subscribe to cable (51.1 percent) or satellite (11.2 percent) television service. These video subscription numbers are low relative to other, comparable markets. This is possibly because of the high use of free, broadcast programming (23.2 percent) and because of the high use of Internet-based viewing alternatives (9.9 percent). In addition, 4.6 percent of respondents indicated they do not watch television at home, a relatively high number.

2.1 Business Survey Results

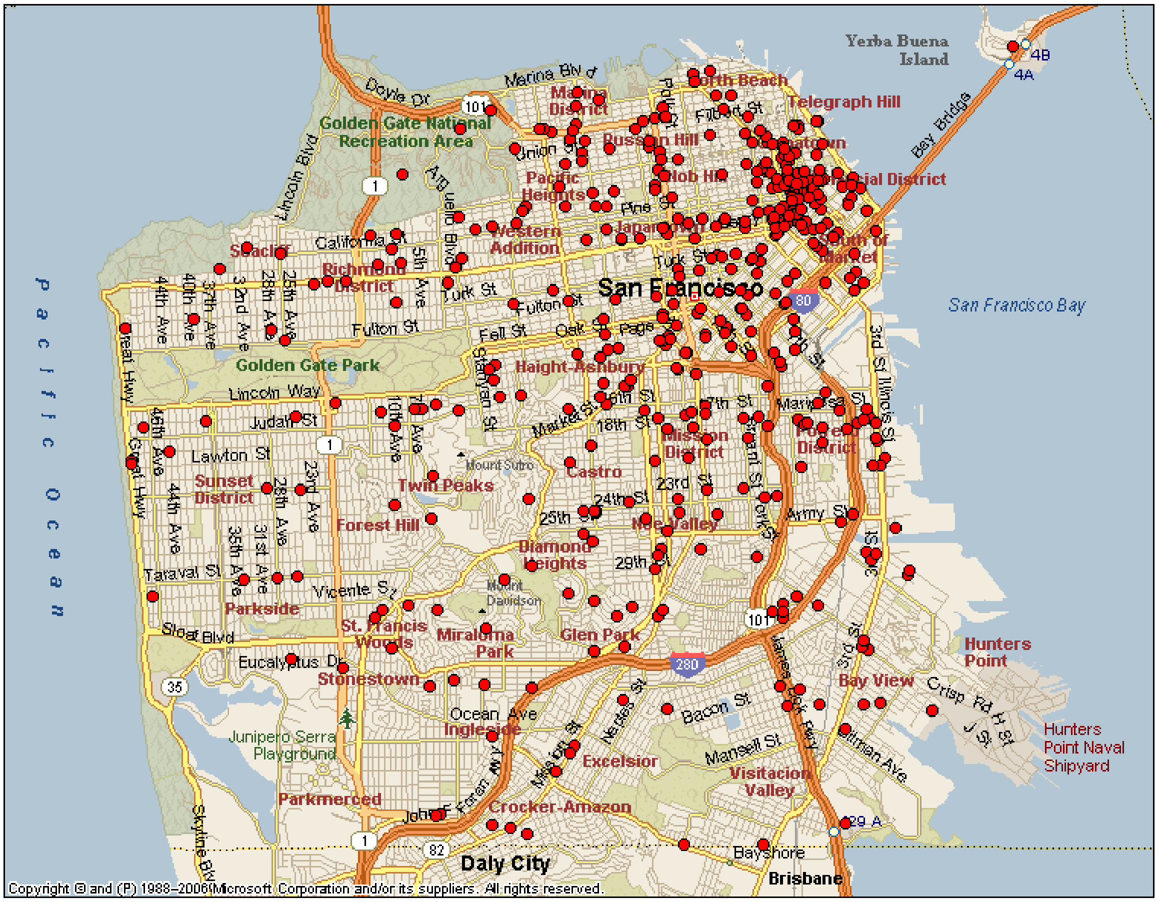
The CTC market research team conducted telephone surveys of 500 randomly-selected San Francisco businesses in July 2008 to solicit information about their communications services and needs. Assuming a total of 30,000 San Francisco businesses,[39] 500 completed surveys provide results with a confidence interval of ±4.35 percent at the 95 percent confidence level for aggregate responses.

2.1.1. Characteristics of the Business Respondents

The locations of the businesses responding to the survey are shown in Figure 1. The responses are geographically dispersed, with higher density in the downtown area.

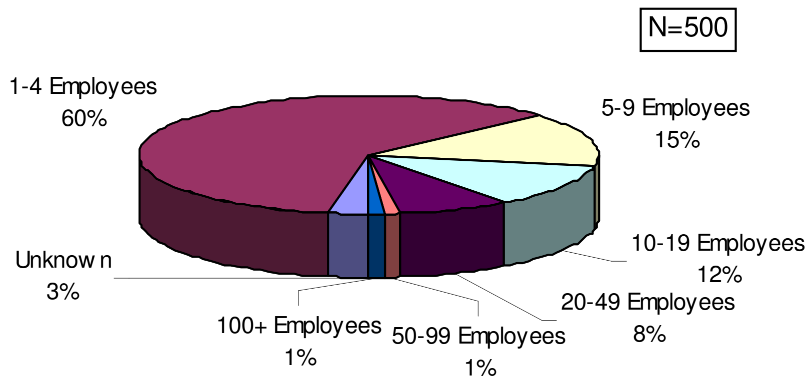
[39] Source: County Business Patterns, http://factfinder.census.gov/servlet/IBQTable?_bm=y&-ds_name=CB0600A2&-geo_id=05000US06075&-search_results=01000US&-_lang=en, accessed December 22, 2008.

Figure 1: Locations of Business Respondents



A large concentration of relatively small businesses exists in San Francisco. Figure 2 illustrates the range of business sizes of the respondents -- more than 60 percent of businesses responding to the survey had less than five employees and 90 percent had fewer than 20 employees.

Figure 2: Number of Employees of Business Respondents

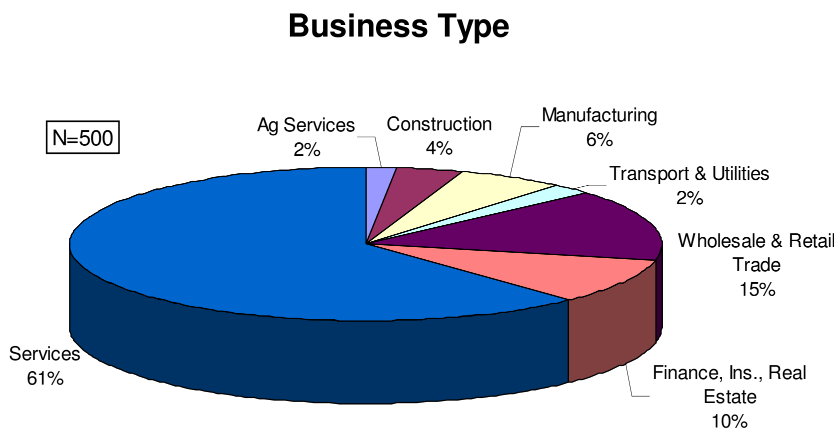


The larger business respondents are generally located downtown. Figure 3 illustrates the location of the business by number of employees.

Figure 3: Location of Business Respondents by Number of Employees

More than 60 percent of business survey respondents are in the services sector, 15 percent are in the wholesale and retail trade sectors, 10 percent in financial, insurance, and real estate sectors, and six percent in the manufacturing sector. Figure 4 illustrates the percentages by category.

Figure 4: Industry Categories of Respondents



The great majority of the business respondents, approximately 90 percent, make choices locally regarding what communications services they purchase. There appears to be a small relationship between the number of employees and where decisions are made. Almost 20 percent of businesses with 10 to 19 employees indicate that decisions are a combination of local and non-local.

Figure 5: Where Communications Purchase Decisions are Made

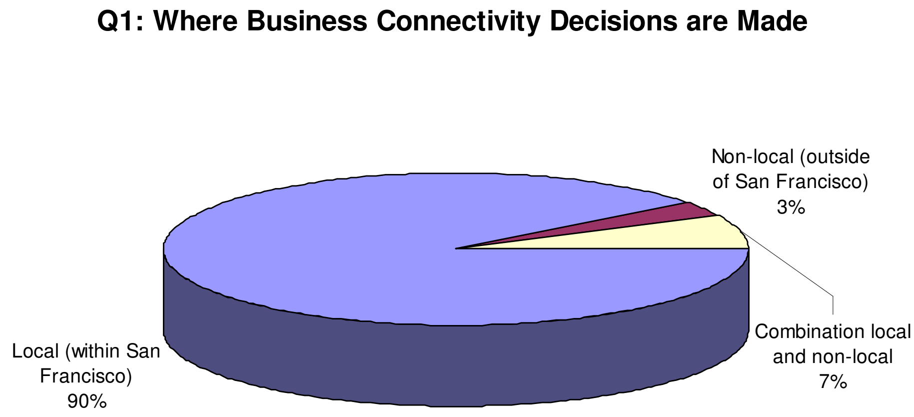
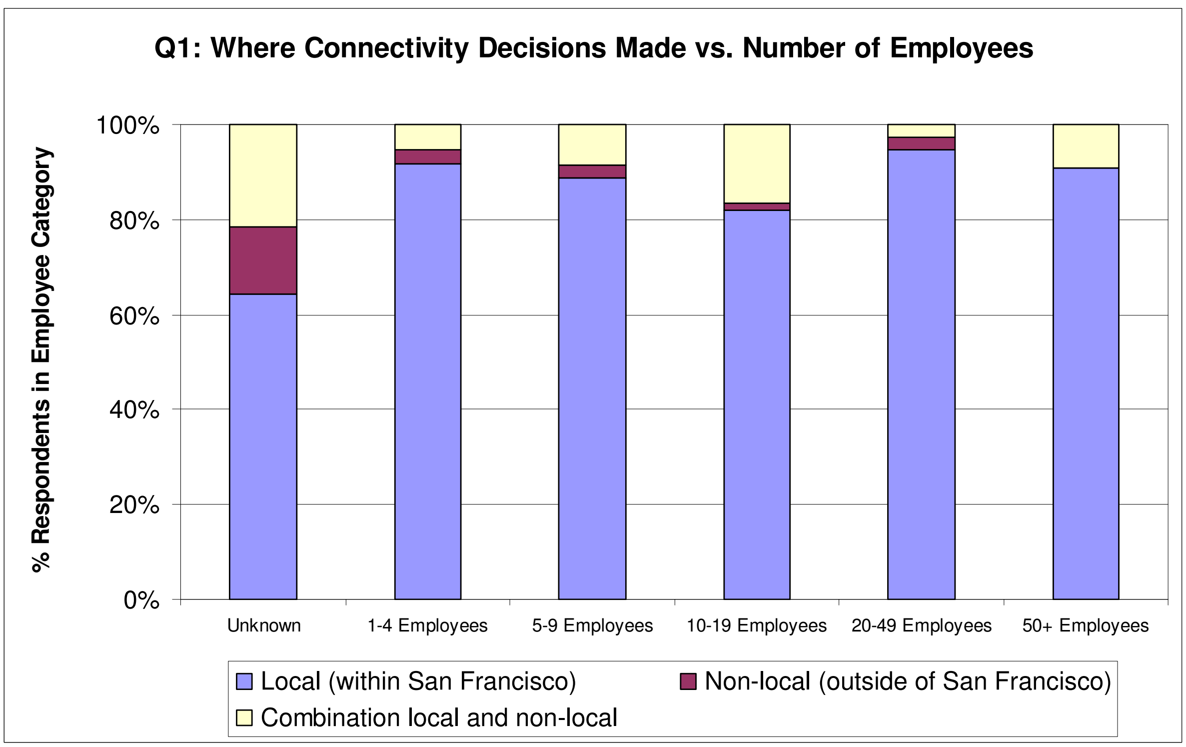


Figure 6: Relationship Between Where Purchase Decisions are Made and Number of Employees



2.1.2. Business Perceptions of Appropriate City Role in Facilitating Communications

A majority of business respondents believe that San Francisco should play a role in facilitating communications information and services.

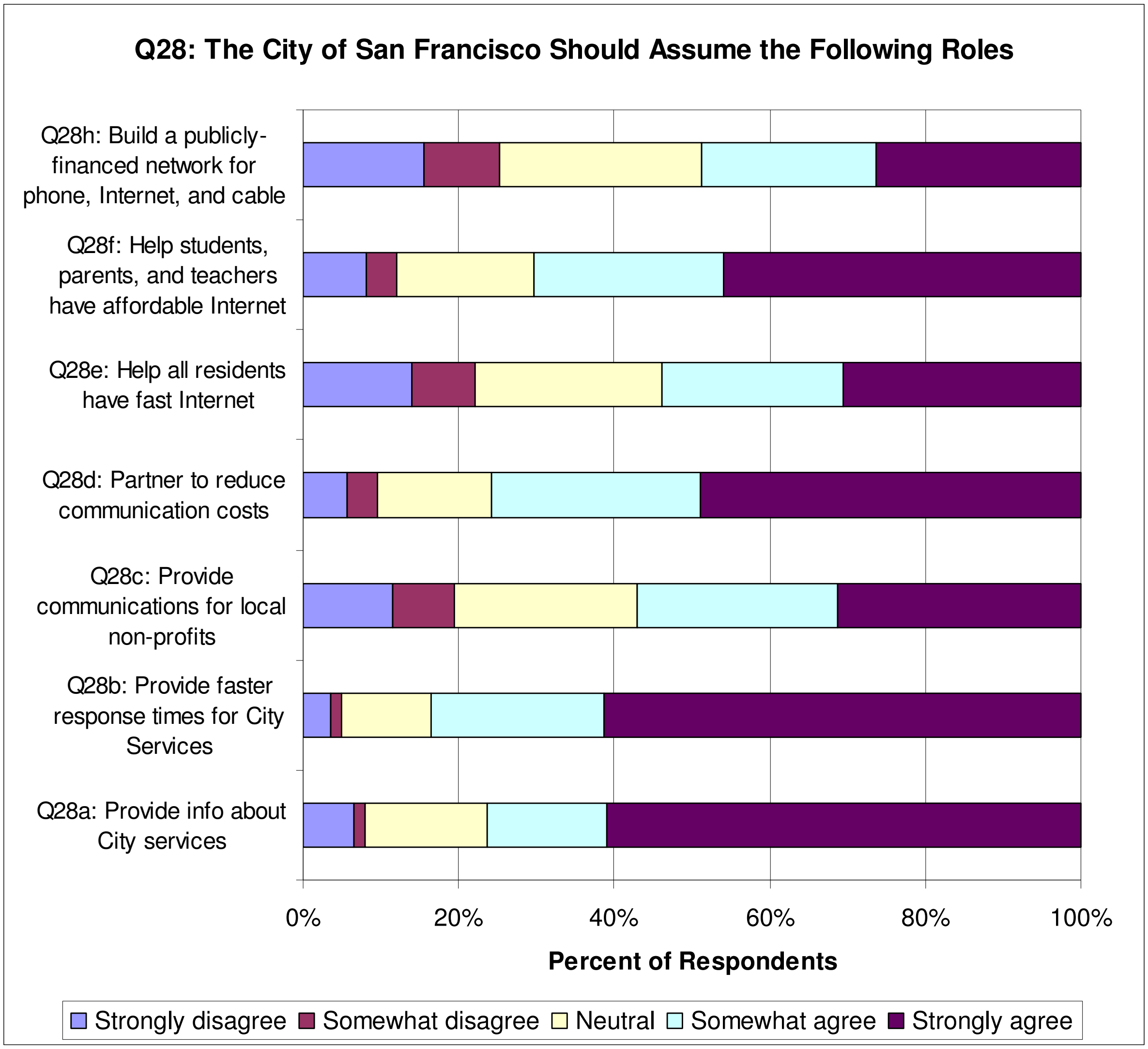
More than 70 percent of respondents believe that the City should provide information about its services, provide faster response times for City services, use partnerships to reduce communications costs, and help students and teachers have access to affordable Internet service.

Nearly 60 percent believe that the City should provide communications services for non-profits, and should help all residents gain fast Internet.

Perhaps most interestingly, nearly 50 percent of business respondents indicate agreement with the prospect that the City should build a publicly-financed communications network.

Figure 7 illustrates the percentages of business support for these propositions.

Figure 7: Business Perceptions of City Roles in Facilitating Communications

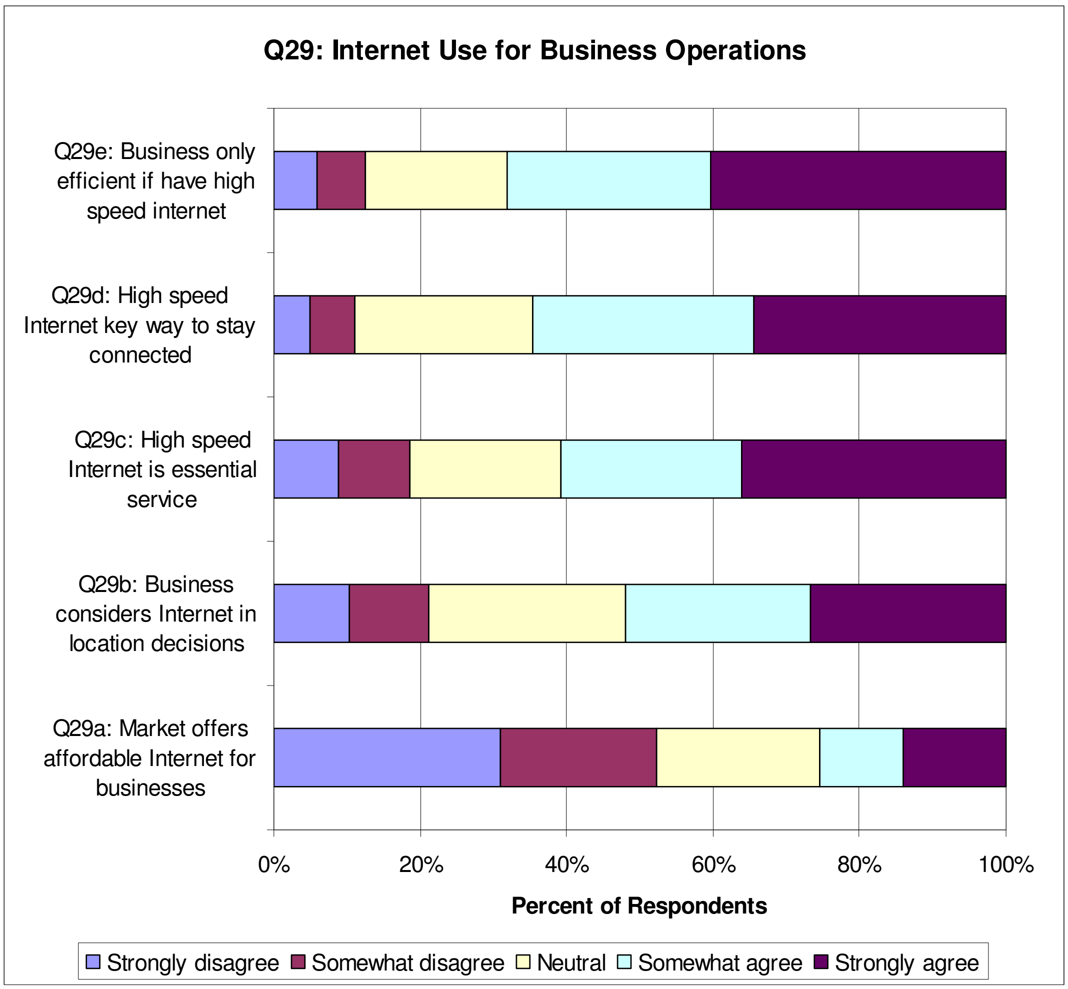


A significant number of respondent businesses believe that high-speed Internet is an important part of doing business. A majority of respondents (68 percent) indicate that businesses can only function efficiently if they and their customers have high-speed Internet access. Moreover, a majority believes that the market is not currently meeting that need -- only one-quarter of respondents somewhat or strongly agree that the market currently provides affordable Internet service for businesses while more than 50 percent disagree.

More than 50 percent also believe that Internet is an essential service, is essential to efficiency, and that businesses take Internet access issues into account in determining where to locate.

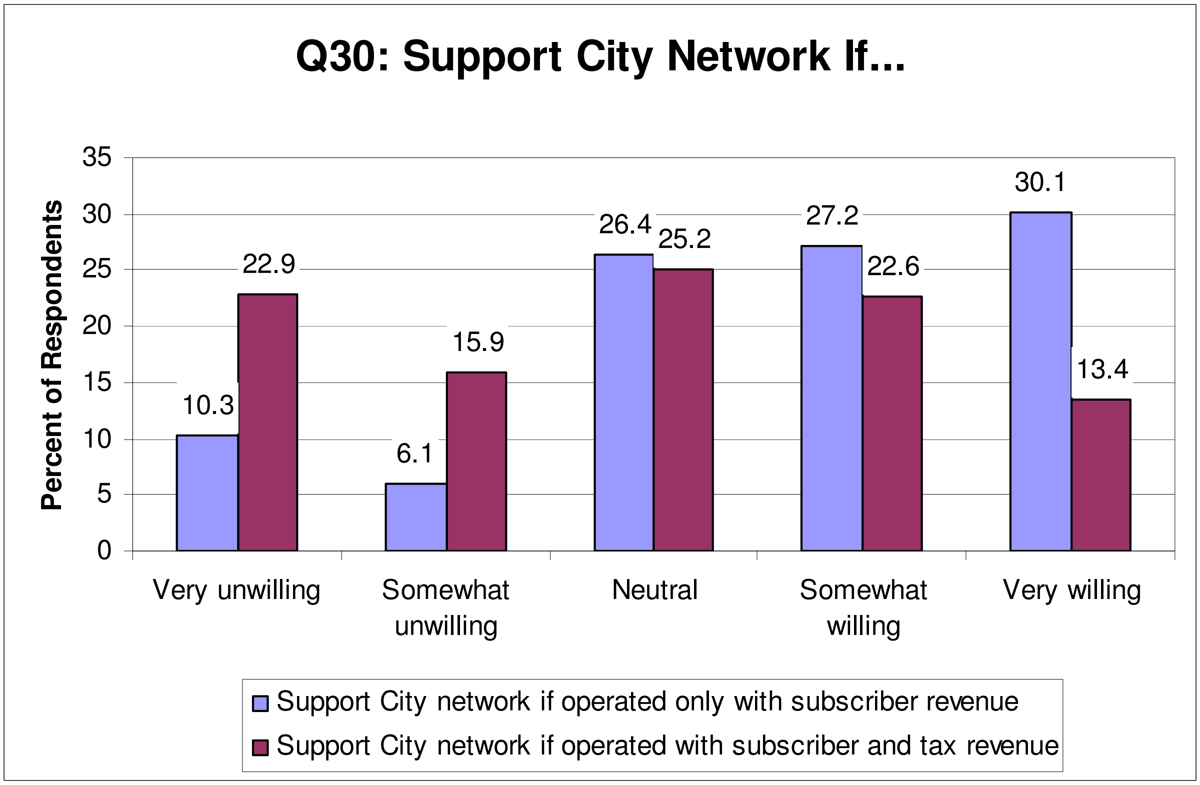
Figure 8 illustrates these perceptions of Internet Use for Business Operations.

Figure 8: Internet Use for Business Operations



More than 50 percent of respondents are somewhat or very willing to support a City-owned communications network if it is supported only with subscriber revenue, while 36 percent are willing to support a City-owned network that is supported by both subscriber and tax revenue (Figure 9).

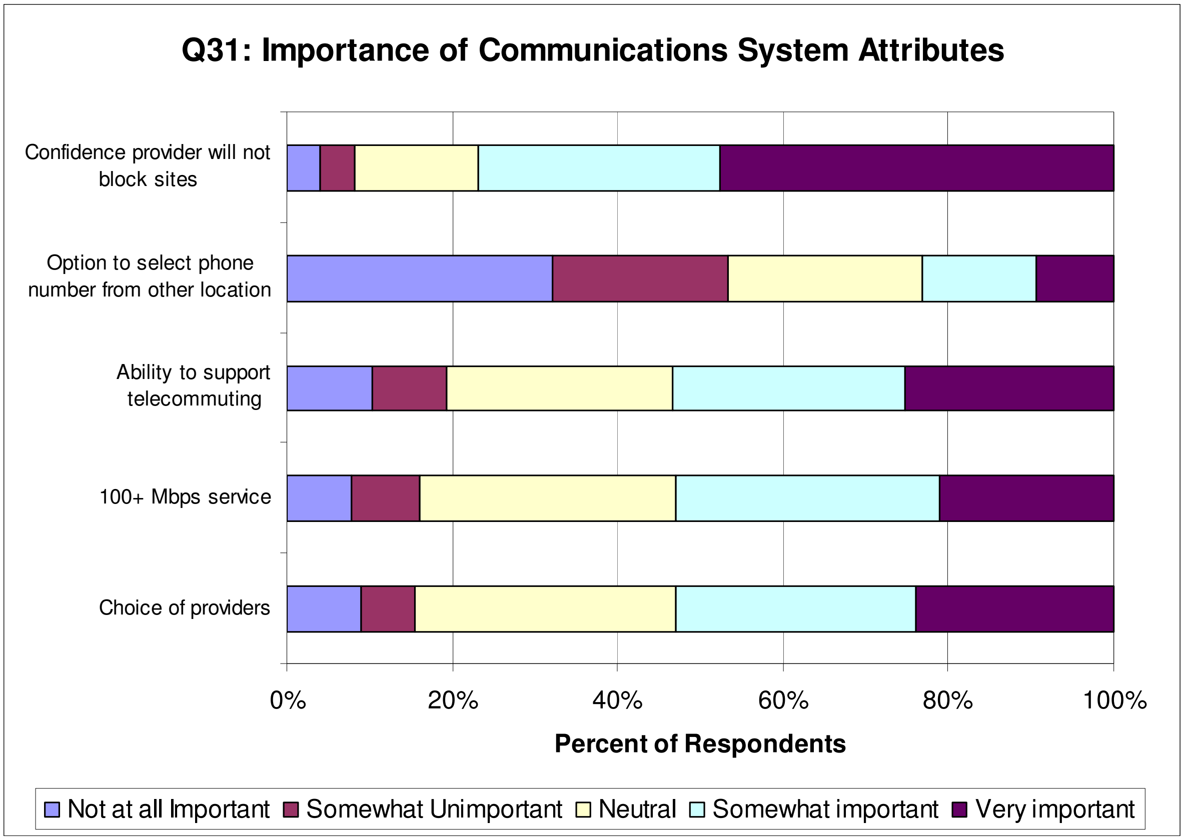
Figure 9: Impact of Use of Tax Revenue to Support Communications Network



The most important feature of communications services to the business respondents is an Internet provider that does not block sites -- more than 75 percent of respondents agree that this is somewhat or very important. More than 50 percent of respondents signal a strong interest in speeds of more than 100 Mbps, and in choice of providers and services.

There is limited interest in the choice of selecting phone numbers with a non-San Francisco area code and exchange. These interests are illustrated in Figure 10.

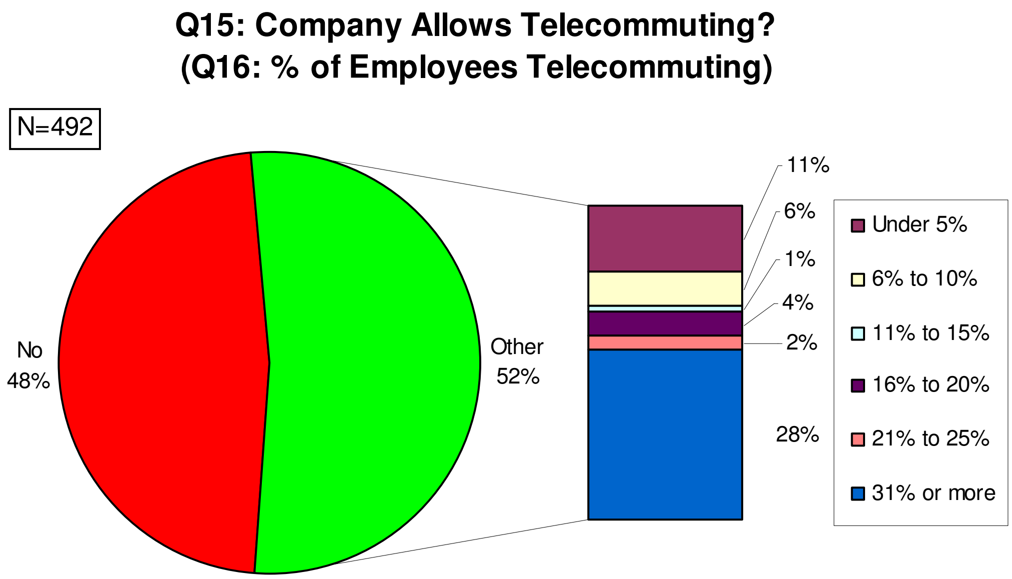
Figure 10: Importance of Connectivity Attributes



2.1.3. Business Use of Telework and Interest in More Telework

Slightly more than half of San Francisco business respondents currently allow telework. Of these, more than half report that 30 percent or more of employees telework.

Figure 11: Telework Use by Industry Category

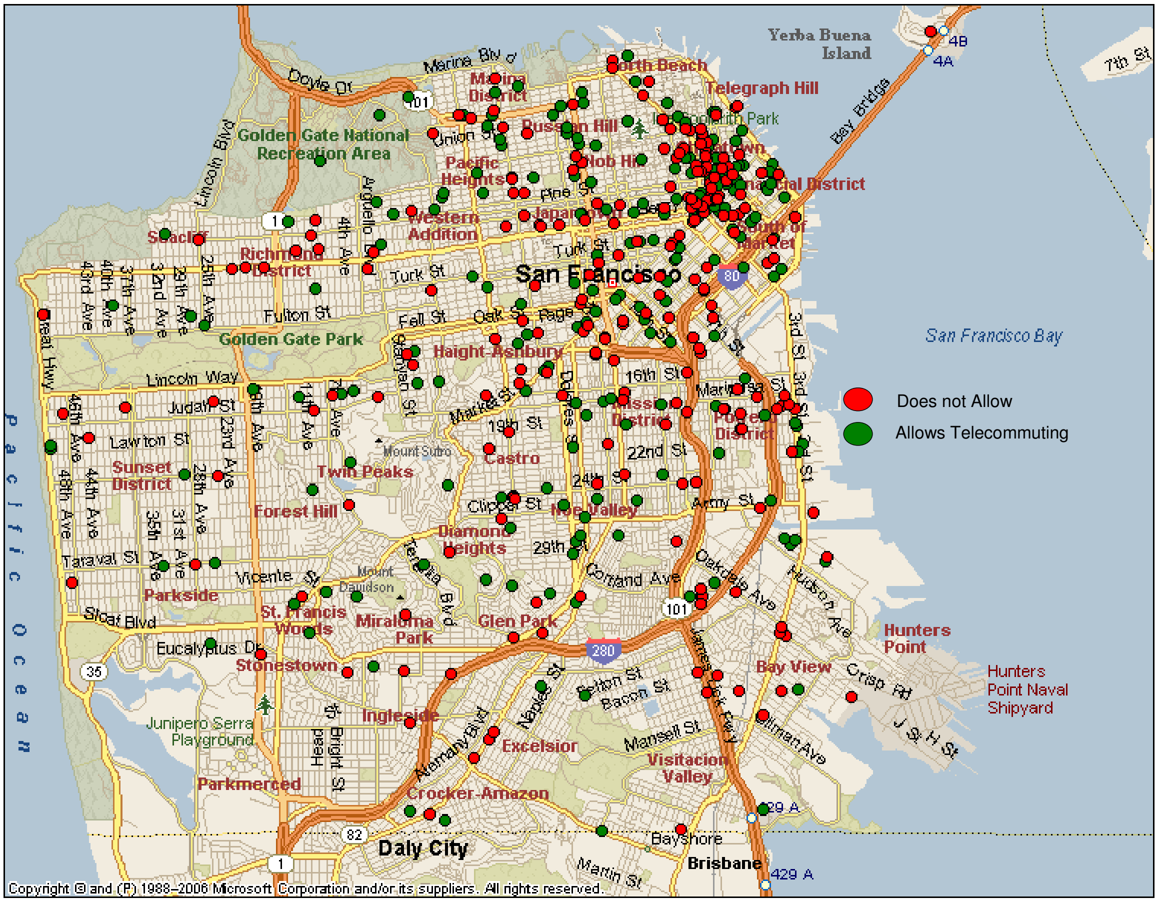


Of those businesses that do not currently allow telework, 6.7 percent may allow telework within the next year.

More than one-third of all businesses indicated that they would encourage more telework if employees had faster home Internet connections that could support video teleconferencing and large data transfers.

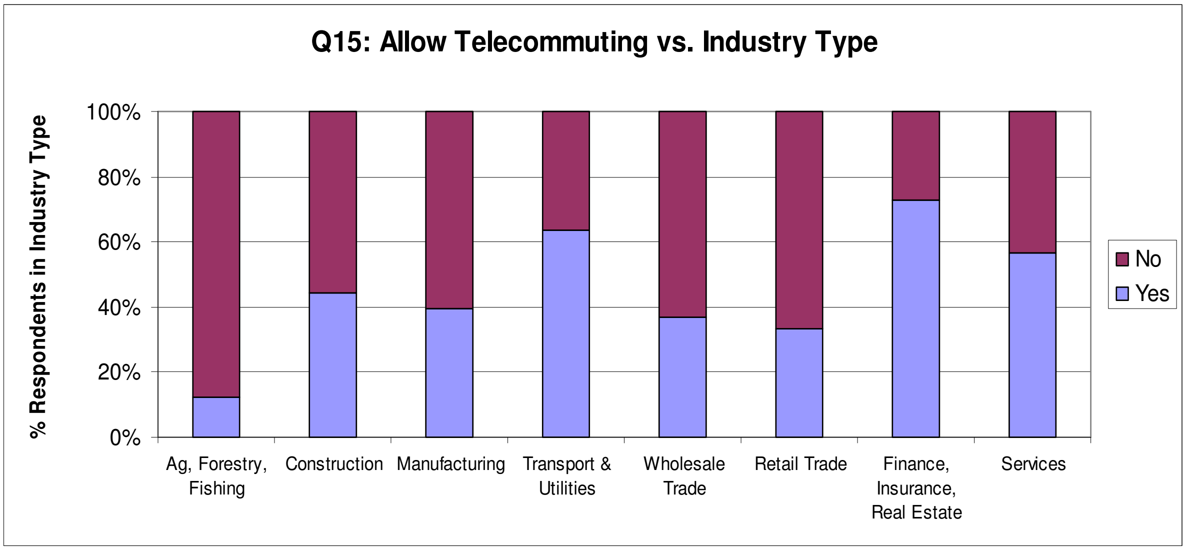
Figure 12 maps the location of the businesses and their position regarding telework. There does not appear to be any correlation or pattern between location and attitude toward telework.

Figure 12: Business Locations vs. Allowing Telework



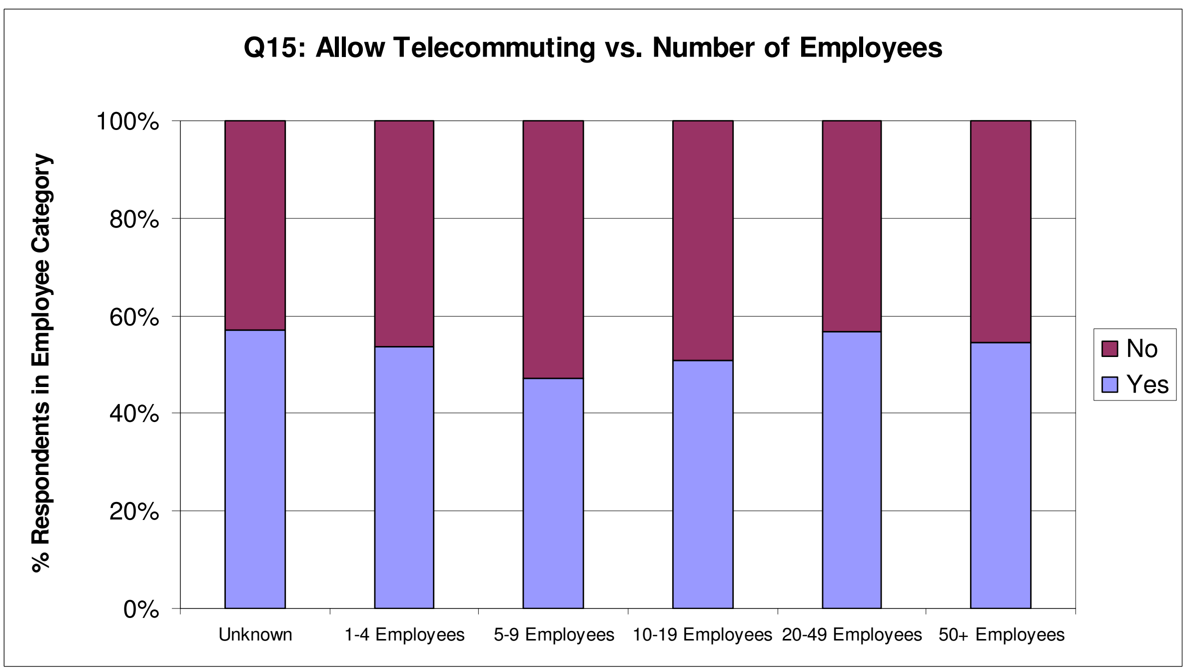
Not surprisingly, there exists a correlation between the type of business and whether telework is allowed. The finance, insurance, and real estate businesses are the most likely to allow telework, and retail and wholesale trade businesses are least likely (Figure 13).

Figure 13: Attitude Toward Telework Varies According to Type of Business



There appears to be no significant correlation between the number of employees and whether a business allows telework (Figure 14).

Figure 14: No Apparent Correlation Between Telework and Number of Employees



2.1.4. Business Interest in Paying Up-Front for Direct Fiber Connections

The survey queried businesses regarding their interest and willingness to pay a one-time, up-front fee for a direct fiber optic connection, under a range of cost scenarios, to obtain higher-speed and to be able to purchase services from competing providers over the fiber.

To our knowledge, this series of questions is the first time this model has been market-surveyed in the United States. The model has never been trialed in the U.S. and is virtually unknown among American businesses and consumers, although it has apparently seen some success and discussion in Europe.

That, however, is changing in the United States. In the past few months, we have seen significant discussion and interest in the model. The model and its variations are currently attracting significant attention from cities, technologists, and advocates that are focused on attempting to address the U.S. broadband deficit. For example, like San Francisco, Seattle has also recently conducted market research regarding interest in up-front payment for direct fiber connections. The UTOPIA consortium in Utah is considering adoption of this model to further build out its open access, inter-community fiber infrastructure. The New America Foundation recently released a paper by Professor Tim Wu of Columbia Law School and Derek Slater of Google, Inc. that proposes and describes a condominium variation of this model in which customers would own their fiber connections as personal property attached to their homes, and would share a collective ownership interest in the trunk fiber leading from the curb or sidewalk of their homes through the neighborhood to a Point of Presence at which the fiber would connect to service providers. That ownership model is currently being piloted in Ottawa, Canada in an innovative model that seeks to reduce energy consumption through fiber use.

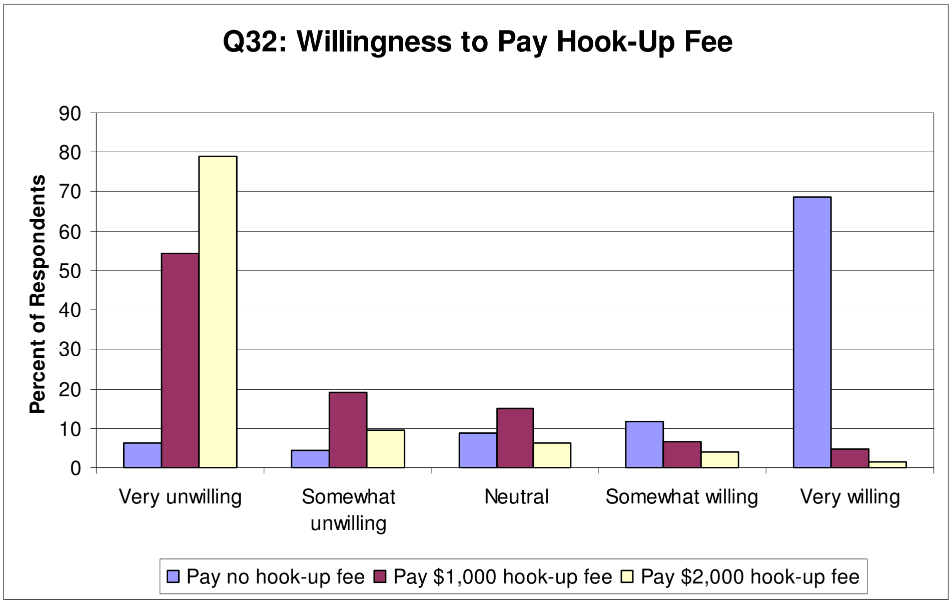
The market research data demonstrates that consumer and business interest in the model increase with knowledge of the costs and benefits associated with it. Absent knowledge of the value proposition for a direct fiber connection, there is some limited willingness to invest the up-front payment for the direct connection. We conclude that these respondents represent the early adopter community -- those who are interested in having the extraordinary capacity of fiber and for whom cost is not a sole determining factor.

The market research demonstrates an increased willingness to pay an up-front fee as the successive questions include assumptions of some of the presumed benefits -- that communications service fees could be lower on an ongoing basis, and that there would be a choice of providers of voice, video, and data services over the fiber connection.

Put another way, there is limited interest in this model in an environment where it is unknown and its benefits are not apparent. As the value proposition becomes apparent, interest in the model spikes.

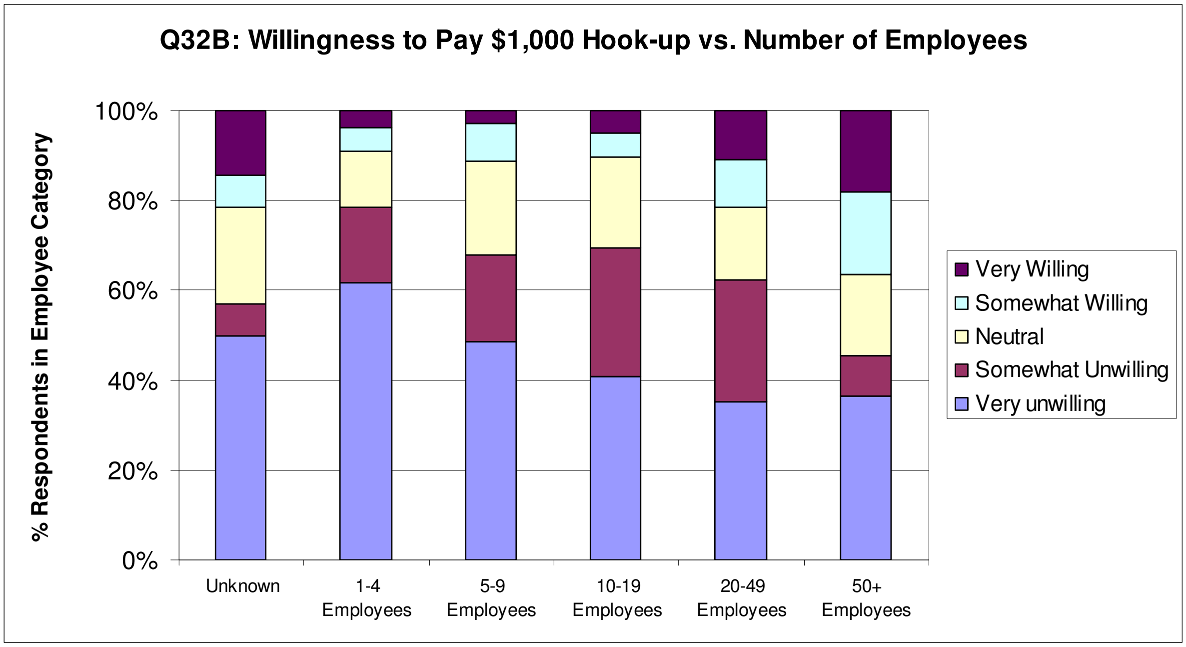
Without further detail or discussion of the details of the long-range cost benefits of a direct fiber connection, only 11.5 percent of respondents indicate willingness to pay a $1,000 fee for a fiber optic connection. Only 5.3 percent indicate willingness to pay a $2,000 for the connection (Figure 15).

Figure 15: Business Willingness to Pay Up-Front Fee for Fiber Connection



The data demonstrates a correlation between the number of employees a business has and its interest in paying up-front for a fiber connection. Nearly 40 percent of business respondents with 50 or more employees indicate willingness to spend $1,000 for fiber connections. More than 20 percent of business respondents with 20 or more employees indicate the same willingness (Figure 16).

Figure 16: Willingness to Pay $1,000 for a Fiber Connection Cross-Tabulated with Number of Employees



The financial, insurance, and real estate industries show the greatest willingness to pay $1,000 for a fiber optic connection (Figure 17).

Figure 17: Willingness to Pay $1,000 for a Fiber Connection Cross-Tabulated with Industry Type

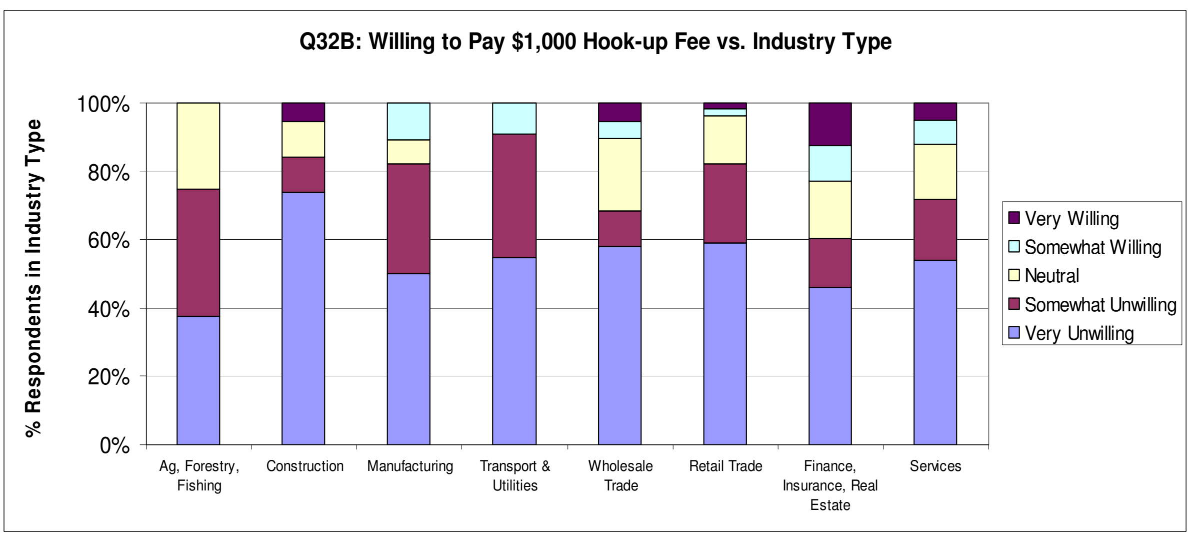
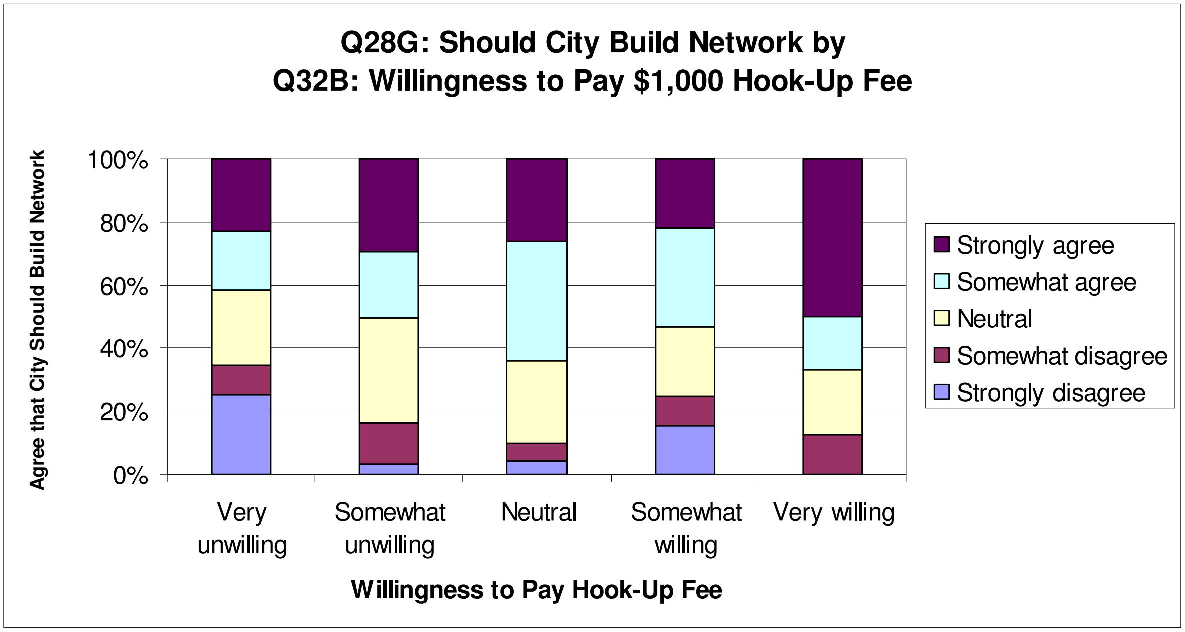


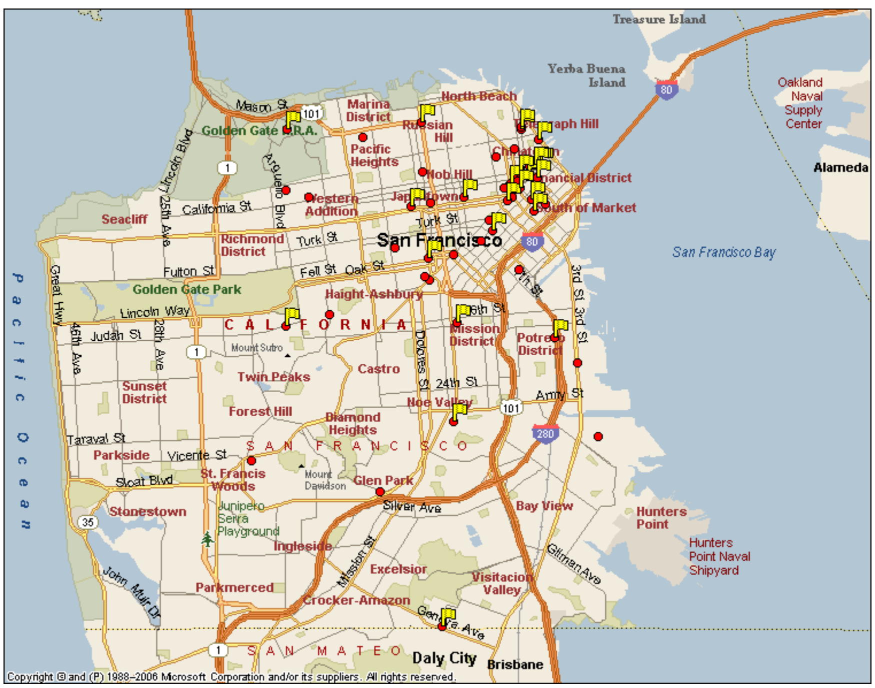
Figure 18: Willingness to Pay $1,000 for a Fiber Connection Cross-Tabulated with Support for a City Network



Not surprisingly, the business respondents willing to pay $1,000 for a fiber connection are concentrated in the Downtown area and Financial District (Figure 19) -- the areas that have the most dense concentration of businesses in San Francisco. The same concentration is evident when we add to the map those businesses willing to pay $2,000 for the fiber connection (those businesses are identified in Figure 20 with a yellow flag).

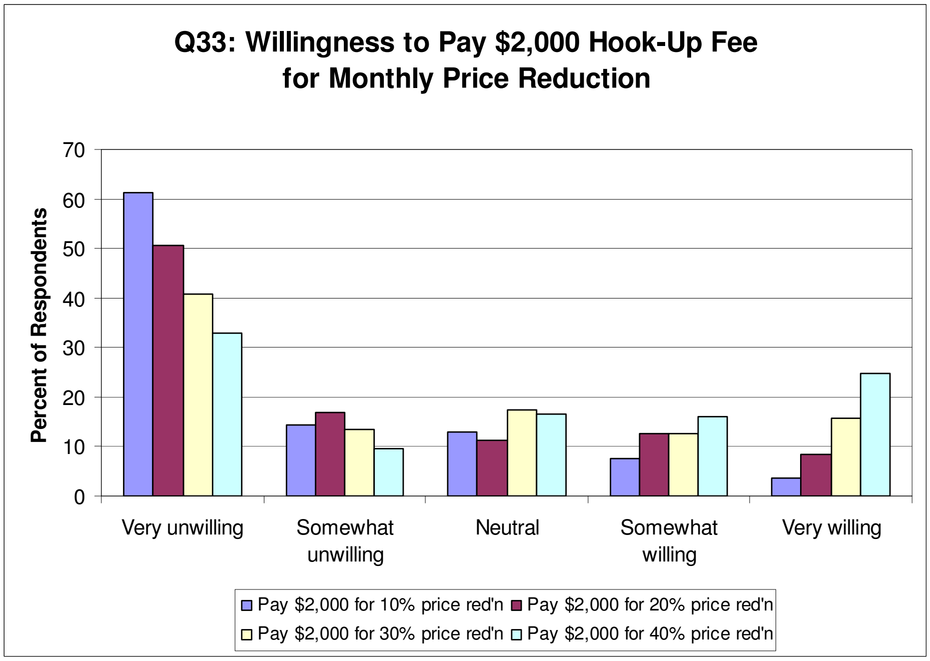
Figure 19: Location of Businesses Willing to Pay $1,000 for a Fiber Connection

Figure 20: Location of Businesses Willing to Pay a $2,000 Hook-up Fee (yellow flag)



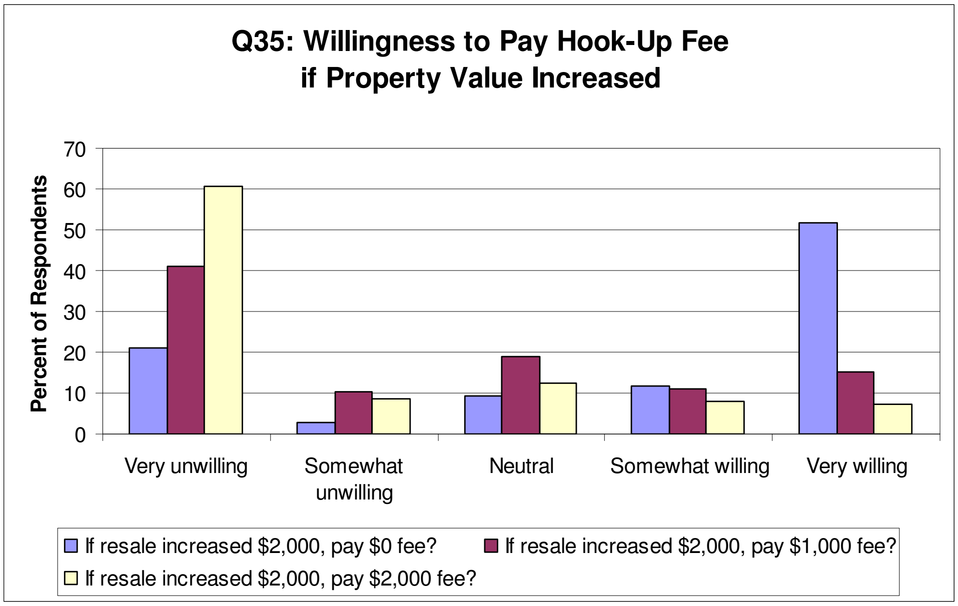
The survey follows these initial questions by adding assumptions about the benefits of a fiber connection. If a $2,000 hook-up fee would result in lower monthly costs for communications services, 21.2 percent indicate they would be somewhat or very willing to switch for a 20 percent price reduction while 41.0 percent are willing to switch for a 40 percent price reduction.

Figure 21: Business Willingness to Pay for Fiber Connection if Monthly Price Reduction



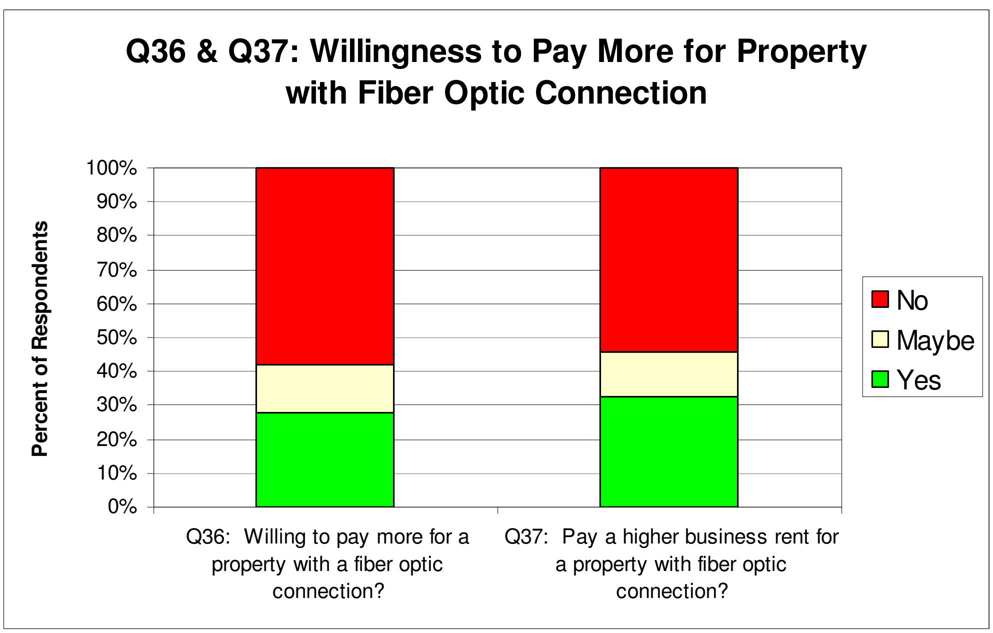
For property owners, if their property resale value were to increase by $2,000 because of the fiber connection, 26.1 percent of respondents are somewhat or very willing to pay a $1,000 fee; 15 percent are willing to pay a $2,000 hook-up fee. In contrast, 51.6 percent are somewhat or very unwilling to pay a $1,000 hook-up fee and 69.3 percent are somewhat or very unwilling to pay a $2,000 hook-up fee (Figure 22).

Figure 22: Business Willingness to Pay Fiber Connection Fee if Property Value Increases



Nearly one-third of respondents are willing to pay more for a business property with a fiber connection or to pay higher rent for a property with a fiber connection (Figures 23).

Figure 23: Business Willingness to Pay More for a Property with Fiber



The market research demonstrates little correlation between the number of employees and willingness to pay more to own or rent a property with a fiber connection (Figures 24 and 26).

However, it does demonstrate a relationship between willingness to pay more and the type of business. The financial, insurance, and real estate businesses recognize more value in a fiber connection than do other kinds of businesses. More than 60 percent of business respondents from those industries signal a willingness to pay more in purchasing a property (Figure 25).

Other industries demonstrate an interest in renting, rather than owning, properties with fiber connections. A cross-tabulation of willingness to pay higher rent with type of business demonstrates that nearly 40 percent of manufacturing businesses are willing to pay higher rent for a property with fiber -- almost double the rate of manufacturing concerns willing to pay a higher purchase price for a property with fiber (Figure 27).

Service-based businesses and financial, insurance, and real estate businesses also indicate a high rate of interest (more than one-third) in paying higher rents for properties with fiber connections (Figure 27).

Figure 24: Willingness to Pay More for Property with Fiber by Number of Employees

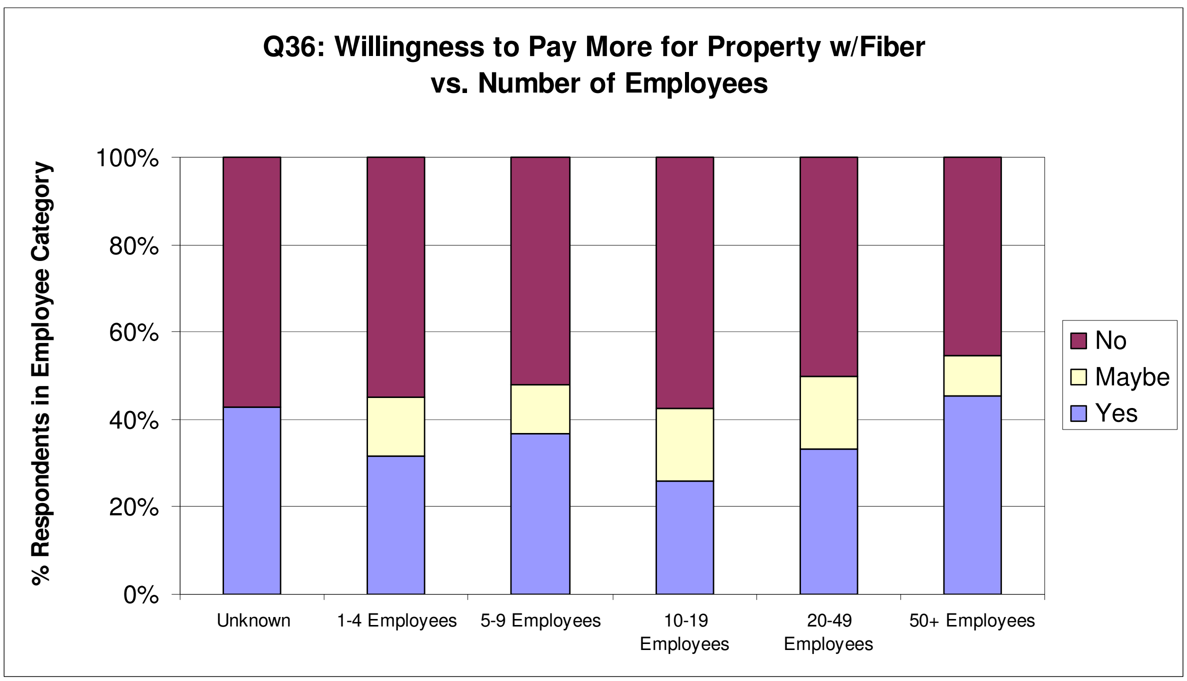


Figure 25: Willingness to Pay More for Property with Fiber by Industry Type

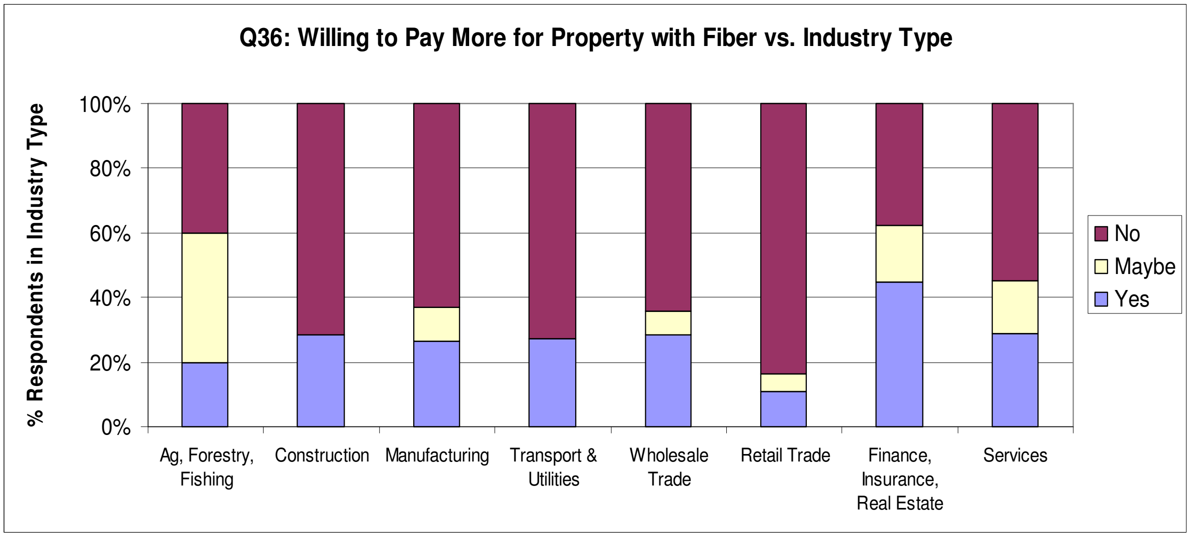


Figure 26: Willingness to Pay Higher Rent for Property with Fiber by Number of Employees

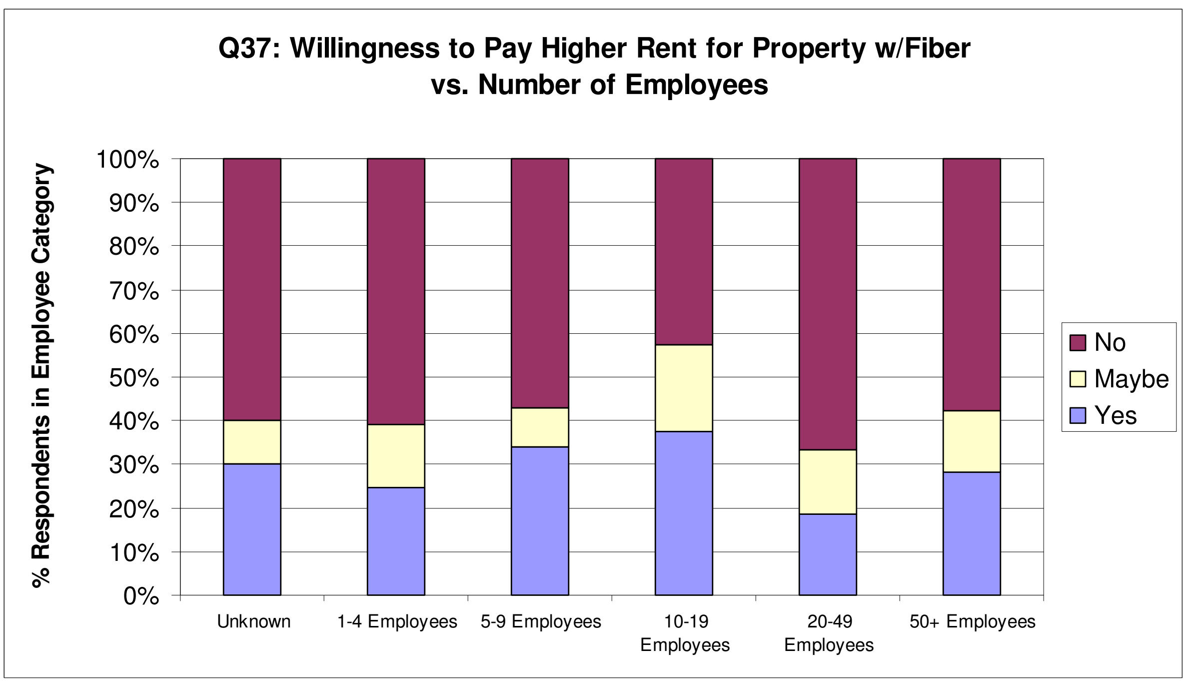


Figure 27: Willingness to Pay Higher Rent for Property with Fiber by Industry Type

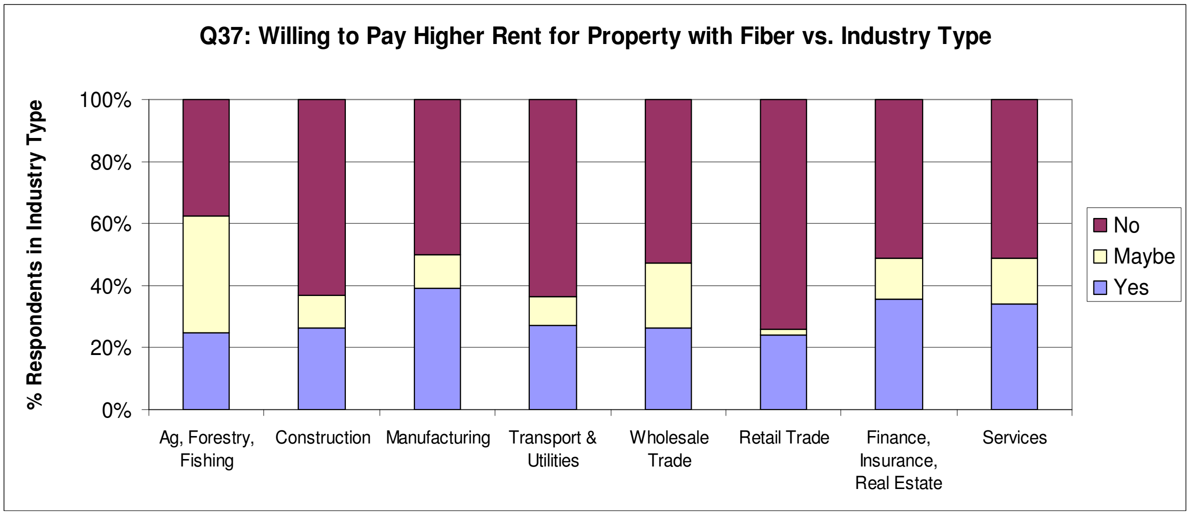
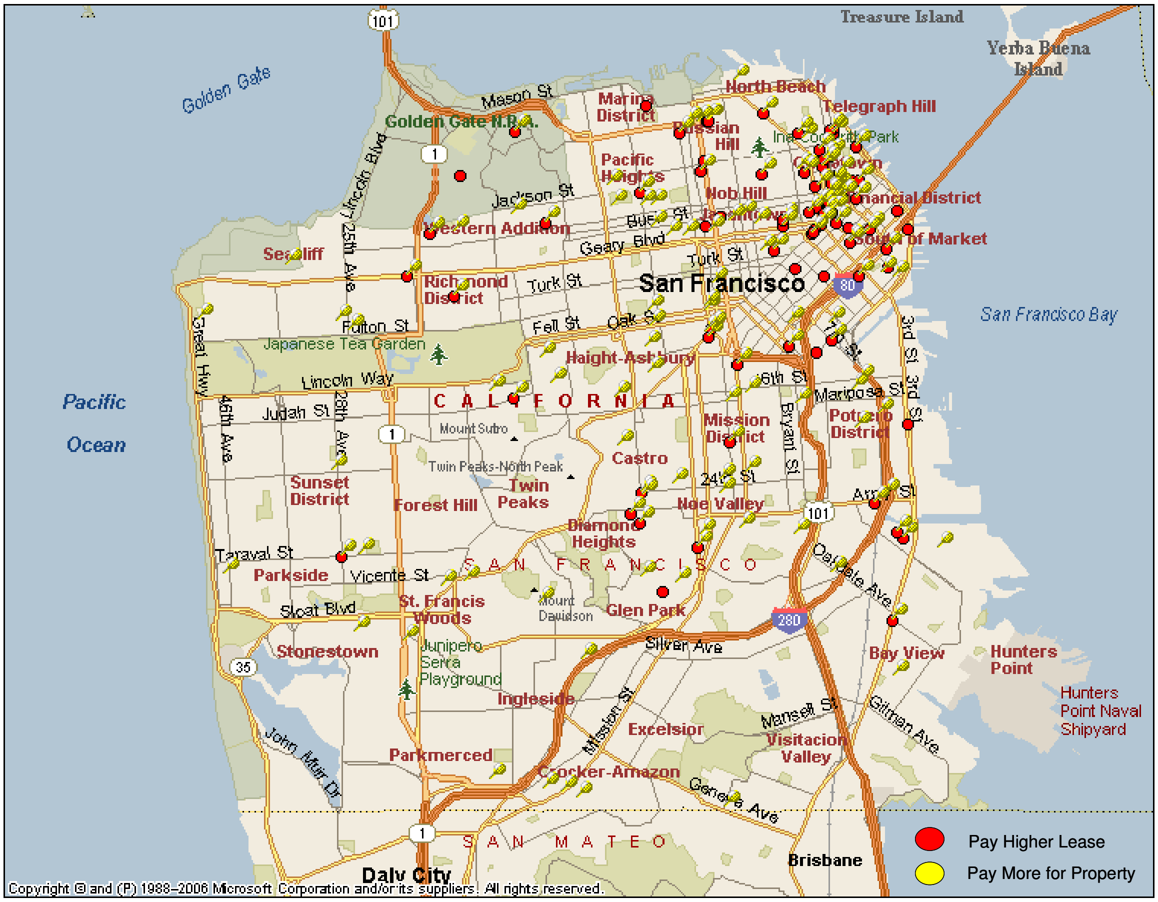


Figure 28 maps the locations of businesses willing to pay more or pay higher rent for a property with fiber connectivity. There is no apparent relationship between location and willingness to pay for fiber.

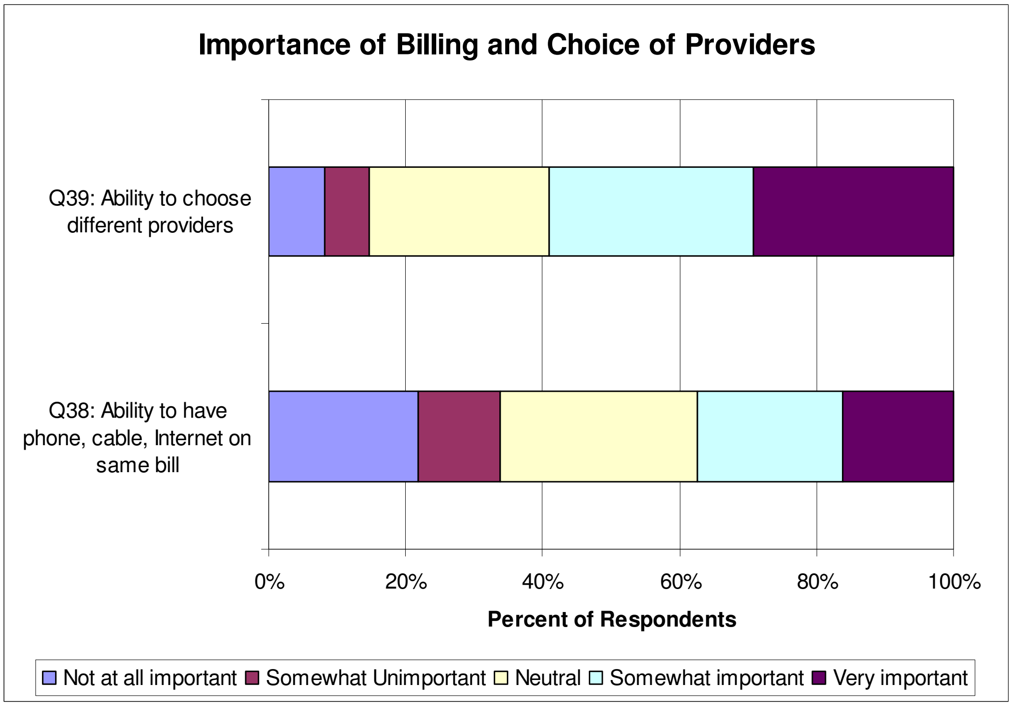
Figure 29: Locations of Businesses Willing to Pay Higher Purchase Price or Rent for a Property with Fiber Connection



2.1.4.1. Choice of Providers

The ability to choose different providers for phone, Internet, and television service was somewhat or very important to 59 percent of respondents. The convenience of having all three services on the same bill was important to approximately one-third of respondents and unimportant to approximately one-third of respondents (the final third was neutral).

Figure 30: Importance of Bundled Billing and Provider Choice



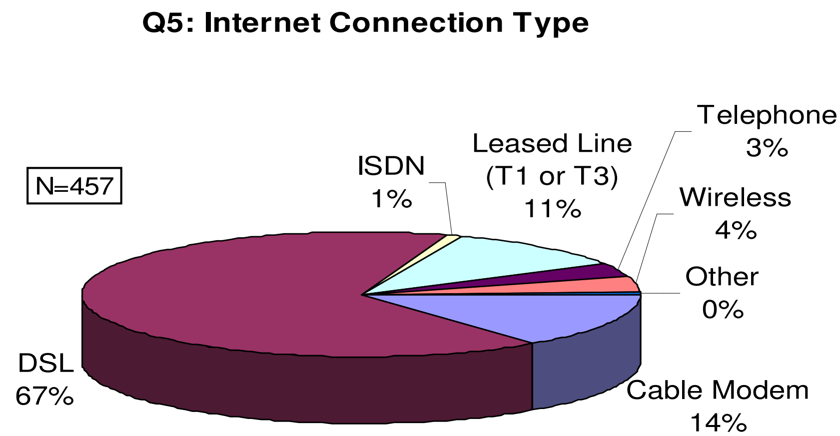
2.1.5. Business Internet Service

Internet access has become an essential part of operating a business. Demands and customer expectations for quality-of-service, speed, and capacity will continue to increase.

2.1.5.1. Business Internet Access Type

Nearly 93 percent of businesses surveyed had Internet access, with another two percent indicating that they may acquire Internet service within the next year. Of those with Internet service, two-thirds have DSL service, 14 percent have cable modem access, and 11 percent have a leased line (T1 or T3).

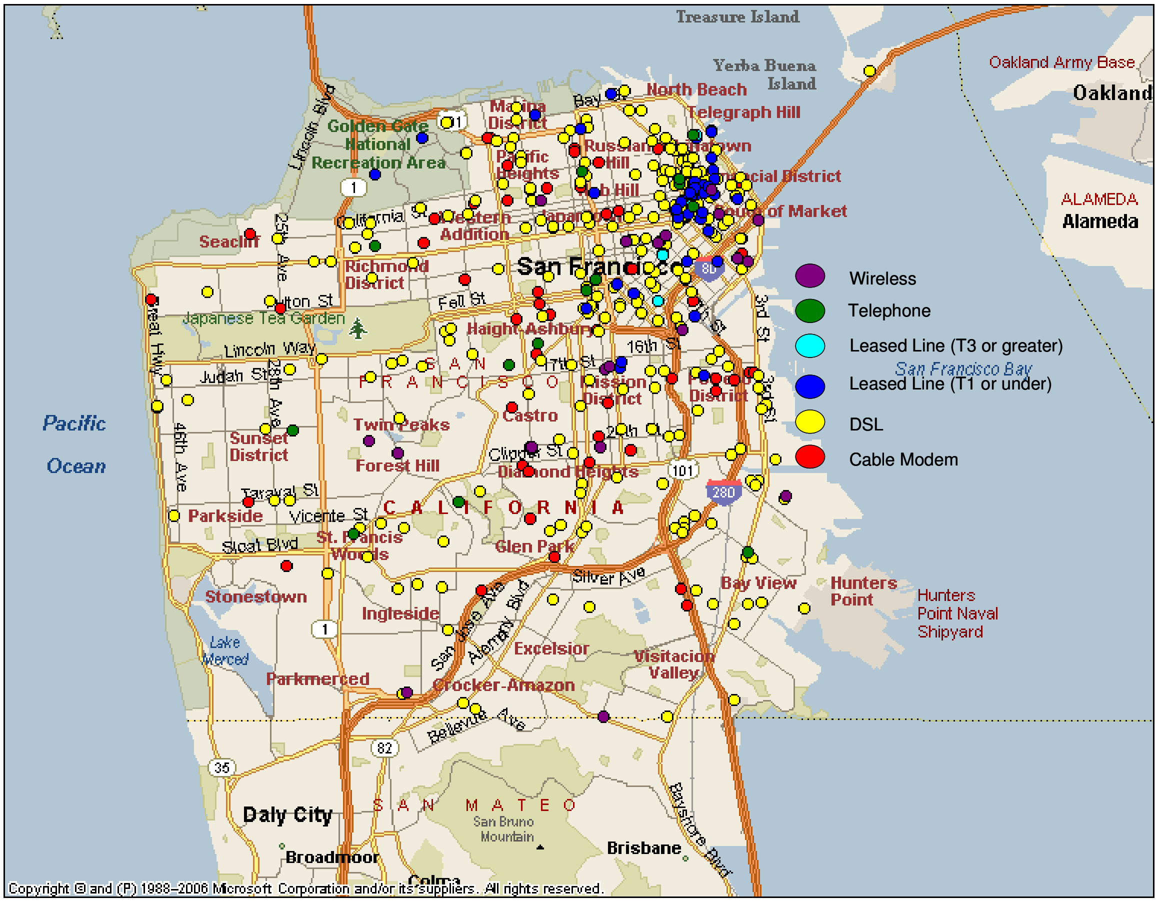
Figure 31: Internet Access Type at Business



Businesses that do not currently have Internet access are mostly in the service or retail sectors. All of businesses without Internet access have fewer than 10 employees (80 percent had fewer than 4 employees). This condition is consistent with other surveys that CTC has conducted.

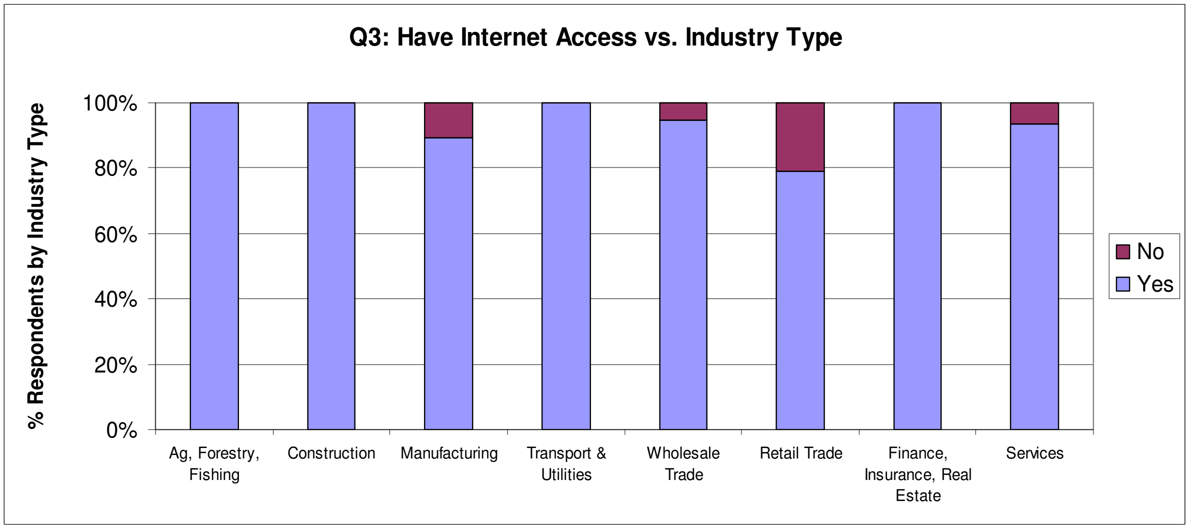
The locations of businesses using DSL and cable modems appear to be spread throughout the City with no "apparent holes" seen. This may indicate a general availability of these services in the City.

Figure 32: Type of Internet Access by Location



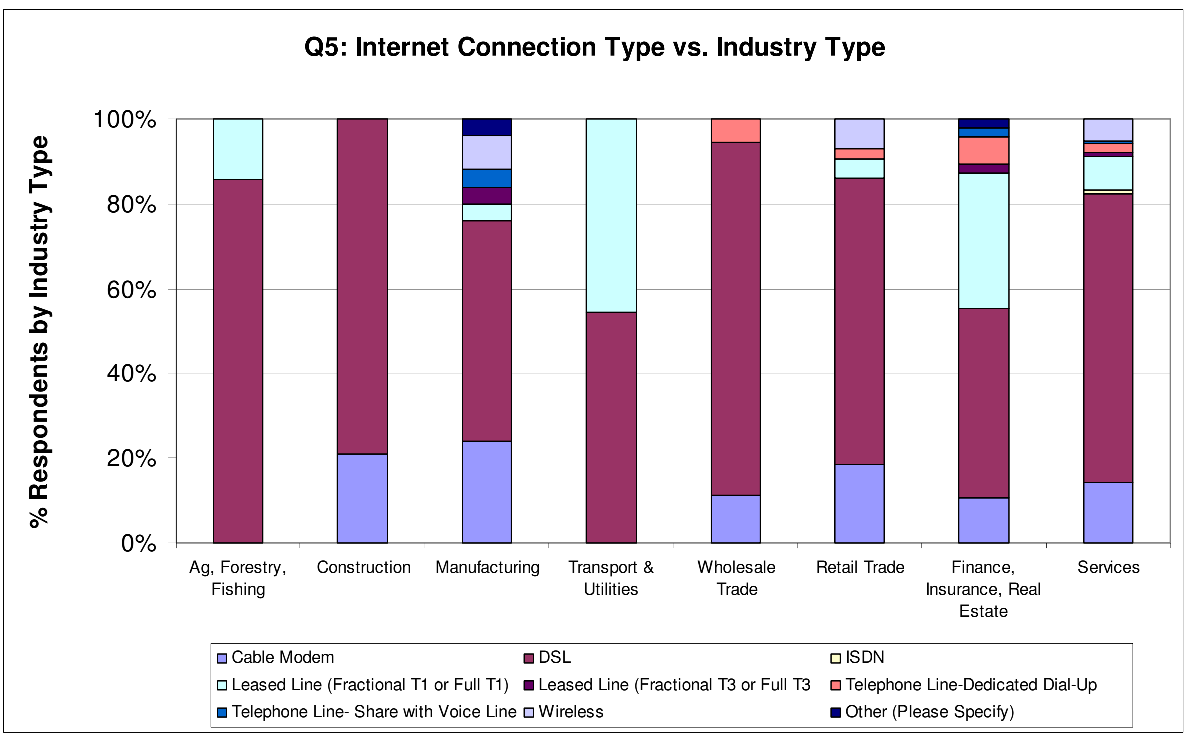
Over 20 percent of businesses in Retail Trade indicate they have no Internet connection, this is followed by Manfacturing (ten percent), Services (six percent), and Wholesale Trade (under five percent).

Figure 33: Internet Access vs. Industry Type



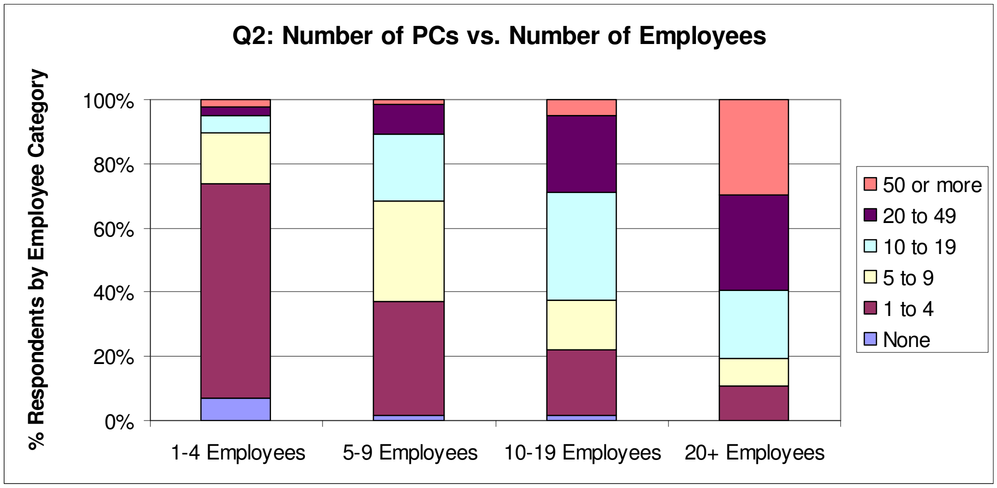
DSL has the highest use across the range of industry types while the Manufacturing segment uses the complete range of access alternatives (dial-up telephone to T3).

Figure 34: Internet Connection Type vs. Industry Type



As expected, the responses indicate there is a strong relationship between the number of employees and the number of personal computers.

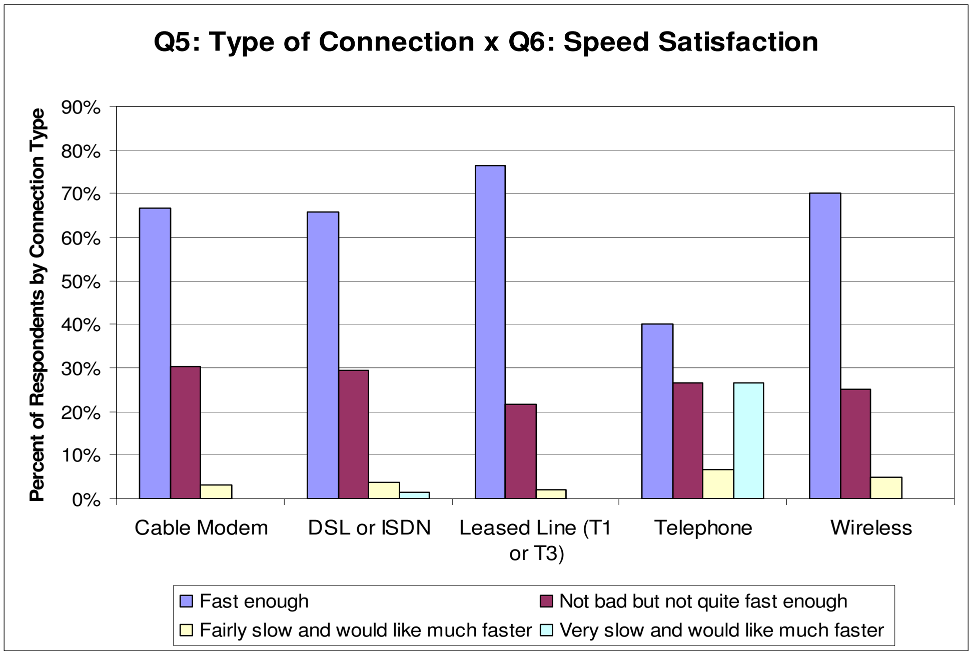
Figure 35: Number of Personal Computers by Number of Employees



2.1.5.2. Business Internet Aspects

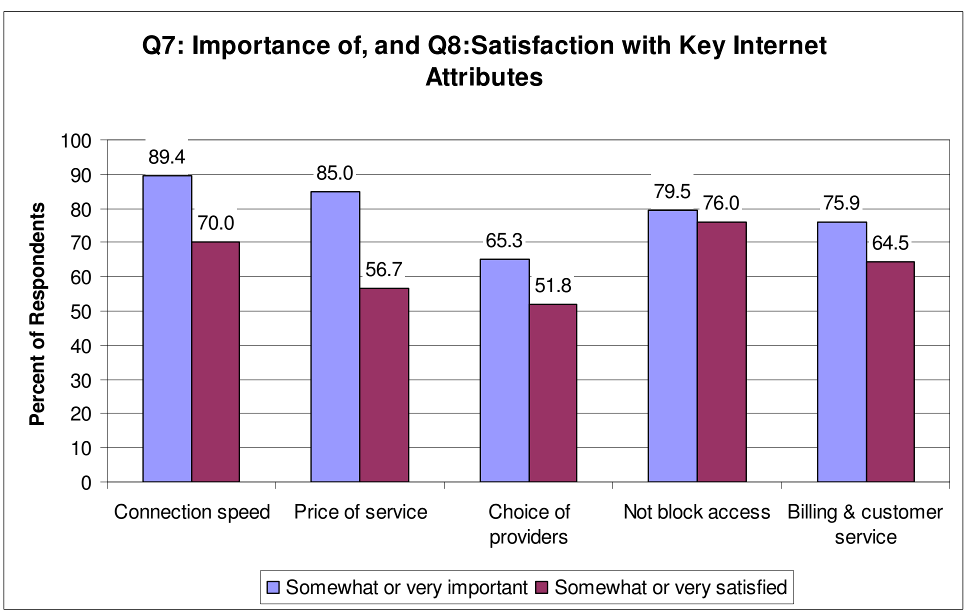
Approximately two-thirds of businesses indicate that their current Internet connection is "fast enough" while only 5.4 percent indicate that it is fairly slow or very slow. As indicated in Figure 36, satisfaction with speeds varies by Internet connection type with telephone line users experiencing the lowest satisfaction.

Figure 36: Internet Type vs. Speed Satisfaction



The most important Internet attribute is speed, followed closely by price. Nearly 90 percent of businesses indicate that speed was somewhat or very important, and 85 percent indicate that price was important. Approximately 70 percent of respondents were somewhat or very satisfied with their connection speed, but only 57 percent were satisfied with the price paid.

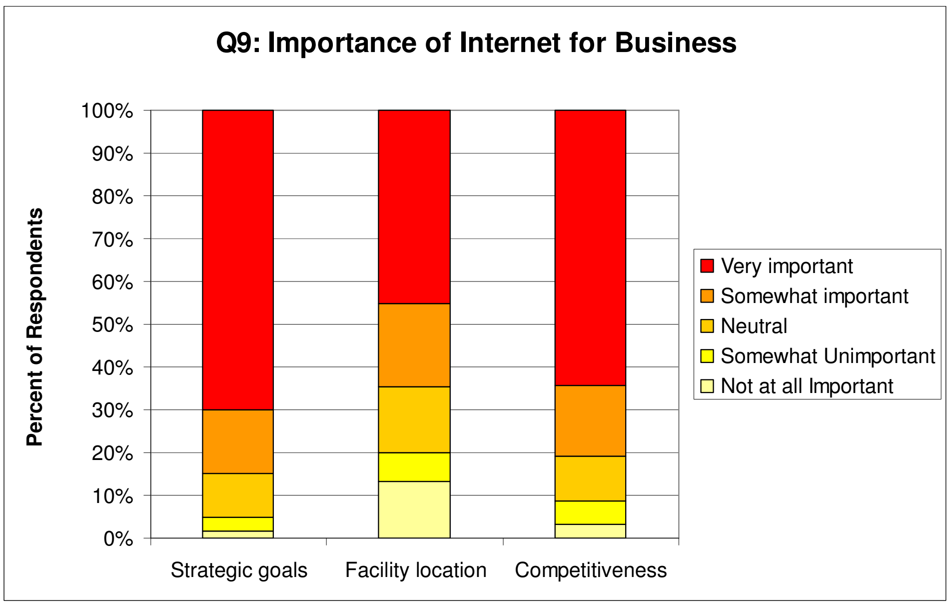
Figure 37: Importance and Satisfaction with Key Internet Attributes



The largest gaps between importance and satisfaction with key Internet aspects were price (Δ=28 percentage points), connection speed (Δ=19 percentage points), choice of providers (Δ=13.5 percentage points), and billing & customer service (Δ=11.4 percentage points). These are areas where the market is falling the most short of the important attributes needed by businesses. The difference between satisfaction and importance of the provider not blocking access is not statistically significant.

San Francisco businesses stated that the Internet was very important to achieving their strategic goals, their competitiveness, and business location decisions. Nearly 85 percent indicated that the Internet was somewhat or very important to meeting strategic goals, 81 percent for competitiveness, and 65 percent for business location decisions.

Figure 38: Importance and Satisfaction with Key Internet Attributes



2.1.5.3. Internet Access Fees

Businesses in San Francisco typically pay $25 to $99 per month for Internet service. This varies by connection type. Leased line subscribers pay substantially more than average, while telephone and wireless users pay the least.

Figure 39: Monthly Subscriber Fees

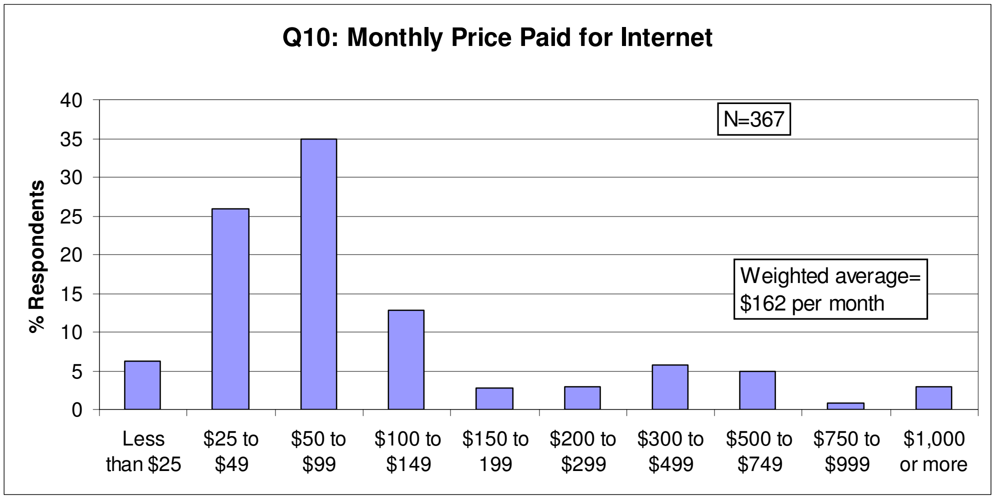
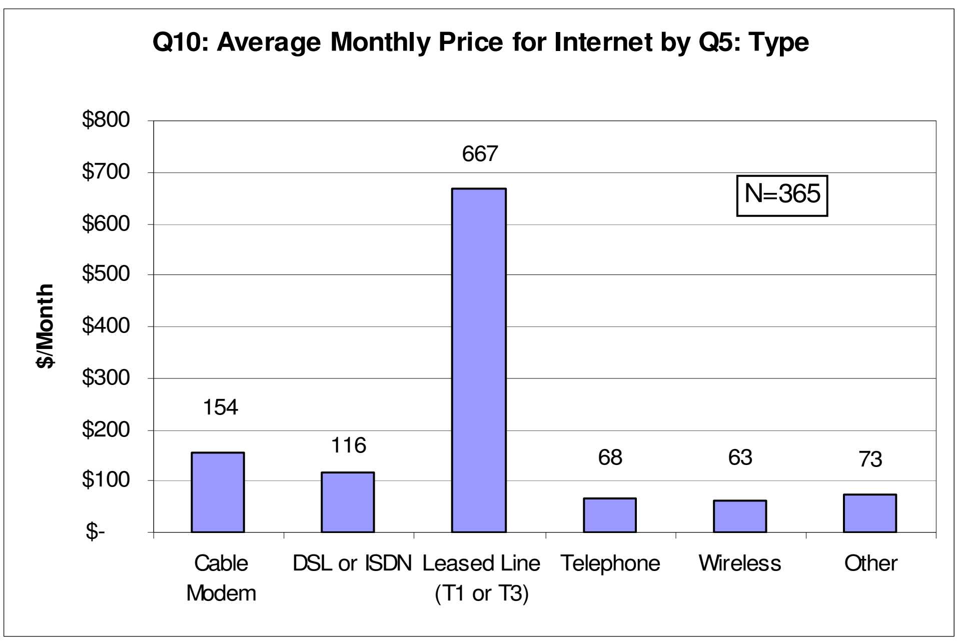


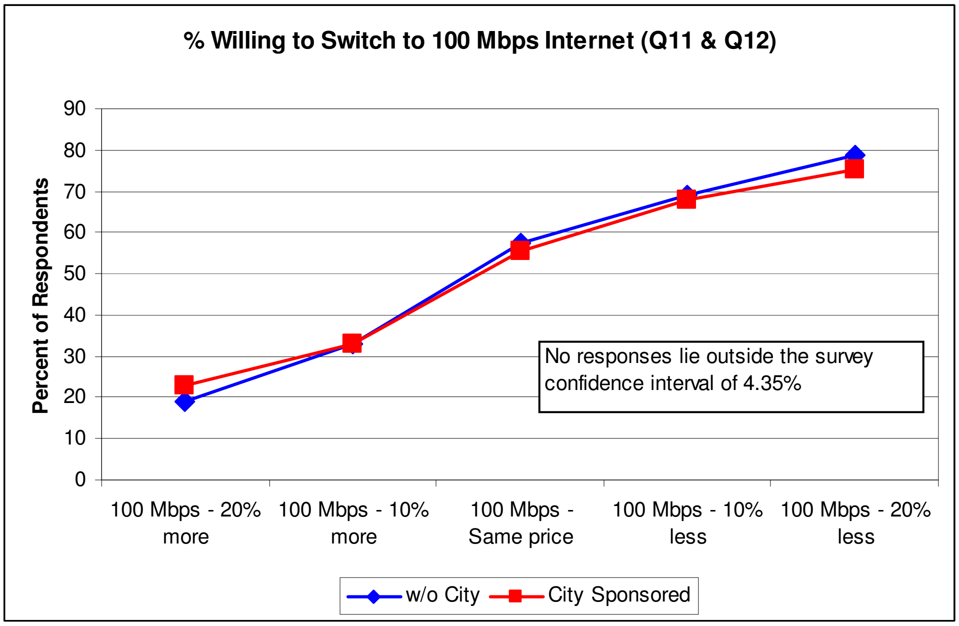
Figure 40: Average Monthly Subscriber Fees by Access Type



2.1.5.4. Business Willingness to Switch Internet Providers

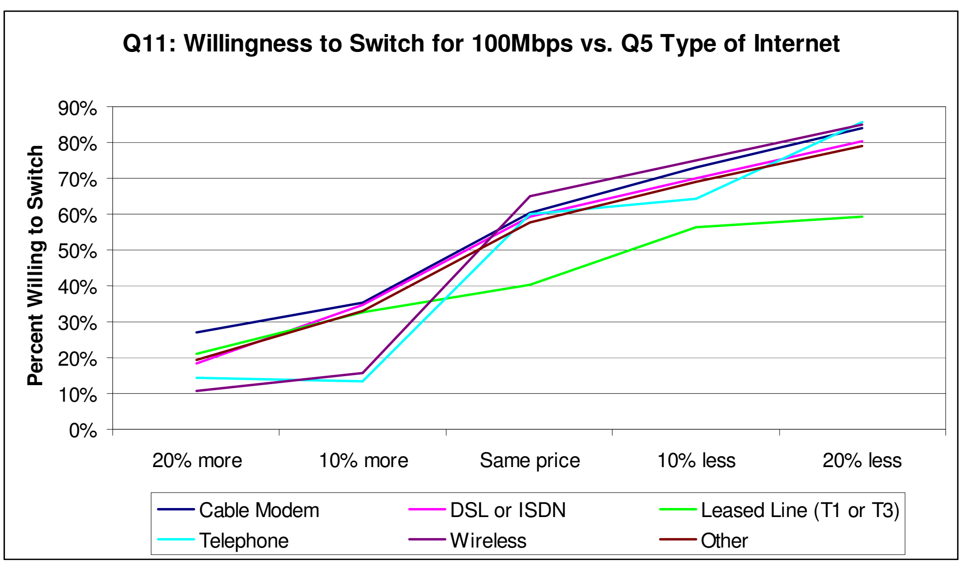
Business customers are willing to switch Internet providers for a price discount. If they can receive 100 Mbps services for a 10 percent price reduction, approximately 70 percent stated that they were somewhat or very willing to switch. If price is reduced by 20 percent, the percent willing to switch approaches 80 percent. There is no statistical difference between willingness to switch for a City-sponsored Internet service compared to a non-City-sponsored service.

Figure 41: Willingness to Switch to a 100Mbps Service



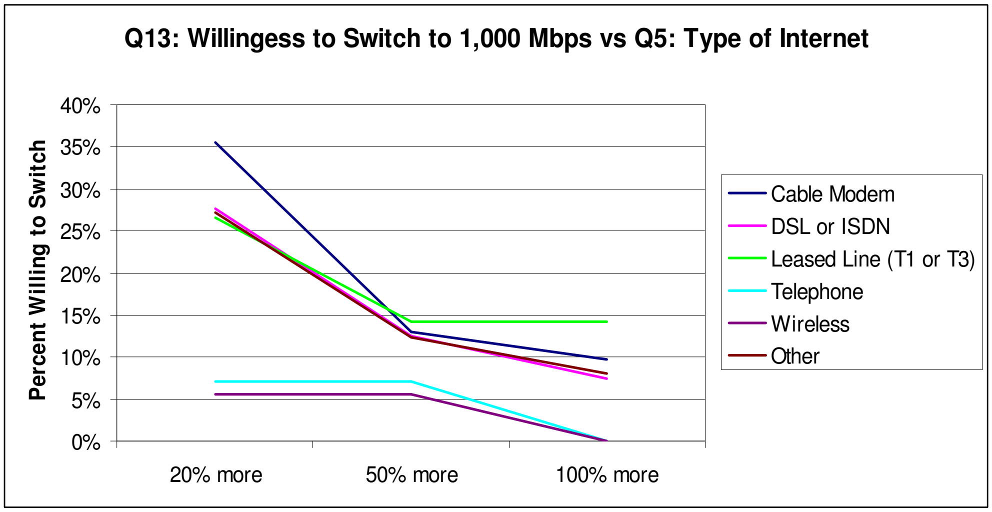
Leased line subscribers are less willing to switch to a 100 Mbps service even for a 20 percent price reduction.

Figure 42: Willingness to Switch to a 100Mbps Service by Access Type



If speed is increased to 1,000 Mbps, leased line subscribers are more likely to switch providers for a 20 percent price increase. If the price were to double, 15 percent of leased line subscribers indicate that they would switch while less than 10 percent of non-leased line subscribers would switch.

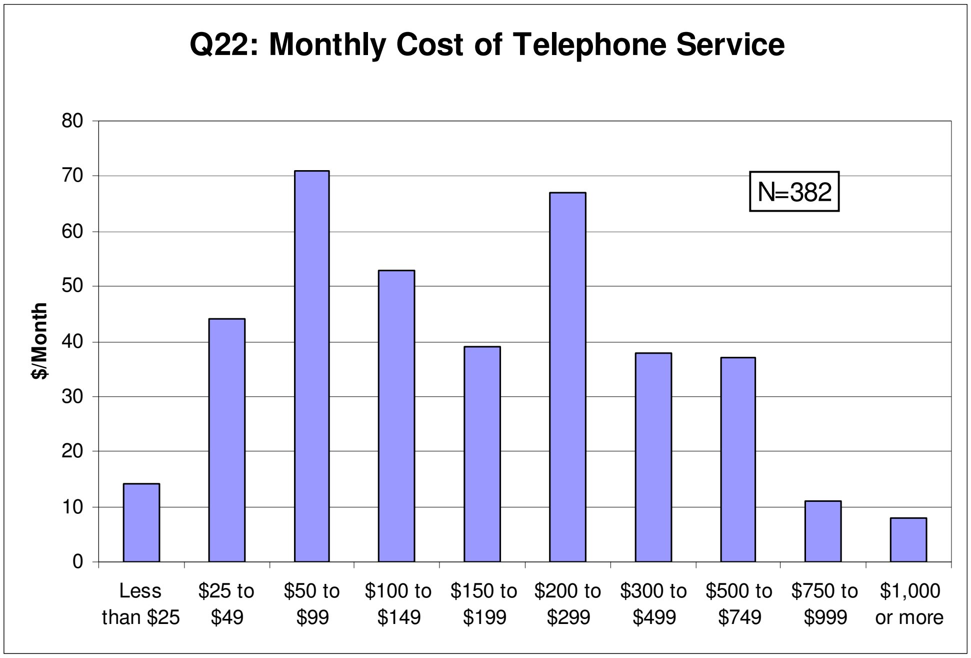
Figure 43: Willingness to Switch to a 1,000 Mbps Service by Access Type



2.1.6. Business Telephone Use

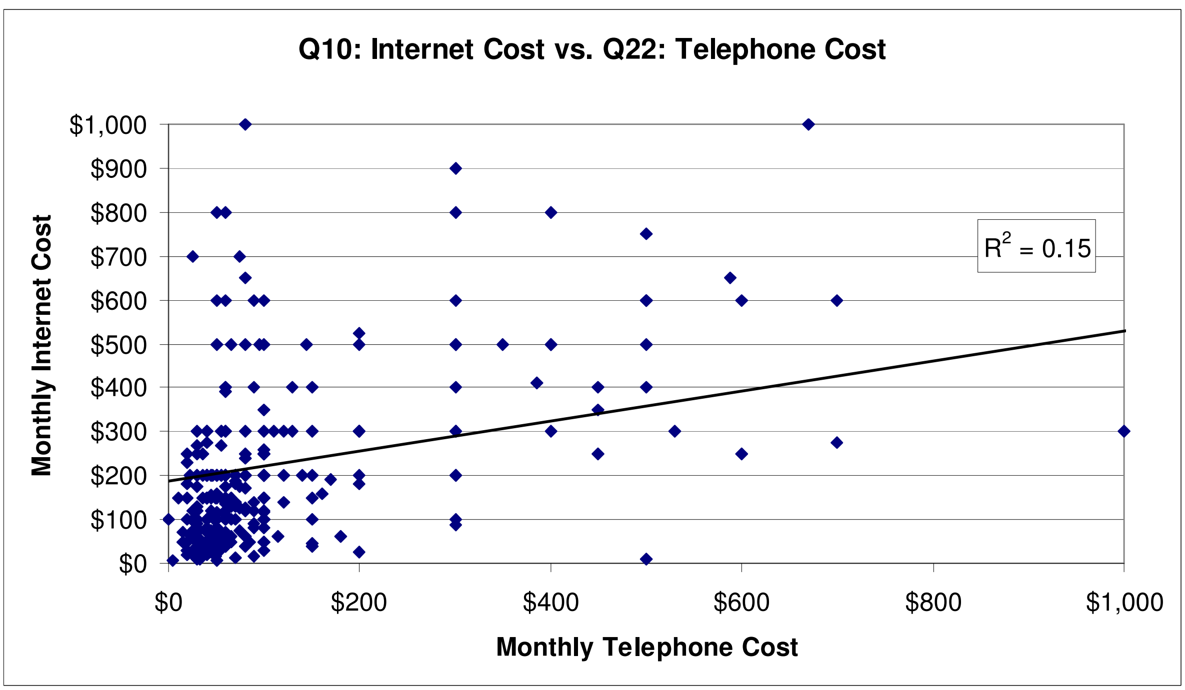
AT&T provides local telephone service to 87 percent of business survey respondents, with no other provider serving more than 2.5 percent of the market. On average, San Francisco businesses spend $250 per month on telephone service with slightly over one-half paying $150 or less per month.

Figure 44: Monthly Cost of Business Telephone Service



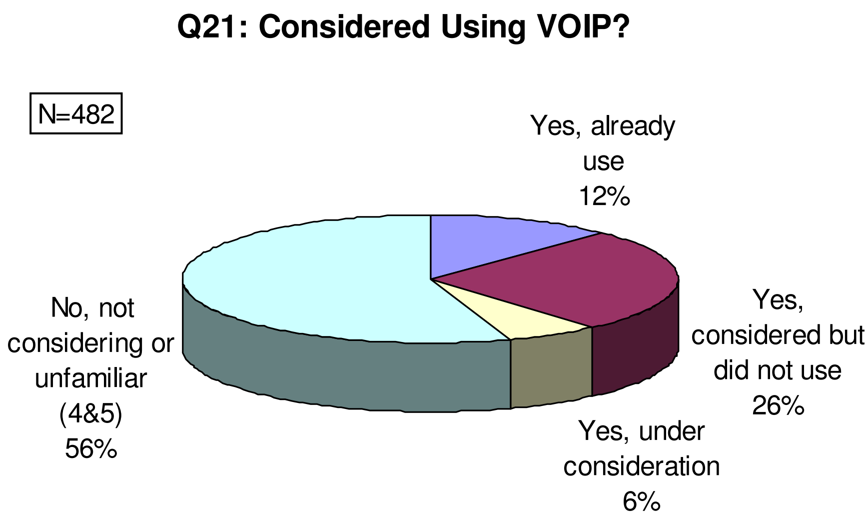
As shown in Figure 45 below, there is a very weak correlation between monthly Internet cost and monthly telephone cost.

Figure 45: Average Cost of Internet Service vs. Average Cost of Telephone Service



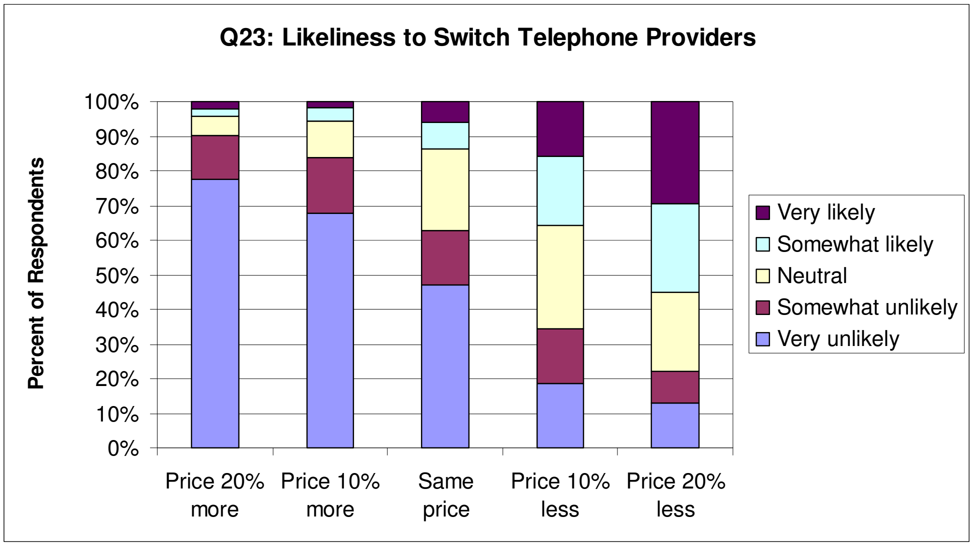
Only 12 percent of businesses use Voice over Internet Protocol (VoIP) and another 6 percent are considering VoIP. One half of businesses have not considered using VoIP and another 26 percent have considered VoIP, but chose not to use it.

Figure 46: Use of VoIP



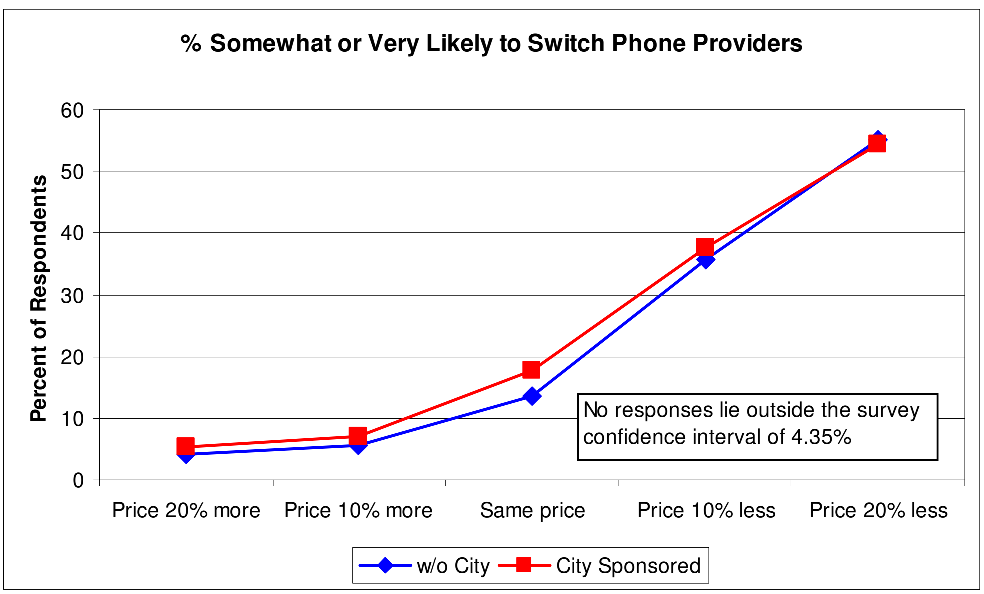
Most San Francisco businesses are unlikely to switch telephone providers until the price discount approaches 20 percent. For a 10 percent price discount, equal numbers are likely to switch as are unlikely to switch. However, for a 20 percent price discount, 55 percent of businesses indicated that they are somewhat or very likely to switch phone providers while only 22 percent stated that they were somewhat or very unlikely to switch.

Figure 47: Likelihood to Switch Telephone Providers



There is no statistical difference between willingness to switch providers and City sponsorship of the telephone service.

Figure 48: Likelihood to Switch Telephone Providers if City Sponsored



2.1.7. Business Television Use

Only 15 percent of businesses surveyed had cable television service and another 6 percent had satellite television service. On average, cable subscribers pay $72 per month while satellite subscribers pay $76 per month.

Figure 49: Use of Television Service

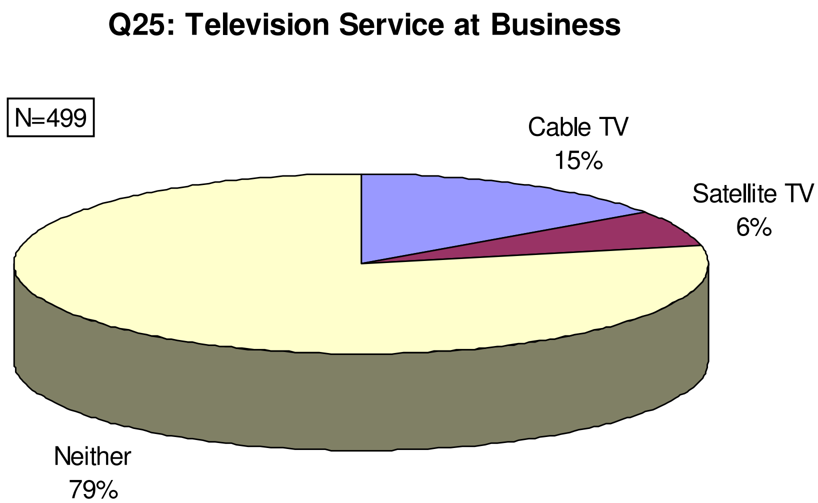
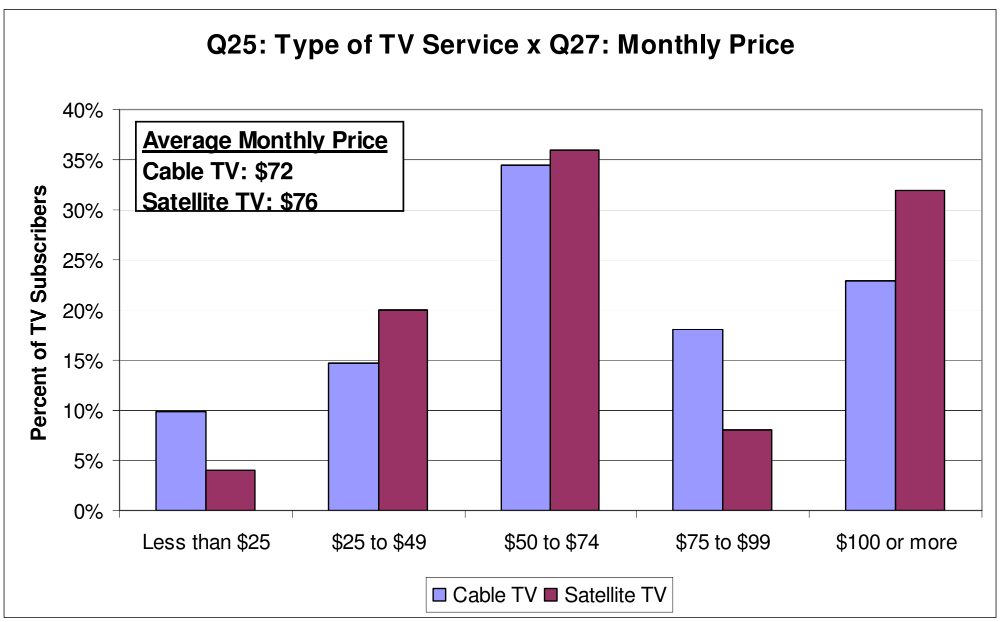


Figure 50: Monthly Price of Television Service



2.2 Residential Survey Results

A total of 5,000 surveys were mailed to randomly selected San Francisco residents in July 2008. A copy of the survey instrument can be found in Appendix B. A total of 868 useable surveys were returned by the cut-off date of August 29, 2008 -- providing a net response rate of 17.8 percent including only the 4,868 surveys that were delivered (132 surveys were undeliverable).

Given approximately 320,000 occupied households[40] in San Francisco, 868 responses provide results at the 95 percent probability level with a confidence interval of ±3.33.

The residential survey results presented in this report are weighted by the age of the respondent to reconcile the differences between the ages of survey respondents and the San Francisco population as a whole. The 2000 Census is used as the benchmark for the population distribution by age cohort (for all persons age 18 and older). The weighting calculations are shown in Table 1. The residential results shown in the remainder of this Report represent the age-weighted survey responses to most accurately represent the broader population.

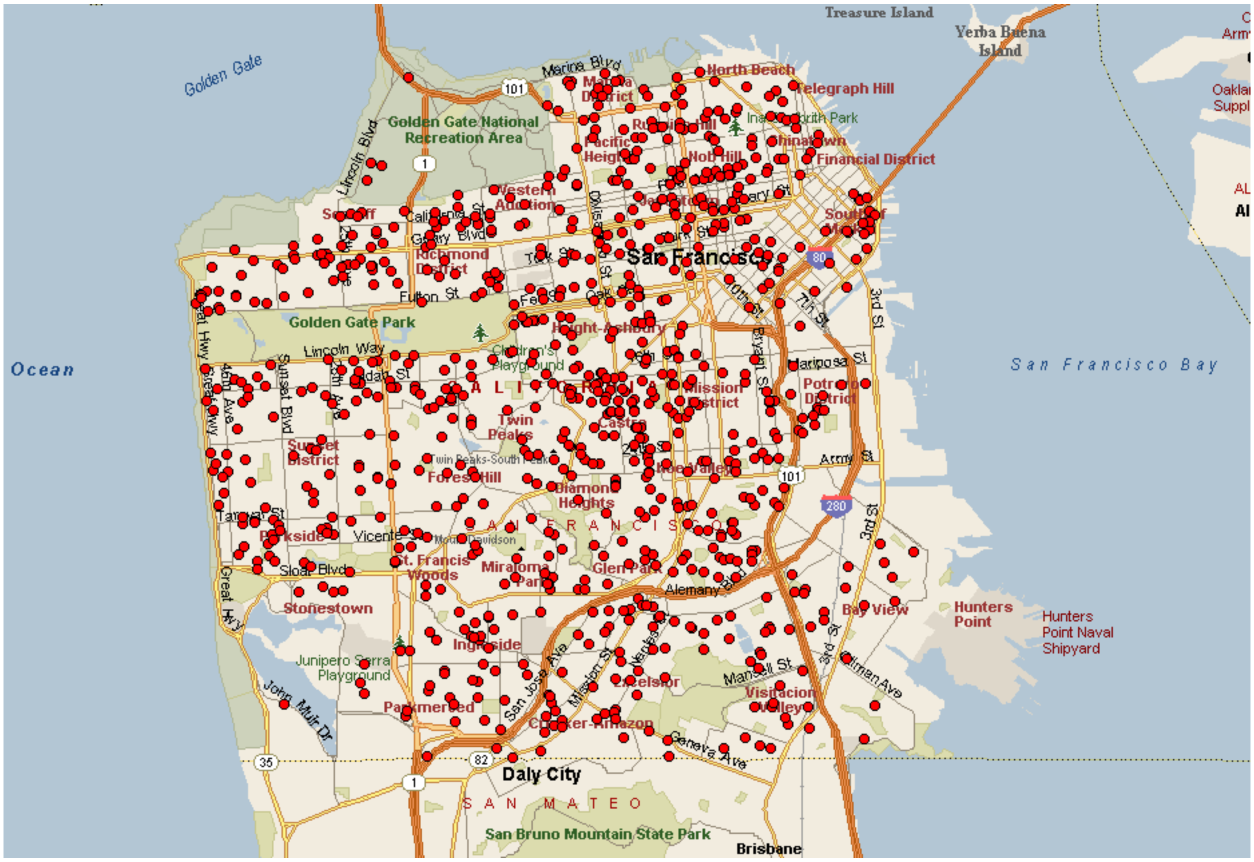
Table 1: Residential Weighting Calculations

Age Cohort	Survey Respondents	2000 Census	Weight
18 to 34 years	16.0%	37.7%	2.36
35 to 44 years	21.4%	20.2%	0.94
45 to 54 years	22.3%	16.3%	0.73
55 to 64 years	21.0%	9.9%	0.47
65 years and older	19.3%	16.0%	0.83
Total	100.0%	100.0%	

The households responding to the survey were dispersed geographically across the City of San Francisco. A map showing the locations of the respondents is provided in Figure 51.

[40] Source: http://www.bayareacensus.ca.gov/counties/SanFranciscoCounty.htm, accessed December 22, 2008. This Report uses the total occupied households (322,000) as the market size, and uses the total number of housing units (356,000) for the FTTP network cost estimate.

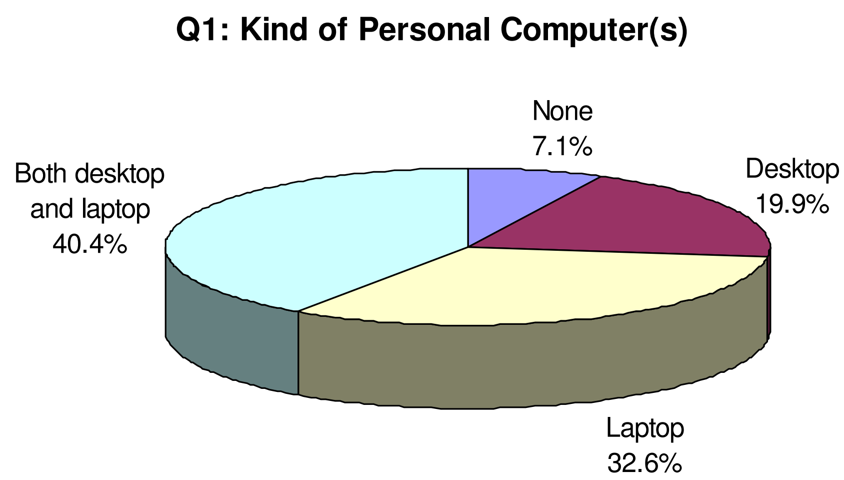
Figure 51: Residential Survey Respondent's Location



2.2.1. Residential Computer and Internet Characteristics

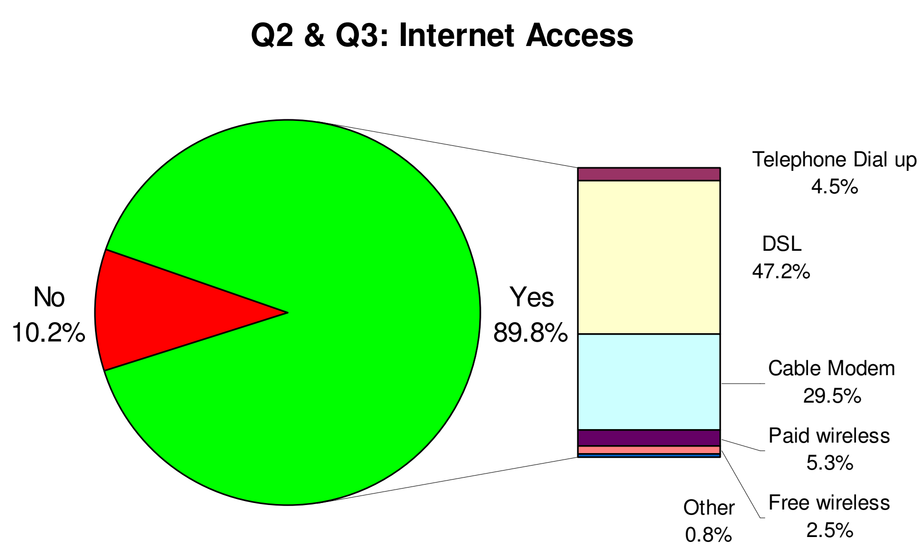
Approximately 93 percent of San Francisco households have at least one computer in their home with 40 percent using both laptop and desktop computers.

Figure 52: Households with a Computer



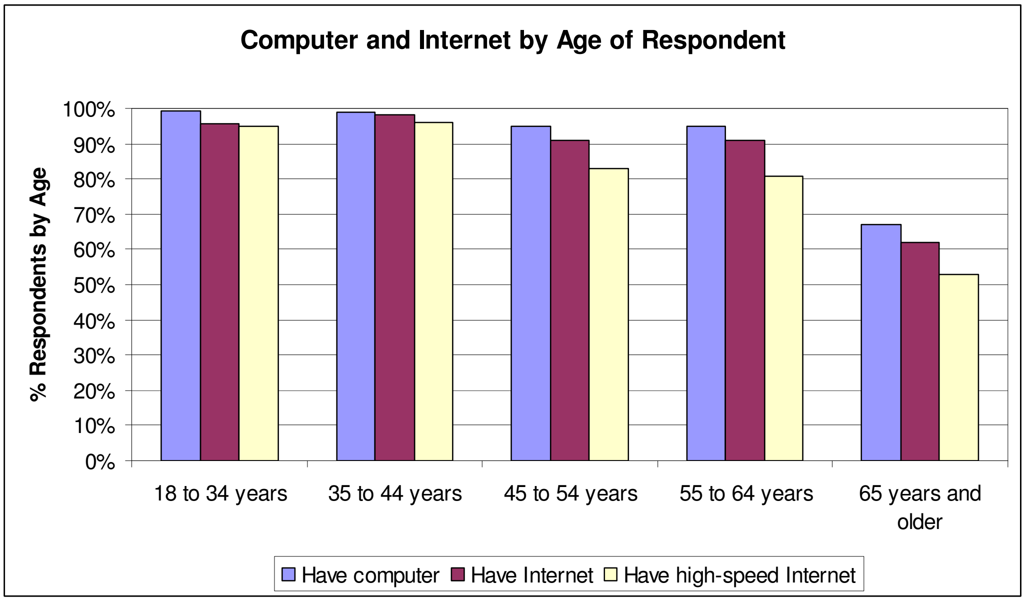
Approximately 90 percent of San Francisco homes have Internet access. Nearly one-half of homes have DSL and 30 percent have cable modem access, while less than five percent have telephone dial-up access.

Figure 53: Internet Access and Connection Type



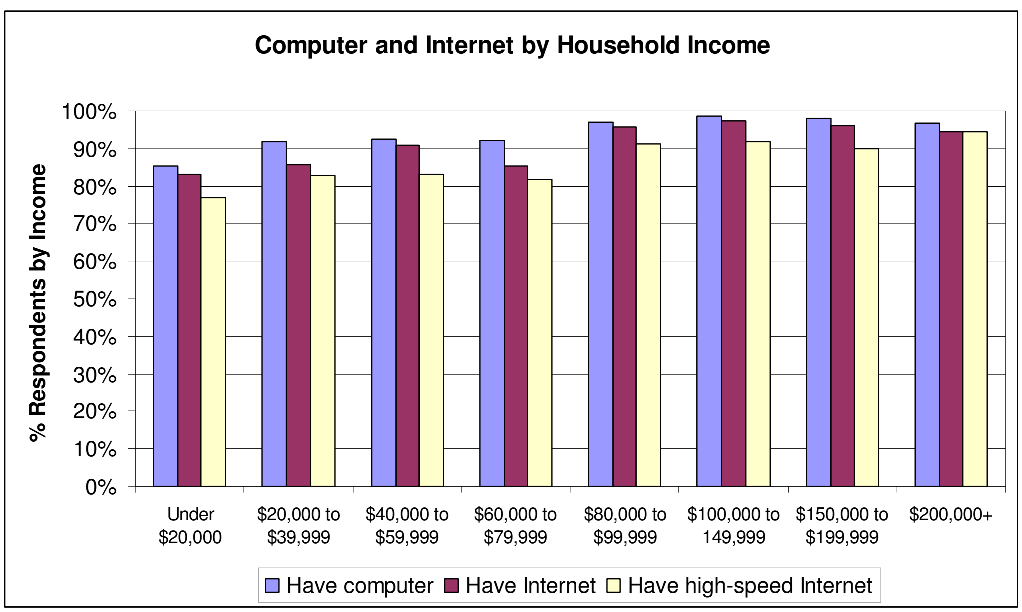
There is a strong correlation between computer ownership, Internet access, and Internet connection type with the age of respondent. Nearly all respondents under the age of 45 have a computer while only two-thirds of respondents 65 and older own a computer. Nearly all respondents under 45 have Internet at home, while only 62 percent of respondents age 65 and older have Internet at home. The proportion of respondents with high-speed Internet access also decreases with the age of the respondent.

Figure 54: Computer and Internet by Age of Respondent



There is also a correlation between computer ownership and Internet access with the respondents' household income, although the correlation is much weaker than it is for age.

Figure 55: Computer and Internet by Household Income



More than one-half of respondents indicate that their current Internet connection is "very fast" or "fast," while only 11 percent indicate that it is "slow" or "very slow." Telephone (dial-up) users and free wireless users report having the slowest connection speed.

Figure 56: Speed of Internet Connection

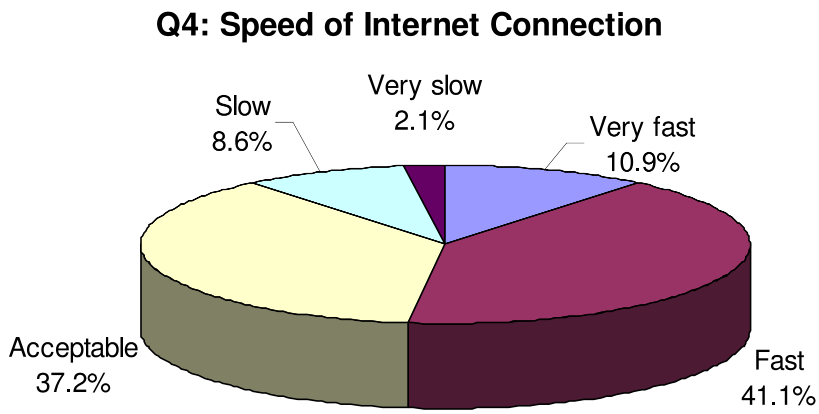
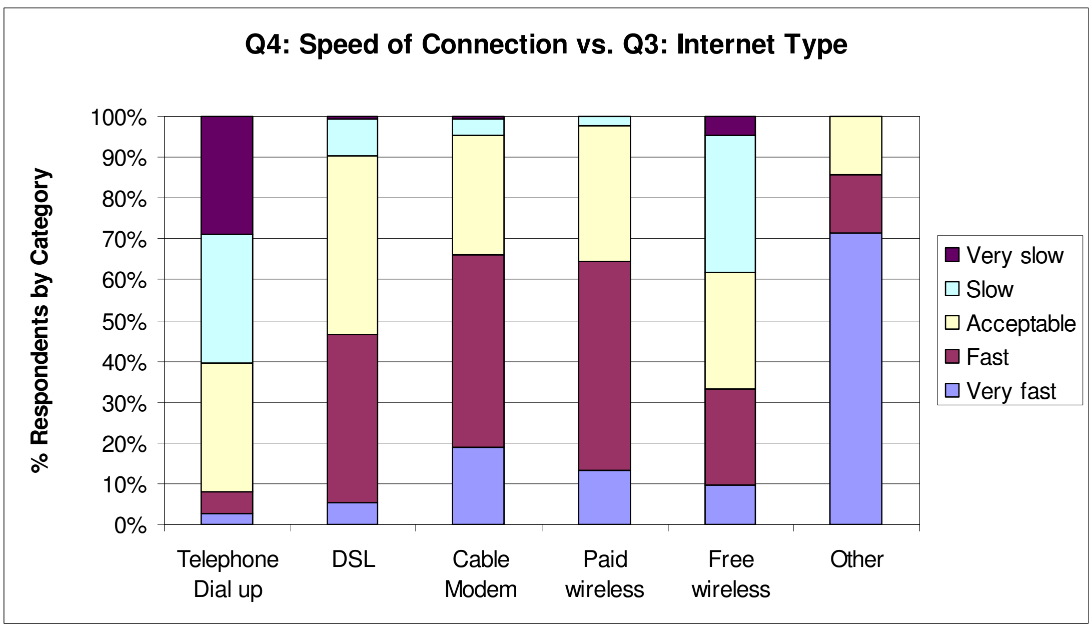
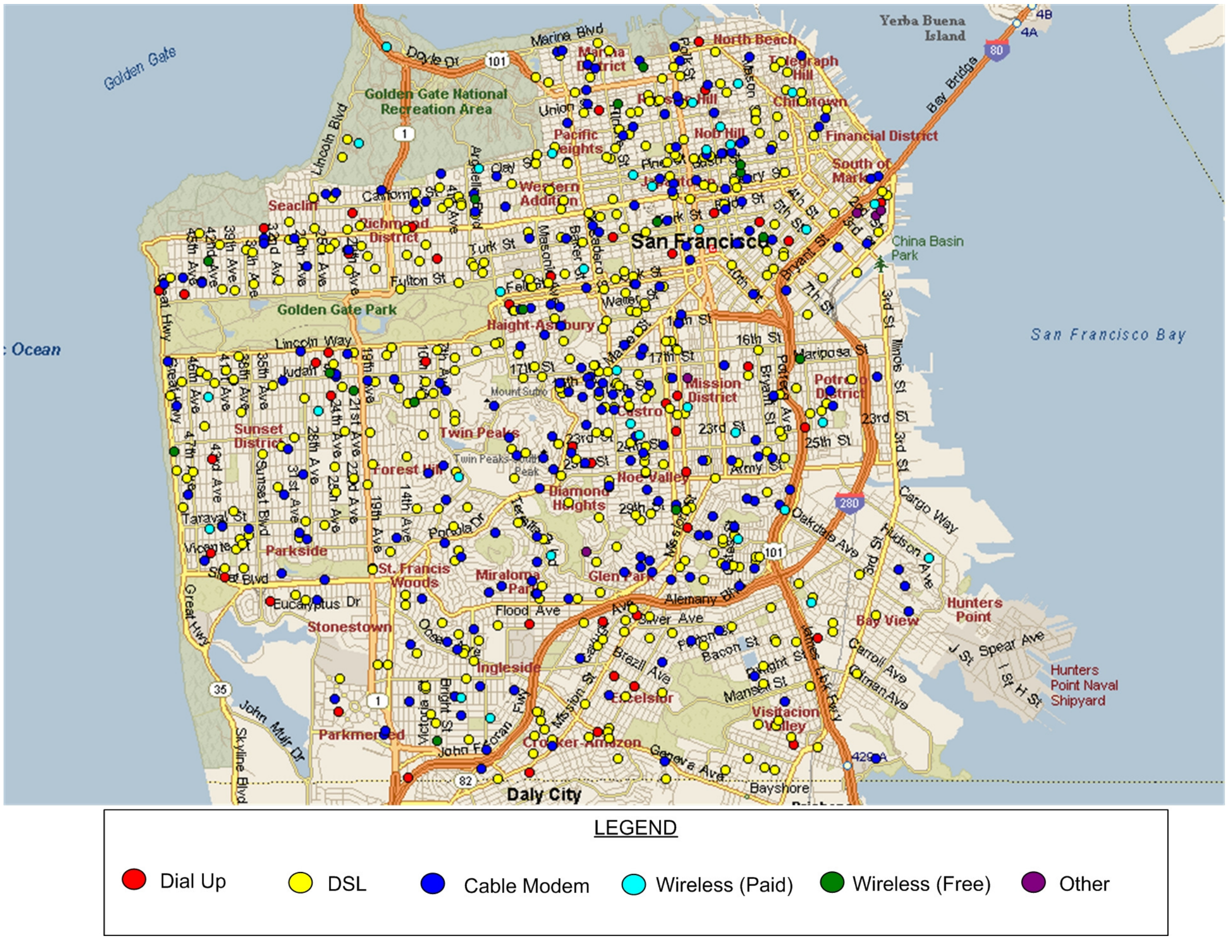


Figure 57: Speed of Internet Connection by Connection Type



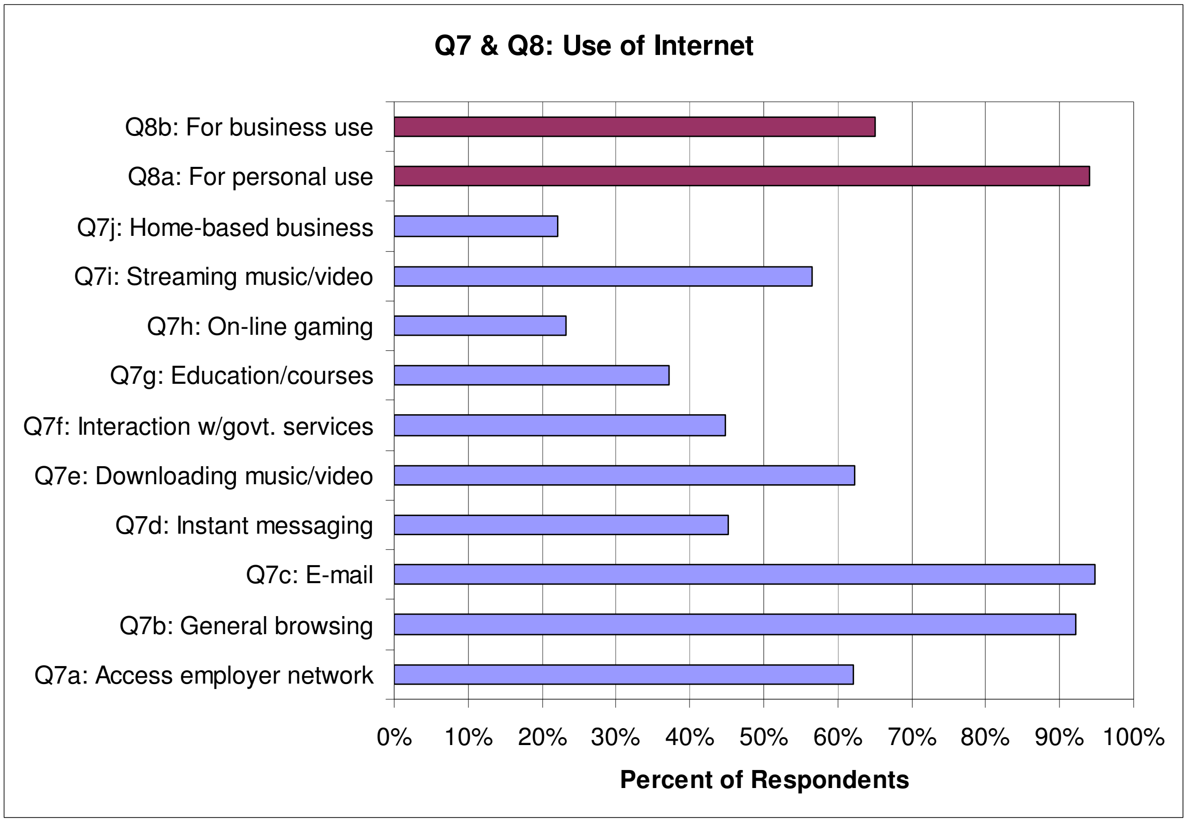
The type of Internet connection by location of respondent is mapped in Figure 58.

Figure 58: Residential Internet Customers



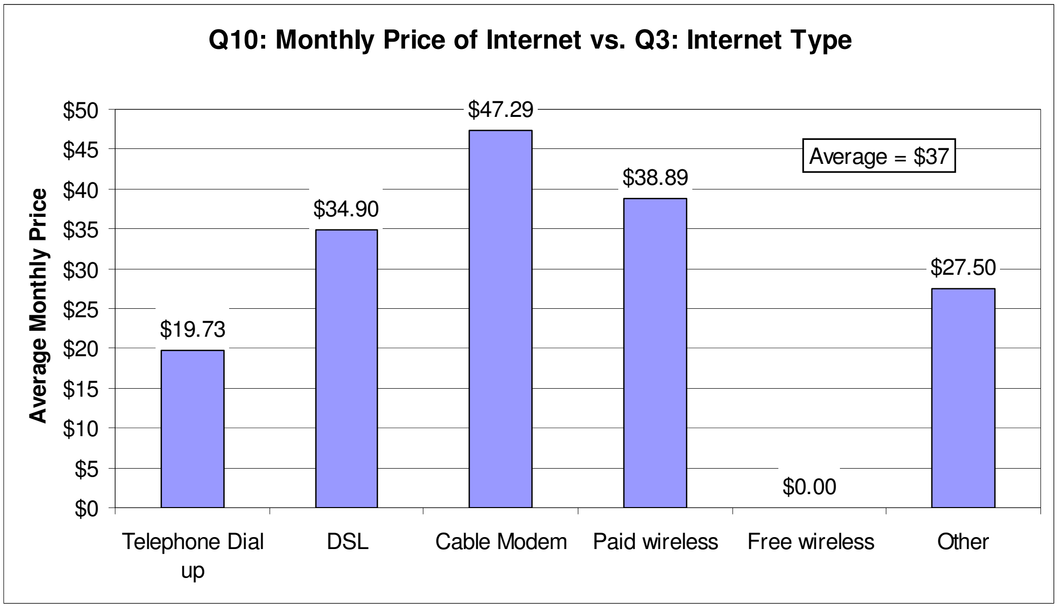
Over 90 percent of respondents with Internet access at home use the Internet for E-mail or general browsing. Less than 25 percent use the Internet for gaming or for a home-based business. Approximately two-thirds use the Internet for business purposes at least part of the time.

Figure 59: Internet Uses



San Francisco residents pay an average of $37 per month for Internet service. This varies greatly by connection type, with cable modem users paying the most, on average, and telephone dial-up users paying the least (with the exception of free wireless).

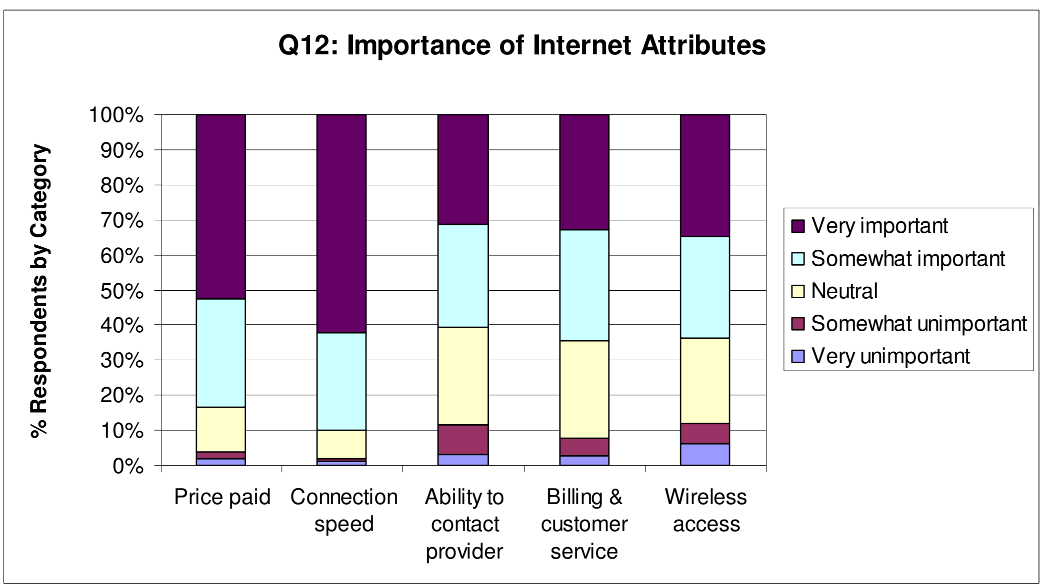
Figure 60: Monthly Price by Internet Connection Type



2.2.2. Internet Attributes and Opinions

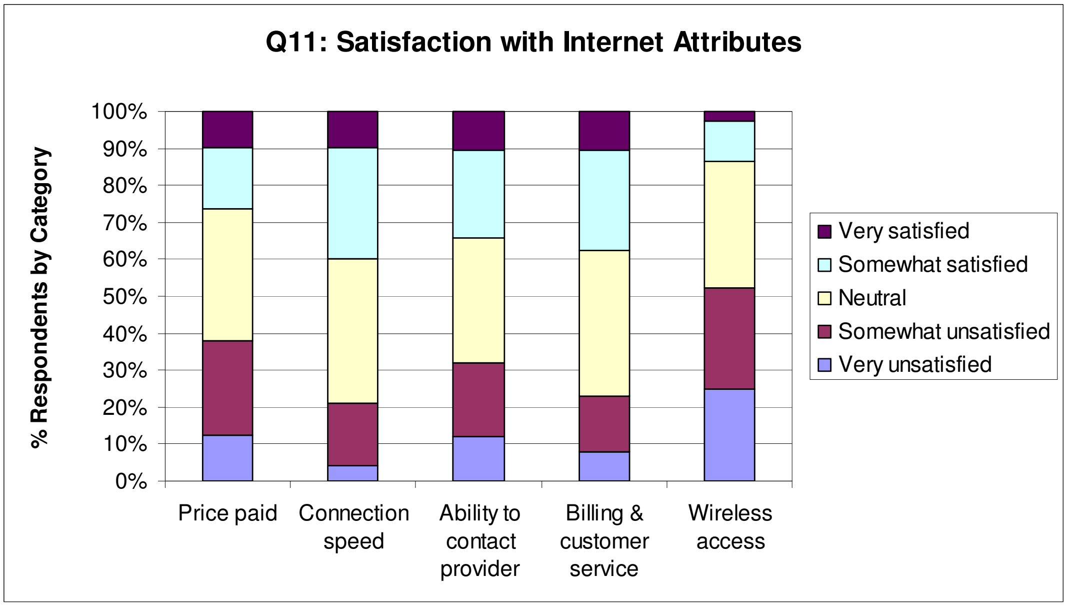
Speed and the price paid are the most important attributes of Internet service. The ability to contact the provider, billing and customer service, and mobility around San Francisco (wireless access) are less important than speed and price.

Figure 61: Importance of Internet Attributes



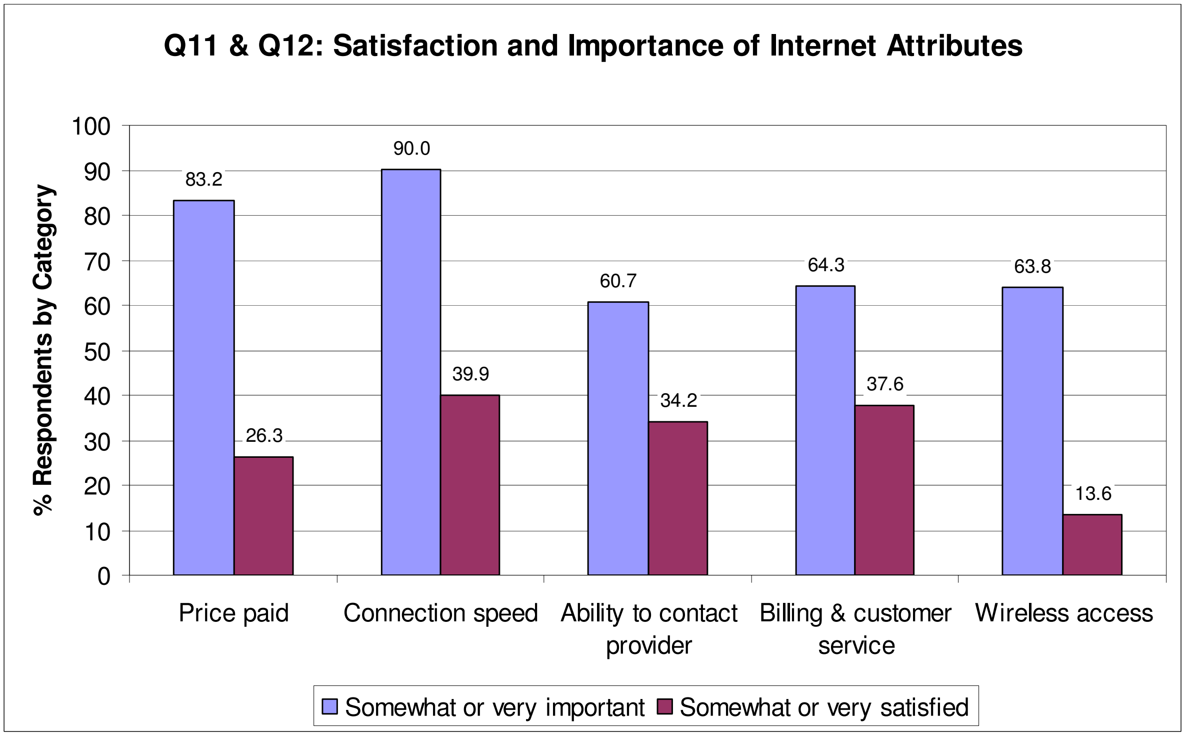
Respondents are generally satisfied with their connection speed and customer service. They are less satisfied with the price paid, ability to contact the provider, and wireless access.

Figure 62: Satisfaction with Internet Attributes



Comparisons of importance of and satisfaction with key Internet attributes reveal that satisfaction levels are well below importance levels, especially for price, speed, and wireless access. Only 26 percent of respondents were somewhat or very satisfied with the price paid for Internet service while 83 percent indicated that price was important.

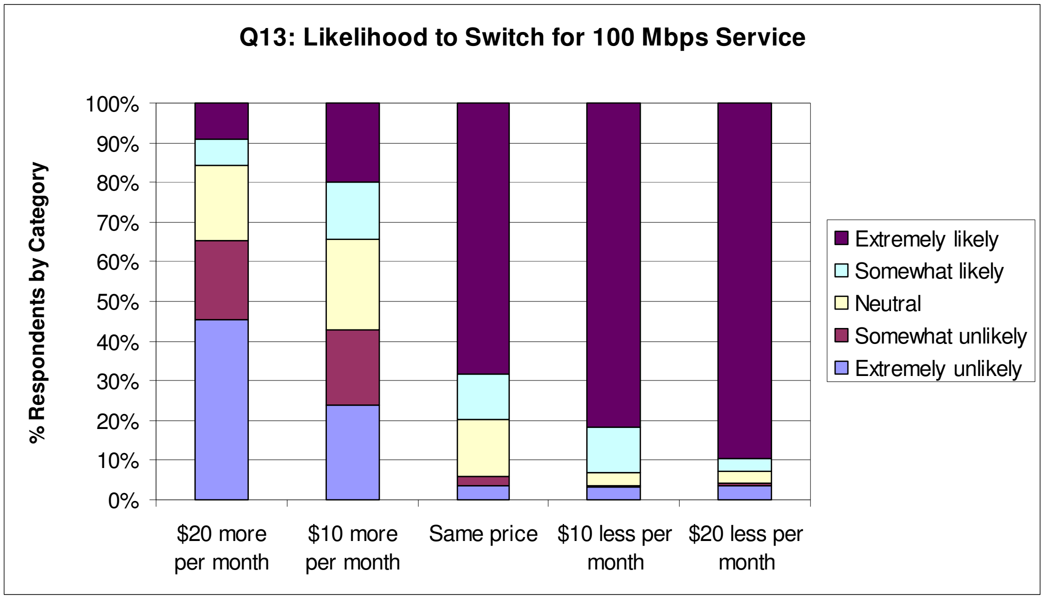
Figure 63: Satisfaction and Importance of Internet Attributes



2.2.3. Likelihood to Switch Internet Provider

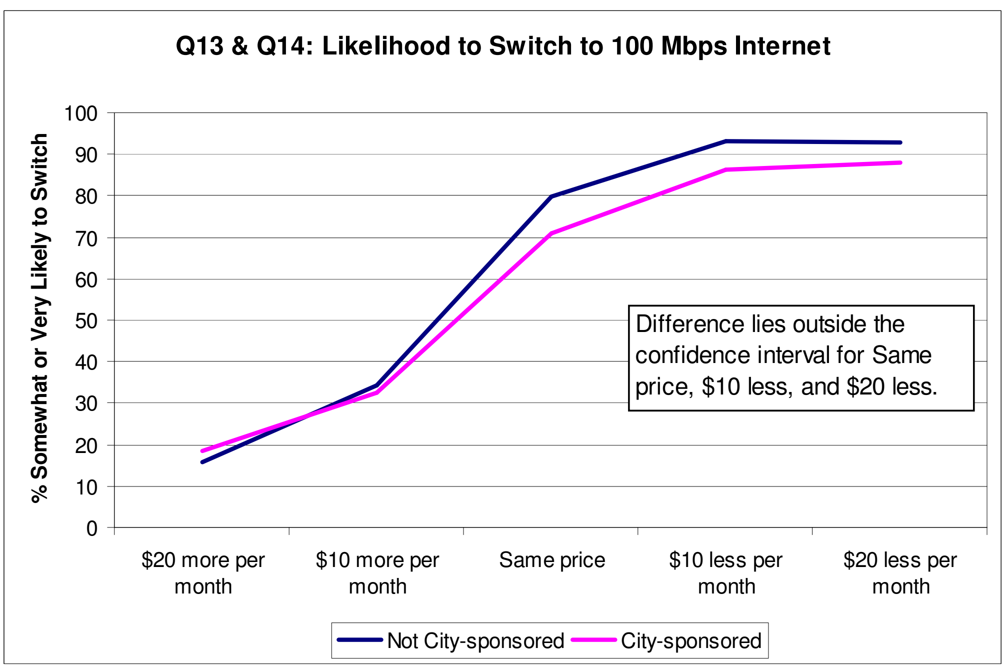
Respondents were asked if they would switch their Internet service to 100 Mbps service (about 10 times faster than cable modem or DSL) for varying price levels. Nearly 80 percent of respondents were somewhat or very likely to switch for the same price, while only 16 percent were somewhat or very willing to switch for a $20 per month price increase.

Figure 64: Likelihood to Switch Internet Provider



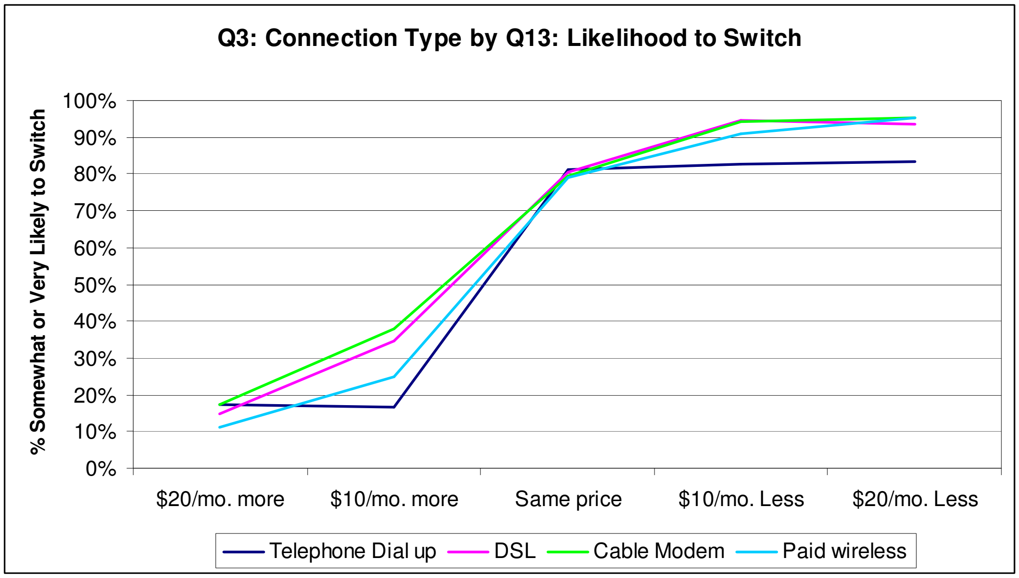
Provided the option to switch to 100 Mbps service sponsored by the City of San Francisco, respondents were somewhat less likely to switch providers, especially in the lower price categories. This indicates that residents are slightly more comfortable with a non-government provider of Internet services at similar price levels.

Figure 65: Likelihood to Switch Internet Provider Comparisons



There is not a great difference between Internet connection type and the likelihood to switch Internet providers to 100 Mbps service at any price. Telephone dial-up users are somewhat less likely to switch at most price levels.

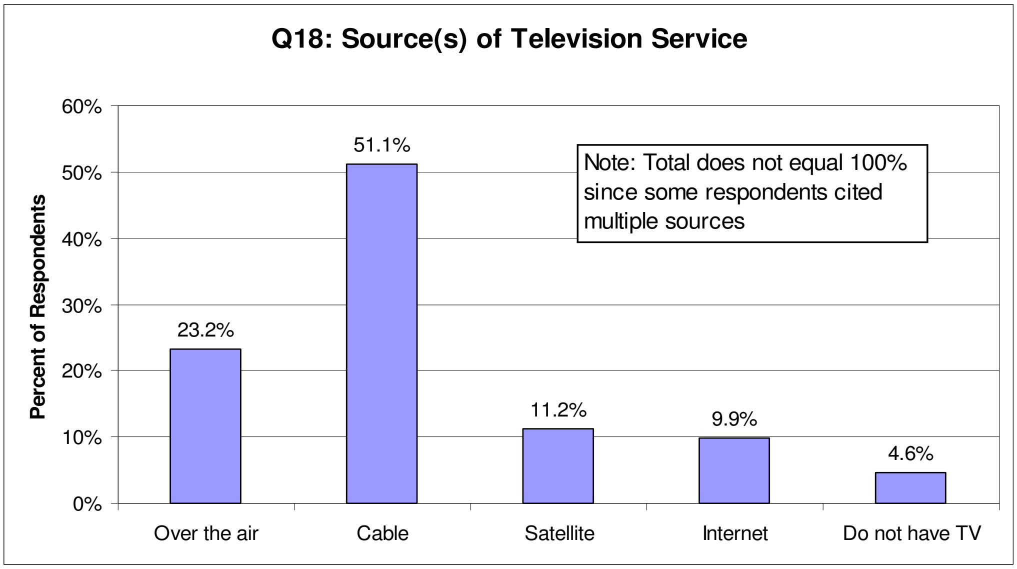
Figure 66: Connection Type by Likelihood to Switch



2.2.4. Residential Television Use

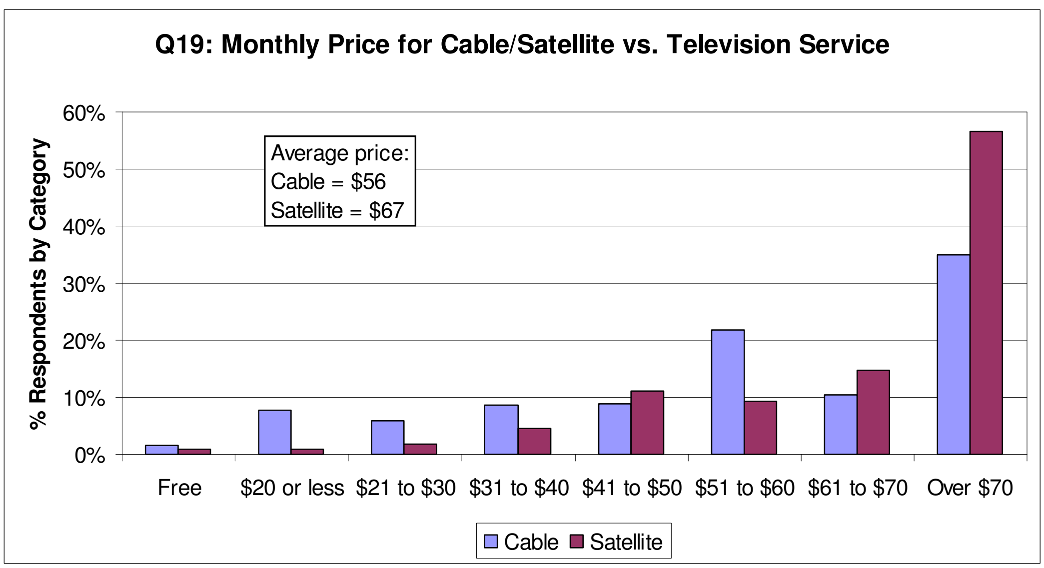
Respondents were asked about their current television service. More than one-half of respondents subscribe to cable television and 11 percent subscribe to satellite TV. Nearly 10 percent of respondents also use the Internet to watch television at least some of the time.

Figure 67: Television Service



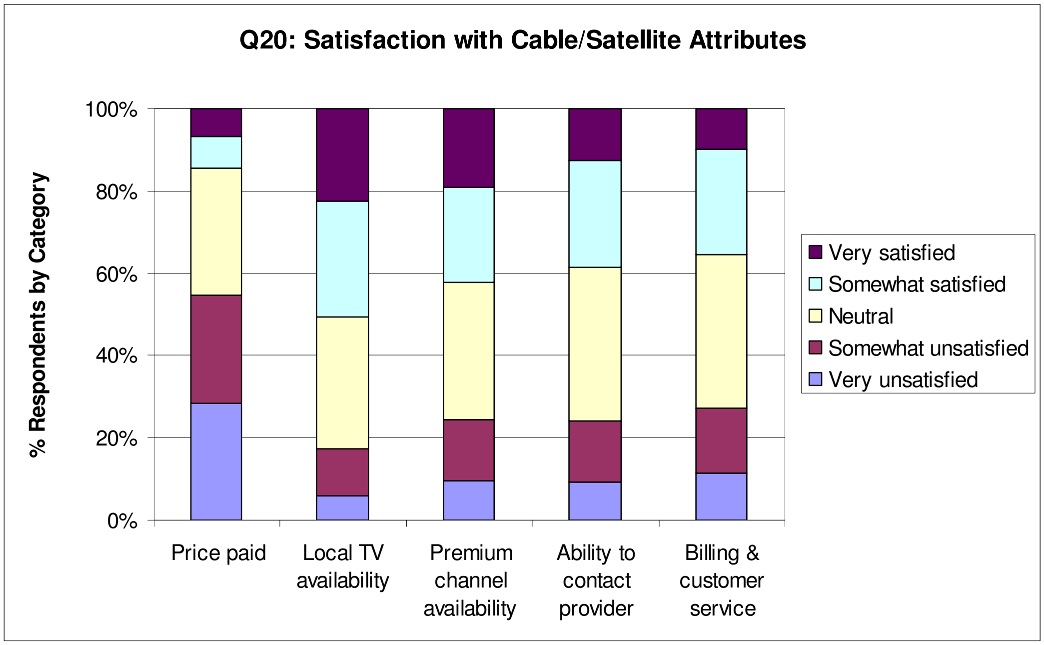
Cable subscribers pay $56 per month on average while satellite subscribers pay an average of $67 per month. This is high compared to surveys completed in other markets, although it is unclear whether the higher price is due to local subscription fees or a greater number of premium services ordered in San Francisco. Over one-third of cable subscribers and over one-half of satellite subscribers pay more than $70 per month for service.

Figure 68: Price for Cable/Satellite



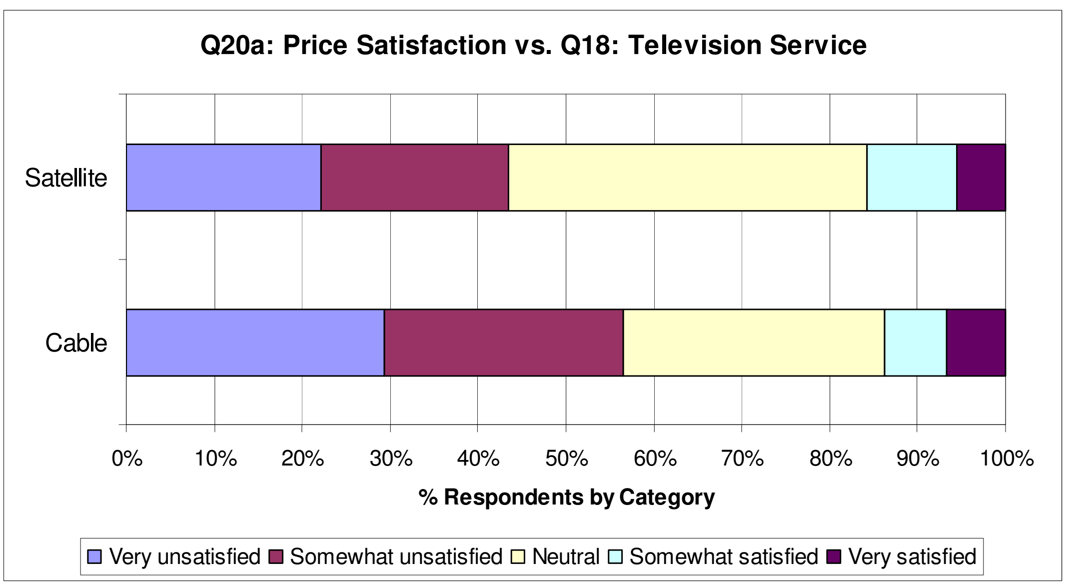
Cable and satellite subscribers are generally satisfied with most aspects of services except for price. More than half of cable and satellite subscribers were somewhat or very dissatisfied with the price paid for service.

Figure 69: Price for Cable/Satellite



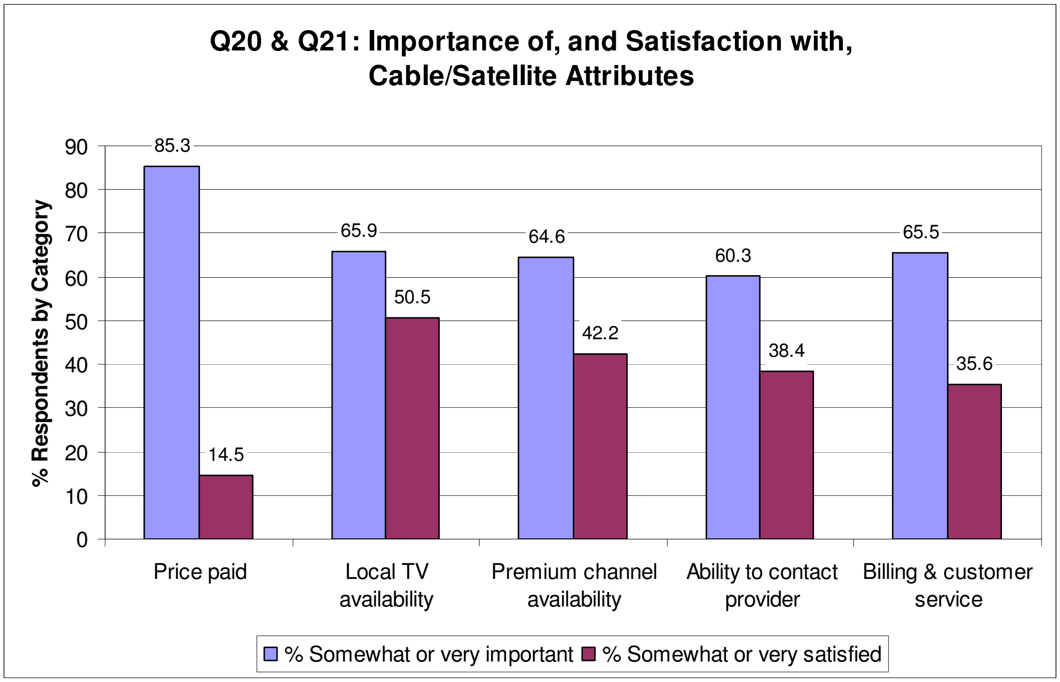
Surprisingly, satellite subscribers are generally more satisfied (or less dissatisfied) with the price paid for service despite paying a higher average cost than cable subscribers.

Figure 70: Price Satisfaction for Cable/Satellite



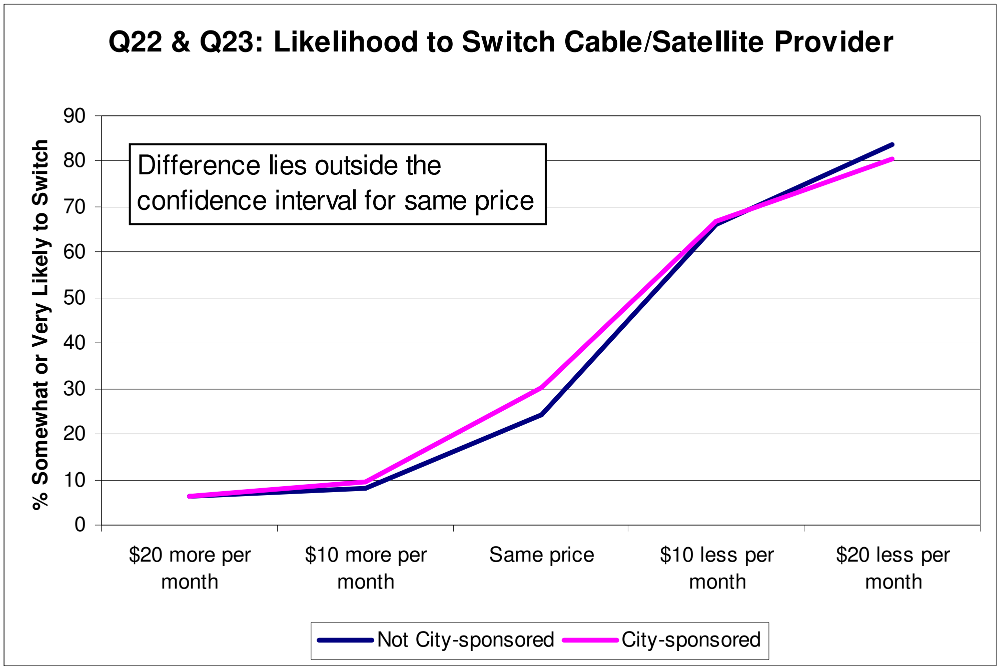
Respondents were also asked to rate the importance of a number of television service attributes. Price paid ranked as the highest importance to cable and satellite subscribers with 85 percent ranking price as somewhat or very important. Only 15 percent of respondents were somewhat or very satisfied with the price paid. Other attributes rank of lower importance, but greater satisfaction than price.

Figure 71: Importance and Satisfaction with Cable/Satellite Attributes



Cable and satellite subscribers were asked their likelihood to switch providers at a variety of price levels. For a monthly price $10 less than the current price, approximately two-thirds indicated that they were somewhat or very likely to switch providers. If the monthly price were $20 less than the current price, over 80 percent were willing to switch. There is no significant difference for service provided by the City at most price levels.

Figure 72: Likelihood to Switch Television Provider



2.2.5. Residential Telephone Use

Respondents were asked about their telephone service(s). Only 70 percent of respondents have a landline from AT&T, and only 45 percent consider a landline their primary number. Nearly 15 percent have telephone service over cable television lines. Approximately 8.8 percent of respondents have Internet-based phone service, but only 1.1 percent consider this their primary phone service.

Figure 73: Type(s) of Phone Service

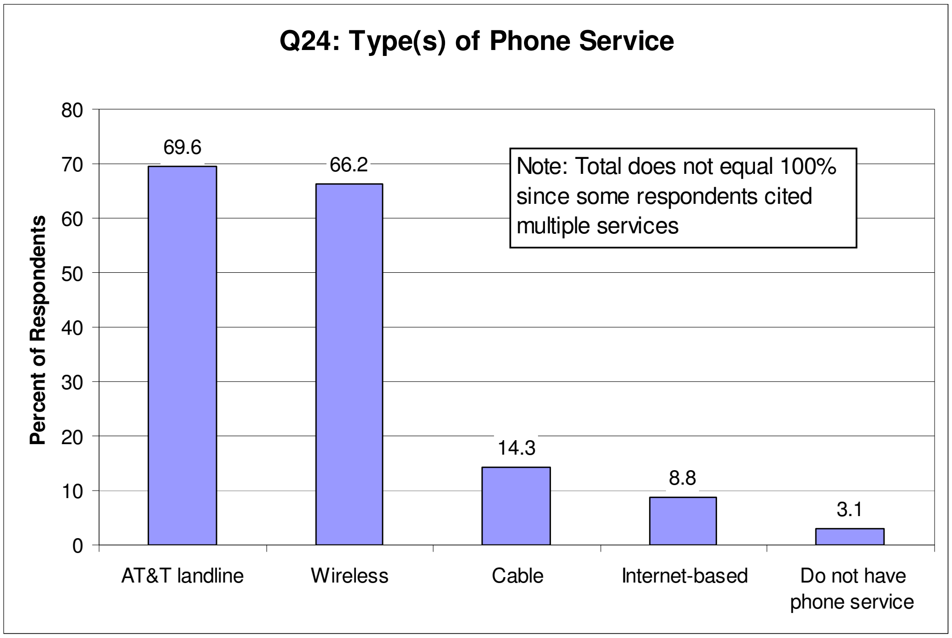
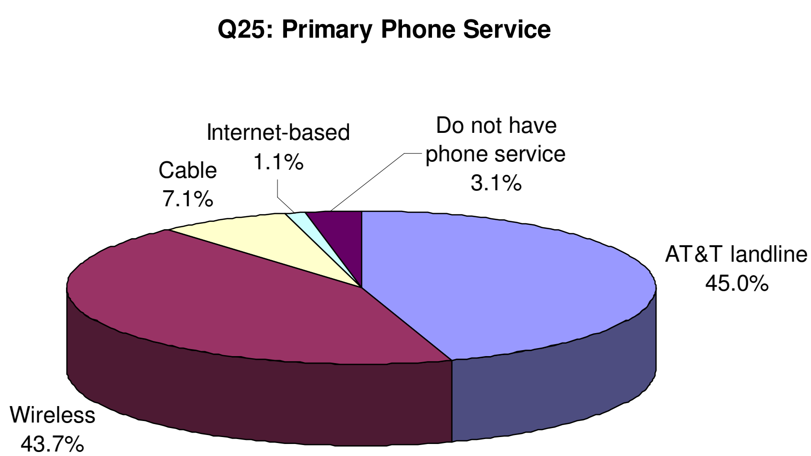
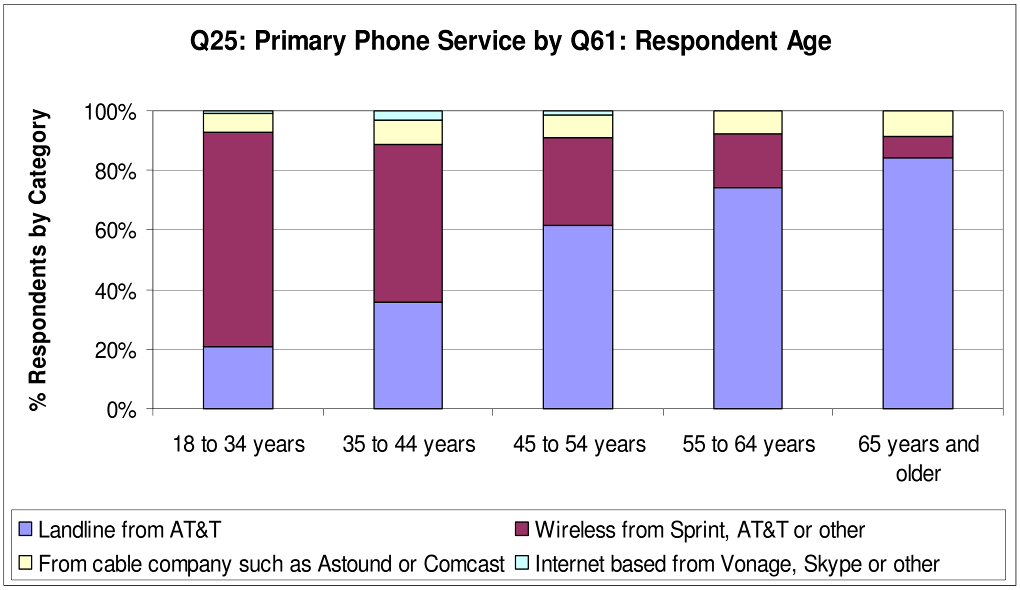


Figure 74: Primary Phone Service



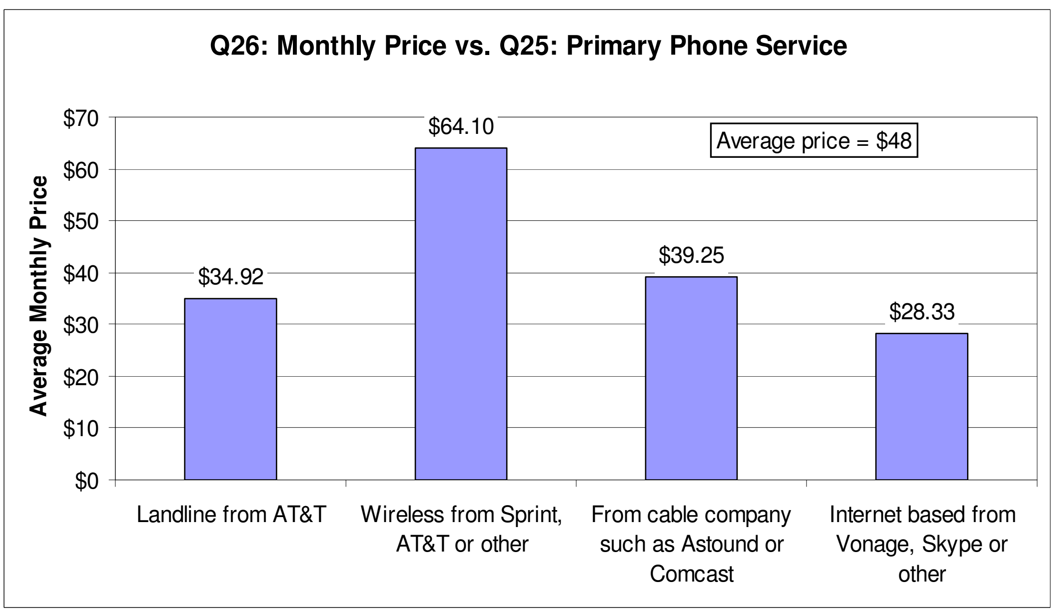
Older respondents were much more likely to use an AT&T landline as their primary phone service, while only 20 percent of younger respondents used a landline as their primary phone service.

Figure 75: Primary Phone Service by Age



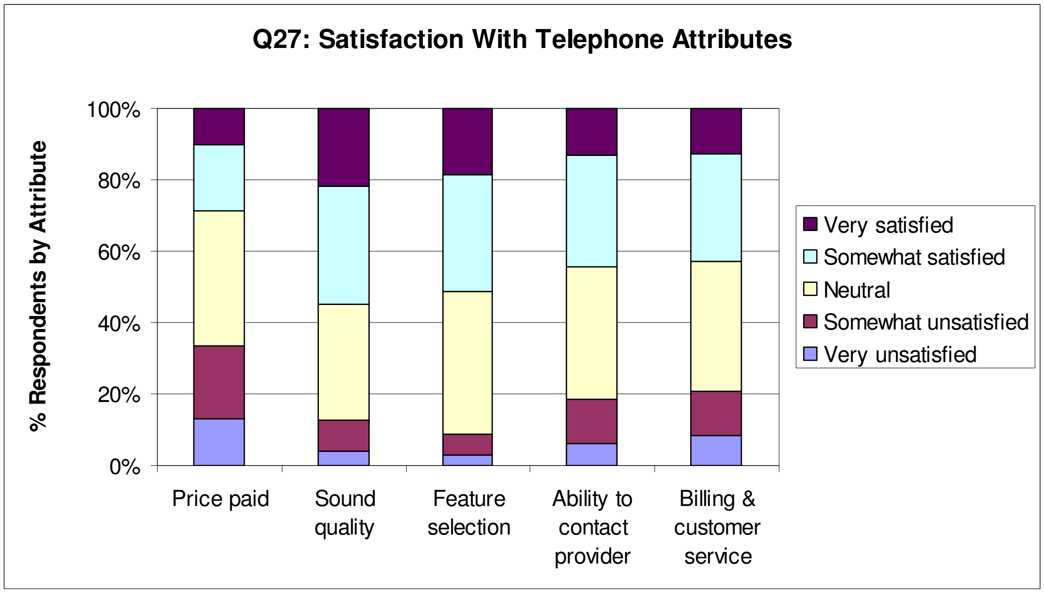
On average, San Francisco residents pay $48 per month for their primary telephone service. This ranges from $28 for Internet-based service to $64 for wireless service.

Figure 76: Monthly Price for Phone Service



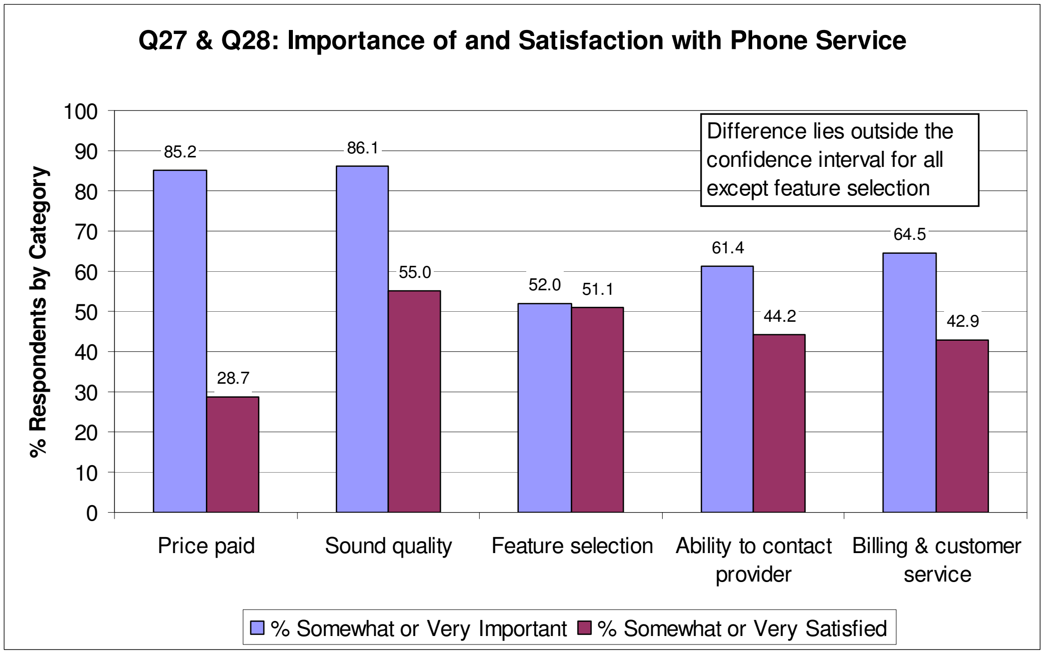
Respondents were generally satisfied with most aspects of their primary phone service with the exception of price paid. Approximately 29 percent were somewhat or very satisfied with price while 33 percent were somewhat or very dissatisfied.

Figure 77: Satisfaction with Primary Phone Attributes



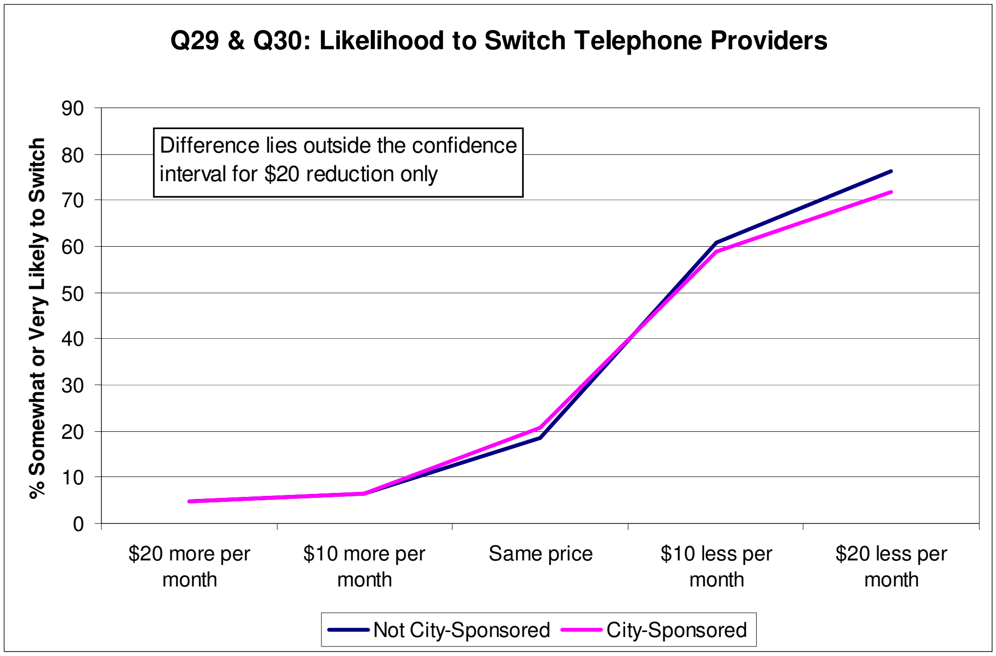
When asked to rank the importance of telephone service, respondents indicated that sound quality and price paid were the most important attributes. The level of satisfaction with telephone attributes was well below the level of importance -- except for feature selection.

Figure 2-28: Importance and Satisfaction with Phone Attributes



Respondents were asked if they would switch their telephone service at a variety of price levels. Less than 20 percent of respondents indicated the likelihood to switch providers at the same price, while 60 percent were willing to switch for a $10/month price reduction and over 70 percent were willing to switch for a $20/month reduction. There was no significant difference between propensity to switch and City sponsorship of the service at most price levels.

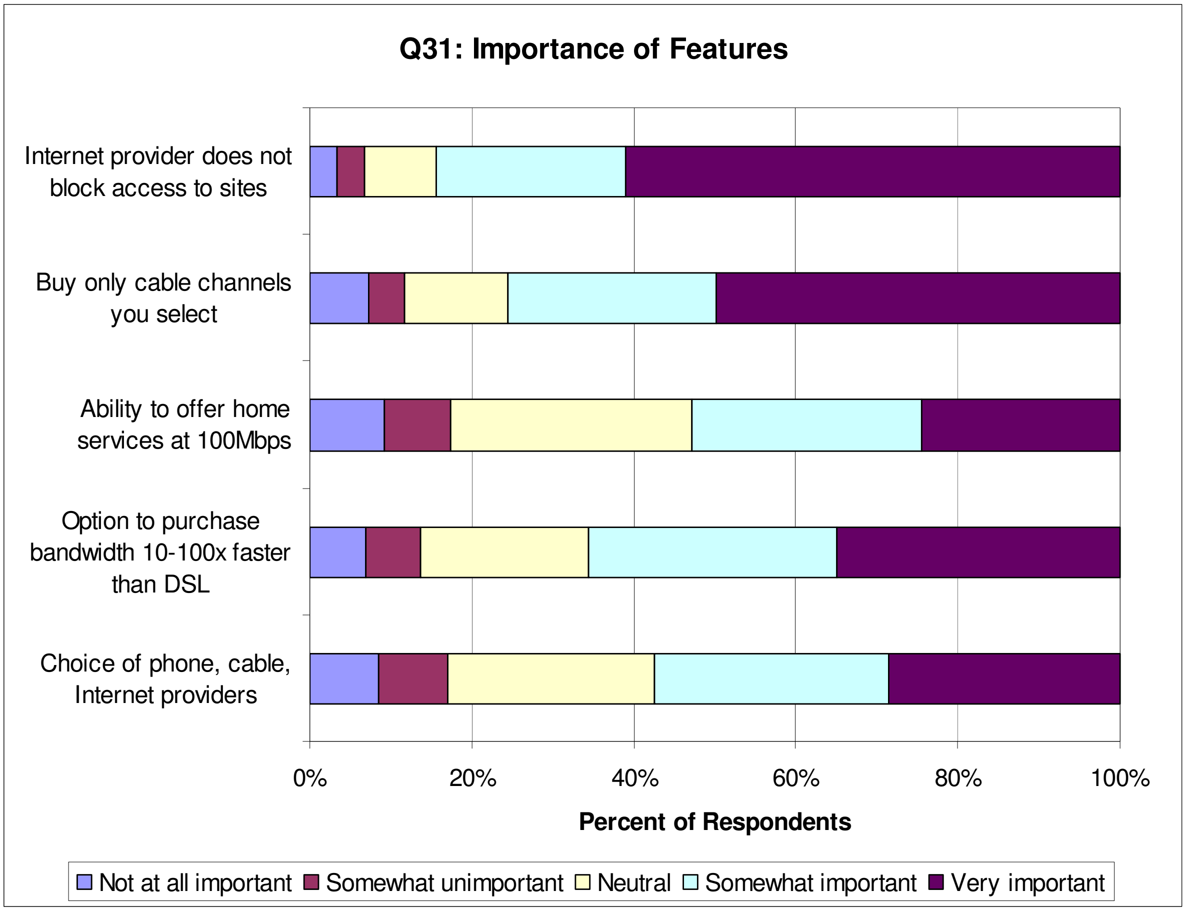
Figure 2-29: Likelihood to Switch Telephone Providers



2.2.6. Enhanced Services

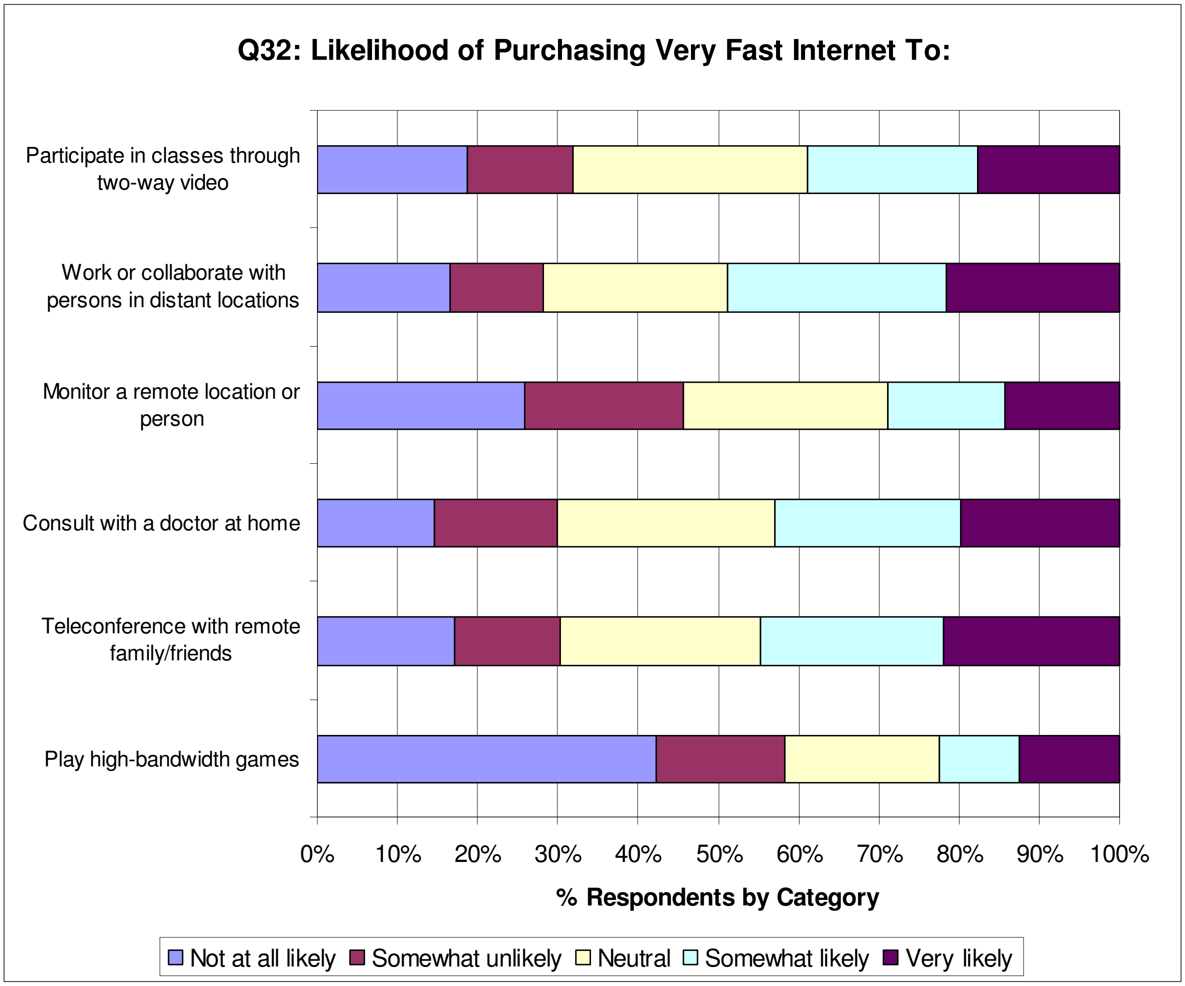
Respondents were asked about enhanced communications service including their desire for and the importance of a number of options. Confidence that the Internet provider does not block access to certain websites ranked as the most important feature, with more than 80 percent of respondents indicating that this was somewhat or very important. In addition, 75 percent of respondents stated that the ability to purchase only selected cable channels was important. The ability to offer home services at 100 Mbps ranked as the least important feature of those asked.

Figure 78: Importance of Features



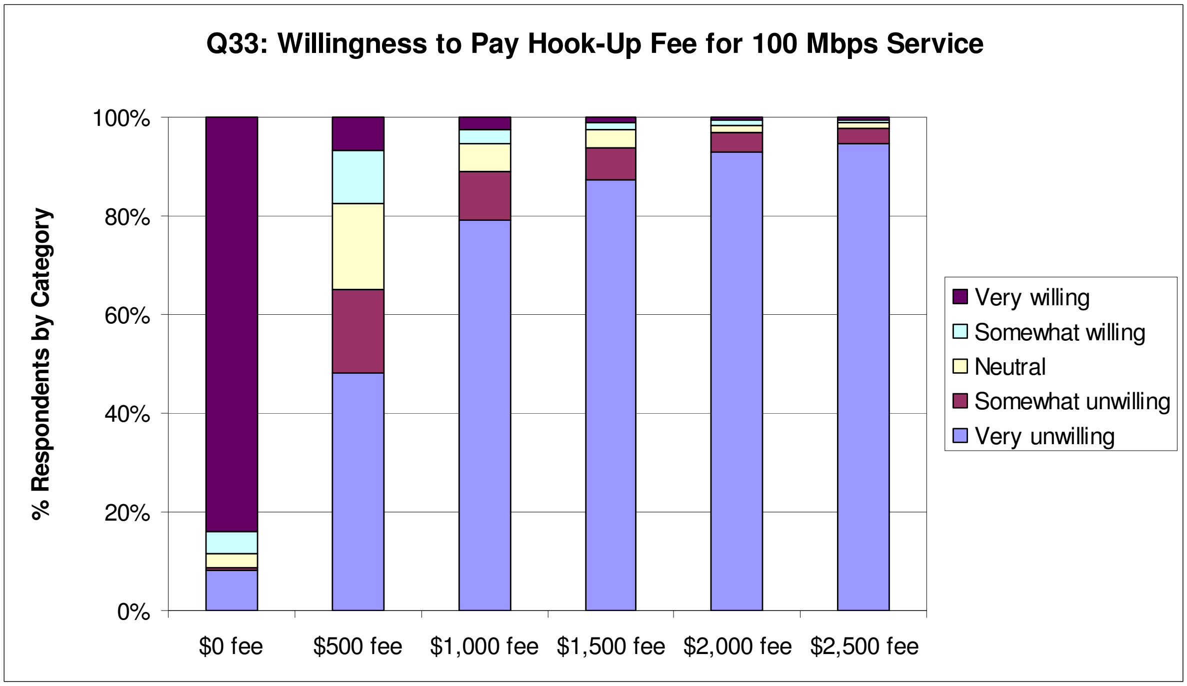
The primary motivations for purchasing very fast Internet are communicating with persons, family, or friends in distant locations. Playing high-bandwidth games ranks as the least likely reason a respondent would subscribe to very fast Internet service. Less than 50 percent of respondents listed any one of the options as a somewhat or very likely reason to subscribe to very fast Internet.

Figure 79: Reasons to Purchase Very Fast Internet



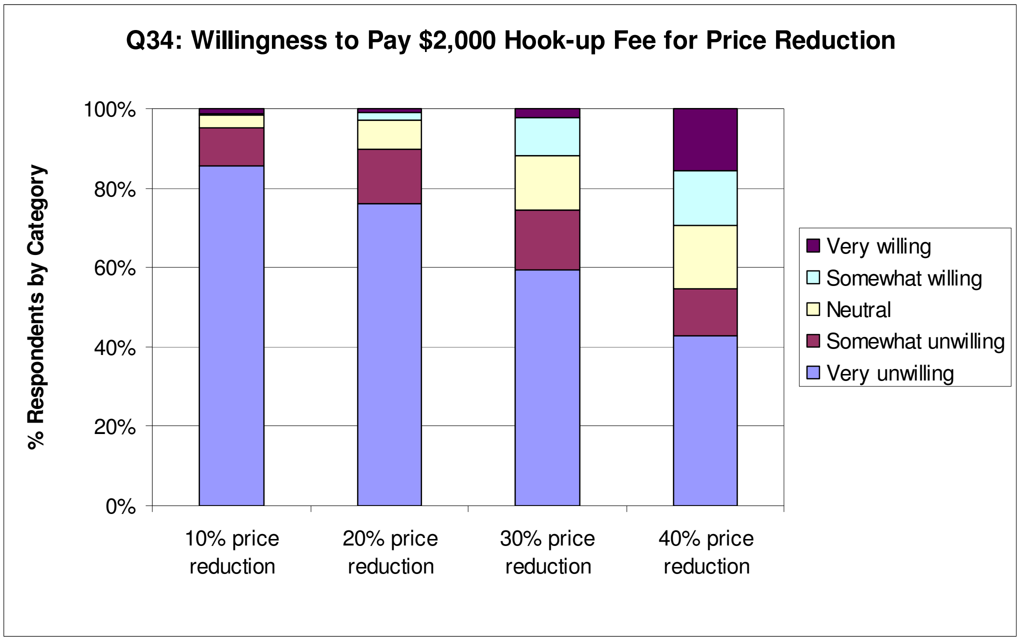
In general, residents were unwilling to pay a hook-up fee to receive 100 Mbps service. Less than 20 percent were somewhat or very willing to pay a $500 fee, and only 5.3 percent were willing to pay a $1,000 fee.

Figure 80: Willingness to Pay Hook-Up Fee for 100 Mbps Service



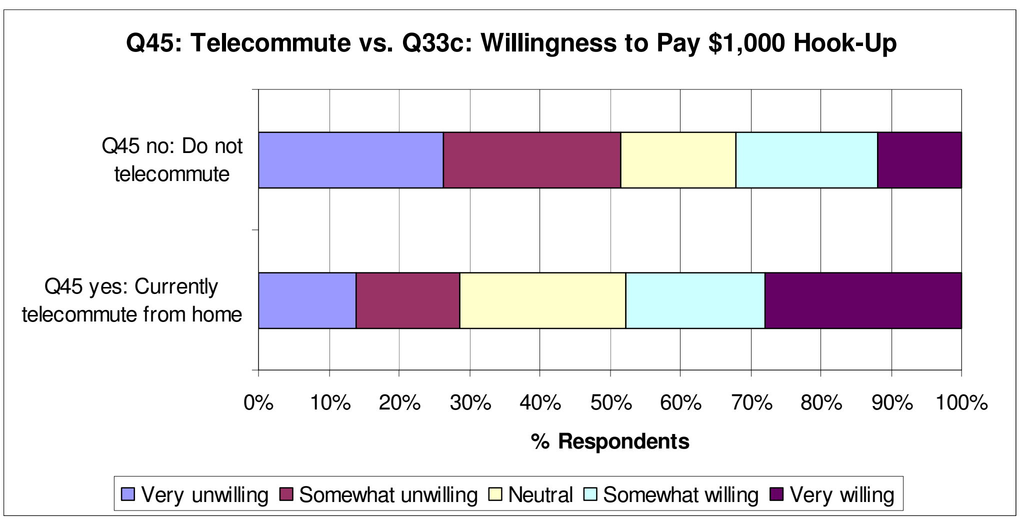
If the hook-up fee resulted in a reduction in the monthly price paid for Internet service, more customers were willing to pay a $2,000 hook-up fee, although the monthly price would need to decrease by at least 30 percent before a significant number were willing to pay the fee. For a 30 percent price reduction, 12 percent were somewhat or very willing to pay a $2,000 hook-up fee. If the price is reduced by 40 percent, nearly 30 percent would be willing to switch.

Figure 81: Willingness to Pay Hook-Up Fee If Monthly Price Reduced



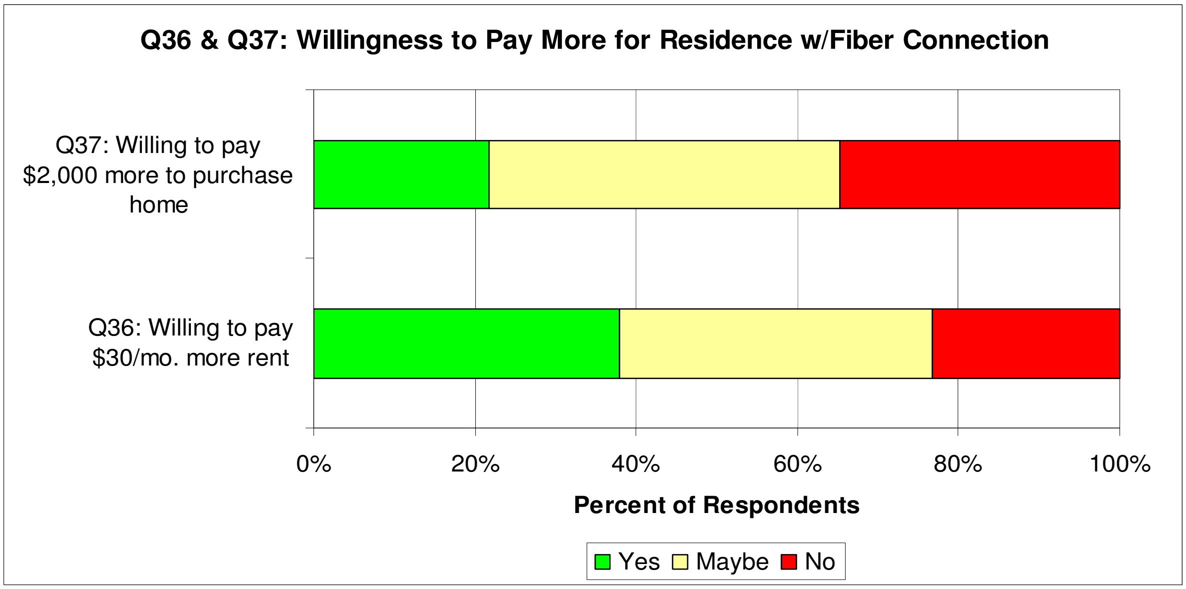
Residents who currently telework from home are more willing to pay a $1,000 hook-up fee for a fiber connection than those who do not currently telework.

Figure 82: Willingness to Pay $1,000 Hook-Up Fee by Telework



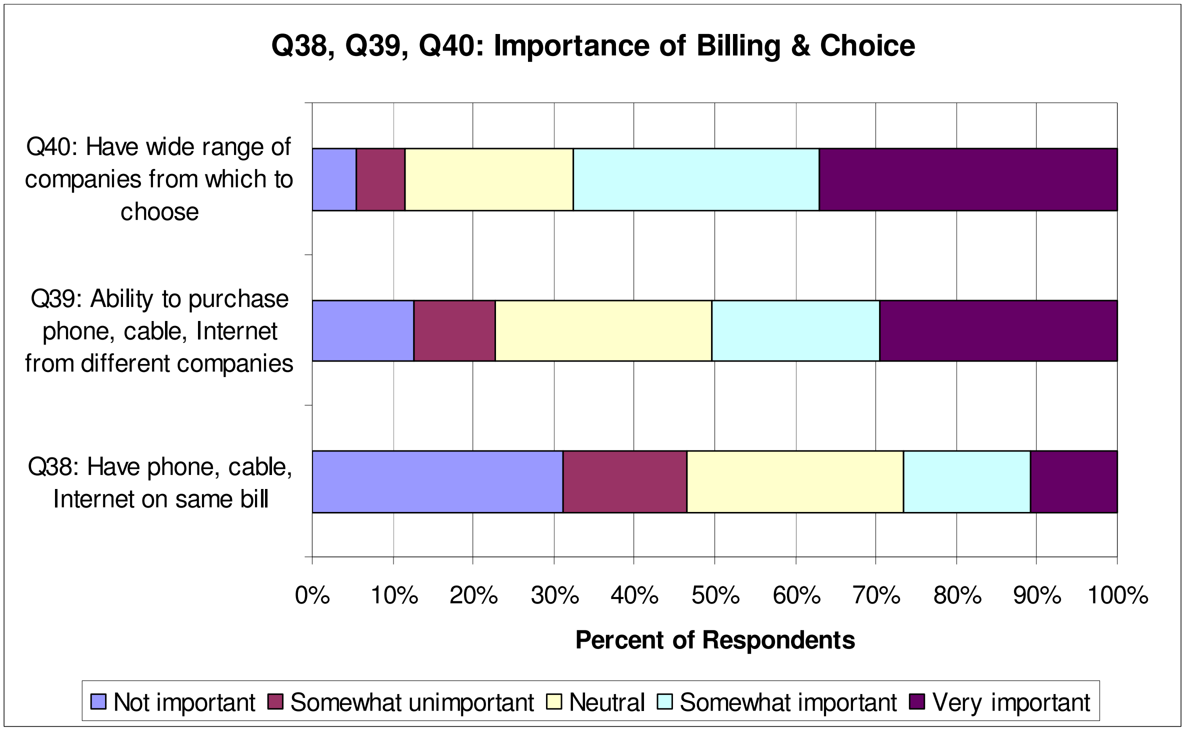
Slightly more than 20 percent of homeowners indicated that they would be willing to pay $2,000 more for a home with a fiber optic connection, while nearly 40 percent of renters were willing to pay $30 a month more for a dwelling with a fiber-optic connection.

Figure 83: Willingness to Pay for Residence with Fiber



Respondents were asked about several aspects of billing options and customer choice. Respondents generally agreed that it was important to have a wide range of companies from which to choose phone, cable, and Internet services. Approximately 50 percent said it was important to have the ability to purchase these services from different companies. Only 27 percent said that it was important to have phone, cable, and Internet on the same bill while 47 percent said it was unimportant.

Figure 84: Importance of Billing and Choice



2.2.7. Residential Use of Telework and Interest in More Telework

Approximately 68 percent of respondents work full time and another 10 percent work part time. Of those that are employed, 40 percent telework at least part of the time, including five percent that telework full time.

Figure 85: Employment Situation

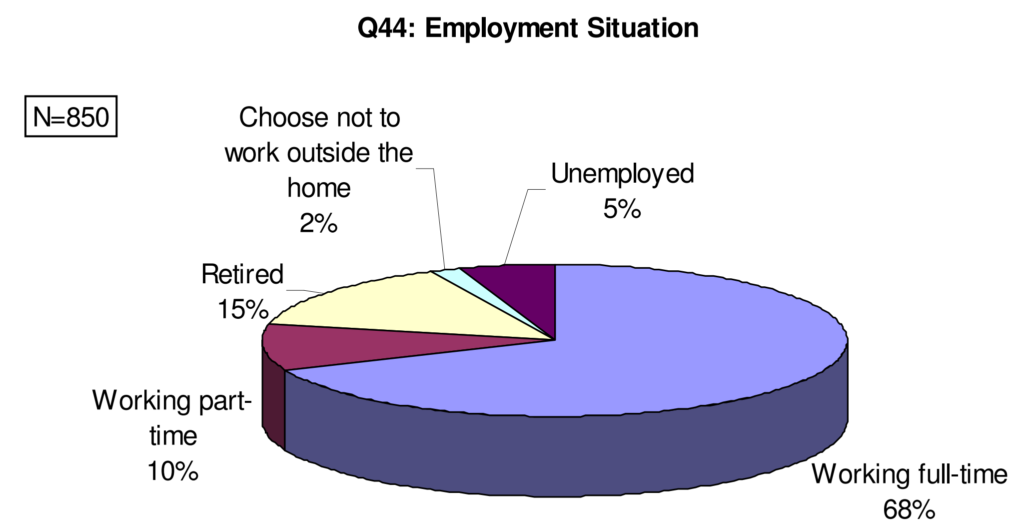
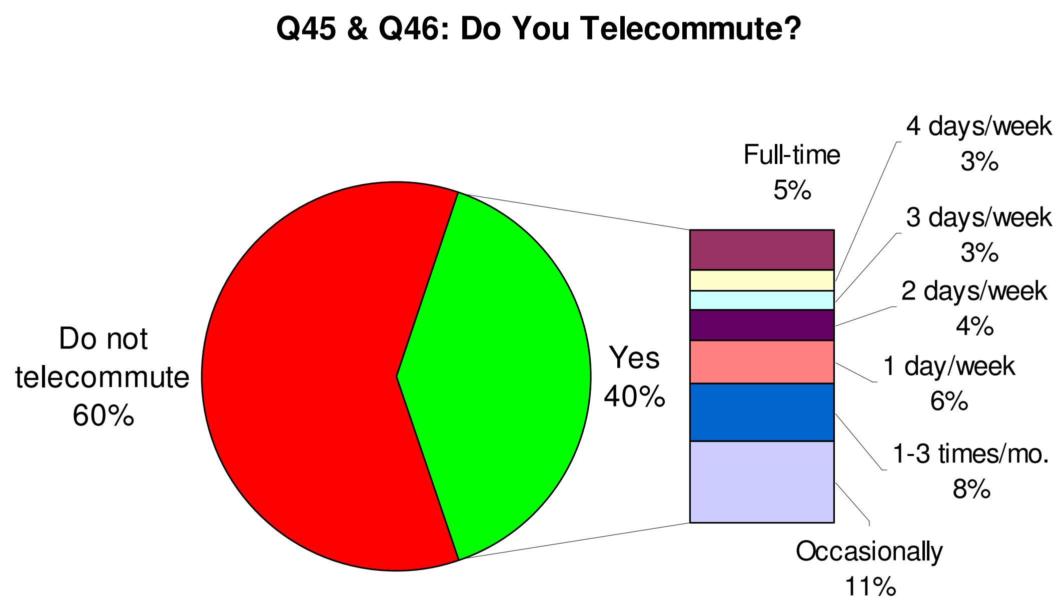
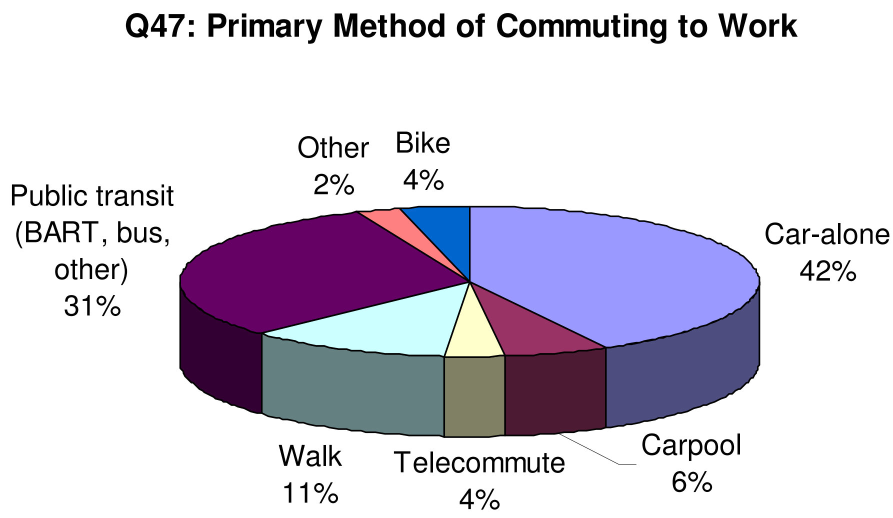


Figure 86: Telework



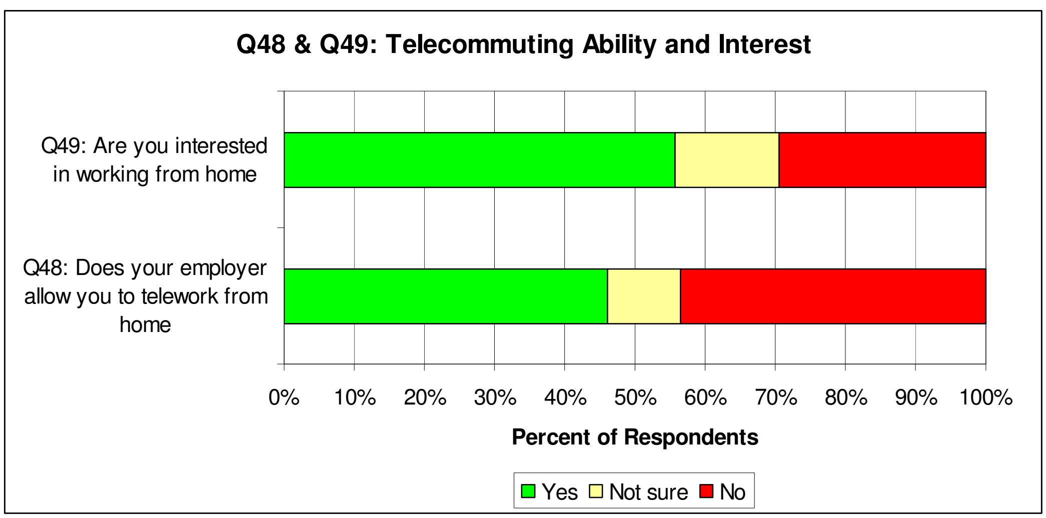
The most common method of commuting to work was driving alone in a car (42 percent) closely followed by public transport (31 percent). Nearly 20 percent stated that they primarily walk, bike, or telework. Most respondents (60 percent) commuted to work five days per week.

Figure 87: Primary Commute Method



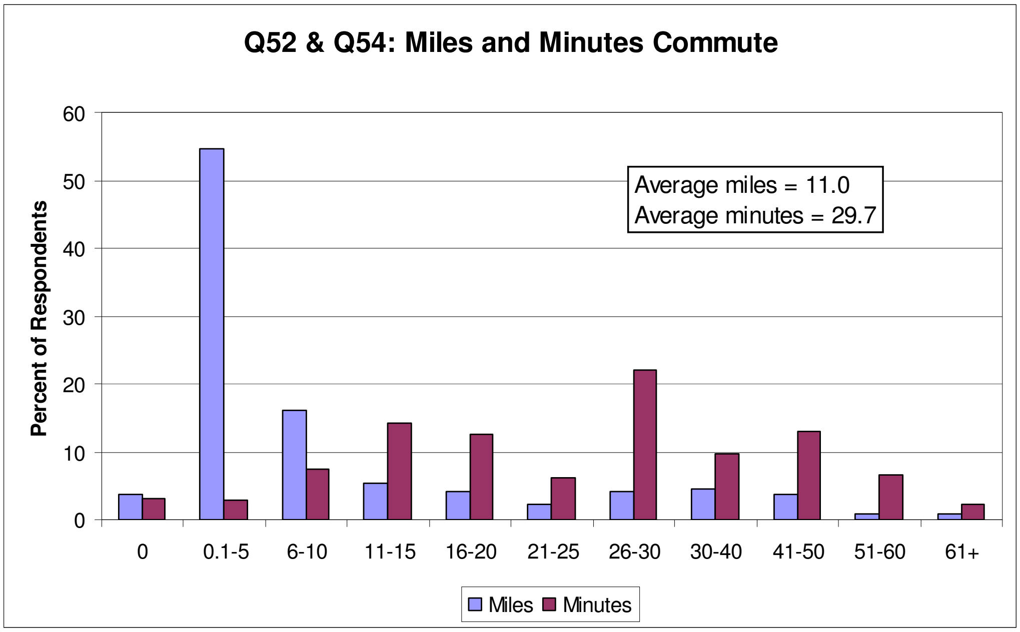
Slightly less than one-half of respondents' employers allow telework while slightly more than one-half of respondents indicated an interest in telework.

Figure 88: Telework Ability and Interest



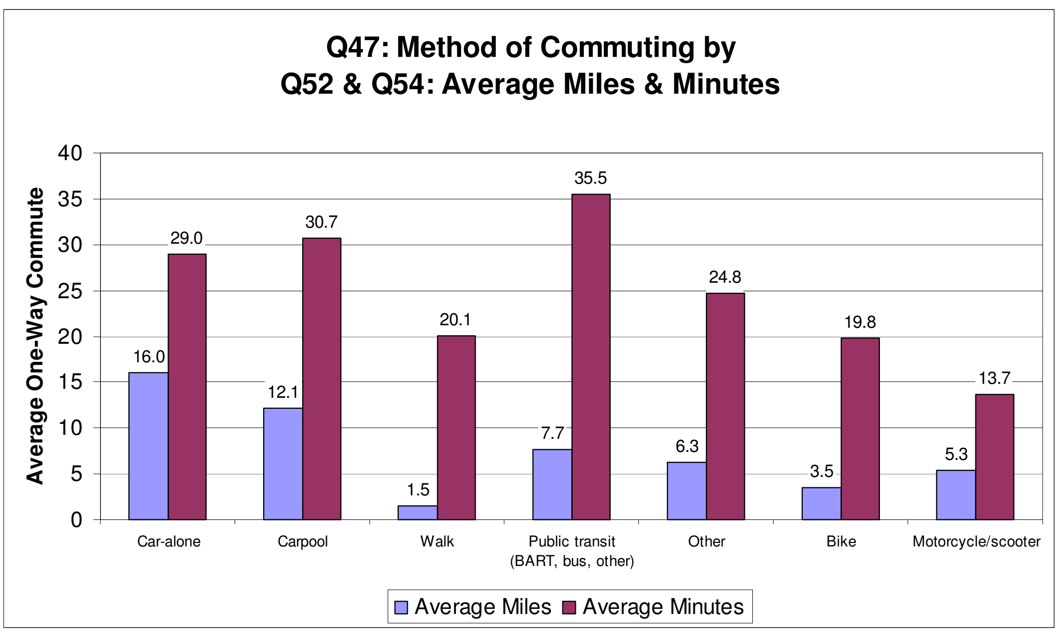
Respondents commute an average of 11 miles (one way) to work each day, taking an average of 30 minutes. More than one-half of respondents commute less than five miles one way.

Figure 89: Miles and Minutes Commute



On average, residents commuting in a car alone have the longest distance commute, averaging 16.0 miles each way. Those using public transportation have the longest time commute, averaging 35.5 minutes each way.

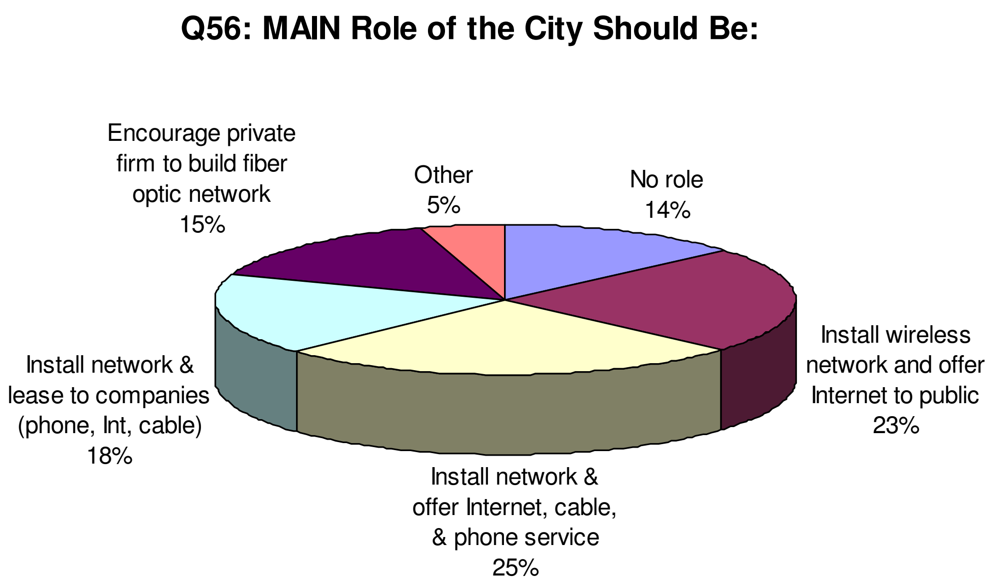
Figure 90: Method of Commuting by Miles and Minutes



2.2.8. Residential Perceptions of Appropriate City Role in Facilitating Communications

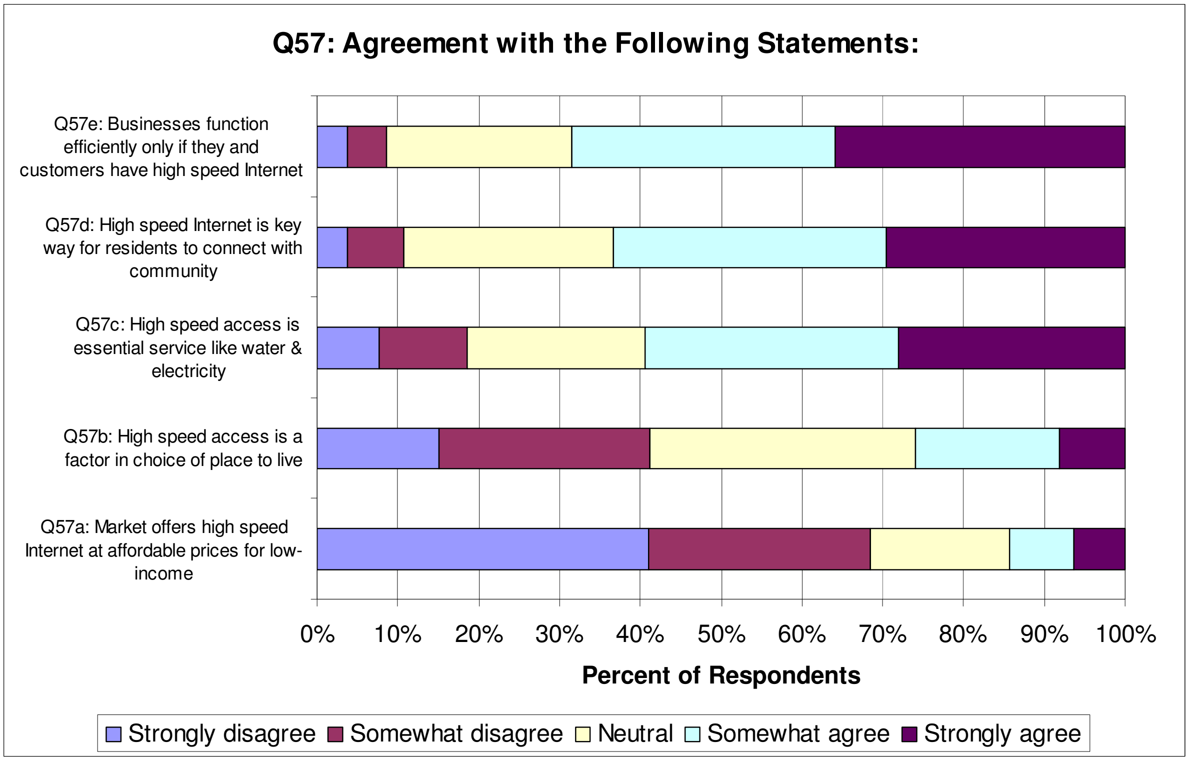
Nearly one-half of respondents indicated that the main role of the City should be to install a network and offer communications services to the public. This includes one-fourth who thought the City should build a state-of-the-art network and offer phone, cable, and Internet services to the public, along with 23 percent who thought the City should install a wireless network and offer Internet services. Approximately 18 percent thought the City should build a network and lease it to private companies, 15 percent thought the City should encourage a private firm to build a fiber optic network, and 14 percent thought the City should have no role in a communications network. Of respondents aged 65 and older, 30 percent thought the City should have no role (compared to 14 percent of all respondents).

Figure 91: Main Role of the City



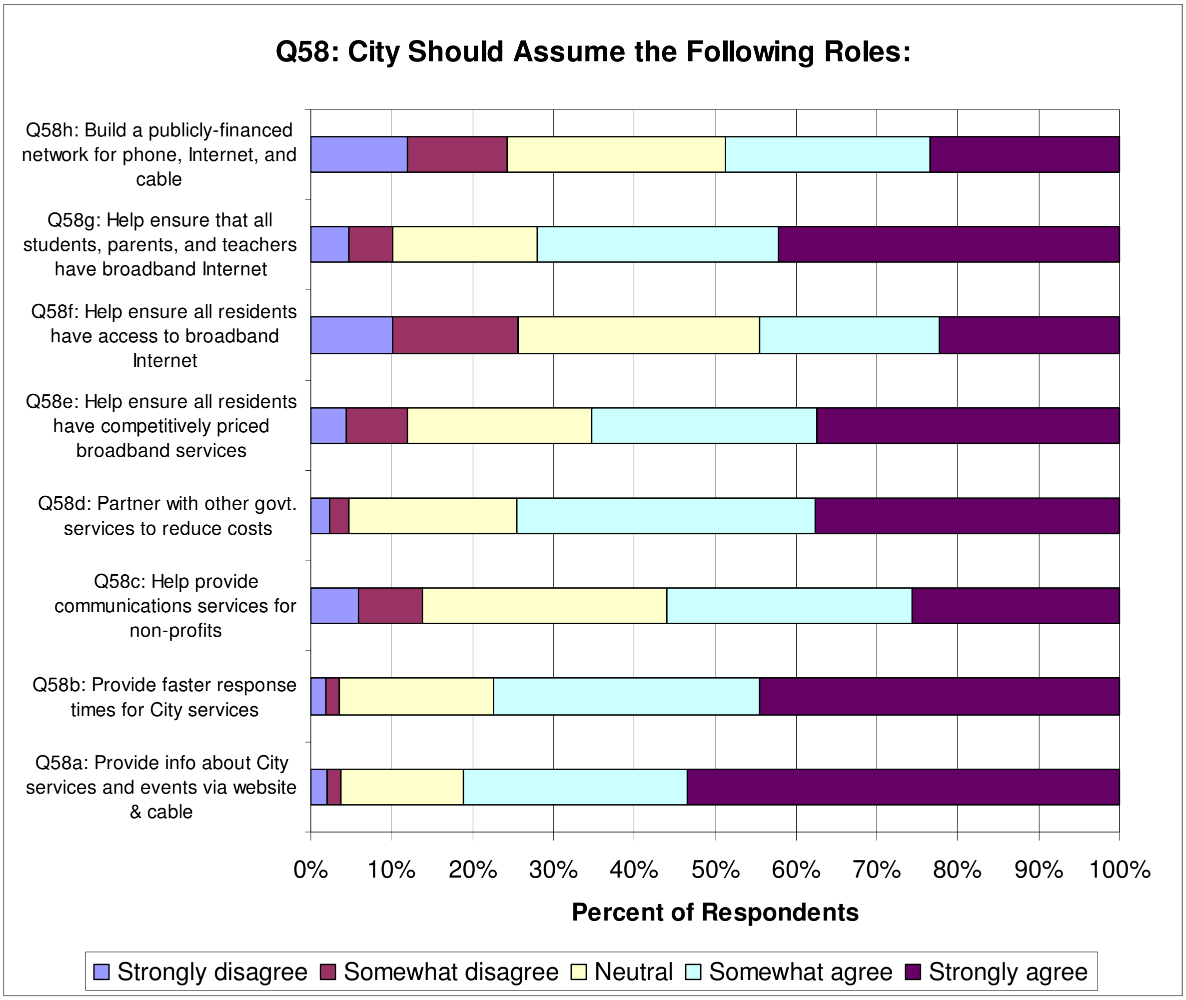
More than one-half of respondents agreed that high-speed Internet is becoming an essential service similar to water and electricity. More than one-half also agreed that high-speed Internet is essential for businesses to function efficiently, and for residents to stay connected with their community. Approximately two-thirds of respondents believed that the market did not provide high-speed Internet at a price that low-income households could afford.

Figure 92: Residents' Opinions



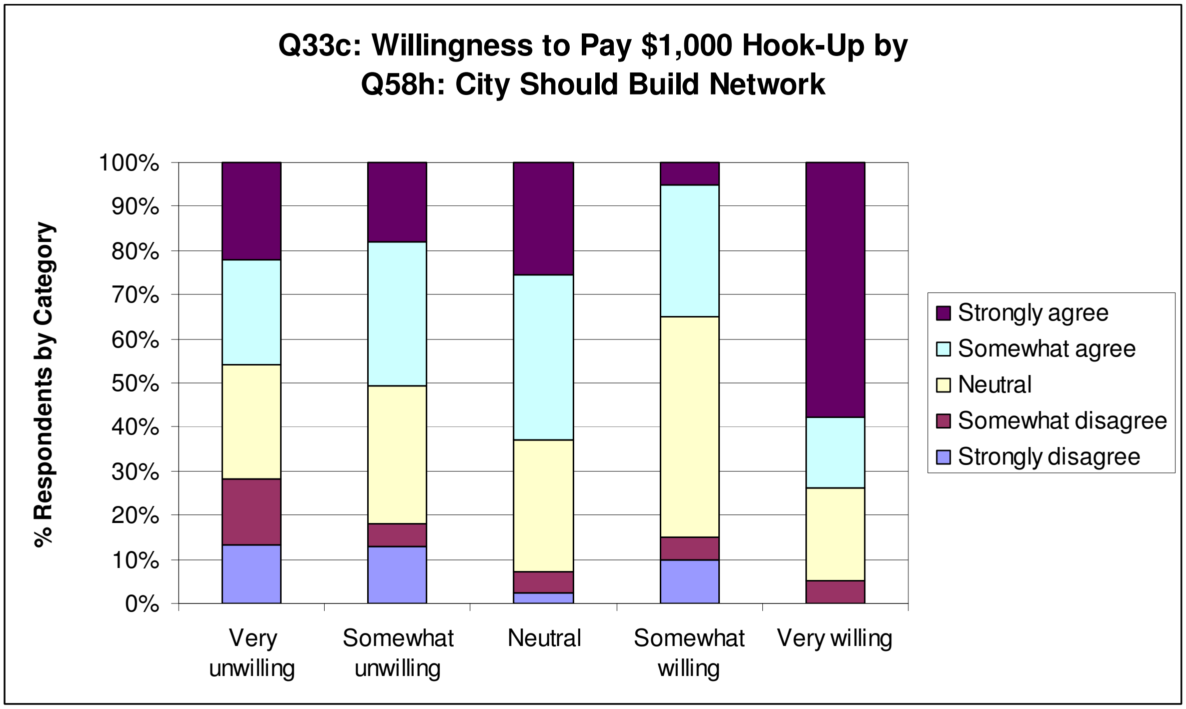
Respondents were asked about the role that the City should assume regarding high-speed Internet access. The most favorable roles are for the City to use the Internet to provide information about services and events, provide faster response times for City services, and to partner with other governmental agencies to increase efficiencies. Nearly 50 percent of responses agreed that the City should build a publicly-financed network for the private sector to offer communications services.

Figure 93: Opinions of City Roles



There is a correlation between the respondents' willingness to pay a $1,000 hook-up fee for a fiber connection and their desire of the City to build a communications network. While less than 50 percent of all respondents agreed that the City should build a network, nearly three-fourths of respondents who were willing to pay a $1,000 hook-up fee agreed that the City should build a network. This indicates that those most in favor of a City network are willing to pay a hook-up fee to obtain services over that network.

Figure 94: Willingness to Pay by City Should Build Network



3 The Existing Market Fails to Meet San Franciscans' Needs

This Section of the Report provides a brief overview of the existing broadband landscape in San Francisco including announced future projects and deployments, and evaluates the reach and capability of existing and planned private-sector broadband infrastructure and services. In summary, this Section concludes that San Francisco's residents and businesses have a relatively broad range of services available, as compared to other urban areas where there has been little or no FTTP deployment. However, as compared to FTTP areas (such as Verizon FiOS build areas and the FTTP networks in major cities in Europe and the Pacific Rim); San Francisco is at a great disadvantage with respect to affordability, access, speed, and ubiquity of broadband. See Appendix A for a "snapshot" of residential and business broadband service availability in early 2009.

San Francisco's incumbent providers are taking certain steps to deploy some new technologies, but they are constrained in their investment choices by a number of key factors including capital markets, the high cost of required infrastructure investment, and the impact the Internet has on traditional telephone and cable television products.

First, the capital markets reward short-term profits and punish long-term expense for investments like FTTP. As was noted in a Strategy Analytics study:

> Unlike local governments, which can justify investing in expensive FTTH technology on the grounds that it may benefit the public or stimulate economic growth, telcos and other shareholder-owned companies face intense pressure to limit costs and show near-term returns on investment. This financial pressure will continue to make FTTH difficult to rationalize in the near term.[41]

Second, the existing broadband market precludes true broadband competition because of the impracticability of construction of numerous broadband physical networks.

The cost of building fiber all the way to the home or business constrains incumbent investment choices -- and, under current law, building their own network is the only way competitive providers can reach consumers. With the "overbuild" model, each provider must build out competing networks in each neighborhood they want to serve. The required infrastructure and investment to serve one consumer is quite similar to the investment to pass all potential customers in the community. In other words, the required investment must be repeated for each provider, double the providers, double the network costs, double the investment.[42] As a result,

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[41] Jim Penhune and Martin Olausson, "Fiber To The Home in Europe: Will Municipalities or Markets Drive Growth?," Strategy Analytics, November 10, 2006.

[42] The alternative "open access" model separates the network itself (provided by a "wholesaler") from the services (provided by "retailers" who compete over the single network). A single infrastructure provider (either private or public) sells wholesale access on a non-discriminatory basis to any private service provider. This model eliminates duplicate network infrastructure investment and reduces market-entry barriers to new and innovative service

each incumbent can justify major investments only by increasing revenues per household by selling many services rather than just one or two.

To increase revenues, incumbents attempt to sell consumers "triple play" services -- bundled voice, video, and data. Their goal by offering “triple play” is to increase both the market size and the net contribution margins.

Third, there is not an incentive for incumbents to build big pipes because those pipes will enable consumers to use free or cheap services provided by competitors over the Internet rather than buying the incumbents’ phone and video services -- this represents a significant loss of revenue for incumbents, but a great savings for consumers and a great incentive for web-based innovation by thousands of competing companies.

For example, Internet-based Voice over Internet Protocol (VoIP) is a threat to incumbent voice revenues. VoIP, combined with high-speed Internet access, transforms voice communication from a service to an application.[43] Consumers can get VoIP as a free service (from companies such as Skype) or as a paid service (from companies such as Vonage). Similarly, video multicasting and video streaming is a threat to incumbent video revenues. Current incumbent networks limit the functionality of video over the Internet. But very high-bandwidth will enable quality video multicasting and streaming. Consumers will not have to purchase a package, or “tier” of video channels, many of which they never watch. Rather, consumers will simply acquire programming over their data connections from Internet-based distributors (such as AppleTV or CinemaNow) or directly from the content producer (such as Comedy Central or a production studio).

Some incumbents are well-served by limited-bandwidth -- scarcity protects their business model and revenues, and does not adequately enable Internet-based applications that compete with their own service offerings.

However, scarcity does not deliver the big pipe for innovation and creativity, new capabilities, opportunities for competitive and innovative service providers, enhanced customer alternatives, or consumer choice.

3.1 The Private Sector has No Plans to Build FTTP in San Francisco

None of the City’s incumbent wired providers (AT&T, Astound, and Comcast) has indicated any plans to deploy FTTP facilities throughout San Francisco.

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providers. This model enables the same creativity, innovation, and competition over new networks as existed over open dial-up networks in the 1990s.

[43] Services are bundled with the connectivity infrastructure. The voice telephone service acquired from AT&T is an example of a service. Applications separate the traditional service from the infrastructure. For example, a VoIP telephone application can follow the user, and is not tied to a particular infrastructure.

Verizon offers FiOS in parts of Southern California, as shown in Figure 95, but has not indicated any plans of extending the service to San Francisco. Paxio Inc has been involved with some FTTH buildouts in a few communities in the San Francisco Bay area including Sunnyvale and Palo Alto. Paxio has been working primarily with land developers and property owners to build fiber to communities. It offers residential Internet services with speeds ranging from 3 Mbps to 1 Gbps with monthly recurring charges ranging from $26.50 to $245.[44]

Figure 95: Availability of Verizon FiOS in California

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44 http://www.paxio.com/home.php?link=Internet, accessed October 22, 2008

4 Projection of New Entrant Market Share

This Section analyzes the market research data to estimate the potential market share the City's FTTP network could realize for cable television, Internet, and telephone services.

Consumer propensity to switch Internet, cable television, and telephone products is a balance of their satisfaction and the importance of various service attributes, such as price, user features, customer service, and availability of substitute products. For example, residential survey respondents indicated significant gaps between satisfaction and the importance of price, speed, mobility, and customer service (in order of the size of the gap) with their Internet service. To capture market share, new market entrants and alternatives can focus on identified gaps to develop appropriate marketing strategies and product development.

To help quantify the influence the gaps between satisfaction and importance have on consumers, we asked a series of questions regarding willingness to acquire services with varying performance attributes and prices. The responses had a 5 point scale ranging from very willing or likely to very unwilling or unlikely to switch services, and a mid-point of neutral.

It is important to recognize that actual actions taken by consumers (residential and business) will differ from survey responses. Survey responses tend to overstate actions consumers will actually take. Further, survey data is temporal -- consumer preferences and choices are influenced by advertising, product enhancements by existing providers, special offers, and other factors of influence. To compensate the condition described, we used a multiplier for each response category – which indicates the percentage of responses that will actually respond as indicated. The factors used are as follows:

- Very likely/Likely: .75
- Somewhat willing /Likely: .50
- Neutral: .25
- Somewhat unwilling /Unlikely: .00
- Very unwilling /Unlikely: .00

4.1.1. Retail Services

4.1.1.1. Residential Internet

The Internet product presented in the surveys was a 100 Mbps symmetrical service compared to DSL and cable modem services in use by residents with prices ranging from under $20 per month to $70 or more per month.

As illustrated in Figure 96, if a 100 Mbps service is priced the same as what the customer is paying for an existing DSL or cable modem service, we might expect to capture over 60 percent of residential customers. If the 100 Mbps service was priced $20 less than what the customer is paying for current DSL or cable modem service, we might expect to capture over 69 percent of the market.

Figure 96: Residential Internet (100 Mbps) Market Share Estimate

Next, we asked a series of questions regarding the respondent's interest in obtaining a 100 Mbps service if the service were to be sponsored by the City. With a City sponsored offering, we might expect to capture 55 percent of the market if the service was priced the same as the current DSL or Cable modem connection. If the 100 Mbps service was priced $20 less than what the customer is paying for current DSL or cable modem service, we might expect to capture over 66 percent of the market.

The difference in interest between anticipated market shares for a non-City sponsored and a City sponsored service is just above the survey tolerance -- indicating the City has a slight negative brand image for sponsoring residential Internet service.

Figure 97: Residential Internet (100 Mbps) sponsored by City Market Share Estimate

Using the average monthly cost of $37[45] for Internet access as the base price, we project a new provider would see up to a 55 percent market share with a 100 Mbps service (50 percent of households). Dropping the price to $27 per month increases the anticipated market share to 63 percent (57 percent of households).

4.1.1.2. Residential Telephone

Telephone is more of a commodity product than Internet. Telephone consumers have a wide-range of alternatives from Internet-based voice over Internet protocol (VoIP) products to wireless cell phones. Just a few years ago, 98 plus percent of all households had a landline telephone from incumbent telephone providers (AT&T in San Francisco). By the end of 2008, it is estimated that 20 percent[46] of households will no longer have a landline telephone and only use a wireless service.

Further the survey indicated that slightly less than 44 percent of respondents use a wireless service for their primary telephone number. Slightly less than 84 percent[47] of respondents indicated they have a landline telephone from AT&T (70 percent) or their cable television provider (14 percent). For AT&T, this indicates they have gone from serving virtually every resident in San Francisco to less than 70 percent of households. We anticipate the size of the landline telephone market share will continue to decline.

The weighted average monthly price indicated by survey respondents for landline services from AT&T and the cable television companies is $36 – including long distance. As shown in Figure 98, we anticipate seeing up to a 21 percent market share with a similar priced service. Decreasing the price by $10 per month will increase the anticipated market share by almost 20 percent – to 43 percent. With number portability and expanding alternatives, continued price pressure and high customer churn rates can be expected. Again, the market size for residential

[45] Weighted average of all residential Internet service offerings. The $37 is used just for initial modeling purposes. A provider may have a selection of services a varying price levels.
[46] "Call My Cell: Wireless Substitution in the United States," The Nielson Company, September 2008.
[47] This represents the current market size of the residential landline telephone market in San Francisco.

landline telephone service is shrinking – wireless and Internet-based alternatives and use is on the rise.

Figure 98: Residential Telephone Market Share Estimate

Next we asked the respondents their willingness to switch service if the telephone service were to be provided by the City. It might be expected to capture slightly greater than 22 percent of the market share if the service were priced the same as what the customer was paying presently. If the price were to be reduced by $10, we anticipate it could capture up to 41 percent of the market.

Figure 99: Residential Telephone Sponsored by City Market Share Estimate

4.1.1.3. Residential Cable Television

As in the case of the telephone, cable television has seen a declining market size due to the adoption of satellite and other options. Although the market has declined in size, the drop is not as dramatic as the landline telephone market. In San Francisco today, 51 percent of households are estimated to purchase cable television services, 11 percent use satellite, 23 percent use over-the-air television, and almost five percent do not own a television[48].

An increasing alternative to cable television is viewing television over the Internet. Today in San Francisco, almost 10 percent of respondents indicted that they use the Internet as a source of television programming. As higher speed and more reliable Internet connections are made available, we anticipate the use of the Internet for television to increase dramatically. In addition, the conversion from off-the-air broadcast to high definition will greatly increase the numbers of "free" channels available to San Francisco residences – without the picture "snow" frequently experienced with analog broadcasts. Given these factors, we anticipate the size of the cable television market will continue to decline.

Currently, San Francisco residences pay an average of $56 per month for cable television service. A new entrant in the market may expect up to a 26 percent market share (25 percent of households) for a similar offering at the same price. Decreasing prices by $10 per month, we expect to see the anticipated market share to increase to almost 47 percent.

Figure 100: Residential Cable Television Market Share Estimate

We asked respondents their willingness to switch television service if it were to be sponsored by the City. Slightly over 28 percent of respondents were willing to switch to a television service sponsored by the City if it was priced the same as what consumers are paying for their present service. If the price were to be reduced by $10, slightly greater than 47 percent of the market can be expected to be captured.

[48] Does not equal 100 percent since some respondents cited multiple sources.

Figure 101: Residential Cable Television Sponsored by City Market Share Estimate

A major challenge for new entrants into the cable television market is maintaining contribution margins[49]. Program fees paid by cable television operators continue to rise and customer willingness to pay more is in the decline. Cable operators are no longer able to shift all programming cost increases to consumers, and have seen lower contribution margins resulting in lower profitability for the cable television distributors. In other words, dropping cable television prices by $10 per month may be attractive politically, but is not advisable from a cash flow perspective.

4.1.1.4. Business Internet

The range of needs and the range of satisfaction levels for Internet use for business are much greater than in the residential market. Large organizations tend to have fewer issues and complaints with Internet access and related costs. Smaller businesses are frustrated with cost and connection speed.

Approximately 93 percent of San Francisco businesses use an Internet connection, with about 67 percent being DSL and 14 percent are cable modem customers. Larger businesses will use leased lines, and at times, Gbps-based fiber connections.

Significant satisfaction and importance gaps exist with the choice of providers, customer service, price, and speed. As in the case of residential services, a new market entrant must view these gaps as opportunities.

First, we looked at the likelihood of businesses obtaining a 100 Mbps service at different price levels. As illustrated in Figure 102, a 100 Mbps service is attractive to over 43 percent of businesses with Internet access priced at the same level as their existing Internet service.

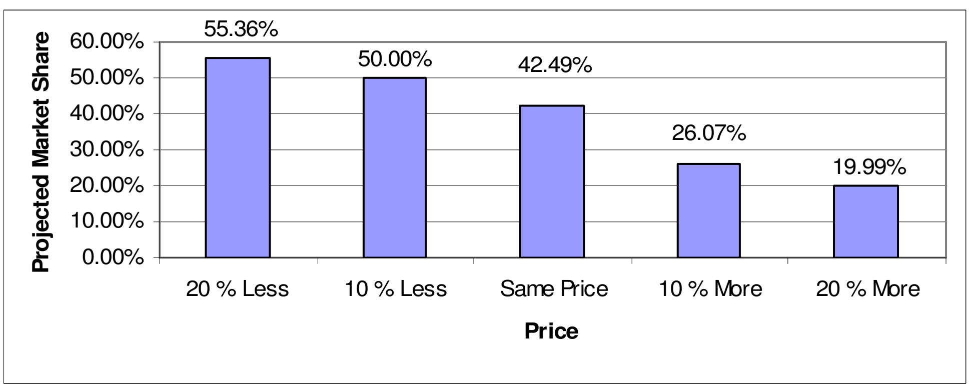
[49] Differences between gross revenues and cost-of-goods sold.

Figure 102: Business Internet (100 Mbps) Market Share Estimate

There is a large difference in the average monthly price paid for leased line services ($667 average monthly price) compared to other connectivity services, such as cable modem, DSL, ISDN, telephone and wireless (weighted average cost per month is $118[50]). For the sake of comparison, we evaluate the 100 Mbps service to the weighted average monthly cost of $118 and the 1000 Mbps service to the average price of leased service of $667.

We asked the respondents their willingness to switch to a 100 Mbps Internet service if it was sponsored by the City. The survey results indicate that we can expect up to 42 percent of businesses with Internet that may acquire a 100 Mbps service priced at the same rate as they pay for their existing service which is an average monthly price of $118.

Figure 103: Business Internet (100 Mbps) Sponsored by City Market Share Estimate



As shown in Figure 104, we can expect to see a market share of 23 percent for a 1000 Mbps service offered at 20 percent more than what the respondent is presently paying for which is an average monthly price of $667. If the price were to be increased by 50 percent to an average monthly price of $1,000, we can anticipate approximately 12 percent of the market share would

[50] Weighted average of cable modem, DSL, ISDN, telephone, and wireless services.

be captured. If the price were increased by 100 percent to an average monthly price of $1,334, we can anticipate approximately 8 percent of the market share to be captured.

Figure 104: Business Internet (1000 Mbps) Market Share Estimate

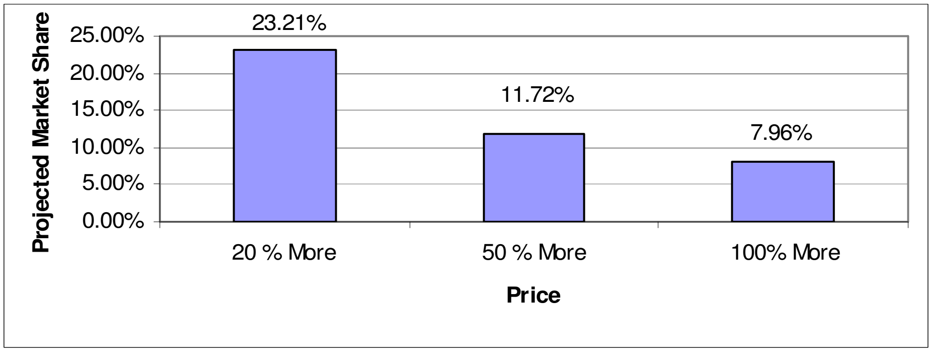


Figure 105 shows the market share estimate for 1000 Mbps service if the service were to be sponsored by the City. A market share of 23 percent can be expected for a 1000 Mbps service sponsored by the City offered at 20 percent more than what the respondent is presently paying for. If the price were to be increased by 100 percent to an average monthly price of $1,334, approximately eight percent of the market share can be expected to be captured. A slightly higher percent of business respondents were willing to switch to a 1000 Mbps service at a price 50 or 100 percent more than the present price if the service were to be sponsored by the City.

Figure 105: Business Internet (1000 Mbps) Sponsored by City Market Share Estimate

4.1.1.5. Business Telephone

As discussed in the case of residential telephone, business telephone has become a commodity. However, businesses still primarily use a landline connection since wireless is not a direct substitute product at this time. This is not to say that it will not change in the future.

As shown in Figure 106, in order to capture a 29 percent market share, discounts of at least 10 percent must be offered.

Figure 106: Business Telephone Market Share Estimate

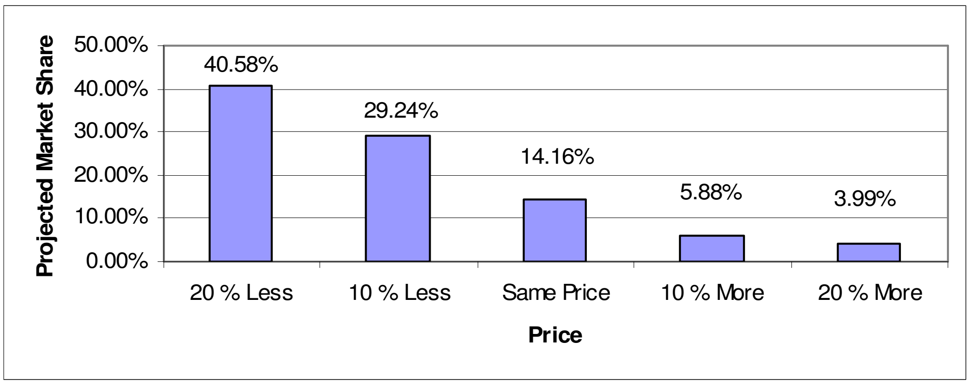
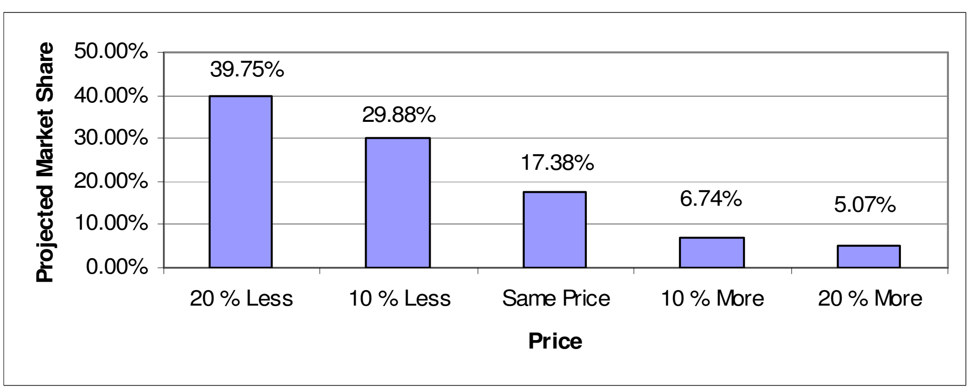


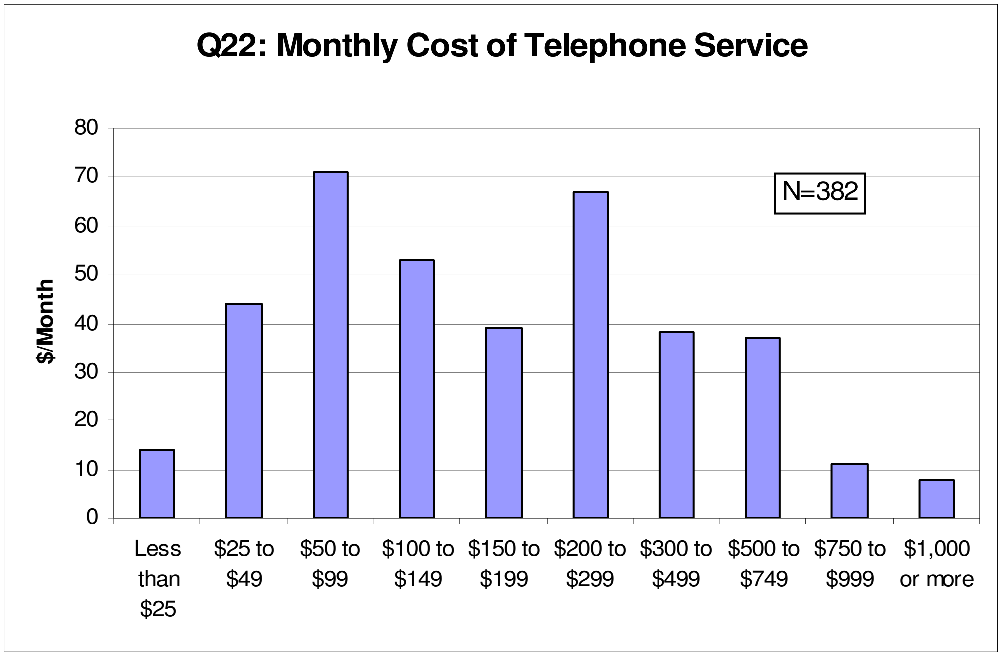
Figure 107 illustrates the market share estimate for business telephone service if it were to be sponsored by the City. An estimate of 17 percent of market share can be captured if the telephone service were to be offered by the City at the same average monthly price paid by business customers.

Figure 107: Business Telephone Sponsored by City Market Share Estimate



The average monthly telephone fees paid per month is currently $249. However, there is a large range of prices paid by businesses. For example, over 33 percent of the businesses see an average monthly phone cost of less than $100, while over 42 percent pay over $500 per month. The ranges of costs are shown in Figure 108.

Figure 108: Price Paid for Telephone Service



4.1.1.6. Business Cable Television

The market size for cable television used by businesses is low. Only 15 percent of businesses acquire cable television services at an average cost of $72 per month, and six percent acquire satellite services at an average cost of $76 per month.

Given the low usage of cable and satellite television by businesses, and the need to keep the survey as short as possible, we did not ask propensity to switch questions in the survey.

In the financial model, we assume the business market will respond similarly to price changes as in the residential market. Further, we assume the market size for cable television is 15 percent (existing cable television users) since business satellite users typically are interested in sports and entertainment programming that only available via satellite (example: NFL Game Day).

4.1.2. Equity Financing

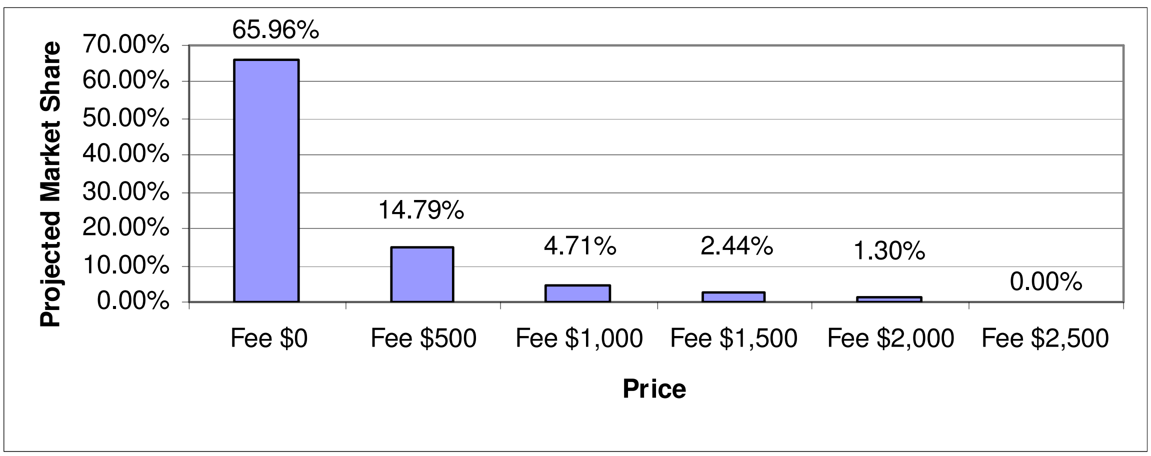
One emerging business model is having consumers pay a hook-up fee for the ability to receive a FTTP connection which provides a portal to a large selection of voice, video, and data providers.

This model has shown some success in Europe and in earlier stages of consideration in a handful of cities in the United States.

The survey results do not necessarily suggest equity financing would be unsuccessful; however, it does show that a considerable education effort is required to demonstrate the value proposition that equity financing may offer. Convincing residences and businesses to participate in the equity financing will not be done successfully through the use of door hangers and 12 month price promotions. A grass roots personal contact campaign that educates consumers on the model, and its value proposition (choice of providers, reduced service fees, increased property value), is required.

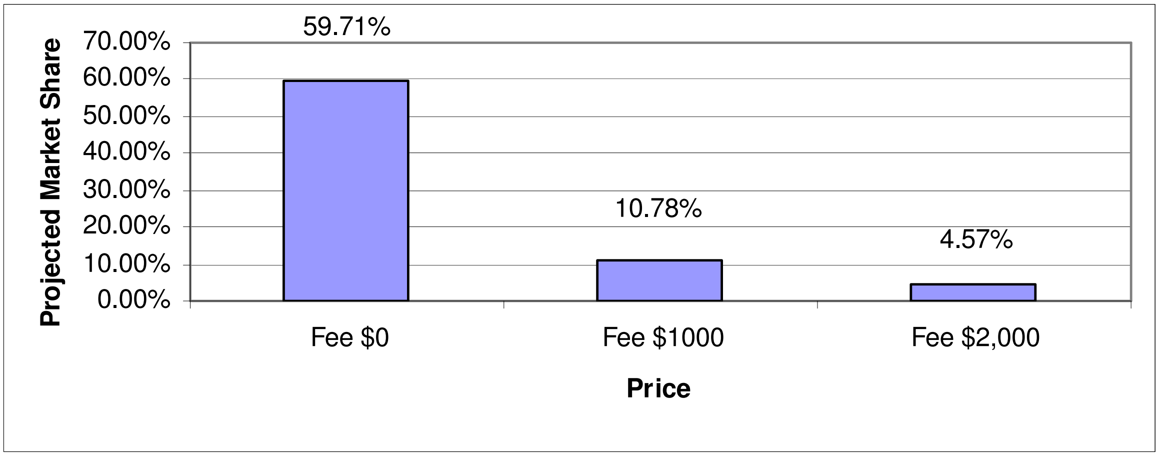
When residences and businesses were asked about their willingness to pay a hook-up-fee, the interest is quite low. Slightly more than one percent of residences and under five percent of businesses were willing to pay[51] a $2,000 one-time fee. The responses are shown in Figure 109 and Figure 110.

Figure 109: Residential Willingness to Pay Hook-up Fee



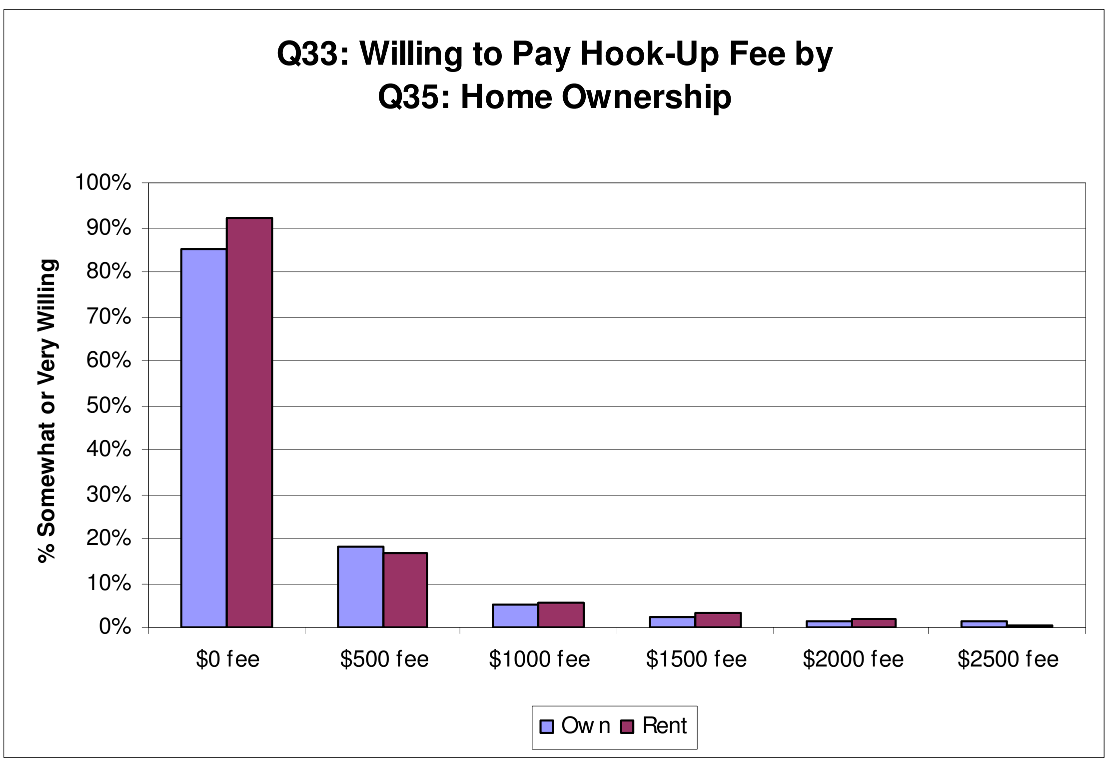
[51] Uses the calculation adjustment as is described for the new entrant market share projections.

Figure 110: Business Willingness to Pay Hook-up Fee



For the residential responses, we examined the responses to see if any significant differences exist between renters and homeowners. As shown in Figure 111, no significant differences are found.[52]

Figure 111: Residential Willingness to pay a Hook-up Fee Vs, Home Ownership



[52] Note - the percentages listed are for somewhat and very willing responses. These percentages are not adjusted as described in the projection of new market entrants.

The willingness to pay a hook-up fee does increase with the promise of service price discounts. If a 30 percent discount is possible, then 41 percent of businesses and 19 percent of residences would pay a $2,000 hook-up fee. Please note this includes the "neutral" response which increased significantly for the residential responses as the service price discounts increased. The responses with various price discounts are shown in Figure 112 and Figure 113.

Figure 112: Residential Willingness to pay a $2,000 Hook-up Fee

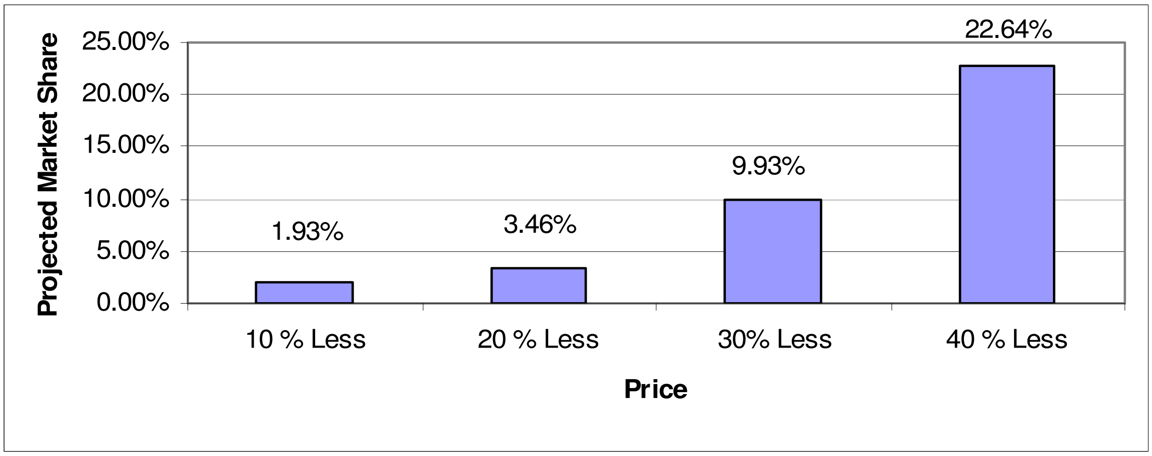
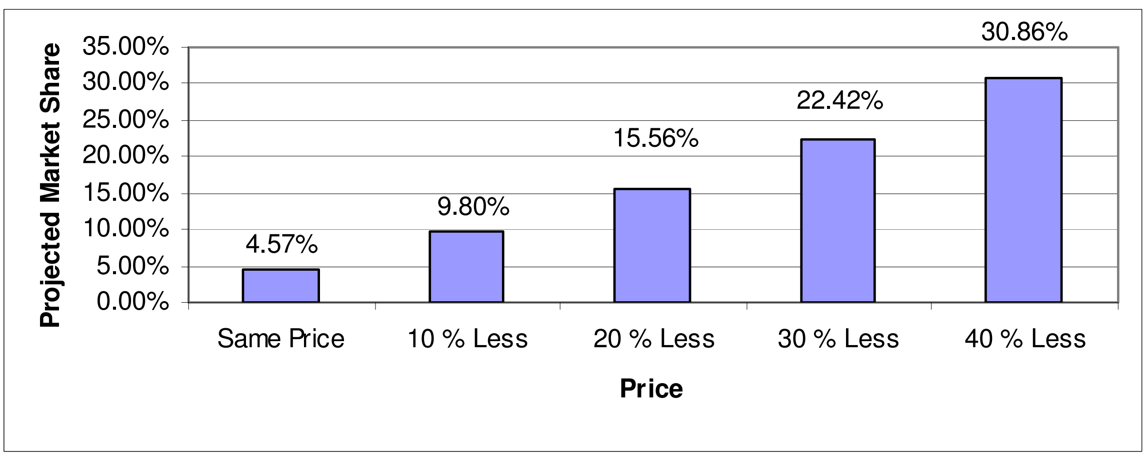


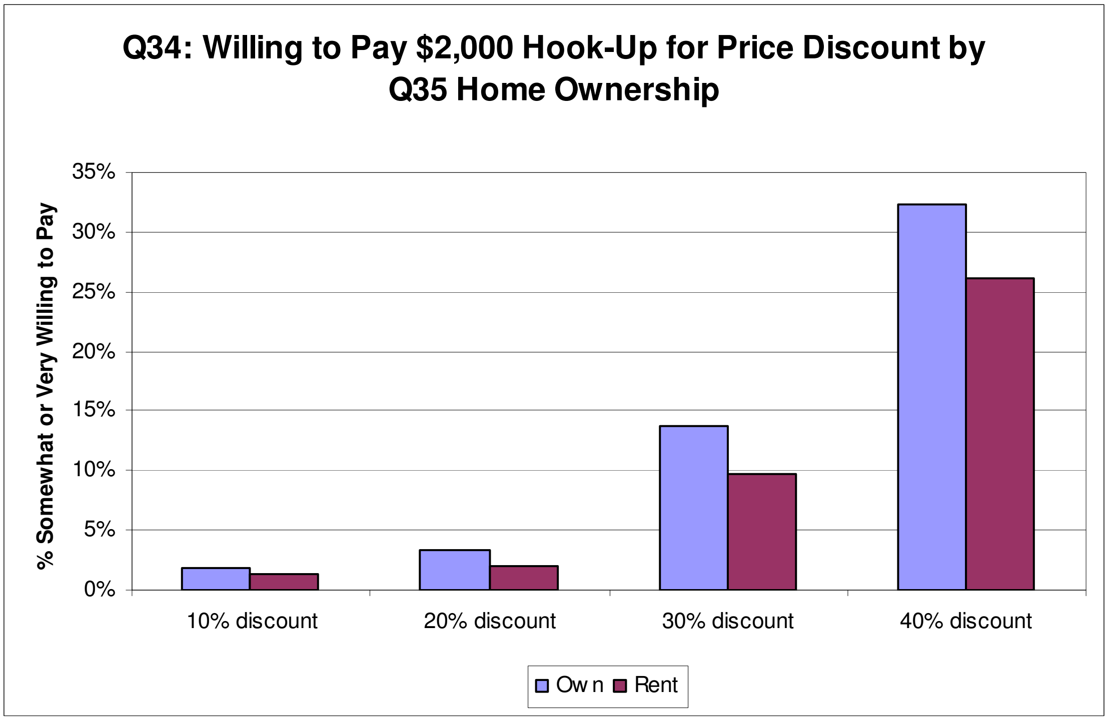
Figure 113: Business Willingness to pay a $2,000 Hook-up Fee



For the residential responses, we examined to see if any significant differences exist between renters and homeowners. As illustrated in Figure 114, homeowners are slightly more willing to participate in equity financing if service discounts are provided.[53]

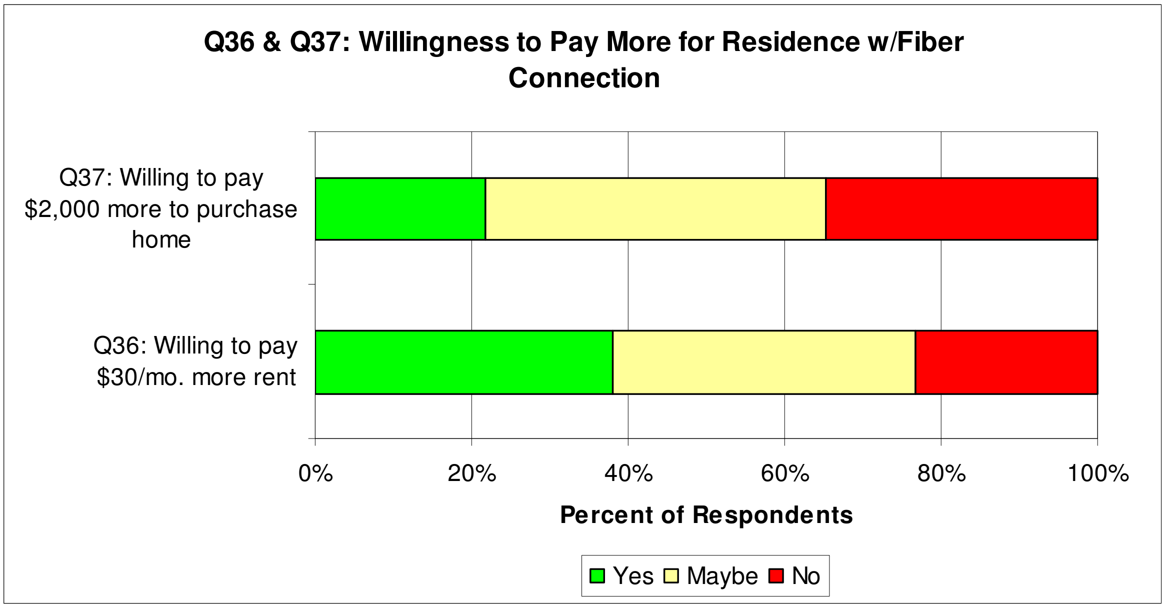
[53] Note - the percentages listed are for somewhat and very willing responses. These percentages are not adjusted as described in the projection of new market entrants.

Figure 114: Residential Willingness to pay a Hook-up Fee vs. Home Ownership



As is discussed in this Report, equity financing for connectivity services is a new value proposition for residential and business consumers. Given it is a new concept, it not surprising to see a low interest when survey respondents were asked their interest in paying a one-time fee. The interest is likely to increase if the respondent would expect their property values to increase. To show this potential, we asked residential survey respondents if they would be willing to pay more in a purchase price or rent for a property with a fiber optic connection. As shown in Figure 115, over 20 percent of respondents are willing to pay $2,000 for a property with fiber optics compared to just over one percent when asked to pay $2,000 to have fiber hooked up. This difference may indicate a stronger potential for equity participation if a correlation can be demonstrated with property values.

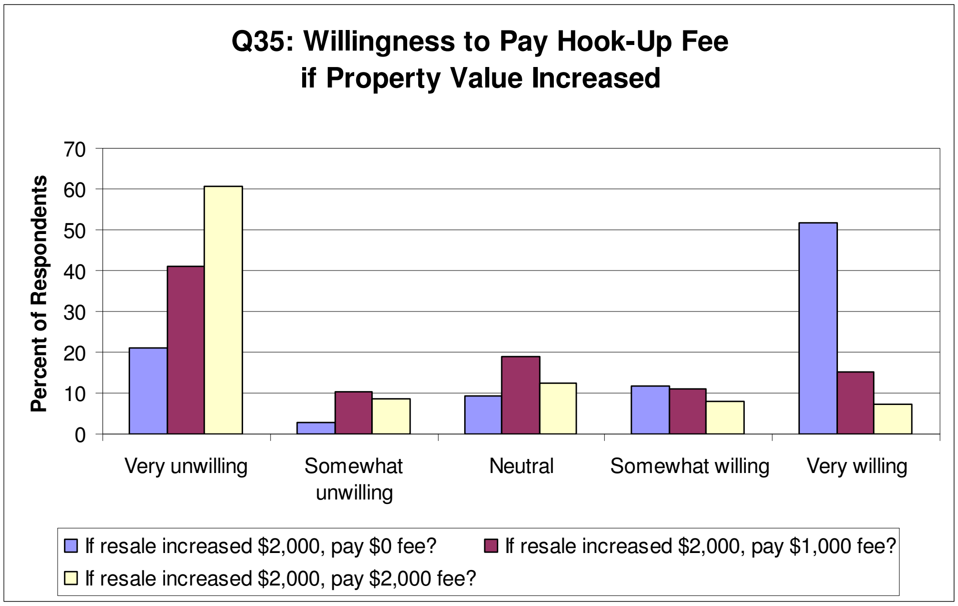
Figure 115: Willingness to pay more for a property with Fiber Optics



We also noted a similar impact with the business responses. For businesses, if their property resale value were to increase by $2,000 due to the fiber optic connection, 13 percent[54] were willing to pay a $2,000 hook-up fee in contrast to less than five percent if an association to property value is not made.

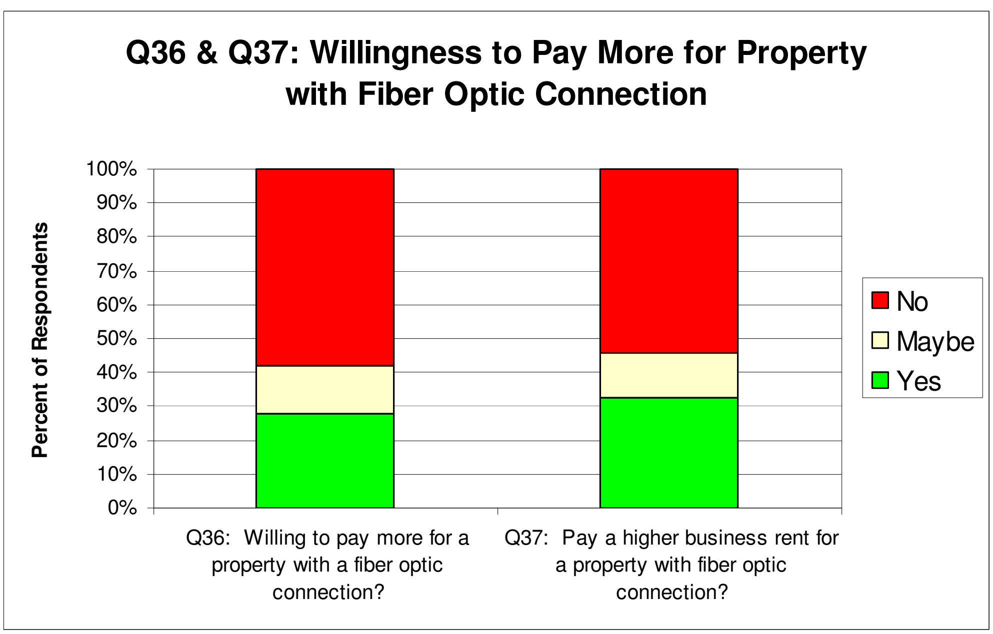
[54] Calculated by multiplying: the neutral response (12.4 percent) by .25; the somewhat willing response (7.8 percent) by .5; and the very willing response by (5.4 percent) by .75.

Figure 116: Business Willingness to Pay Fiber Hook-Up Fee if Property Value Increases



In addition, almost one-third of business respondents indicated that they were willing to pay more for a business property with a fiber optic connection or to pay higher rent for a property with a fiber optic connection.

Figure 117: Business Willingness to Pay More for a Property with Fiber



5 Potential for Environmental and Efficiency Savings through Telework

This Section evaluates the potential external benefits of enhanced broadband access through increased levels of telework or telecommuting. The market research for this Report includes a pioneering analysis of the impact on commuting patterns or telework with questions regarding San Franciscans' interest in: telework; whether existing cable modem and DSL connections are sufficient to support telework; and if higher speed Internet connections were available, would workers increase their frequency of telework. Specifically, the survey instruments asked both residential and business consumers questions designed to determine:

- Current commuting patterns
- Current telework patterns
- Barriers to telework
- Business willingness to let employees telework (assuming adequate connectivity)
- Employee interest in telework (assuming adequate connectivity)
- Potential efficiency impact of telework on commute times, distances, and emissions

This Section summarizes the results of the market research and the potential efficiency and cost savings to San Francisco commuters, as well as the potential emission reductions.[55]

Over time, a successful telework program will show significant cost savings to the City of San Francisco and its residents by reducing vehicle operating expenses, the amount of time spent traveling, reduced road repairs, reduced congestion on roads, and other factors. In addition, with

[55] Sustainability is one of the key benefits of fiber networking that is only now being recognized. A recent European Union-commissioned Report notes that communications technology's carbon reduction impact is 10 times more than its direct carbon dioxide reduction. "Saving the Climate @ the Speed of Light: First Roadmap for Reduced CO_2 Emissions in the EU and Beyond," published by European Telecommunications Network Operators' Association and World Wildlife Foundation, 2007. According to the European Union study, the strategic use of communications technologies, such as fiber, can contribute to energy efficiency, job creation, and sustainable growth—by "bridging distance problems,… allow[ing] people to work in more flexible ways,… and allow[ing] for dematerialization of the economy." Ibid. In recognition of this connection between communications technology and environment protection, a number of projects are underway to demonstrate the importance of communications infrastructure to sustainability. The Clinton Global Initiative, for example, is working with Cisco's Connected Urban Development project to partner with local communities (member communities include San Francisco, Seoul, Amsterdam, Madrid, Hamburg, Lisbon, and Birmingham) to demonstrate through pilot projects the potential of the ICT, including FTTP networking, to reduce carbon emissions. Connected Urban Development has noted that if city-based FTTP can enable remote work, telework, distributed work, and satellite offices, the reduction in emissions can be dramatic. Other private sector companies are also realizing the environmental benefits of high bandwidth. NEC's Broadband Solutions Center in Japan demonstrated a 41 percent reduction in carbon dioxide of a broadband-based office relative to a conventional office. NEC employees at this office "changed their working style using broadband solutions, such as IP telephony, a wireless LAN, and systems for remote access, web conferencing, and document sharing." NEC "An Environmental Load Assessment Method for Broadband Solutions," http://www.nec.co.jp/rd/rel/english/topics/t36.html.

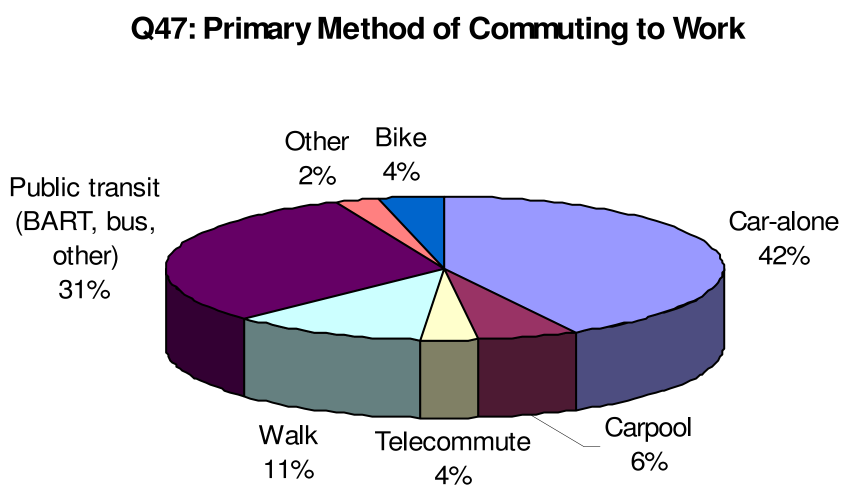
the decrease of mileage driven and gasoline burned, telework serves its part in benefiting the environment and reducing greenhouse gases by lowering the amount of auto emissions.[56]

5.1.1. Telework Rates are Suppressed by Lack of Sufficient Broadband

A number of questions were asked in order to establish the current working environment of San Francisco's residents. These questions included determining working status, primary mode of transportation, distance traveled to work, and ability or willingness to telework on a daily or weekly basis.

In San Francisco, the use of public transportation, walking, and other non-personal vehicles for commuting is high by US standards. As shown in Figure 118, less than 50 percent drive to work, and 42 percent of full time and part time workers drive alone when commuting for work.[57]

Figure 118: Primary Method of Commuting to Work



In San Francisco today, 40 percent of full or part time workers do some telework, though it is primarily infrequent.

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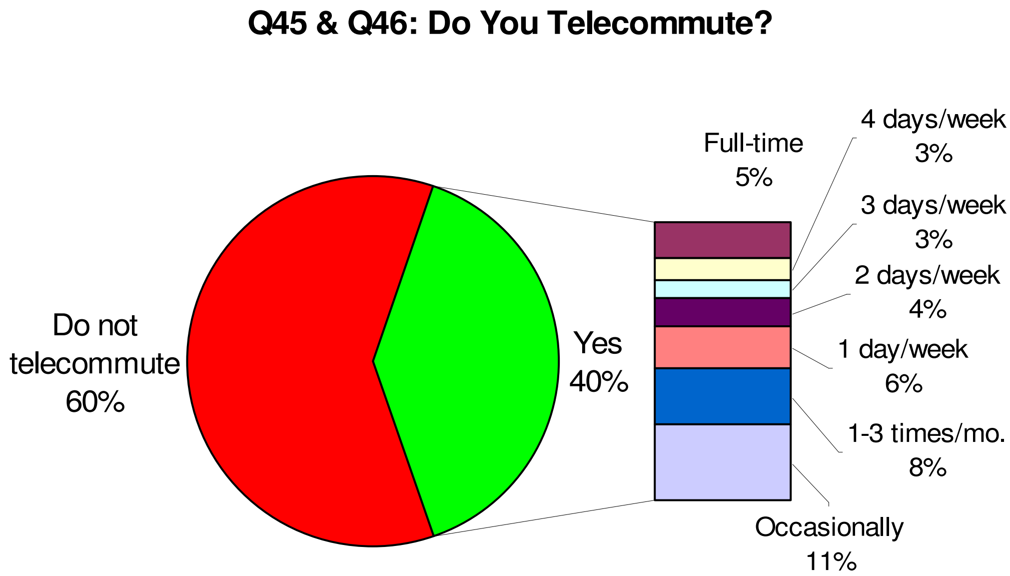
[56] There are a number of other indirect benefits afforded by telework that are not analyzed here because they are beyond the scope of this Report. Beyond the direct benefits that can be determined from the market research, a more detailed model of the impact of increased telework would also take into account a reduction in such indirect factors as: (1) cost of roadway repair and maintenance; (2) maintenance and expansion of public transportation; (3) overhead costs; (4) traffic volume and congestion and associated commute time; (5) office space congestion; (6) parking congestion; and (7) other soft benefits including quality of life and employee morale.

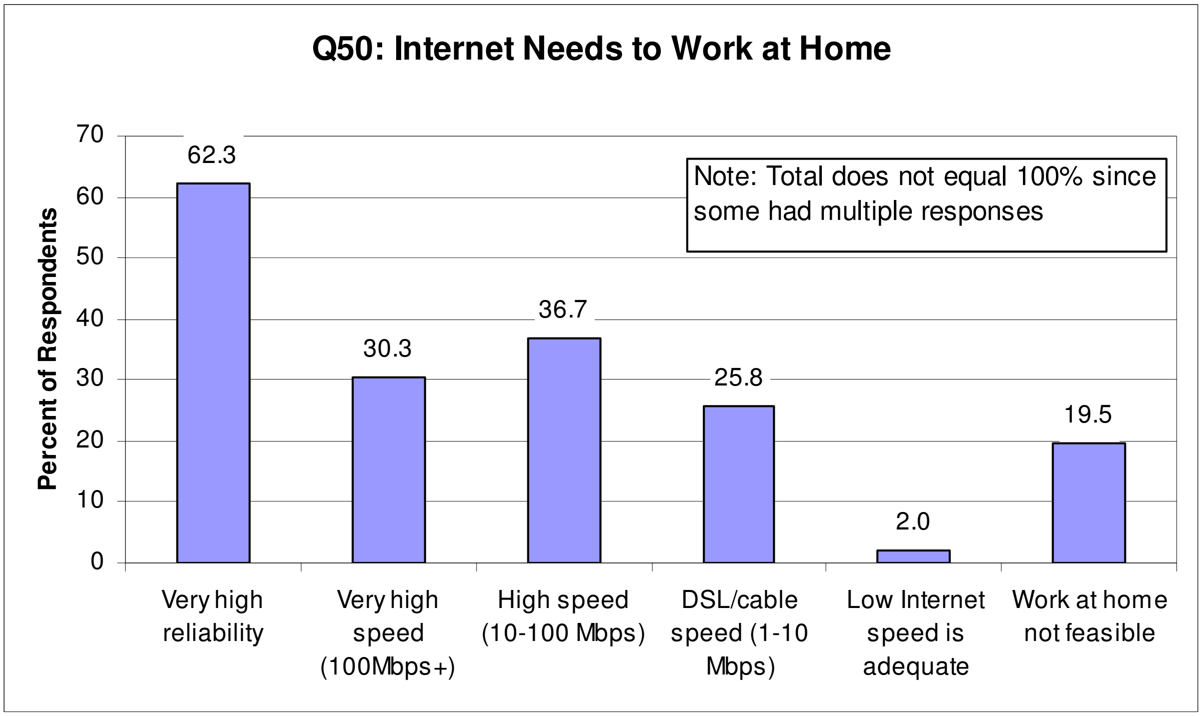
[57] Of the survey respondents, 78.4 percent individuals work full time or part time.

Figure 119: Percentage of Working Residents who Telework



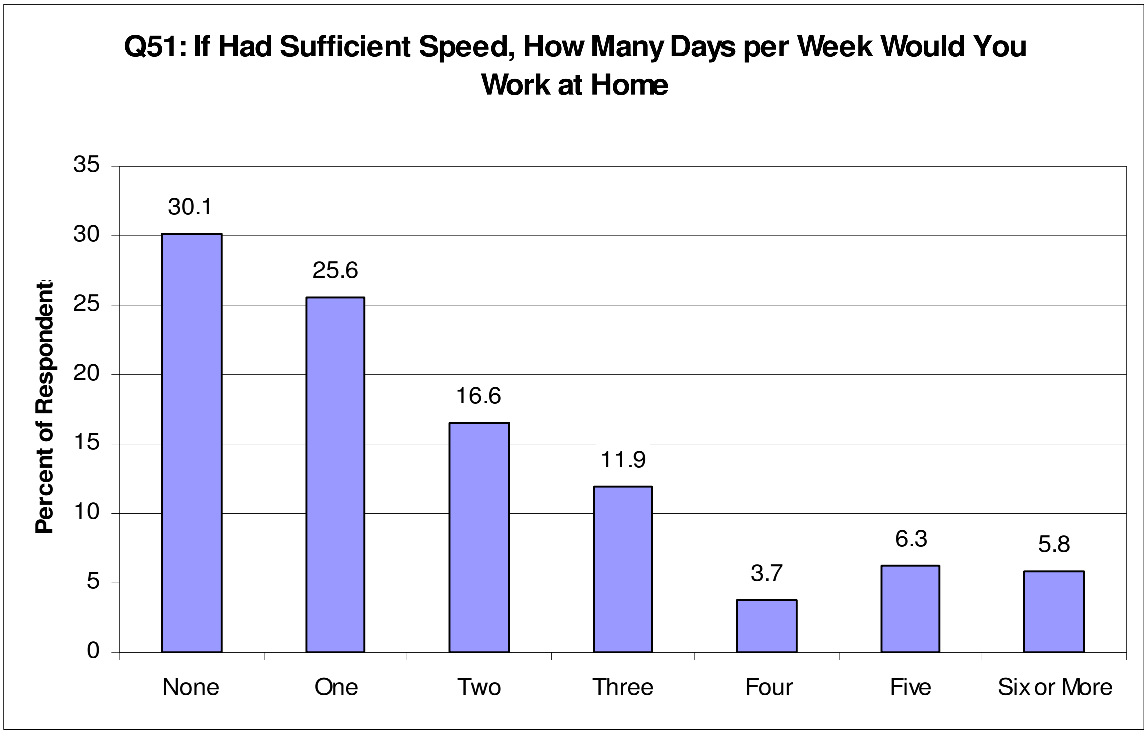
One major factor allowing an employee to telework is the speed of a high-speed Internet connection comparable to what is supported by DSL or cable modem speeds. As seen in Figure 120, 67 percent of respondents indicated that speeds beyond cable modem or DSL is required for telework (30 percent indicated speeds of 100 Mbps or over are required).

Figure 120: Connection Required for Telework



As illustrated in Figure 121, 70 percent of respondents would be willing to telework at least one day per week if connection speed were not an issue. This is a 30 percent increase of the workers who telework today (40 percent of workers currently telework at least occasionally).

Figure 121: Interest in Telework



We also asked if the respondent is interested in telework, how many days per week would they telework. We then compared the results of the frequency of telework today versus what residents might telework if given the availability of an improved Internet connection. Figure 122 shows the estimated total percentage of occupied households that do the some telework today compared to their primary commute method.

Figure 122: Percentage of Households that Telework by Primary Commuting Method

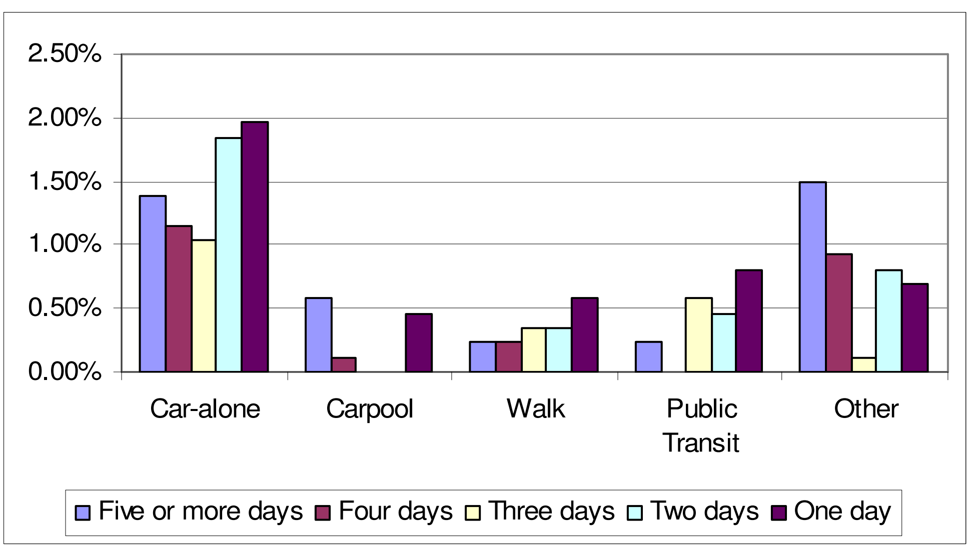


Figure 121 shows the estimated total percentage of occupied households that would telework if they had a sufficient Internet connection at home.

Figure 123: Interest in Telework if sufficient Internet speed at home is available

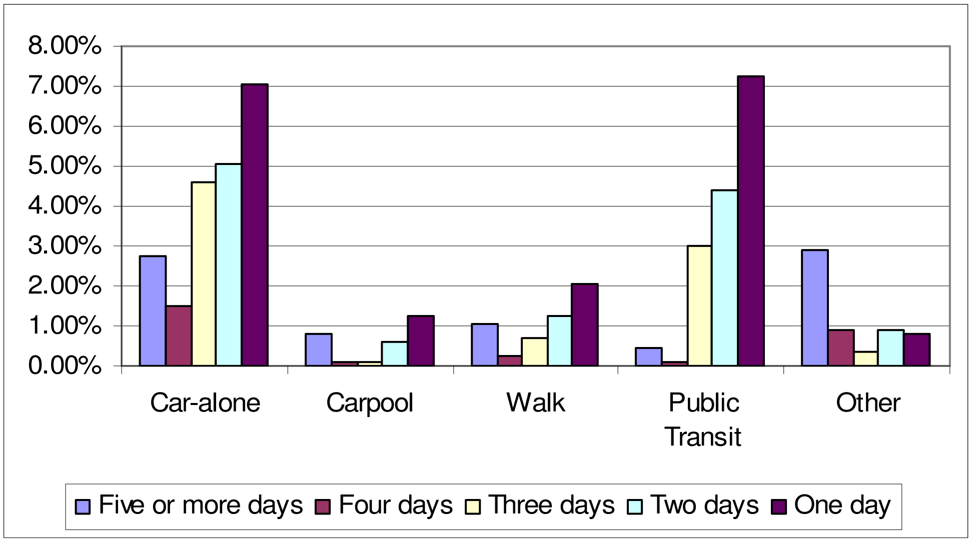


Table 2 indicates the projected increase of telework for those working that drive alone as they physically commute to work. Table 3 shows the projected increase for workers that use public transportation.

Table 2: Likely increase in Telework for Lone Drivers

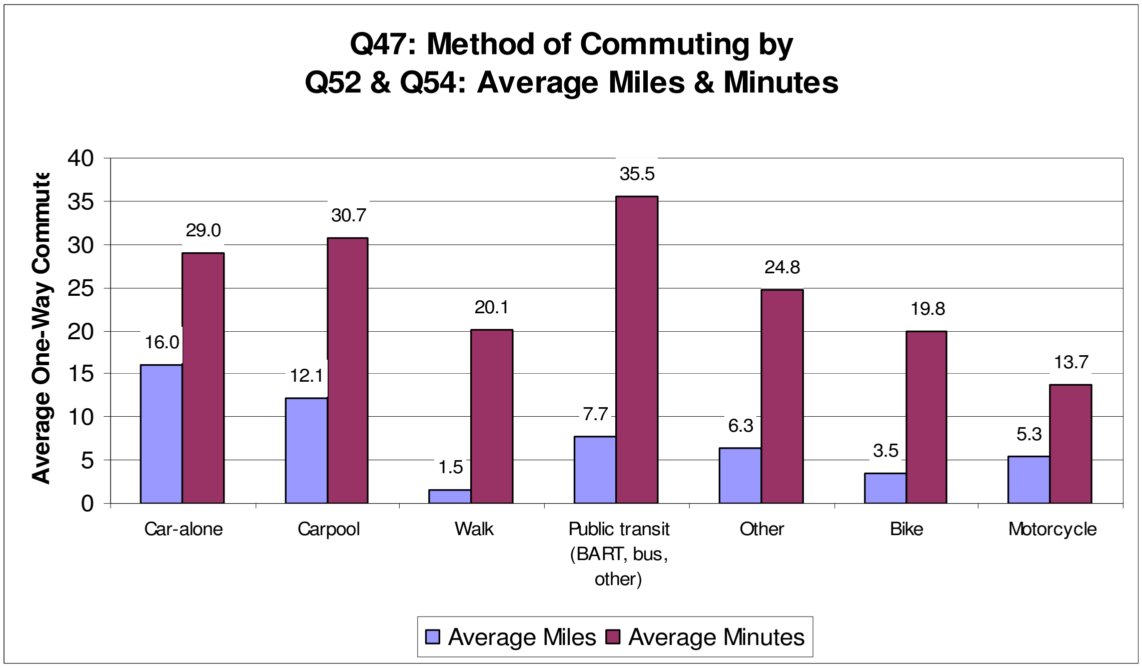
Frequency of Telework (per week)	Percentage of Households Today	Percentage of Households with Improved Internet	Increase of Households Teleworking
5 or more days	1.38%	2.76%	1.38%
4 days	1.15%	1.50%	0.35%
3 days	1.04%	4.61%	3.57%
2 days	1.84%	5.07%	3.23%
1 day	1.96%	7.03%	5.07%

Table 3: Likely increase in Telework for Public Transport Users

Frequency of Telework (per week)	Percentage of Households Today	Percentage of Households with Improved Internet	Increase of Households Teleworking
5 or more days	0.23%	0.46%	0.23%
4 days	0.00%	0.12%	0.12%
3 days	0.58%	3.00%	2.42%
2 days	0.46%	4.38%	3.92%
1 day	0.81%	7.26%	6.45%

The average time for commuting by primary method is shown in Figure 124.

Figure 124: Average Commuting Time by Commuting Method



As illustrated, the average one-way driving commute is 16 miles taking 29 minutes, and the average time taken for commuting using public transportation is over 35 minutes.

5.1.2. Increased Telework Would Reduce Miles and Time Expended

Given the estimate that approximately 106,000[58] households use at least one vehicle to travel to work at an average of 16 miles taking 29 minutes, teleworking even one day per week provides some time and cost savings. For drivers commuting alone, Table 4 shows the projected reduction in miles driven through increased telework. Table 5 shows the reduction in time commuting, for drivers commuting alone, due to increased telework. The projected reduction is almost 151 million miles driven per year with an annual time savings of almost 4.6 million hours.

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[58] Based on 42 percent of 78.4 percent of the 322,000 occupied households driving at least one car to work at least once per week.

Table 4: Miles Saved by Increased Telework (Drive Alone)

Frequency (Days per week)	Increase in Telework	Miles per Year (48 weeks)
5 or more days	1.38%	34,188,000
4 days	0.35%	6,838,000
3 days	3.57%	52,992,000
2 days	3.23%	31,909,000
1 day	5.07%	25,071,000

Table 5: Hours Saved by Increased Telework (Drive Alone)

Frequency (Days per week)	Increase in Telework	Hours per Year (48 weeks)
5 or more days	1.38%	1,033,000
4 days	0.35%	207,000
3 days	3.57%	1,601,000
2 days	3.23%	964,000
1 day	5.07%	757,000

We also calculated the time saved in the use of public transportation by increased telework. Table 6 shows the reduction in commuting time for those who use public transport due to increased telework. The projected hour reduction is over 4.2 million hours.

Table 6: Hours Saved by Increased Telework (Public Transportation)

Frequency (Days per week)	Increase in Telework	Hours per Year (48 weeks)
5 or more days	0.23%	211,000
4 days	0.12%	84,000
3 days	2.42%	1,328,000
2 days	3.92%	1,433,000
1 day	6.45%	1,180,000

5.1.3. Increased Telework Would Reduce Cost of Operation of Vehicles

Based on the increase in telework, CTC calculated the cost savings in vehicle expenses to residents teleworking at least one day per week. If residents are traveling millions of miles less per year, they are consequently consuming less gas and incurring less vehicle operating costs.

If a vehicle obtains an average of 20 miles per gallon through increased telework, San Francisco residents could save almost 7.6 million gallons of gasoline per year. Gas savings, however, do not represent the total cost of driving. The Internal Revenue Service (IRS) mileage rate was created to determine the permanent and changeable costs for operating a vehicle, including the cost of gasoline. The 2009 standard IRS mileage rate for businesses is 55 cents per mile. Based on the average miles saved per week, and the IRS rate, residents would save over $80 million on their vehicle expenses per year.

Most of the time spent commuting has limited or no productivity. It reduces the amount of time available to spend with family, working on household projects, or learning new skills to increase one's value in the workplace. If we place a value of $10 per hour on commuting time, telework would save an additional $87.9 million per year.[59] At a six percent discount rate over 15 years, this represents a net present value of the time savings at $854 million. This, combined with vehicle savings, yields a potential discounted 15 year savings to commuters of $1.7 billion.

The above estimates assume that, of the respondents that work full or part-time, only one person works per household. This actually understates the number of commuters. If we adjust the projection based on married couple families and married couple families with both couples working, the projections are increased by 16 percent resulting in:

- Annual vehicle cost savings of $96.6 million
- Annual time savings (driving and public transportation) of $102.4 million

The combined vehicle and time savings yields a potential discounted 15 year savings to commuters of $1.9 billion.

5.1.4. Increased Telework Would Reduce Emissions

Telecommuting or telework has been documented to reduce carbon and toxic emissions.[60] Emissions are substances and gases released into the air as byproducts including exhaust and evaporation of fuel.[61] One of the largest sources of air pollution is from cars and trucks. Emissions from an individual car are typically low, but as the number of cars on the roadways

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[59] Includes time savings for drivers commuting to work alone and workers using public transportation.

[60] The U.S. Department of Transportation and Highway Administration aggregated three studies on emissions savings by telecommuting in Philadelphia, Houston, and the Washington Metropolitan Region (http://www.fhwa.dot.gov/environment/cmaqpgs/telework/index.htm). The purpose of the projects was to provide employers with incentives to enable telecommuting. The Philadelphia-area project began in March 2000 and had 79 employees from five companies enrolled in the program by early 2002. The estimated emissions reduction was 52kg/day volatile organic compounds (VOC), and 6kg/day nitrogen oxides (NOx). The Houston-Galveston area project was designed to provide tax credits to employers who successfully reduce emissions through telecommuting. The project cost $9.6 million and received $7.68 in Congestion Mitigation and Air Quality (CMAQ) funds. The estimated emissions reduction was 32 kg/day VOC, 112 kg/day carbon monoxide (CO), and 45 kg/day NOx. The Washington Metropolitan area project was designed to assist employers to evaluate telecommuting based on travel behavior, cost savings, and employee performance. The total cost of the project was $397,600 funded with CMAQ funds. The estimated emissions reduction was 9 kg/day VOC and 18 kg/day NOx.

[61] Data obtained from, http://www.merriam-webster.com/dictionary/Emissions, accessed September 15, 2008.

increase, the volume of emissions also increases.[62] The types of pollutants emitted from gasoline powered vehicles are:

- ROG (Reactive Organic Gases)
- NOx (Nitrogen Oxide)
- PM 10 (fine particulates/Particulate Matter)
- CO (Carbon monoxide)
- CO_2 (Carbon dioxide)

Table 7 indicates the types of automobile emissions and the reduction of emissions per year. The total reduction was calculated by taking the amount of miles saved per year by increased telework times the reduction factor.

Table 7: Projected Emission Reduction

Types of Emissions	Reduction Factor (pounds/mile)[63]	Total Reduction (pounds/year)
ROG	0.000749571	113,180
NOx	0.001036171	156,460
PM10	0.001146402	173,100
CO	0.006415444	968,720

Carbon dioxide emissions are dependant upon the gallons of gasoline burned, not miles driven. Based upon the EPA's factors (19.42 lbs of carbon dioxide per gallon), a reduction of over 146.6 million pounds of carbon dioxide is possible in San Francisco through increased telework enabled by improving the performance of available Internet connections. As in the cost savings estimate, this projection increases by 16 percent to 170.6 million pounds of carbon dioxide if we account for married households in which both couples work outside the home.

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[62] Data obtained from, http://www.epa.gov/OMS/consumer/05-autos.pdf, accessed September 15, 2008, and http://www.dot.ca.gov/hq/transprog/reports/CMAQCAL.pdf , accessed September 23, 2008.

[63] Data obtained from, http://www.epa.gov/OMS/consumer/05-autos.pdf, accessed September 15, 2008, and http://www.dot.ca.gov/hq/transprog/reports/CMAQCAL.pdf , accessed September 23, 2008. Factors are adjusted from kilograms to pounds.

6 Summary of Business Models & Appropriate Financing Options

This Section describes a range of potential FTTP business structures and models, and offers a survey of means for financing communications infrastructure.[64] In particular, each of the business structures is examined in light of its potential to meet San Franciscans' demonstrated requirements for price and consumer choice, as demonstrated by the market research summarized above.

6.1 Evaluation of Business Models' Capability to Meet San Franciscans' Need for Choice and Cost

This Report considers two basic business structures:

1. **Retail Overbuild:** In this structure, the City builds, owns, operates, and offers exclusive services over the FTTP network. The City becomes a competitive provider of voice, video, and data services. This is the model used most frequently by municipalities in rural and suburban parts of the U.S. A variation of this structure is to segment key users or user groups for a retail offering.
2. **Open Access or Wholesale:** In this structure, the City builds the FTTP network and wholly controls that asset. Private sector service providers are selected to offer data, voice, and video services over the network. In this model, the City's role is limited to building and maintaining the FTTP network. The open access structure (also referred to as the "wholesale" structure) separates the infrastructure from the retail service. In this structure, the City is in the business of infrastructure, not communications service provision. In the open access structure, the City's customer is not the retail consumer, but rather it is the service provider. A common variation of this model is to construct FTTP to selected business parks or users and lease capacity or fiber strands to providers or large consumers. Another variation of this structure is to encourage a private sector provider to become an infrastructure provider by allowing access to key City assets or assist in the network financing.

Each of these models is discussed below with respect to its capability to meet San Franciscans' demonstrated need for provider choice and reasonable costs.

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[64] The analysis conducted in this Report provides a foundation for the development of a business plan. To pursue any of the models reviewed, development of a business plan is recommended. The business plan should include details on sales and marketing strategies, implementation schedules, controls, market segmentation, model selection, network design, and other elements of initiating a new business venture. In addition, CTC recommends that the City seek counsel regarding any strategies considered for transfer of assets to other entities, and for any provision of communications services under any of the models discussed in this Report. As discussed with the City, CTC is not a law-firm and this Report does not purport to offer guidance or expertise on legal matters. CTC recommends that the City seek specialized legal counsel on any strategies contemplated.

6.1.1. Retail Overbuild Model

In summary, in a mature market like San Francisco, a retail FTTP overbuilder has the advantage of offering better communications services and products, but obtaining sufficient market share while holding down subscriber costs might be an insurmountable task. In addition, the retail overbuild model does not fully address the consumers desire to choose from a variety of providers, not just a select few.

If the City pursues a retail overbuild model, it will become the fourth infrastructure provider and another choice for consumers.[65] The key concerns with the retail overbuild model include: 1) whether the retail overbuild structure will offer sufficient consumer choice to create a competitive market structure; and 2) whether the retail overbuild structure can lower or control rising subscriber costs.

Provider Choice – Competitive Markets
The most commonly used measure of market concentration or market competition is the Herfindahl-Hirschman Index (HHI), which is used by the U.S. Department of Justice (DOJ) when reviewing potential mergers.[66] The HHI sums the squares of market share percentage for all companies, and uses an index to define the level of market concentration. Any industry with an HHI greater than 1,800 is considered to be "heavily concentrated" or to have "limited competition."

We conducted an HHI calculation for San Francisco residential Internet. Given that AT&T and Comcast have a combined 70 percent market share, the HHI is quite high (3,200). If a new provider were to take a 15 percent share from AT&T and 15 percent share from Comcast, the HHI would drop dramatically to 2,200. But a HHI of 2,200 is still considered "heavily concentrated" or one with limited competition under the DOJ definition.

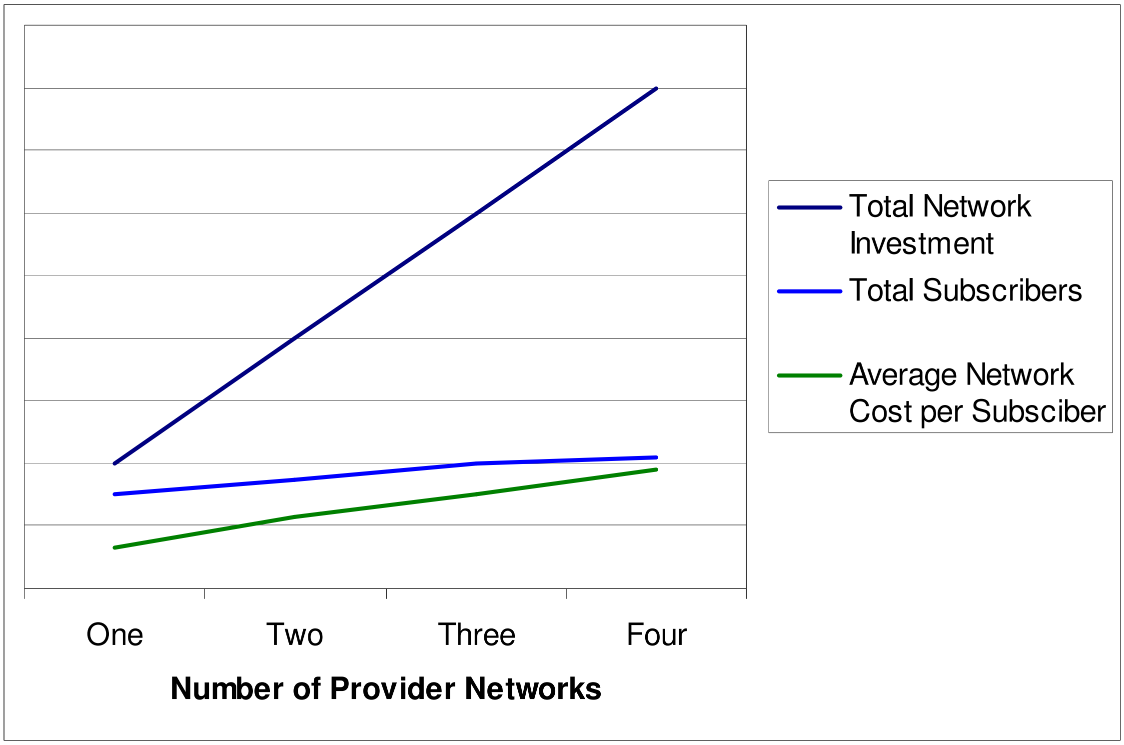
Provider choice also includes consumer ability to have more reliable access to the growing number of Internet based video and telephone products. If a retail FTTP provider offers an unfettered 100 Mbps Internet offering, consumers have virtually unlimited voice and data options. For a municipal retail overbuild, consumer education and encouragement for use of Internet-based alternative voice and video products would help address consumer choice.

Cost Control
Now we will consider the ability to lower costs, or at least slow down subscriber fee increases. In the overbuild structure, each provider invests in its own network to serve its own subscribers. In theory, each additional network built increases total network costs proportionally, but the total

[65] The majority of San Francisco voice, video, and data consumers are served by three existing infrastructure-based service providers; AT&T, Astound, and Comcast. Each of these providers maintains and operates independent networks. There is limited competition because residential and small businesses must select services among these three existing providers. For large businesses, more competition is offered by non-facilities based competitors and private networks, but is still limited.
[66] http://www.usdoj.gov/atr/public/testimony/hhi.htm, accessed February 9, 2009.

number of subscribers does not increase. As a result, the average network cost per subscriber increases as competing networks are added (Figure 125).

Figure 125: Average Network Cost per Subscriber



To cover financing and operating expenses, the FTTP retail overbuild structure requires the new provider to capture a large percentage of potential subscribers or charge a premium for enhanced services enabled by FTTP network capabilities. This is not a model that lends itself well to reduce costs.

To mitigate the increased cost per subscriber, Verizon deploys FTTP only in neighborhoods that will acquire multiple high end services. This strategy holds down the required total network investment and maximizes revenue per subscriber. In high-end neighborhoods, residences receive the benefits of enhanced data services, but lower income neighborhoods do not have access to the new capabilities. For a private sector investor, this "cherry-picking" is justified by the primary objective of maximizing profits. However, this strategy creates difficulties for municipal overbuilds because their objective is to maximize user access and participation, not profits.

6.1.2. Open Access or Wholesale Model

The open access or wholesale network structure addresses consumer choice of providers. In this structure, the FTTP network is made available to any qualified service provider. Competition increases in theory because the cost of market entry for new providers is greatly reduced or eliminated. In addition, the subscriber cost issue is partially addressed because greater competition among retail providers will provide incentive for reduced costs and improved services.

This structure, however, does not directly address the increased network cost per subscriber. As is discussed above, the new entrant bears all of the costs of new construction, but the number of potential subscribers remains roughly equivalent to before the network was built. This means that each network owner receives a smaller piece of the same size pie. Ideally, the aggregate size of the market will increase as new applications are enabled by the big pipe of FTTP. In that case, however, some revenues will go to online service providers and further limit the amount of revenue available to network owners.

One potentially innovative way to address these high costs per subscriber is to allow residents and businesses to finance the costs of their own fiber connection (from the home to a point on the backbone network), thereby holding down the new entrant's deployment costs and potentially increasing return on investment. In one variation on this model, the new entrant would build the network to neighborhoods in which some significant percentage of residents or businesses agree to pay a one time hook-up fee for their fiber connection. In another variation on this model, the consumers would own their fiber connection as personal property attached to their home or business premises.[67] One potential problem with this model is that some neighborhoods, potentially those that are lower income, will not have a sufficient number of consumers willing or able to pay the upfront fee for a fiber connection. As a result, alternative funding for some neighborhoods will be required.

6.2 Summary of Financing Options for Municipal FTTP

Financing is one of the largest challenges for a public or private FTTP infrastructure and citywide wireless projects. To date, the mechanism to finance a vast majority of U.S. municipal FTTP projects has been: bonds either secured with established municipal electric or water revenues (revenue bonds); bonds by the general obligation of the community (General Obligation bonds); or with sales tax revenue.

A common lingering question with any model for private or public FTTP is the type of financing guarantees required by the municipality. As of this writing, the City of Palo Alto, CA is in negotiations with a consortium of companies for FTTP financing, construction, and operations. Early speculation is that although Palo Alto may not be required to provide financing, the City may be asked to guarantee the private Consortium's investment.

[67] Derek Slater and Tim Wu, "Homes With Tails: What if You Could Own Your Own Internet Connection," New America Foundation, November 2008, http://www.newamerica.net/publications/policy/homes_tails, accessed February 9, 2009.

Absent full private sector financing, a municipality has a choice of at least five basic funding alternatives. These are described below. Some financing alternatives are appropriate for capital investment while others are more appropriate for operating and maintenance expenses.

It is prudent to expect that all financing alternatives, especially non-subscriber assessment-based financing, are likely to be challenged by incumbents in a variety of ways, including public relations campaigns, regulatory challenges, legal action, and political challenges.

6.2.1. Subscriber Fees (Appropriate for Operating and Maintenance Expenses)

Under the retail model, consumers are charged a monthly fee for services obtained. This financing method is appropriate for ongoing operation and maintenance expenses, including debt service coverage.

The determination of the rate charged to consumers is based upon estimated market shares and competitive pressures. As a result, failure to meet projected market share results in cash flow shortages. Exceeding projected market share results in cash flow reserves.

6.2.2. Provider Access Fees (Appropriate for Operating and Maintenance Expenses)

Under the open access model, service providers are charged an access fee per month to cover the required FTTP infrastructure investment, customer drops, and installation costs. As these costs would presumably be passed on to consumers, only subscribers that use the network are charged. This financing method is appropriate for ongoing operation and maintenance expenses, including debt service coverage.

The determination of the rate charged of the provider is based upon estimated market shares. As a result, failure to meet projected market share results in cash flow shortages. Exceeding projected market share results in cash flow reserves.

6.2.3. Equity Participation Fees (Appropriate for Capital Investment)

Subscribers pay an upfront subscriber fee of approximately $2,000 to $3,000 (or obtain a loan for that amount which entails smaller monthly payments over time, possibly rolled into a traditional mortgage). Subscribers then “own” and are responsible for maintenance and upgrades of the customer premises equipment and possibly the fiber drop to the premises.

Equity participation was used by many municipalities to finance the initial deployment of sewer systems -- providing an emerging essential service while increasing property values.

The equity participation fee is appropriate for financing infrastructure deployments. A variation of this could be an annual assessment to subscribers similar to ones paid by condominium associations for ongoing property maintenance.

6.2.4. Property Owner Assessment (Appropriate for Capital Investment)

Under this alternative, the City assesses all property owners for proportionate shares of the costs of the FTTP infrastructure (likely excluding consumer drops, customer premises equipment, and installation).

The assessment approach to financing FTTP infrastructure arises from the growing consensus that broadband constitutes essential infrastructure for the viability of the community. Roads, water supply, and wastewater are all considered essential infrastructure and are publicly financed through an assessment-type approach. In the case of water and waste water, the infrastructure is "bundled" with the service. In the case of the roads, infrastructure costs are "unbundled" from use in a mechanism comparable to that contemplated here for FTTP infrastructure.

The assessment alternative is appropriate for financing infrastructure deployments. A variation of this could be an annual assessment to property owners similar to ones paid by condominium associations for ongoing property maintenance.

6.2.5. Bonding or Loans (Appropriate for Capital Investment)

The majority of municipal FTTP projects in the U.S. are financed through General Obligation, revenue bonding[68], and operating loans. Bond and loan payments (principal and interest) are covered by revenues from subscriber (retail model) or provider (open access) fees. Frequently, the municipality seeks a three to five year moratorium on bond principal payments to allow for system expansion and acquisition of a critical mass of paying consumers.

Bonding is appropriate for financing infrastructure deployments at times for initial expenses. Loans are often used for startup expenses and short term capitalized equipment.

6.3 Summary of How Financing Options Match Business Models

The advantages and disadvantages of the financing alternatives are presented in Table 8. Table 9 matches the financing alternatives to the selected business structures. A combination of financing alternatives and business structure will define the business models discussed below and presented in the financial analysis Section.

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[68] Revenue bonds are secured with existing utility (gas, water, or electric), sales tax, or other established revenue stream.

Table 8: Financing Alternatives Advantages and Disadvantages

Financing Model	Advantages	Disadvantages
Subscriber Fees (Fees)	• Fee applies only to consumers acquiring services	• Variations in market share will impact available funds
Provider Access Fees (Fees)	• Fee applies only to consumers acquiring services • Some investment risk shifted to retail provider	• Variations in market share will impact available funds
Equity Participation Fees (Equity)	• Fee applies only to consumers acquiring services	• Low income areas will require supplemental financing • Multiple dwelling unit owners and condominium association boards must agree to participate for apartments and condos to be included
Property Owner Assessment (Assessments)	• Treats fiber and broadband as essential infrastructure • Lowers investment risk of FTTP	• Increased potential for legal, political, and public relations challenges • Potentially requires referendum
Bonding and Loans (Debt)	• Tested and understood financing method • Many options are available	• For the City of San Francisco, funding is likely to require revenue bonds backed by sales tax or other established revenue stream • The City of San Francisco absorbs borrowing risk

Table 9: Funding Alternatives and Business Structures

Financing Alternative	Retail Overbuild	Open Access
Subscriber Fees (Fees)	• Used for support of operation and maintenance costs and debt service coverage • Fees apply only to consumers acquiring services	• NA
Provider Access Fees (Fees)	• NA	• Used for support of operation and maintenance costs and debt service coverage • Fees apply only to consumers acquiring services
Equity Participation Fees (Equity)	• Used for financing of initial capital expenditures • Potential to support operation and maintenance costs and debt service coverage • Fees apply only to consumers acquiring services	• Used for financing of initial capital expenditures • Potential to support operation and maintenance costs and debt service coverage • Fees apply only to consumers acquiring services
Property Owner Assessment (Assessments)	• Used for financing of initial capital expenditures • Potential to support operation and maintenance costs and debt service coverage • Treats fiber and broadband as essential infrastructure	• Used for financing of initial capital expenditures • Potential to support operation and maintenance costs and debt service coverage • Treats fiber and broadband as essential infrastructure
Bonding and Loans (Debt)	• Used for financing of initial capital expenditures	• Used for financing of initial capital expenditure

6.4 Development of Business Models

For initial analysis we have developed six business models ranging from a retail overbuild model financed with debt (bonds and loans) to a strategic fiber deployment directed at key business and institution accounts. These models are presented below and are discussed in greater detail in the following Section. Many combinations and variations of these models are possible, and can be further developed during preparation of a business plan.

6.4.1. Debt Financing – Retail Overbuild Model

As described above, this model requires the City to become a retail provider of services. A potential variation of the model is for the City to finance the network infrastructure and contract the network services and retail operations to a private provider.

The majority of municipal FTTP projects in the U.S. are financed through General Obligation or revenue bonding.[69] Bond payments (principal and interest) and operation and maintenance expenses are covered by revenues from subscriber fees. Frequently, the municipality seeks a three to five year moratorium on principal payments to allow for system expansion and acquisition of a critical mass of paying consumers.

6.4.2. Debt Financing – Open Access Model

In this model, retail services and the infrastructure are separated. The City installs and operates a FTTP network; however, rather than offering retail services, qualified providers are sought to deliver retail services to consumers.

Financing of the network is accomplished with a combination of bonds and operating loans. Ongoing operation and maintenance expenses are covered with provider access fees. The determination of the rate charged to the provider is based upon estimated market shares. As a result, failure to meet projected market share results in cash flow shortages. Exceeding projected market share results in cash flow reserves.

6.4.3. Equity Participation – Open Access Model

Under the equity model (also known as “coop” or “customer ownership”), a combination of private, public, and consumer investment is used to build various parts of the FTTP network. Generally, subscribers pay an upfront subscriber fee of approximately $2,000 to $3,000 (or obtain a loan for that amount that entails smaller monthly payments over time, possibly rolled into a traditional mortgage). The build-out of the FTTP is phased by neighborhood once a neighborhood reaches a predetermined subscriber level.

In order to initiate this model, the municipality or infrastructure provider constructs fiber to the neighborhood or to the node in a configuration designed to support FTTP. In the municipal example, the fiber to the neighborhood financing is accomplished through General Obligation or revenue bonding. Although municipal-backed financing is still required, the total amount of required financing is substantially less than it would be otherwise because consumers are bearing the cost of the attachments to their homes. Bond payments (principal and interest) and operation and maintenance expenses are covered by revenues from provider access fees.

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[69] Revenue bonds are secured with existing utility (gas, water, or electric), sales tax, or other established revenue stream.

The determination of the rate charged to the provider is based upon estimated market shares. As a result, failure to meet projected market share results in cash flow shortages. Exceeding projected market share results in cash flow reserves.

In the event that the provider is private sector, financing for the backbone network into the neighborhood is presumably private, but the customer receives some kind of ownership interest in the connection to his or her home. There are quite a few possible variations of this model, with some difference as to how far customer ownership reaches into the network, and how the ownership is structured.

This model is both creative and potentially useful. It first emerged in Sweden where it is referred to as the "coop" model. This model is currently under consideration by the Utah UTOPIA network in hopes of improving cash flow and reducing the financing exposure of each participating community. To our knowledge, this would be the first use of this model for a residential FTTP network in the U.S.

Variations on this model of customer fiber purchase and ownership appears to have met with some success in Europe, and it is currently being piloted in Ottawa, Canada. In just the last few months, we have seen significant chatter on this topic within the non-carrier communications community, and it is the subject of a recently-released New America Foundation paper by Derek Slater, a researcher at Google, and Tim Wu of Columbia Law School, an influential intellectual in communications policy.[70]

6.4.4. Essential Service – Open Access Model

This model is the same as the "Equity Participation - Open Access," however, rather than using consumer equity financing, the model uses property assessments. Under this model, the City assesses all property owners for proportionate shares of the costs of the FTTP infrastructure (likely excluding consumer drops, customer premises equipment, and installation). Consumers pay for fiber drops, customer premises equipment, and installation when they subscribe to a voice, video, or data service (one-time charge, amortized fee, or combination), and consumers pay for services directly to the provider of their choice.

The assessment approach to financing FTTP infrastructure arises from the growing consensus that broadband constitutes essential infrastructure for the viability of the community. Roads, water supply, and wastewater are all considered essential infrastructure and are publicly financed through an assessment-type approach. In the case of water and waste water, the infrastructure is "bundled" with the service. In the case of the roads, infrastructure costs are "unbundled" from use in a mechanism comparable to that contemplated here for FTTP infrastructure.

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[70] Derek Slater and Tim Wu, "Homes With Tails: What if You Could Own Your Own Internet Connection," New America Foundation, November 2008, http://www.newamerica.net/publications/policy/homes_tails, accessed February 9, 2009.

This model has had limited discussion for an alternative for FTTP financing, and to our knowledge, has not been pursued by any municipality.

6.4.5. Infrastructure Participation – Open Access Model

In this model, the City makes available to a private sector entity, for lease, selected assets that will enable the private entity to more efficiently and expeditiously build and operate a network. Interest in this model is currently running high -- even without the benefit of a municipal electric utility, Palo Alto is in negotiations with a private consortium for citywide FTTP -- apparently at no cost to the City.

6.4.6. Key Accounts Model

In this model, the City deploys a robust fiber network to meet its own internal needs for communications. The network is not marketed to residents, but businesses and large institutions have the opportunity to lease spare capacity (dark fiber) or selected retail transport services (Ethernet, wavelengths, or other service). This model is used by a major municipal electric utility in the U.S.

7 Business Models and Risk/Benefit Analysis

This Section of the Report is intended to provide the City of San Francisco with financial data by which to evaluate the feasibility and relative merits of alternative business models for a FTTP network.

It is important to note that this Section details only the quantifiable financial factors that are relevant to the business case for the network. Many of the additional benefits of the network include such key items as economic development, small business empowerment, job creation, livability, education, increased property values, and other factors that measure the overall benefit of a next generation communications infrastructure such as FTTP.

On the basis of these and other factors, this Report recommends consideration of an "Open Access" model because it offers a lower risk that meets the City's financial objective while facilitating competition goals by lowering the market entry barrier for private providers. Further, the Open Access model can be used with a variety of financing mechanisms, such as property assessments or "equity" financing, an innovative mechanism that has shown early success in Sweden.

To reach this recommendation, we examined the primary models for a municipally-owned fiber ranging from the full-blown offering of communications services as an additional utility to simple leasing of dark fiber.

Where appropriate, CTC's methodology in evaluating these models was to use the market share projections derived from the market research. In addition, we concentrate on cash flow because, within the financing community, the key measurement for a municipal communications network is the capability to maintain sufficient cash flow to cover debt service (principal and interest), operating expenses, and ongoing network enhancements.

For each model, we mention the American or European jurisdictions where the business models have been implemented or are under consideration. The municipal FTTP movement is still in its infancy, especially in larger communities, and there is limited data from deployed networks on which to rely for purposes of understanding how processes and business plans have worked. In addition, there are dramatic differences in circumstances between San Francisco and each of the existing municipal FTTP networks in the United States and elsewhere. Most municipal networks in the U.S. have been deployed in small rural communities where the municipality was the first to market high-speed Internet options. We offer caution against simple comparisons, and note instead, that these municipalities face major differences in financing, topography, technology evolution, market timing, customer base, competitive situation, and other factors.

In Table 10 a brief comparison of the financing requirements, capital costs, and cash balance projections for each of the models is presented. The details, including assumptions used for each model, are presented below.

Table 10: Comparison of the Business Models

	Debt Financing - Retail Overbuild	Debt Financing - Open Access	Equity Participation - Open Access	Essential Service - Open Access
Bonds Issued	$ 580,000,000	$ 570,000,000	$ 320,000,000	$ 160,000,000
Loans	$ -	$ -	$ -	$ -
Year 1 to Year 3 Capital Costs	$ 564,895,000	$ 558,641,000	$ 558,641,000	$ 558,641,000
Total Capital Costs	$ 732,463,000	$ 716,979,000	$ 716,979,000	$ 716,979,000
Cash Balance Year 10	$ 7,162,000	$ (8,634,000)	$ 104,196,000	$ 15,891,000
Cash Balance Year 20	$ (30,866,000)	$ (53,953,000)	$ 69,322,000	$ 102,695,000

7.1 Debt Financing - Retail Overbuild Model

In this model, the City builds, owns, operates, and offers exclusive services over the network. The City becomes a competitive provider of voice, video, and data services. This is the model used most frequently by municipal utilities in rural and suburban parts of the U.S. If the City requires the network to pay all its own costs, including financing, this model entails some risk.

This model requires the City to directly compete with AT&T, Astound, and Comcast. It requires the City to finance the buildout of the network, and potentially operations, in the event that the network does not cash-flow. It also requires the City to define and update services on an ongoing base, establish consumer level sales and marketing efforts, establish a consumer-level help desk, and other support mechanisms.

The retail model requires the broadest range of staff additions, training, marketing, and other activities to run and maintain the business venture. This Section provides an overview of the estimated requirements and the projected financial results.

The retail model presented in this Section provides a magnitude[71] projection and includes a wide-range of estimates of staffing, operating, maintenance, and other costs. Prior to a decision, we recommend that these projections be refined in a more detailed business plan.

Given the market penetration and other assumptions detailed below, the total estimated implementation costs for year 1 through year 3 is $564.9 million (see Table 11).

Table 11: Projected Implementation Costs

	Total Year 1 to Year 3	Total through Year 20
Network Equipment	$ 35,318,000	$ 88,296,000
Outside Plant and Materials	307,029,000	307,029,000
Last Mile and Customer Premises Equipment	221,074,000	333,821,000
Miscellaneous Implementation Costs	1,474,000	3,317,000
Total	$ 564,895,000	$ 732,463,000

[71] A “magnitude” projection provides projected data sufficient for initial planning purposes. Refinement of the analysis is planned after results of the residential and business market research is completed.

7.1.1. Considerations

The FTTP network will need to acquire staff and facilities to support the new business. We estimate that over 430 additional employees are likely required to operate the proposed business.

7.1.2. Risks and Benefits

The success of the retail model greatly depends on the City's capability to compete in a consumer market with established and experienced providers. Other municipal FTTP systems have obtained such shares, but they are located in communities where competition is limited (or nonexistent) and the local government possesses a strong branding or trust image with its citizens. In addition, most of these municipal networks were first to market with a high-speed Internet offering, and the incumbent cable television network was in a state of disrepair.

7.1.3. Financial Analysis

7.1.3.1. Financing Costs

Our analysis estimates total financing requirements to be $580 million for the retail model. For financing, we assume the issuance of two bonds[72].

1. A $360 million bond[73] in year 1 to cover the cost of new fiber. This bond is issued at an interest rate of 4.50 percent and is paid off in equal principal and interest payments over the 20-year depreciable life of the fiber. Further, we assume that principal payments do not start until year 4.

2. We assume a $220 million bond in year 1 to cover the remaining implementation costs, including headend equipment, operating equipment, customer premises equipment, and other miscellaneous costs. All of this initial equipment investment is depreciated over seven years, and the financial projections include reinvestment and upgrades to keep the equipment useful over a twenty year life. This bond is paid off over 20 years[74] at an interest rate of 5.00 percent. Further principal payments do not start until year 4.

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[72] The scope of work for this Report does not include a review of the City's bonding capability or review of local or state bonding restrictions. A more detailed review and opinion from the City's accountants of bonding capability and restrictions is recommended in the business planning phase.

[73] Experience suggests that the financial community is unlikely to offer the required bonding based on the projected voice, video, and data revenues. Securing the bonds through existing revenue streams (water, electric, sales tax, other) or through the general obligation of the City may be required.

[74] Please note that the anticipated lifetime of some equipment is lower than the period of the bond repayment. This creates a situation where the debt associated with the asset is higher than the market value. To help negate this effect in years 5 and after, we have included expenses for equipment replenishment paid from incoming revenues.

For both bonds we assume that the issuance costs are equal to 1.0 percent of the principal borrowed. For each bond, a debt service reserve account is maintained at 5.0 percent of the total issuance amount. An interest reserve account equal to years 1 and 2 interest expense is maintained for the first two years.

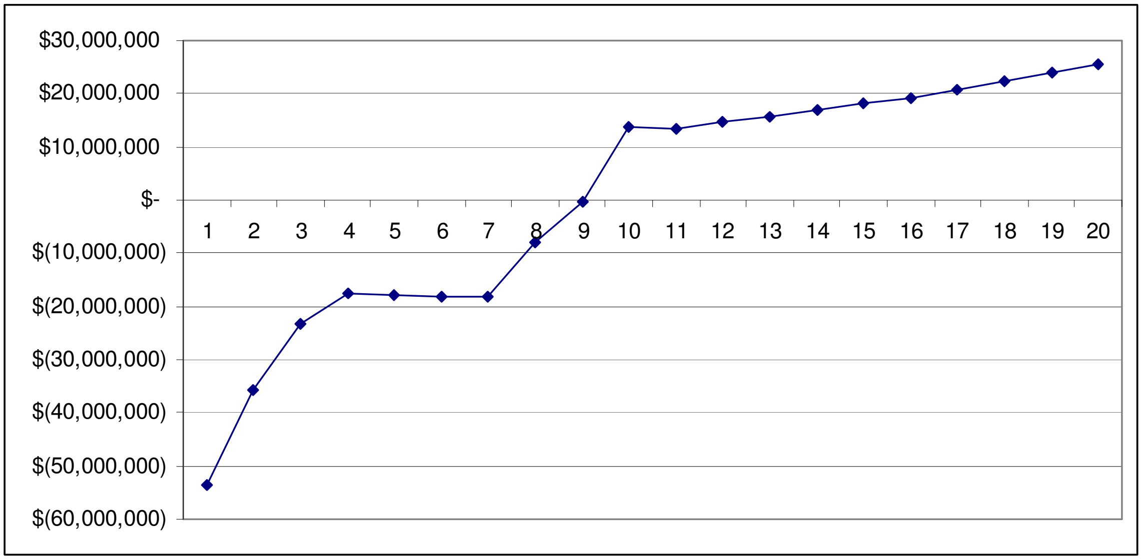
Interest earned on excess cash is assumed to be 4.0 percent of the previous year's ending cash balance.

The projected Income Statement is shown in Table 12 and in Figure 12.

Table 12: Retail Model Income Statement

Year		1	10	20
a. Revenues				
Video		$ 6,000,000	$ 29,453,000	$ 29,453,000
Internet		26,332,000	95,499,000	95,499,000
Voice		5,364,000	16,422,000	16,422,000
Provider Fee		-	-	-
Customer Entry Fee		-	-	-
Economic Development Contribution		-	-	-
Ancillary Revenues		443,000	2,111,000	2,111,000
	Total	$ 38,139,000	$ 143,485,000	$ 143,485,000
b. Content Fees				
Video		$ 3,350,000	$ 9,602,000	$ 17,928,000
	Total	$ 3,350,000	$ 9,602,000	$ 17,928,000
c. Operating Costs				
Labor Expense		$ 11,713,000	$ 19,093,000	$ 30,298,000
Operation and Maintenance Expenses		20,164,000	26,789,000	44,997,000
Pole Attachment Expense		-	-	-
Depreciation		29,320,000	38,005,000	52,189,000
	Total	$ 61,197,000	$ 83,887,000	$ 127,484,000
d. Operating Income		$ (26,408,000)	$ (13,114,000)	$ 600,000
e. Non-Operating Income				
Interest Income		$ -	$ 235,000	$ -
Interest Expense (5-Year Bond)		-	-	-
Interest Expense (Headend and CPE Bond)		(11,000,000)	(8,104,000)	(929,000)
Interest Expense (Fiber Bond)		(16,200,000)	(11,802,000)	(1,324,000)
	Total	$ (27,200,000)	$ (19,671,000)	$ (2,253,000)
f. Net Income		$ (53,608,000)	$ 13,837,000	$ 26,976,000
g. Taxes (Franchise Fees & In Lieu Tax)		$ 300,000	$ 1,473,000	$ 1,473,000
h. Net Income After Fees & In Lieu Taxes		$ (53,908,000)	$ 12,364,000	$ 25,503,000

Figure 126: Estimated Net Income



In Figure 12, the increase in net income in years 7, 8, and 9 is due to the fact that the initial network electronics installed (years 1, 2, and 3) are depreciated over 7 years. The slow rise in net income over the remaining years is due to the depreciation ending on annual CPE replacements.

7.1.3.2. Operating and Maintenance Expenses

Years 1, 10, and 20 operating and maintenance expenses are presented in Table 13. These expenses are in addition to the cable television (video) programming (content) fees, pole attachment expenses, and labor expenses shown in the Income Statement (Table 12).

Table 13: Summary of Operating and Maintenance Expenses

Year		1	10	20
Annual Fixed Operating Expense				
Insurance		$ 400,000	$ 400,000	$ 400,000
Utilities		200,000	200,000	200,000
Office Expenses		400,000	400,000	400,000
Contingency		400,000	400,000	400,000
Billing Maintenance Contract		50,000	50,000	50,000
Fiber Maintenance		1,540,000	1,540,000	1,540,000
Legal Fees		300,000	150,000	150,000
Content Aquisition		350,000	100,000	100,000
Marketing		7,983,000	1,500,000	1,500,000
Annual Variable Operating Expense		-	-	-
Education and Training		469,000	1,212,000	1,212,000
Customer Handholding		64,000	221,000	221,000
Customer Billing (Unit)		32,000	111,000	111,000
Allowance for Bad Debts		572,000	2,152,000	2,152,000
Internet Connection Fee		7,404,000	25,541,000	25,541,000
PSTN Connection Fee		-	-	-
	Total	20,164,000	33,977,000	33,977,000

Facilities: The addition of new staff and inventory requirements will require allocation of office and warehousing space:

- Expand office facilities for management, technical, and clerical staff.
- Expand retail “storefront” to facilitate customer contact and their experience with doing business with the City.
- Provide warehousing for receipt and storage of cable and hardware for the installation and ongoing maintenance of the broadband infrastructure.
- Establish location to house servers, switches, routers, and other core-network equipment.

Training: Training of existing City staff is important to fully realize the economies of adding a business unit. This training is especially important for electric customer service representatives, account managers, and other staff that deal directly with the taxpayers or electric ratepayers - even if they will not be directly assigned to the new enterprise.

Cable Programming: To provide retail cable television service, the City will need to obtain programming through independent negotiations with content providers, including Comcast and Time Warner. In the past, small cable operators have joined the National Cable Television Cooperative (NCTC) to acquire a substantial portion of programming via NCTC negotiated contracts. The NCTC, however, has a moratorium on adding new members which is unlikely to be lifted in the near future. Given this, the City is on its own in negotiating programming contracts with each programming content owner. We anticipate the City will spend $350,000 in year 1, $150,000 in year 2 and $100,000 each following year to negotiate and maintain programming contracts. These expenses are in addition to ongoing programming fees. Ongoing cable programming fees are the highest expense[75] as a percentage of revenue in the retail model. This makes reduction of cable television pricing difficult unless the provider is willing to use cable television as a loss-leader[76] product.

Billing and Collections: The City already has billing software capabilities. The estimated incremental cost of billing for the new broadband utility is five cents per bill. In addition, we have included $1,000,000 for the upgrade or purchase of a billing module. Incremental maintenance of billing software is estimated to be $50,000 annually.

Marketing and Sales: It is important to be proactive in setting customer expectations, addressing security concerns, and educating the customers on how to initiate services.

Staffing Levels: Skills in the following disciplines are required:

- Sales and Promotion
- Internet and related technologies
- Staff Management
- Strategic Planning
- Finance
- Vendor Negotiations
- Networking (addressing, segmentation)
- Marketing

Based upon our experience, the recommended support staffing levels for the technical employees are shown in Table 14.

Table 14: Recommended Support Staffing Levels

Position	Metric
Plant Service Technician	1 per 100 miles of plant
Customer Service Technicians (CST)	1 per 2,500 subscribers (per shift)
Customer Service Representatives (CSR)	1 per 2,500 subscribers (per shift)

The expanded business and increased responsibilities will require the addition of new staff. The initial additional positions and staffing levels are shown in Table 15. These numbers are based upon the levels discussed above, and assumes that three shifts of customer service representative support is provided (24x7 support) and two shifts of customer technicians are available. It is possible to contract out a portion of the customer service support.

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[75] See line b of the Income Statement.

[76] Enticing customers to purchase a base product through discounted pricing which encourages them to buy other services with high margins. The provider expects that the typical customer will purchase Internet and/or telephone services at the same time as the loss leader (cable television) and that the margins made on these items will be such that positive cash flow (profits for private sector - cash flow for the public sector) is generated for the provider.

Table 15: Estimated Staffing Requirements

Service Position Total	Year 1	Year 2	Year 3+
Business Manager	1	1	1
Market & Sales Manager	1	1	1
Broadband Service Manager & Administrators	1	3	3
Headend Technician	1	2	2
Telephone Technician	1	2	2
Internet Technician	2	4	4
Customer Service Representative/Help Desk	66	123	225
Service Technicians/Installers	44	82	150
Sales and Marketing Representative	7	13	23
Contract Administrator	1	2	2
Fiber Plant O&M Technicians	23	23	23
Total	148	256	436

For purposes of this analysis, benefits in the amount of 35 percent of base salary are assumed.

7.1.3.3. Summary of Assumptions

Key annual operating and maintenance assumptions include:

1. With the exception of cable television programming (content) fees, annual increases in subscriber fees will offset annual increases in expenses. Cable television fee increases will exceed increases of cable television subscriber fees by two percent per year.
2. Content fees are estimated based on adding a slight premium on current fees paid to content owners by cable television providers. The premium is due to the fact that the City will not be able to directly join the NCTC.
3. Upgrades to headend and network electronics in year 8 will be 75 percent or original cost and in year 15 it will be 50 percent of original cost.
4. Starting in year 4, three percent per year of the CPEs in service will require replacement.
5. Salaries and benefits are based on estimated market wages. See Table 15 for the list of staffing requirements. Benefits are estimated at 35 percent of base salary.
6. Insurance is estimated to be $400,000 per year in years 1 through 20.
7. Utilities are estimated to be $200,000 per year in years 1 through 20.
8. Office expenses are estimated to be $400,000 per year in years 1 through 20.
9. Contingency expense is estimated to be $400,000 per year in years 1 through 20.
10. A billing package is implemented for a cost of $1,000,000. Maintenance of billing software is estimated to be $50,000 per year in years 1 through 20.
11. Annual fiber maintenance fees are assumed to be $5,000 plus 0.5 percent of total accrued fiber implementation cost.
12. Annual legal fees are estimated to be $300,000 in years 1 and 2, and then are reduced to $150,000 in years 3 through 20.
13. Negotiation of cable television programming fees is assumed to be $350,000 in year 1, $150,000 in year 2, and $100,000 per year in years 3 through 20.

14. A "partner" is used to offer telephone services. The partner is responsible for interconnect, number porting, 911 access, and other regulatory requirements. The partner holds the CLEC license and will splint gross revenues evenly with the City.
15. Marketing and promotional expenses are estimated at $150 per new subscriber in years 1 through 3, and $1,500,000 per year in years 4 through 20.
16. Annual education and training expenses are calculated as 4.0 percent of direct payroll expense.
17. Customer handholding is estimated to be 10 cents per subscriber per month.
18. Customer billing (incremental) is estimated to be 5 cents per bill per month.
19. Allowance for bad debts is computed as 1.5 percent of revenues.
20. Internet connection fees are estimated at an average of 25 Mbps per user at a 40 oversubscription ratio. Cost of Internet backhaul is estimated a $20 per Mbps per month.
21. Public Switched Telephone Network (PSTN) connection fees are included in the telephone partner fees.
22. No pole attachment fees are included for fiber cable located on an estimated 18,000 utility poles since the City is a member of the joint pole association. The one-time attachment cost is included in the implementation estimate.
23. The City will provide one set top box with the cable television service. Additional set top boxes are leased for $4 per month. Set top box lease payments are shown as ancillary revenue in the income statement.
24. Franchise fees are estimated to total five percent of cable television revenue annually.
25. The market size for residential telephone will continue to decline. The residential market size is 80 percent[77] of households in year 1, declining to 65 percent by year 4. The market size for business telephone (businesses making local decisions) will start at 90 percent of businesses in year 1, declining to 85 percent in year 6.
26. The market size for residential Internet will remain at 90 percent of households. The market size for business Internet will remain at 93 percent of businesses.
27. The market size for residential cable and satellite television will decline to 46 percent of households by year 6. The market size for business cable television will remain at 15 percent.

Inflation and salary cost increases were not used in this analysis as it is assumed that cost increases will be passed on to customers in the form of increased prices.[78]

7.1.3.4. Pricing

Pricing is a critical part of the retail model, for obvious reasons, because it impacts the consumer's cost/benefit analysis and their willingness to purchase the product -- and thereby impacts the provider's market share. It is important to keep in mind that maximizing market share is not necessarily the same as maximizing revenue -- a very inexpensive product can drive

[77] Market size is 83 percent today.
[78] Models that add the same escalation factor on revenues and expenses will overstate the anticipated gross margins (revenues less expenses) in the out years. For example: in year 1, $2 in revenues and $1 in expenses results in a gross margin of $1. Increasing each of these by 10 percent results in $2.20 in revenues and $1.10 in expenses -- yielding a gross margin of $1.10. In other words, gross margins will also increase by the escalation factor.

market share, but the revenue generated may not maintain operation expenses and make debt service payments.

Our model leverages the results of the market research and selects pricing at a level that balances revenue generation and obtaining market share. Specifically:

- The model prices cable television packages similar to Comcast's current package pricing.
  - The mix of cable television packages and options nets an average of $56 per month per subscriber.
  - Package prices (without premium channels) range from $12 per month to $52 per month.
  - Premium packages (incremental) ranges from $10 per month to $40 per month.
- Internet average prices are set to be competitive with existing area Internet service providers while offering higher capacity connections. Specifically, residents and businesses are offered a 100 Mbps connection at the average current price of high-speed options, and a 1 Gbps for the average price of a leased line.
  - $37 per month for a residential 100 Mbps connection.
  - $118 per month average for a business 100 Mbps connection.
  - $667 per month for a business 100 Mbps to 1 Gbps connections.
- The model prices telephone packages to be competitive with AT&T, Astound, and Comcast.
  - $36 per month for residential unlimited local and long-distance.
  - $249 per month average[79] for business unlimited local and long-distance.

7.1.3.5. Cash Flow Results

Examining a stand-alone Income Statement is not a sufficient analysis. Our analysis also examines the cash flow after principal[80] payments are made, accumulated unrestricted cash balances, and restricted[81] cash balances.

Year-end net income and cash flow results are compared in Table 16. As illustrated in that table, although net income is positive, it is not sufficient to cover debt service. The results indicate a projection of a net cash shortage of $30.1 million[82] at the end of year 20.

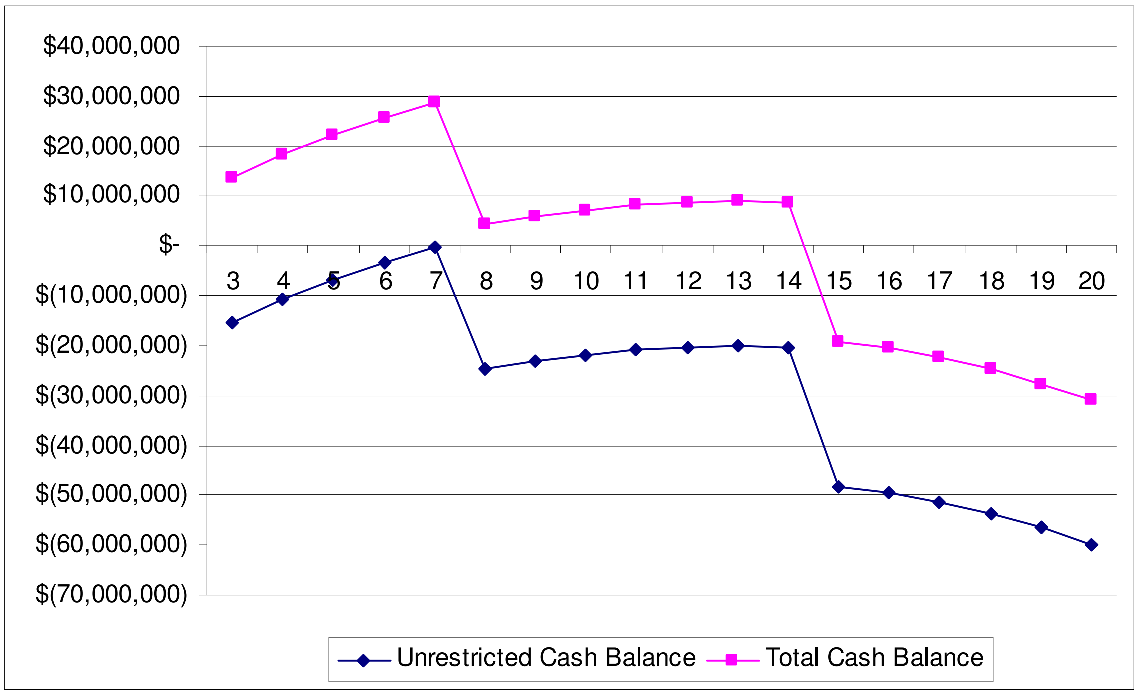
[79] Actual offering will have a range of products from under $50 per month to over $1,000 per month.
[80] The Income Statement accounts for interest expense, but not principal payments on debt. The cash flow statement excludes non-cash expense, such as depreciation, and includes principal payments.
[81] The restricted cash balance is the debt service reserve fund, and is held in escrow until the last bond payment is made.
[82] Unrestricted cash balance plus the restricted cash balance.

Table 16: Base Case (Retail) Net Income and Cash Flow

	Year 1	Year 5	Year 10	Year 15	Year 20
Net Income	$ (53,908,000)	$ (19,333,000)	$ 12,364,000	$ 18,288,000	$ 25,504,000
Cash Flow	$ 88,603,000	$ 3,975,000	$ 1,277,000	$ (27,830,000)	$ (3,266,000)
Unrestricted Cash Balance	$ 88,603,000	$ (6,841,000)	$ (21,838,000)	$ (48,129,000)	$ (59,866,000)
Restricted Cash Balance (Debt Service Reserve)	29,000,000	29,000,000	29,000,000	29,000,000	29,000,000
Net Cash Balance	$ 117,603,000	$ 22,159,000	$ 7,162,000	$ (19,129,000)	$ (30,866,000)

In Figure 127, we show the projected cash balances for each year. The decline in cash positions in year 7 and in year 14 are due to the projected network upgrades.

Figure 127: Accumulative End of Year Cash Balance Projection



As shown in the cost estimate for the FTTP implementation, make-ready and labor costs could increase the fiber implementation costs to $486.6 million, an increase of $179.6 million. Increasing the implementation costs by this amount increases the bonding requirements to $760 million, and results in an end of year 20 cash shortage of $344 million.

The cash flow balances are quite sensitive to the pricing and projected market shares. For example, we will look at the sensitivity of residential Internet by maintaining all other assumptions except for residential Internet pricing and market share. If residential Internet pricing is increased by $10 to $47 per month, while leaving market share at 55 percent, an end of year 20 cash balance of $480 million is obtained, an increase of $511 million. However, as indicated in the surveys, market share is highly sensitive to price. The survey results indicate if the residential Internet price is increased by $10 per month, market share declines to 27 percent.

This combination results in a cash balance of $161 million. This indicates that a pricing of residential Internet in the $45 range maybe a good balance between maximizing participation while striving to maintain a break-even cash flow.

As a further example, if we reduce the residential Internet market share by half, to 22.5 percent, and maintain the $37 per month fee, the cash flow balances drop to a shortage of $100.1 million. This impact is shown in Table 17.

Table 17: Reduced Market Share (Retail) Net Income and Cash Flow

	Year 1	Year 5	Year 10	Year 15	Year 20
Net Income	$ (52,769,000)	$ (14,941,000)	$ 3,236,000	$ 7,182,000	$ 14,529,000
Cash Flow	$ 96,717,000	$ (3,528,000)	$ (7,851,000)	$ (38,936,000)	$ (14,241,000)
Unrestricted Cash Balance	$ 96,717,000	$ 72,459,000	$ 15,199,000	$ (62,510,000)	$ (129,121,000)
Restricted Cash Balance (Debt Service Reserve)	29,000,000	29,000,000	29,000,000	29,000,000	29,000,000
Net Cash Balance	$ 125,717,000	$ 101,459,000	$ 44,199,000	$ (33,510,000)	$ (100,121,000)

Cable television and telephone market shares also have an impact on results. If the residential cable television market share is dropped in half, net cash drops to a $74 million shortage (a $43.1 million reduction). If residential telephone market share is dropped in half, net cash shortage drops to $106 million (a $76.1 million reduction).

The sensitivity of, and the ability to obtain, the required market shares while maintaining contribution margins is one of the key challenges with the retail model.

Another financial measurement is the debt service coverage ratio. The debt service coverage ratio does not go above 1.1 in the base model.

7.1.3.6. Market Share

A measure of success often specified by municipal overbuild is the ability to maintain a positive cash flow throughout the life of the proposed model. To maintain a positive cash flow, a substantial market share is required without offering substantial discounts from existing subscriber fees. The market research results indicate this may be possible, but, as previously discussed, results are quite sensitive to changes in the market.

At the price levels stated above, the surveys indicate a new provider may expect up to the following market shares:

- 55 percent of residential Internet.
- 39 percent of business Internet (42 percent of small to medium businesses, 23 percent of larger businesses).
- 22 percent of residential telephone.
- 17 percent of business telephone.
- 28 percent of residential cable television.
- 28 percent of business cable television.

To sustain the retail model cash flow, a new provider will need to maintain these market shares without lowering prices. For the retail overbuild model, sustaining these market shares and pricing are critical from a cash flow perspective. To help justify a municipal overbuild in San Francisco, a range of indirect and direct benefits can be considered.

A new market entrant is likely to face difficulty obtaining such market penetration because it already has three facilities-based providers that will fight to maintain their outdated business models. Each of these providers currently offers a suite of voice, video, and data services, and will offer price discounts in an attempt to retain consumers.

7.1.4. Existing Project in Another Community

Many municipal electric utilities, such as Reedsburg, Wisconsin and Jackson, Tennessee, have successful FTTP deployments that use the retail service model. One key difference in each of these cases is the municipal electric was the first to market with a high-speed Internet product, and the incumbent providers had ignored network upgrades in the community for a number of years. Given the market status in San Francisco, it is our opinion that the City would be challenged to maintain sufficient market share and service contribution margins to maintain cash flow under this model.

7.2 Debt Financing-Open Access Model

In this model, the City builds the FTTP network and wholly controls that asset. Private sector service provider(s) are selected to offer data, voice, and video services over it, respectively. In this model, the City's role is limited to building and maintaining the FTTP network.

A variation of this is the model emerging in parts of Europe, most notably Amsterdam, where the City (and a number of private investors) own the fiber infrastructure; a TelecomItalia subsidiary operates the lit network; and four competing Internet Service Providers provide services over the network.

The open access model (also referred to as the "wholesale" model) separates the infrastructure from the retail service. In this model, the City is in the business of infrastructure, not communications service provision. In the open access model, the City's customer is not the retail consumer -- rather, it is the service provider.

By building an open infrastructure on which capacity is leased to private sector providers, the City would address the key barrier to market entry for potential retail providers -- the cost of the FTTP infrastructure. The result is the potential for new competition-delivering, enhanced services.

Given the market penetration and other assumptions detailed below, the total estimated implementation costs for year 1 through year 3 is $558.6 million (see Table 18).

Table 18: Projected Implementation Costs

	Total Year 1 to Year 3	Total through Year 20
Network Equipment	$ 29,668,000	$ 74,171,000
Outside Plant and Materials	307,029,000	307,029,000
Last Mile and Customer Premises Equipment	221,074,000	333,821,000
Miscellaneous Implementation Costs	870,000	1,958,000
Total	$ 558,641,000	$ 716,979,000

7.2.1. Considerations

The open access model requires fewer staff additions than does the retail model because it does not require consumer level support, sales, and marketing. The staff additions are geared towards operating and maintaining the FTTP network, promoting the network to potential service providers, and managing those providers leasing network access.

The open access model presented in this Section provides a magnitude projection and includes a wide-range of estimates for staffing, operating, maintenance, and other costs. Prior to a decision, we recommend that these projections be refined in a more detailed business plan.

For comparison purposes, this analysis maintains the same market shares used in the retail model. However, we are not projecting that these market shares are obtainable or sustainable.

Our wholesale model assumes that the City operates and maintains the fiber, the transport electronics, consumer drops, and the customer premises equipment. Contracting these activities to a management partner is a variation that reduces the required number of staff, while still allowing the City to maintain control of network availability and encouragement of new services and competition. In this variation, the City owns the fiber network and transport electronics, a management partner is contracted to provide network maintenance and operations, and the retail services supplier is chosen by the consumer. Further exploring this and other variations is an important step in business plan development.

7.2.2. Risks and Benefits

The theory behind open access is that as multiple providers will seek market share, the probability of capturing sufficient market share is increased. In other words, the FTTP network has a greater chance of achieving higher aggregate market share if many providers are actively competing for customers than if only the City is marketing (as in the retail model). We believe there is some merit to this point in highly contested markets, such as those in San Francisco; however, it will take an active City involvement in promotion efforts.

Early results of the open access model in less desirable markets have proved to be different. Without the open access infrastructure provider facilitating customer communications, potential consumers have not understood the breadth of provider options available. Further, the retail providers do not have a high capital investment, and therefore require a relatively low market share to remain profitable -- reducing their incentive to market aggressively. As a result, in many of the open access deployments to date, retail providers have been satisfied at a much lower market share than the infrastructure provider requires to maintain cash flow. To increase the potential for success, the City will need to facilitate communication with consumers informing them of provider service options and alternatives.

7.2.3. Financial Analysis

Critical assumptions in the open access model include the access fees charged to the retail providers. In our analysis, we used the following access fee structure.

- $18 per month for per residential Internet customer.
- $70 per month average for per business Internet customer (estimated at $36 for 100 Mbps service and $300 per month for the 1 Gbps business service).
- $15 per month for per residential telephone customer.
- $100 per month for per business telephone customer (estimated at 40 percent of the average business telephone retail price).
- $15 per month for per residential cable television customer.
- $15 per month for per business cable television customer.

Assuming the retail pricing remains as indicated in the retail model, the above fees result in net per subscriber revenue to the retail provider of:

- $19 per month for per residential Internet customer.
- $119 per month for per average business Internet customer (estimated at $82 for 100 Mbps service and $367 per month for the 1 Gbps business service).
- $22 per month for per residential telephone customer.
- $149 per month for per average business telephone customer.
- $41 per month for per residential cable television customer.
- $57 per month for per business cable television customer.

The net revenue must cover all of the retail providers' investment, operating, and maintenance expenses plus their profit margins.

Using the same market share and market size assumptions used in the retail model, and charging each provider the above connection fees, the City will have an unrestricted cash shortage of approximately $53.9 million by the end of year 20. A decrease of $5 per month of the residential Internet fee decreases the year 20 cash balance by $182.2 million to a shortage of $236.1 million.

7.2.3.1. Financing Costs

Our analysis estimates total financing requirements to be $570 million for the open access (wholesale) model. For financing, we assume two bonds and an operating loan:

1. A $350 million bond in year 1 to cover the cost of new fiber. This bond is issued at an interest rate of 4.50 percent, and is paid off in equal principal and interest payments over the 20-year depreciable life of the fiber. Further we assume that principal payments do not start until year 4.

2. We assume a $220 million bond in year 1 to cover the remaining implementation[83] costs, including headend equipment, operating equipment, customer premises equipment and other miscellaneous costs. All of this initial equipment investment is depreciated over seven years, and the financial projections include reinvestment and upgrades to keep the equipment useful over a twenty year life. This bond is paid off over 20 years[84] at an interest rate of 5.00 percent. Further principal payments do not start until year 4.

We assume that issuance costs are equal to 1.0 percent of the principal borrowed on each bond. A debt service reserve account is maintained at 5.0 percent of the total issuance amount. An interest reserve account equal to years 1 and 2 interest expense is maintained for the first two years. Further, no bond principal payments are made until year 4

Interest earned on excess cash is assumed to be 4.0 percent of the previous year's ending cash balance.

The projected Income Statement is shown in Table 19 and in Figure 128.

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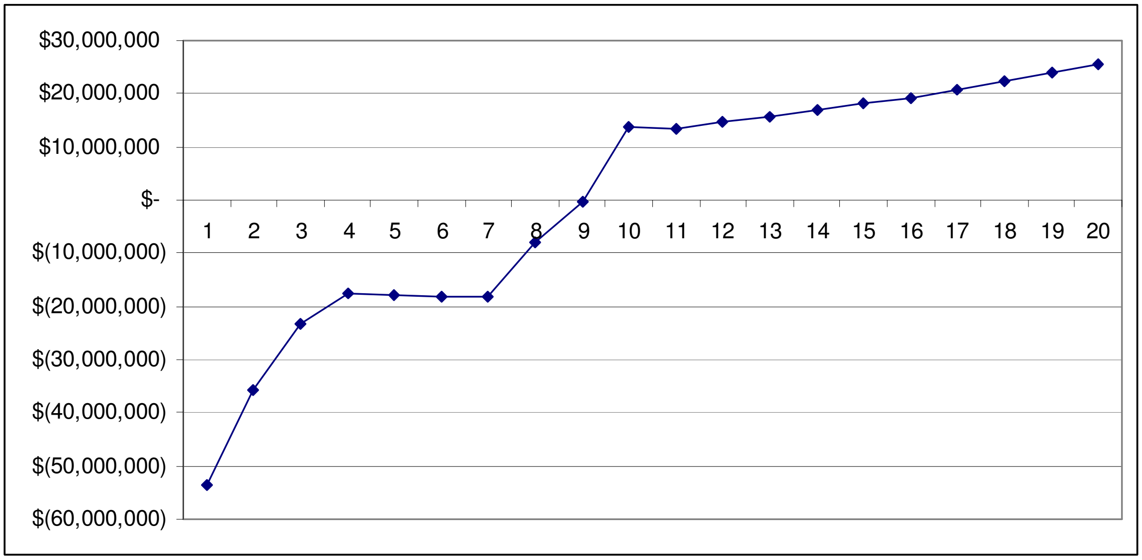
[83] The outlined open-access model allocates the customer premises equipment costs to San Francisco. Development of CPE ownership and other policy issues is an important task in preparation of a business plan.

[84] Please note that the anticipated lifetime of some equipment is lower than the period of the bond repayment. This creates a situation where the debt associate with the asset is higher than the market value. To help negate this effect in years 5 and after, we have included expenses for equipment replenishment paid from incoming revenues.

Table 19: Open Access Model Income Statement

Year		1	10	20
a. Revenues				
Video		$ -	$ -	$ -
Internet		-	-	-
Voice		-	-	-
Provider Fee		15,373,000	55,245,000	55,245,000
Customer Entry Fee		-	-	-
Economic Development Contribution		-	-	-
Ancillary Revenues		16,000	55,000	55,000
	Total	$ 15,389,000	$ 55,300,000	$ 55,300,000
b. Content Fees				
Video		$ -	$ -	$ -
	Total	$ -	$ -	$ -
c. Operating Costs				
Labor Expense		$ 4,884,000	$ 5,731,000	$ 6,183,000
Operation and Maintenance Expenses		4,272,000	4,391,000	4,780,000
Pole Attachment Expense		-	-	-
Depreciation		28,427,000	37,112,000	51,296,000
	Total	$ 37,583,000	$ 47,234,000	$ 62,259,000
d. Operating Income		$ (22,194,000)	$ (15,371,000)	$ (5,650,000)
e. Non-Operating Income				
Interest Income		$ -	$ -	$ -
Interest Expense (5-Year Bond)		-	-	-
Interest Expense (Headend and CPE Bond)		(11,000,000)	(8,104,000)	(929,000)
Interest Expense (Fiber Bond)		(15,750,000)	(11,474,000)	(1,287,000)
	Total	$ (26,750,000)	$ (19,578,000)	$ (2,216,000)
f. Net Income		$ (48,944,000)	$ (475,000)	$ 16,918,000
g. Taxes (Franchise Fees & In Lieu Tax)		$ -	$ -	$ -
h. Net Income After Fees & In Lieu Taxes		$ (48,944,000)	$ (475,000)	$ 16,918,000

Figure 128: Estimated Net Income



In Figure 128 the increase in net income in years 7, 8, and 9 is because the initial network electronics installed (years 1, 2, and 3) are depreciated over 7 years.

7.2.3.2. Operating and Maintenance Expenses

Years 1, 10, and 20 operating and maintenance expenses are presented in Table 20.

Table 20: Operating and Maintenance Expenses

Year	1	10	20
Annual Fixed Operating Expense			
Insurance	$ 400,000	$ 400,000	$ 400,000
Utilities	200,000	200,000	200,000
Office Expenses	400,000	400,000	400,000
Contingency	400,000	400,000	400,000
Billing Maintenance Contract	10,000	10,000	10,000
Fiber Maintenance	1,540,000	1,540,000	1,540,000
Legal Fees	300,000	150,000	150,000
Content Aquisition	-	-	-
Marketing	500,000	250,000	250,000
Annual Variable Operating Expense	-	-	-
Education and Training	195,000	247,000	247,000
Customer Handholding	64,000	221,000	221,000
Customer Billing (Unit)	32,000	111,000	111,000
Allowance for Bad Debts	231,000	830,000	830,000
Internet Connection Fee	-	-	-
PSTN Connection Fee	-	-	-
Total	4,272,000	4,759,000	4,759,000

Facilities: The addition of new staff and inventory requirements will require allocation of office and warehousing space:

- Expand office facilities for management, technical, and clerical staff.
- Provide warehousing for receipt and storage of cable and hardware for the installation and ongoing maintenance of the broadband infrastructure.
- Establish location to house servers, switches, routers, and other core-network equipment.

Training: Training of existing City staff is important to fully realize the economies of adding a business unit.

Billing and Collections: Billing is simplified under the open access model. We estimate that billing costs are $10,000 per year for the billing of service providers and to maintain an access portal. The customer handholding and unit fees described in the retail model are applied to maintaining the customer portal.

Marketing and Sales: Marketing efforts in the open access model are directed towards encouraging new providers to enter the San Francisco marketplace rather than at the consumer as in the retail access model.

Staffing Levels: Staff is required to maintain the core network and customer drops. The retail providers will handle day-to-day subscriber inquiries. Table 21 indicates the estimated staffing levels.

Table 21: Estimated Staffing Requirements

Service Position Total	Year 1	Year 2	Year 3+
Business Manager	1	1	1
Market & Sales Manager	-	-	-
Broadband Service Manager & Administrators	1	3	3
Headend Technician	1	1	1
Telephone Technician	1	1	1
Internet Technician	1	1	1
Customer Service Representative/Help Desk	6	9	12
Service Technicians/Installers	6	9	12
Sales and Marketing Representative	1	1	2
Contract Administrator	1	2	2
Fiber Plant O&M Technicians	23	23	23
Total	42	51	58

We assume benefits are equal to 35 percent of base salary.

7.2.3.3. Summary of Assumptions

Key annual operation and maintenance assumptions include:

1. Salaries and benefits are based on estimated market wages. See Table 21 for the list of staffing requirements. Benefits are estimated at 35 percent of the base salary.
2. Upgrades to headend and network electronics in year 8 will be 75 percent or original cost and in year 15 it will be 50 percent of original cost.
3. Starting in year 4, three percent per year of the CPEs in service will require replacement.
4. Insurance is estimated to be $400,000 per year in years 1 through 20.
5. Utilities are estimated to be $200,000 per year in years 1 through 20.
6. Office expenses are estimated to be $400,000 per year in years 1 through 20.
7. Contingency is estimated to be $400,000 per year in years 1 through 20.
8. A billing package is implemented for $400,000. Billing maintenance is estimated to be $10,000 per year in years 1 through 20.
9. Annual fiber maintenance fees are assumed to be $5,000 plus 0.5 percent of total fiber implementation cost annually.
10. Annual legal fees are estimated to be $300,000 in years 1 and 2, $150,000 in years 3 through 20.
11. Annual marketing and promotional expenses are estimated to be $500,000 in year 1 and $250,000 in years 2 through 20.
12. Education and training are calculated as four percent of direct payroll expense.
13. No pole attachment fees are included for fiber cable located on an estimated 18,000 utility poles since the City is a member of the joint pole association. The one-time attachment cost is included in the implementation estimate.
14. The market size for residential telephone will continue to decline. The residential market size is 80 percent[85] of households in year 1, declining to 65 percent by year 4. The market size for business telephone (businesses making local decisions) will start at 90 percent of businesses in year 1, declining to 85 percent in year 6.
15. The market size for residential Internet will remain at 90 percent of households. The market size for business Internet will remain at 93 percent of businesses.
16. The market size for residential cable and satellite television will decline to 46 percent of households by year 6. The market size for business cable television will remain at 15 percent.

Inflation and salary cost increases were not used in the analysis as it is assumed that cost increases will be passed on in the form of increased prices.

7.2.3.4. Cash Flow Results

These assumptions lead to the year-end net income and cash flow results summarized in Table 22. As shown, we project a cash flow shortage of $53.9 million at the end of year 20.

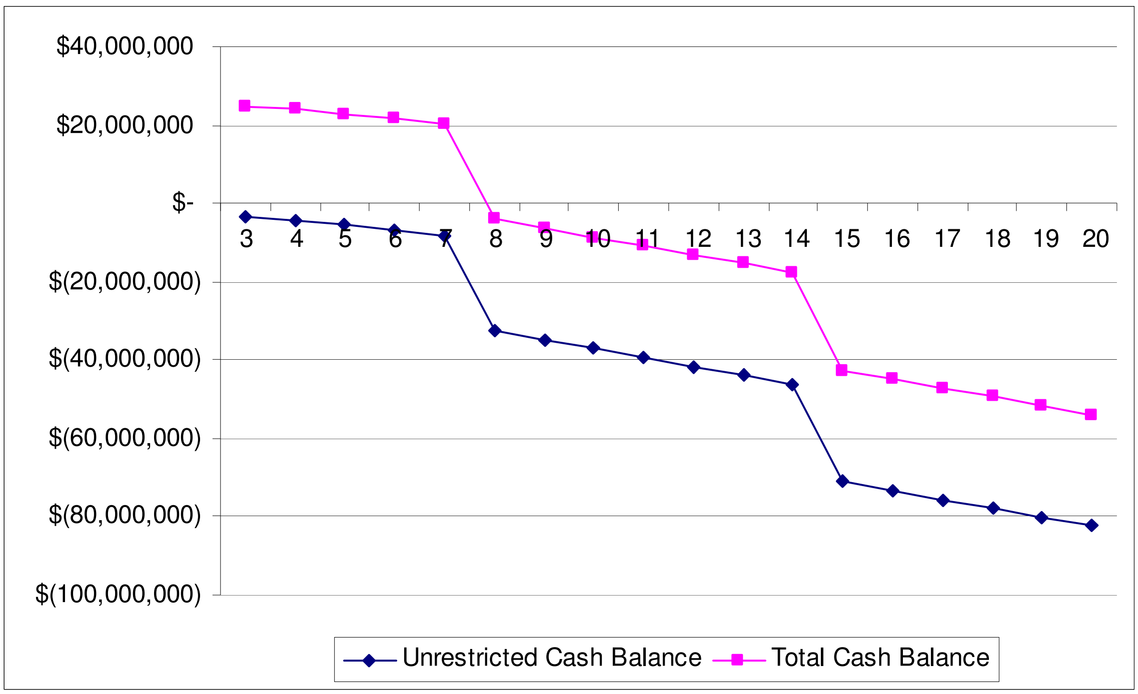
[85] Market size is 83 percent today.

Table 22: Base Case (Open Access) Net Income and Cash Flow

	Year 1	Year 5	Year 10	Year 15	Year 20
Net Income	$ (46,170,000)	$ (23,917,000)	$ 8,945,000	$ 16,663,000	$ 26,338,000
Cash Flow	$ 92,752,000	$ (1,080,000)	$ (2,287,000)	$ (24,908,000)	$ (2,263,000)
Unrestricted Cash Balance	$ 92,752,000	$ (5,509,000)	$ (37,134,000)	$ (71,095,000)	$ (82,453,000)
Restricted Cash Balance (Debt Service Reserve)	28,500,000	28,500,000	28,500,000	28,500,000	28,500,000
Net Cash Balance	$ 121,252,000	$ 22,991,000	$ (8,634,000)	$ (42,595,000)	$ (53,953,000)

In Figure 129, we show the projected cash balances for each year. The decline in cash positions in year 7 and in year 14 are due to the projected network upgrades.

Figure 129: Accumulative End of Year Cash Balance Projection



As indicated in the cost estimate for the FTTP implementation, make-ready and labor costs could increase the fiber implementation costs to $486.6 million, an increase of $179.6 million. Increasing the implementation costs by this amount increases the bonding requirements to $750 million and results in an end of year 20 cash shortage of $365 million.

The cash flow balances are quite sensitive to the subscriber access fees and projected market shares. For example, we look at the sensitivity of residential Internet by maintaining all other assumptions except for residential Internet access fee. If the residential Internet access fee is decreased by $5 to $13 per month while leaving market share at 55 percent, we net an end of year 20 cash shortage of $236.1 million.

As a further example, if we reduce the residential Internet market share to 27.5 percent, and maintain the fee at $18, again the cash flow balances drop considerably. This impact is shown in Table 23.

Table 23: Reduced Market Share (Open Access) Net Income and Cash Flow

	Year 1	Year 5	Year 10	Year 15	Year 20
Net Income	$ (46,281,000)	$ (25,761,000)	$ (4,935,000)	$ 2,784,000	$ 12,459,000
Cash Flow	$ 99,616,000	$ (12,989,000)	$ (16,166,000)	$ (38,787,000)	$ (16,142,000)
Unrestricted Cash Balance	$ 99,616,000	$ 31,842,000	$ (66,203,000)	$ (169,560,000)	$ (250,314,000)
Restricted Cash Balance (Debt Service Reserve)	28,500,000	28,500,000	28,500,000	28,500,000	28,500,000
Net Cash Balance	$ 128,116,000	$ 60,342,000	$ (37,703,000)	$ (141,060,000)	$ (221,814,000)

The sensitivity to market shares is again a concern, but, unlike in the retail model, the City is serving multiple providers that are selling to consumers. In theory, with more retail providers, the probability of obtaining the required market shares increases. This, however, has proved to be difficult in practice since the providers can cash flow at a lower penetration rate than the infrastructure provider since the retail provider does not have a capital intensive market entry.

Another issue is that eventually consumers may obtain all telephone and television programming through wireless or via the Internet. Removing all of the telephone and cable television connection fee revenues results in a cash flow shortage of $456 million.

7.2.3.5. Market Share

We used the same market shares as indicated in the retail model. These are:

- 55 percent of residential Internet.
- 39 percent of business Internet (42 percent of small to medium businesses, 23 percent of larger businesses).
- 22 percent of residential telephone.
- 17 percent of business telephone.
- 28 percent of residential cable television.
- 28 percent of business cable television.

As indicated in the financial analysis, the balance of market share and access fees is critical to maintain cash flow.

7.2.4. Case Study

This model has shown early success in Amsterdam. In the Amsterdam model, the City is one of the investors in the infrastructure. To operate the network, the infrastructure owners have contracted with a network operator. Although the network operator is able to provide retail services, it offers open access to any qualified provider. Four service providers currently compete for consumers on the network.

In the U.S., UTOPIA did not have success with the debt-financing open access approach. They found it difficult to attract qualified providers in the suburban and rural communities in Utah. Most important, UTOPIA left marketing in the hands of the providers. This proved costly since the providers reached profitability at much lower market shares as required by UTOPIA, and the providers had no incentive to advise consumers of other choices. Another challenge is that in many neighborhoods few households opted for a UTOPIA connection, leaving much of the fiber investment stranded.

7.3 Equity Participation - Open Access Model

In a variation on the open access model, the City deploys a FTTP network that delivers fiber into neighborhoods and to residences that meet subscription requirements. Financing of the network is accomplished, in part, with one-time connection fees collected from the property owners who request that their homes and businesses be connected to the network. As in the open access model, the City is involved in the fiber network only -- private sector entities are enabled to offer services to residences and businesses. This is the model used by some European municipalities and that is under consideration for the UTOPIA network of 16 communities in Utah.

The Equity model requires new customers to pay a one-time fee for the fiber connection to their premises and for customer premises equipment (CPE). The customer owns, rather than leases, the connection and CPE.

The Equity model has the potential to facilitate true competition by: allowing retail providers to share access to infrastructure; allowing retail providers access to consumers that is unfettered by the infrastructure owner; and empowering consumers to understand service and provider options.

It is important to note that this Equity model is very innovative. We cannot point to any data that verify that a community can expect to obtain and sustain the subscription numbers necessary to make this model work. Data provided by the Vasteras, Sweden network operator, PacketFront, is encouraging and does suggest that this model is seeing significant success in Europe. However, to CTC's knowledge, there is no existing municipal FTTP network in the United States that uses this model. As a result, there exists no empirical data in the U.S. that could demonstrate or justify assumptions about consumer subscription levels, access fees paid, and other key assumptions under this model. In Sweden, and for that matter, most European countries, cable television is not as dominant as in North America. European citizens are more data-centric. If this model is pursued, negotiations with retail providers are required to finalize access fees, service attributes, and other contract terms.

Given the market penetration and other assumptions detailed below, the total estimated implementation costs for year 1 through year 3 is $558.6 million (see Table 24).

Table 24: Projected Implementation Costs

	Total Year 1 to Year 3	Total through Year 20
Network Equipment	$ 29,668,000	$ 74,171,000
Outside Plant and Materials	307,029,000	307,029,000
Last Mile and Customer Premises Equipment	221,074,000	333,821,000
Miscellaneous Implementation Costs	870,000	1,958,000
Total	$ 558,641,000	$ 716,979,000

7.3.1. Considerations

Technically, this model is the same as the open access model. The exception is that a portion of the required capital is obtained through consumer participation fees.

7.3.2. Risks and Benefits

Table 25 presents a snapshot of the strengths and weaknesses of the Equity model. It shows several challenges (risks) that need to be addressed.

Table 25: Equity Model Strengths and Weaknesses

Advantages	Disadvantages
Offers potential to support deployment and expansion of network with lesser amounts of financing or debt.	Unproven model in the United States; though the Swedish model is encouraging, the U.S. market appears more video-centric than Sweden's.
Directs new investment to "neighborhoods" that have sufficient demand to obtain a positive return on investment.	May increase "digital divide" as investment is directed to areas where households and businesses are willing to invest in fiber or services -- the model may therefore increase access inequities.
Provides a deployment strategy that supports the ability to apply grants or other funding sources directly in low-income neighborhoods.	Requires a substantial number of households to understand a new and complex value proposition (equity, choice, and capability vs. low cost voice, video, and data).
Addresses differing market goals between the City and private providers.	
Has potential to increase home values.	

7.3.3. Financial Analysis

Critical assumptions in the equity model include the access fees charged to the retail providers. In our analysis, we used the following fee structure for the equity financing-open access model.

- $12 per month for per residential Internet customer.
- $40 per month for per business Internet customer (estimated at $20 for 100 Mbps service and $175 per month for the 1 Gbps business service).
- $8 per month for per residential telephone customer.
- $70 per month for per business telephone customer (estimated at 28 percent of the average business telephone retail price).
- $8 per month for per residential cable television customer.
- $8 per month for per business cable television customer.

The fees listed above are lower than the fees used in the open access model. This offers subscribers the potential to see lower fees to compensate for their one-time hook-up fee.

Basing the same market share assumptions used in the retail model, and charging each subscriber a hook-up fee of $2,000, the City will have a cash balance of approximately $69.3 million by the end of year 20. A decrease of $500 for the hook-up fee decreases the year 20 cash balance to a shortage of $87.8 million. Obtaining the market shares used in the retail model, however, will require significant and effective sales and marketing with the equity model. As indicated in the market research analysis, less than two percent of residences and five percent of businesses are willing to pay a $2,000 hook-up fee unless substantial service fee discounts are offered and property values are shown to increase with a fiber connection.

7.3.3.1. Financing Costs

Our analysis estimates total financing requirements, in addition to the hook-up fees, to be $320 million for the equity model. For financing, we assume a $320 million bond in year 1 to cover the cost of new fiber. This bond is issued at an interest rate of 4.50 percent and is paid off in equal principal and interest payments over the 20-year depreciable life of the fiber. Further, we assume that principal payments do not start until year 4.

We assume that issuance costs are equal to 1.0 percent of the principal borrowed on the long-and short-term bonds. A debt service reserve account is maintained at 5.0 percent of the total issuance amount. An interest reserve account equal to years 1 and 2 interest expense is maintained for the first two years. Further, no bond principal payments are made until year 4.

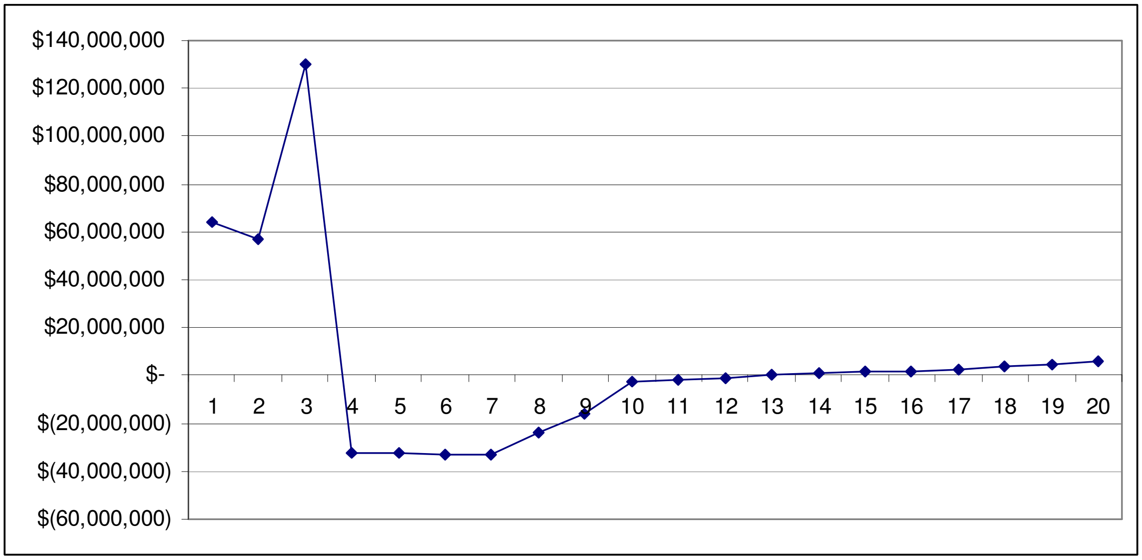
Interest earned on excess cash is assumed to be 4.0 percent of the previous year's ending cash balance.

The projected Income Statement is shown in Table 26 and Figure 130.

Table 26: Equity Model Income Statement

Year		1	10	20
a. Revenues				
Video		$ -	$ -	$ -
Internet		-	-	-
Voice		-	-	-
Provider Fee		11,238,000	39,847,000	39,847,000
Customer Entry Fee		106,439,000	-	-
Economic Development Contribution		-	-	-
Ancillary Revenues		16,000	55,000	55,000
	Total	$ 117,693,000	$ 39,902,000	$ 39,902,000
b. Content Fees				
Video		$ -	$ -	$ -
	Total	$ -	$ -	$ -
c. Operating Costs				
Labor Expense		$ 4,884,000	$ 5,731,000	$ 6,183,000
Operation and Maintenance Expenses		5,807,000	5,716,000	7,036,000
Pole Attachment Expense		-	-	-
Depreciation		28,427,000	37,112,000	51,296,000
	Total	$ 39,118,000	$ 48,559,000	$ 64,515,000
d. Operating Income		$ 78,575,000	$ 71,655,000	$ 142,511,000
e. Non-Operating Income				
Interest Income		$ -	$ 4,192,000	$ 2,850,000
Interest Expense (5-Year Bond)		-	-	-
Interest Expense (Headend and CPE Bond)		-	-	-
Interest Expense (Fiber Bond)		(14,400,000)	(10,491,000)	(1,177,000)
	Total	$ (14,400,000)	$ (6,299,000)	$ 1,673,000
f. Net Income		$ 64,175,000	$ (2,362,000)	$ 5,640,000
g. Taxes (Franchise Fees & In Lieu Tax)		$ -	$ -	$ -
h. Net Income After Fees & In Lieu Taxes		$ 64,175,000	$ (2,362,000)	$ 5,640,000

Figure 130: Estimated Net Income



In Figure 130, the spikes in years 1 through 3 are due to the customer fees collected. The increases in net income in years 7, 8, and 9 are because the initial network electronics installed (years 1, 2, and 3) are depreciated over 7 years.

7.3.3.2. Operating and Maintenance Expenses

Years 1, 10, and 20 operating and maintenance expenses are presented in Table 27.

Table 27: Operating and Maintenance Expenses

Annual Fixed Operating Expense			
Insurance	$ 400,000	$ 400,000	$ 400,000
Utilities	200,000	200,000	200,000
Office Expenses	400,000	400,000	400,000
Contingency	400,000	400,000	400,000
Billing Maintenance Contract	10,000	10,000	10,000
Fiber Maintenance	1,540,000	1,540,000	1,540,000
Legal Fees	300,000	150,000	150,000
Content Aquisition	-	-	-
Marketing	500,000	250,000	250,000
Annual Variable Operating Expense	-	-	-
Education and Training	195,000	247,000	247,000
Customer Handholding	64,000	221,000	221,000
Customer Billing (Unit)	32,000	111,000	111,000
Allowance for Bad Debts	1,765,000	599,000	599,000
Internet Connection Fee	-	-	-
PSTN Connection Fee	-	-	-
Total	5,806,000	4,528,000	4,528,000

Staffing remains the same as in the debt financing open-access model.

7.3.3.3. Summary of Assumptions

Key annual operation and maintenance assumptions are the same as the debt financing-open access model. Inflation and salary cost increases were not used in the analysis as it is assumed that cost increases will be passed on in the form of increased prices.

7.3.3.4. Cash Flow Results

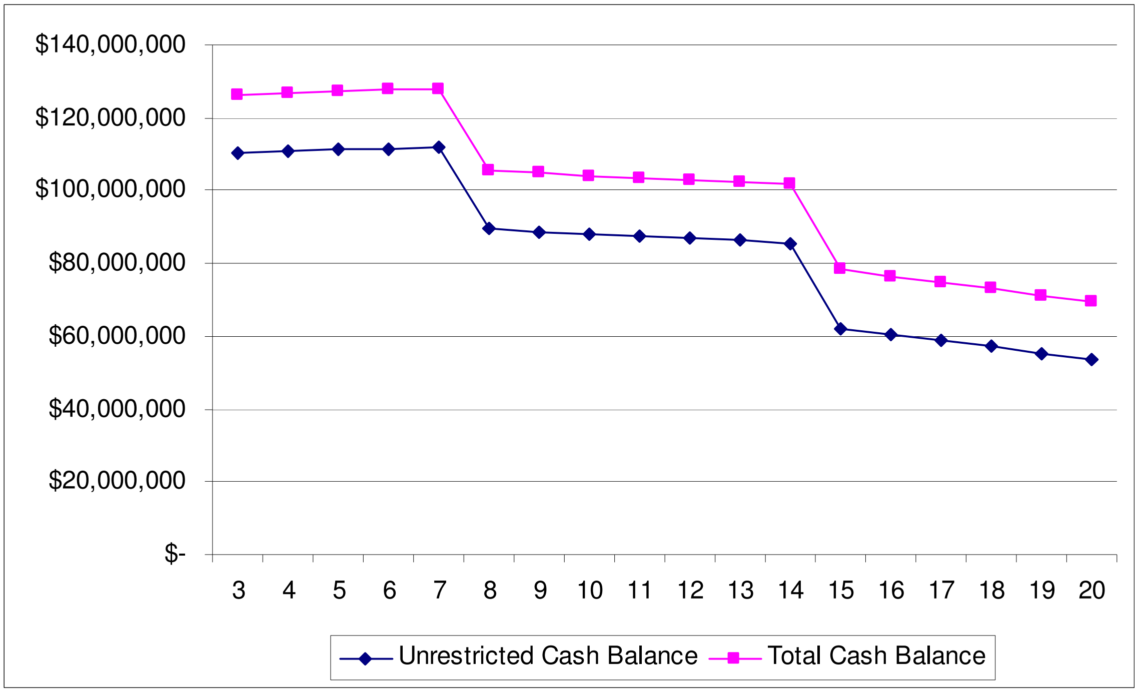
These assumptions lead to the year-end net income and cash flow results summarized in Table 28. As illustrated, given the assumptions discussed, the City will have a cash balance of approximately $69.3 million by the end of year 20.

Table 28: Base Case (Equity) Net Income and Cash Flow

	Year 1	Year 5	Year 10	Year 15	Year 20
Net Income	$ 64,175,000	$ (32,622,000)	$ (2,362,000)	$ 1,688,000	$ 5,640,000
Cash Flow	$ (19,553,000)	$ 421,000	$ (605,000)	$ (23,354,000)	$ (1,924,000)
Unrestricted Cash Balance	$ (19,553,000)	$ 111,253,000	$ 88,196,000	$ 62,269,000	$ 53,322,000
Restricted Cash Balance (Debt Service Reserve)	16,000,000	16,000,000	16,000,000	16,000,000	16,000,000
Net Cash Balance	$ (3,553,000)	$ 127,253,000	$ 104,196,000	$ 78,269,000	$ 69,322,000

In Figure 131, we indicate the projected cash balances for each year. The decline in cash positions in year 7 and in year 14 are due to the projected network upgrades.

Figure 131: Accumulative End of Year Cash Balance Projection



As indicated in the cost estimate for the FTTP implementation, make-ready and labor costs could increase the fiber implementation costs to $486.6 million, an increase of $179.6 million. Increasing the implementation costs by this amount results in an end of year 20 cash shortage of $199.4 million.

The cash flow balances are quite sensitive to the subscriber access fees and projected market shares. For example, we have examined the sensitivity of residential Internet by maintaining all assumptions except for the residential Internet access fee. If the residential Internet access fee is decreased by $5 to $7 per month, while leaving market share at 55 percent, there is a net end of year 20 cash shortage of $157.8 million.

As a further example, if we reduce the residential Internet market share to 27.5 percent while maintaining the $12 fee, cash flow balances drop considerably. This impact is shown in Table 29. The drop is not only due to reduced access fees, but also from fewer one-time hook-up fees collected.

Table 29: Reduced Market Share (Equity Access) Net Income and Cash Flow

	Year 1	Year 5	Year 10	Year 15	Year 20
Net Income	$ 49,203,000	$ (34,879,000)	$ (14,782,000)	$ (10,604,000)	$ (5,437,000)
Cash Flow	$ (27,550,000)	$ (11,900,000)	$ (13,024,000)	$ (35,646,000)	$ (13,001,000)
Unrestricted Cash Balance	$ (27,550,000)	$ (3,406,000)	$ (90,807,000)	$ (178,458,000)	$ (243,504,000)
Restricted Cash Balance (Debt Service Reserve)	16,000,000	16,000,000	16,000,000	16,000,000	16,000,000
Net Cash Balance	$ (11,550,000)	$ 12,594,000	$ (74,807,000)	$ (162,458,000)	$ (227,504,000)

This sensitivity to market shares is a concern, but, unlike in the retail model, the City is serving multiple providers that are selling to consumers. In theory, with an active portal that offers consumers the ability to find more retail providers, the probability of obtaining the required market shares increases.

Another issue is that eventually consumers may obtain all telephone and television programming through wireless or via the Internet. Removing all connection fee revenues and hook-up fees from the models for telephone and cable television leaves a cash flow shortage of $157.2 million.

7.3.3.5. Market Share

We used the same market shares as is discussed in the retail model. These are:

- 41 percent of residential Internet.
- 47 percent of business Internet.
- 13 percent of residential telephone.
- 12 percent of business telephone.
- 21.5 percent of residential cable television.
- 21.5 percent of business cable television.

As we discussed in the financial analysis, the balance of market share and access fees are critical to maintain cash flow.

7.3.4. Case Study

Per the discussion above, UTOPIA is evaluating the potential to move to an equity model. We will continue to closely follow UTOPIA's results.

7.4 Essential Service - Open Access Model

In a variation on financing the open access model, the City deploys a FTTP network that delivers fiber into neighborhoods and to residences. Financing of the network is accomplished, in part, with one-time property assessments. As in the open access model, the City is involved in the fiber network only -- private sector entities are enabled to offer services to residences and businesses. To our knowledge, we have not seen an assessment example in the U.S., Asia, or Europe.

Given the market penetration and other assumptions detailed below, the total estimated implementation costs for year 1 through year 3 is $558.6 million (see Table 30).

Table 30: Projected Implementation Costs

		Total Year 1 to Year 3	Total through Year 20
Network Equipment		$ 29,668,000	$ 74,171,000
Outside Plant and Materials		307,029,000	307,029,000
Last Mile and Customer Premises Equipment		221,074,000	333,821,000
Miscellaneous Implementation Costs		870,000	1,958,000
	Total	$ 558,641,000	$ 716,979,000

7.4.1. Considerations

Technically, this model is the same as the open access model. The exception is that a portion of the required capital is obtained through property assessments.

7.4.2. Risks and Benefits

Table 31 presents a snapshot of the strengths and weaknesses of the Equity model. It shows several challenges (risks) that need to be addressed.

Table 31: Assessment Model Strengths and Weaknesses

Advantages	Disadvantages
Offers potential to support deployment and expansion of network with lesser amounts of financing or debt.	Untested model – likely to see intense consumer and provider opposition.
Provides financing to ensure universal availability.	High percentage of renter occupied housing in San Francisco - 65 percent.
Many essential services financed in this fashion.	Likely to require a referendum.
Addresses differing market goals between the City and private providers.	
Has potential to increase home values.	

7.4.3. Financial Analysis

Based on the same market share assumptions outlined in the retail model, using the same fee structure as in the equity model, and charging each property owner a one time assessment of $1,000, the City will have a cash balance of approximately $102.7 million by the end of year 20. A decrease of $500 for the assessment fee decreases the year 20 cash balance to a shortage of $97.8 million, and nets over a $200 million cash shortage in the first years of operation unless debt is increased. If the assessment model is pursued the balance of assessment levels, debt, and access fees require additional considerations and analysis.

7.4.3.1. Financing Costs

Our analysis estimates the total assessments collected to be $352 million for this model. In addition of the property assessment, we assume issuance of a $160 million bond[86] to cover the remaining implementation costs, including headend equipment, operating equipment, customer premises equipment, and other miscellaneous costs. All of this initial equipment investment is depreciated over seven years, and the financial projections include reinvestment and upgrades to keep the equipment useful over a twenty year life. This bond is paid off over 20 years[87] at an interest rate of 5.00 percent. Further principal payments do not start until year 4.

We assume that issuance costs are equal to 1.0 percent of the principal borrowed on the bond. A debt service reserve account is maintained at 5.0 percent of the total issuance amount. An interest reserve account equal to years 1 and 2 interest expense is maintained for the first two years. Further, no bond principal payments are made until year 4.

Interest earned on excess cash is assumed to be 4.0 percent of the previous year's ending cash balance.

The projected Income Statement is shown in Table 32 and Figure 132.

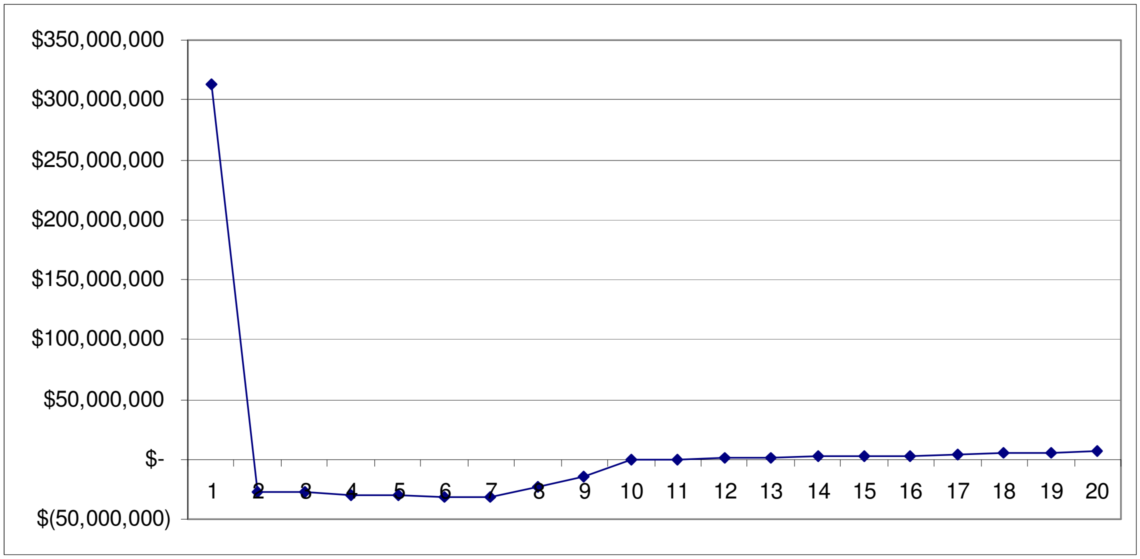
[86] The scope of work for this Report does not include a review of the City's bonding capability or review of local or state bonding restrictions. A more detailed review and opinion from the City's accountants of bonding capability and restrictions is recommended in the business planning phase.

[87] Please note that the anticipated lifetime of some equipment is lower than the period of the bond repayment. This creates a situation where the debt associated with the asset is higher than the market value. To help negate this effect in years 5 and after, we have included expenses for equipment replenishment paid from incoming revenues.

Table 32: Assessment Model Income Statement

Year	1	10	20
a. Revenues			
Video	$ -	$ -	$ -
Internet	-	-	-
Voice	-	-	-
Provider Fee	11,238,000	39,847,000	39,847,000
Property Assessment	352,000,000	-	-
Customer Entry Fee	-	-	-
Economic Development Contribution	-	-	-
Ancillary Revenues	16,000	55,000	55,000
Total	$ 363,254,000	$ 39,902,000	$ 39,902,000
b. Content Fees			
Video	$ -	$ -	$ -
Total	$ -	$ -	$ -
c. Operating Costs			
Labor Expense	$ 4,884,000	$ 5,731,000	$ 6,183,000
Operation and Maintenance Expenses	9,490,000	4,253,000	4,540,000
Pole Attachment Expense	-	-	-
Depreciation	28,427,000	37,112,000	51,296,000
Total	$ 42,801,000	$ 47,096,000	$ 62,019,000
d. Operating Income	$ 320,453,000	$ (24,453,000)	$ (21,406,000)
e. Non-Operating Income			
Interest Income	$ -	$ 270,000	$ 3,608,000
Interest Expense (5-Year Bond)	-	-	-
Interest Expense (Headend and CPE Bond)	-	-	-
Interest Expense (Fiber Bond)	(7,200,000)	(5,245,000)	(589,000)
Total	$ (7,200,000)	$ (4,975,000)	$ 3,019,000
f. Net Income	$ 313,253,000	$ (1,039,000)	$ 6,987,000
g. Taxes (Franchise Fees & In Lieu Tax)	$ -	$ -	$ -
h. Net Income After Fees & In Lieu Taxes	$ 313,253,000	$ (1,039,000)	$ 6,987,000

Figure 132: Estimated Net Income



In Figure 132, the spike illustrated in year 1 is due to the assessments collected. The increases in net income in years 7, 8, and 9 are because the initial network electronics installed (years 1, 2, and 3) are depreciated over 7 years.

7.4.3.2. Operating and Maintenance Expenses

Years 1, 10, and 20 operating and maintenance expenses are presented in Table 33.

Table 33: Operating and Maintenance Expenses

Year	1	10	20
Annual Fixed Operating Expense			
Insurance	$ 400,000	$ 400,000	$ 400,000
Utilities	200,000	200,000	200,000
Office Expenses	400,000	400,000	400,000
Contingency	400,000	400,000	400,000
Billing Maintenance Contract	10,000	10,000	10,000
Fiber Maintenance	1,540,000	1,540,000	1,540,000
Legal Fees	300,000	150,000	150,000
Content Aquisition	-	-	-
Marketing	500,000	250,000	250,000
Annual Variable Operating Expense	-	-	-
Education and Training	195,000	247,000	247,000
Customer Handholding	64,000	221,000	221,000
Customer Billing (Unit)	32,000	111,000	111,000
Allowance for Bad Debts	5,449,000	599,000	599,000
Internet Connection Fee	-	-	-
PSTN Connection Fee	-	-	-
Total	9,490,000	4,528,000	4,528,000

Staffing remains the same as in the debt financing open-access model

7.4.3.3. Summary of Assumptions

Key annual operation and maintenance assumptions are the same as the equity financing-open access model. Inflation and salary cost increases were not used in the analysis as it is assumed that cost increases will be passed on in the form of increased prices.

7.4.3.4. Cash Flow Results

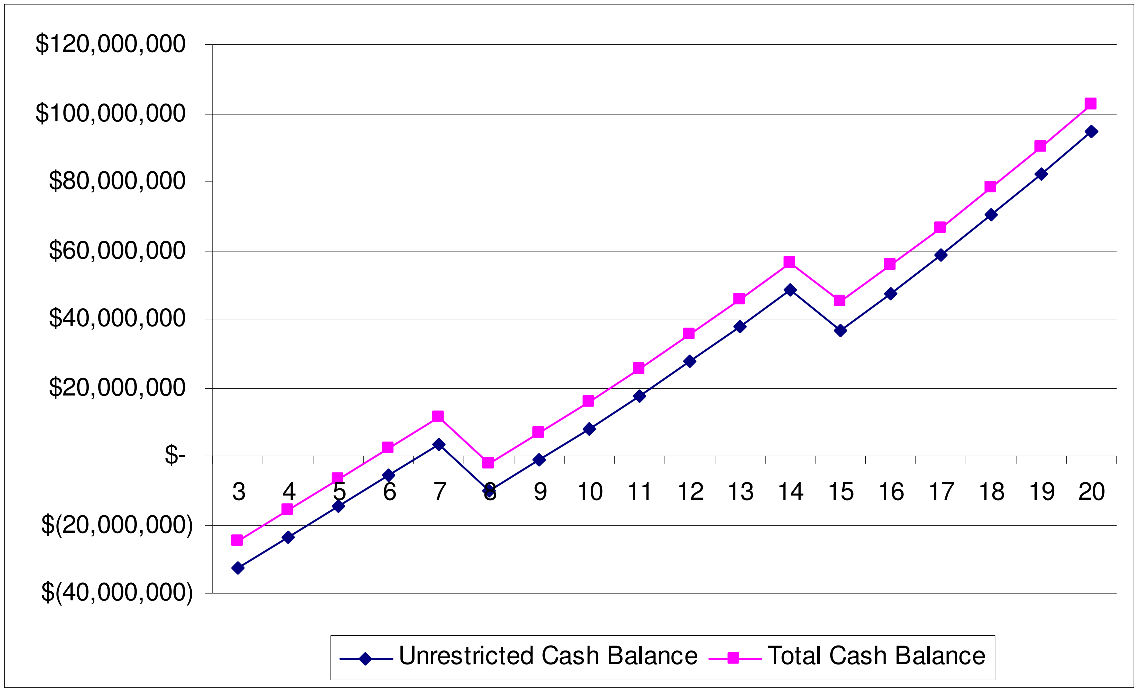
These assumptions lead to the year-end net income and cash flow results summarized in Table 34. As illustrated and given the assumptions discussed, the City will have a cash balance of approximately $102.7 million by the end of year 20.

Table 34: Base Case (Assessment) Net Income and Cash Flow

	Year 1	Year 5	Year 10	Year 15	Year 20
Net Income	$ 313,253,000	$ (30,787,000)	$ (1,039,000)	$ 3,049,000	$ 6,987,000
Cash Flow	$ 86,325,000	$ 9,014,000	$ 9,140,000	$ (11,498,000)	$ 12,501,000
Unrestricted Cash Balance	$ 86,325,000	$ (14,491,000)	$ 7,891,000	$ 36,856,000	$ 94,695,000
Restricted Cash Balance (Debt Service Reserve)	8,000,000	8,000,000	8,000,000	8,000,000	8,000,000
Net Cash Balance	$ 94,325,000	$ (6,491,000)	$ 15,891,000	$ 44,856,000	$ 102,695,000

In Figure 133, we show the projected cash balances for each year. The decline in cash positions in year 7 and in year 14 are due to the projected network upgrades.

Figure 133: Accumulative End of Year Cash Balance Projection



As indicated in the cost estimate for the FTTP implementation, make-ready and labor costs could increase the fiber implementation costs to $486.6 million, an increase of $179.6 million. Increasing the implementation costs by this amount results in an end of year 20 cash shortage of $122 million unless assessments or access fees are increased.

The cash flow balances are quite sensitive to the subscriber access fees and projected market shares. For example, we examine the sensitivity of residential Internet by maintaining all assumptions except for the residential Internet access fee. If the residential Internet access fee is decreased by $5 to $7 per month while leaving market share at 55 percent, there is a net end of year 20 cash shortage of $96.6 million.

As a further example, if we reduce the residential Internet market share to 27.5 percent while maintaining the $13 fee, cash flow balances drop, but not as significant as seen with the equity model. This impact is shown in Table 35.

Table 35: Reduced Market Share (Equity Access) Net Income and Cash Flow

	Year 1	Year 5	Year 10	Year 15	Year 20
Net Income	$ 313,697,000	$ (27,064,000)	$ (8,044,000)	$ (5,473,000)	$ (3,382,000)
Cash Flow	$ 93,744,000	$ 2,673,000	$ 2,135,000	$ (20,020,000)	$ 2,132,000
Unrestricted Cash Balance	$ 93,744,000	$ 41,818,000	$ 31,448,000	$ 20,955,000	$ 30,787,000
Restricted Cash Balance (Debt Service Reserve)	8,000,000	8,000,000	8,000,000	8,000,000	8,000,000
Net Cash Balance	$ 101,744,000	$ 49,818,000	$ 39,448,000	$ 28,955,000	$ 38,787,000

This sensitivity to market shares is a concern, but, unlike in the other models, the dependency on access fees is greatly reduced.

Another issue is that eventually consumers may obtain all telephone and television programming through wireless or via the Internet. Removing all connection fee revenues and hook-up fees from the models for telephone and cable television leaves a cash flow shortage of $54.9 million.

7.4.3.5. Market Share

We used the same market shares as discussed in the retail model.

7.4.4. Case Study

As indicated, we are not aware of any assessment based financing of a municipal FTTP network.

7.5 Infrastructure Participation Model

In this model, the City makes available to a private sector entity, for lease, selected assets that will enable the private entity to more efficiently and expeditiously build and operate a network. This is the model that is under consideration in Portland, Oregon and Palo Alto, California.

Interest in this model is currently running high. Even without the benefit of a municipal electric utility, Palo Alto is in negotiations with a private consortium for citywide FTTP -- apparently at no cost to the City.

7.5.1. Considerations

A common assumption is that a municipality can assist in encouraging a private party installing FTTP by facilitating pole attachments and reducing make-ready costs. In the case of San Francisco, electric assets are not owned by the City. However, making rights-of-way (ROW), spare conduits, and access to facilities available may help encourage a private investment.

7.5.2. Risks and Benefit

Pursuit of the Infrastructure Participation Model is a relatively lower risk approach to facilitate the availability of FTTP. There is risk associated with regulatory and security concerns. Another risk arises from potential public perception. If this model is pursued, but does not prove successful, the City faces the potential perception that they did not do enough.

7.5.3. Financial Analysis

The potential assets do not require a substantial investment by the City to make certain assets available.

7.5.4. Existing Project in Another Community

In Palo Alto, a consortium of three companies (PacketFront, 180 Connect, and Axia NetMedia) have proposed to fund, build, own, and operate an open-access, network-neutral system throughout the city. It appears that the City provided incentive for the private investment in part by: 1) agreeing to acquire services; 2) leasing selected assets to the consortium; and 3) offering use of 36 of the City's dark fiber strands.[88] Based on preliminary information, no up-front investment by the City is required, but it is not clear whether the City will be asked to guarantee financing. To our knowledge, this offer is the first of its kind for FTTP in the United States, and we will continue to monitor the negotiations and update this Report to the extent data about the negotiations are public.

7.6 Key Account Model

In this model, the City deploys a robust fiber network to meet its own internal needs for communications and smart grid technologies. The network is not marketed to residents, but businesses and large institutions have the opportunity to lease spare capacity. This model is used by a major municipal electric utility in the U.S.

7.6.1. Considerations

The City recognizes that expanding connectivity beyond the substations is a requirement for effective operations. The City is willing to consider constructing backhaul fiber into the business parks and other parts of the City, and seeks a commercial means by which to pay for that fiber. However, in the event that a private sector provider builds FTTP in San Francisco, the City could consider an incremental investment in increasing the number of fiber strands in planned routes and adding additional routes that expand the City's position to offer dark fiber or other connectivity services.

7.6.2. Risks and Benefits

The financial analysis is dependent upon what strategy the City might take in seeking dark fiber customers.

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[88] "Investor Pitch Broadband Concept," Kristina Peterson, Palo Alto Daily News, July 8, 2008.

For example, one approach is to extend dark fiber to business parks that are likely to have an interest in acquiring dark fiber. For other areas, as dark fiber customers are added, the cost to connect to the backbone is paid for by the customer.

An example of an opportunity for dark fiber leases involves wireless carriers. See Section 7 where this is discussed for additional detail.

7.6.3. Financial Analysis

The financial analysis is dependent upon what strategy the City might take in seeking dark fiber customers.

7.6.4. Case Study

The following is a case study of a major American municipal electric utility that provides dark and lit fiber optic services to various industrial, commercial, and enterprise customers. This case study is used by permission of the municipal electric utility.

Governance: Since 1995, the municipal electric has been providing dark and lit optical fiber communications services to various industrial, commercial, and enterprise customers. The fiber unit within the utility manages this program. The fiber unit's primary reason for service is to provide connectivity services to the electric utility including Supervisory Control and Data Acquisition (SCADA). In addition, the fiber unit provides services (for a fee) to a range of City departments and agencies (for a fee or exchange of assets).

Initiation Dates: The program was introduced in 1995 with a dark fiber offering. In 2000, the fiber unit expanded its services to include point-to-point video circuits for the entertainment industry, and Ethernet service to large data users.

Business Model: The primary business of the fiber unit is to provide fiber connectivity to support SCADA, a critical aspect of the electric distribution system. SCADA applications protect mission-critical utility systems, enhance the reliability of the utility services, and protect the safety of electric utility work crews.

The fiber unit's physical infrastructure has capacity beyond what is required for electric utility and City needs. It can offer products and services to other customers which generates revenue for the electric utility. The fiber unit seeks to maximize the amount of net revenue it can bring in without compromising its primary mission of serving the electric utility. The fiber unit has several advantages relative to other carriers, all of which arise from the unit's position as a key part of the electric utility. The advantages include:

- Access to electric entrances of buildings which provide a diverse and separate path from other carriers.

- Reach into most buildings in the City via electric ROWs.
- Financing of fiber infrastructure from a long-term perspective.
- The ability to use the electric utility fiber meets connectivity needs (SCADA) and provides a core service footprint in the City.

The electric utility plans to connect all of its larger distribution stations with fiber. Fiber connectivity is attractive because it is reliable, can support future applications such as video monitoring, and does not experience ground potential issues the way copper does.

The electric utility anticipates that the need for fiber connectivity beyond the substations will continue to increase. Future customer automation efforts may require the reliability and capacity of fiber for backhaul from data concentration devices. In addition, Remote Terminal Units (RTUs) are getting smaller and less expensive. Eventually, the electric utility will place RTUs on pole tops and other field devices, which will require expansion of the fiber footprint.

Financing: The fiber unit generates substantial annual revenues, and the majority is derived from dark fiber leases. The revenue from the fiber unit provides an incremental revenue stream from an asset that is required to support the electric utility applications -- directly benefiting electric utility rate payers.

Additional Benefits: The fiber unit also seeks to enhance the range of connectivity services it offers to external customers in the City by taking advantage of fiber and other connectivity assets used to support the electric utility functions. Specifically, its goals include:

- Generate revenue from fiber optic capacity currently unused for the primary mission by making it available to city agencies, businesses, and educational users.
- Assist in economic development by providing alternative connectivity services to certain industry segments.
- Provide connectivity services to support city agency and nonprofit efforts to bridge the digital divide.
- Provide connectivity alternatives and help increase competition for connectivity services in the City.
- Encourage new uses of fiber connectivity by offering fiber as a wholesaler to any organization that meets the fiber unit’s financial requirements.

Benefits from the services offered to external customers do not directly show in the fiber unit’s revenue streams, but the unit support reduces expenditures in connectivity for each entity and the unit’s fiber enables applications that are not possible with traditional leased services.

7.7 Summary Comparison of Models

Table 36 summarizes the comparison among the various models.

Table 36: Comparison of Potential Business Models

Model	Advantages	Disadvantages
Debt Financing-Retail Overbuild	• Network management relatively straight-forward • Well understood and accepted concept to present to consumers	• City responsible to manage customer expectations for technical and other support • Requires sales and marketing at a consumer level • Three Infrastructure-based providers serving residents and small business are already based in San Francisco - which will limit the ability to obtain required market shares required to maintain cash flow • High probability of having plan contested by incumbent providers
Debt Financing-Open Access	• Sales and marketing directed towards new providers entering the San Francisco market • Allows consumers choice of providers • Removes incumbent providers' market control to limit capacity • Removes incumbent providers' market control to manipulate or monitor transmissions	• Network management more complex • Less established business model • Three Infrastructure-based providers serving residents and small business are already based in San Francisco • High probability of having plan contested by incumbent providers
Equity Participation-Open Access	• Addresses limitations of Open Access model • Leverages consumer investment	• Requires consumer investment • Sixty-five percent of households in San Francisco are renter occupied • Potential appearance of "Red-Lining" • Three Infrastructure-based providers serving residents and small business are already based in San Francisco • High probability of having plan contested by incumbent providers
Essential Service-Open Access	• Addresses limitations of Open Access model • Limited debt risk • Provides universal availability	• Requires assessment applied to property owners • Sixty-five percent of households in San Francisco are renter occupied • Extremely high probability of having assessment contested by incumbent providers and consumer groups • Three Infrastructure-based providers serving residents and small business are already based in San Francisco
Infrastructure Participation-Open Access	• Lower Risk	• Limited incentives to attract providers • The City will have limited control or influence over provider offerings • Three Infrastructure-based providers serving residents and small business are already based in San Francisco
Key Account	• Low risk • Provides potential migration path to the range of open access models	• Does not immediately address residential and small business markets

8 Alternative Technologies Cannot Deliver Fiber's Speeds and Capacity

This Section of the Report provides a technical analysis (written for a non-technical audience) of the comparison between the capabilities of fiber optics and those of other technologies:

- Copper networks, operated by the phone companies, including AT&T, with some fiber in the core of the network, but with much of the "last mile" copper dating back many decades
- Coaxial networks, operated by the cable companies, including Comcast and Astound, also with fiber in the core of the network, but with coaxial cable in the last mile that was deployed in the 1970s and 1980s
- Wireless networks, which offer tremendous benefits with respect to mobility and convenience, but which are limited in speeds and therefore serve as complements—not alternatives—to high-bandwidth wired connections like fiber

All of these networks deliver products defined as "broadband" under the FCC's definition, but it is important to put that definition in perspective: the FCC's 2008 definition of "basic broadband" is downstream (not symmetrical) speeds between 768Kbps and 1.5Mbps -- higher than the previous definition of 200 Kbps but still laughably low. As one observer has noted, it would take 8.16 hours to download under the old broadband definition; at the new definition, an American with basic broadband will need 2.12 hours to download a movie.[89]

A service or product that meets even the ceiling of this definition (1.5Mbps) will deliver one 600th of the speed that fiber can deliver using existing, affordable, off-the-shelf technologies (Gigabit Ethernet, 1,000 times one megabit). These speeds will grow dramatically as new technologies become available. The speeds possible over copper, coax, and wireless speeds will also grow, but as a matter of physics, cannot keep up with fiber's ability to scale.

Gigabit speeds represent the norm for consumer-grade connections in such cities as Tokyo and are being deployed in Singapore, Amsterdam, Stockholm, and others. China is aggressively moving to deploy fiber networks, and is considering technologies that will deliver 10 Gbps (gigabits per second)[90]—more than 10,000 times the speed the FCC considers to be broadband.

Put another way, while the Chinese are contemplating deploying two-way 10 Gbps, the U.S. cable industry is considering shared, downstream-only 150 Mbps and U.S. phone companies (excluding Verizon) are discussing migrating to downstream-only 25 Mbps.

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[89] "FCC Definition for Broadband Now 786 Kbps," http://elliottback.com/wp/archives/2008/03/22/fcc-definition-for-broadband-now-768kbps/.

[90] Lynn Hutcheson, "Is China poised to take the lead in FTTx subscribers?," Ovum Telecoms and Software News, November 24, 2008, http://www.ovum.com/news/euronews.asp?id=7525.

8.1 Comparison Between Fiber and Copper Physical Media

Despite the rapid evolution in technologies surrounding telecommunications and computing in the past few decades, the underlying physical media supporting electronic communications within the U.S. continues to be comprised extensively of copper wiring similar to that used during the turn of the twentieth century. Even the most advanced local area networks (LANs) often use "twisted-pair" wire of a design resembling a patent awarded to Alexander Graham Bell in 1881. Notwithstanding tremendous leaps in the capabilities of communications technologies leveraging copper wiring, the fundamental physical properties and limitations of this medium are no different today than when the first telephone exchange was opened in 1877 by the Bell Telephone Company.

The history and long life of copper-based communications infrastructure is both a testament to our ability to derive new value from simple concepts through technological innovation, and a warning that copper communications infrastructure is beginning to provide diminishing returns on continued investments. A wide range of new online services becoming mainstream in the world today, from on-demand access to high-definition video recordings to replication of large quantities of digital data between geographically diverse locations, are being hindered by the limitations of copper infrastructure.

We have reached a point where a new communications medium for the upcoming century must be embraced to continue advancement of communications technologies to meet the exponential growth in demand. Specifically, this advancement requires that the copper communications infrastructure of the past be systematically replaced with fiber optic cabling, which is capable of supporting the capacity requirements and transmission distances necessitated by the current state-of-the-art in communications applications with geographic reach on a global scale. Fiber optics promises to offer a lifespan rivaling the copper wires of the past century, while already forming the backbone of today's largest networks.

Optical fiber has emerged in recent decades as the predominant means for high bandwidth and long distance telecommunications, fueled by its theoretically unlimited bandwidth, the constantly dropping costs of fiber-related materials and construction, and the ongoing development of technologies that continue to increase its practical capacity on an exponential scale. This section provides a comparison between copper and fiber optic communications media, and provides a brief outline of the particular advantages offered by fiber.

8.1.1. Overview of Copper Wire and Fiber

Copper wire has been widely used for carrying voice, video, and data since the days of the telegraph. Progress in telecommunications technology and the growth in popularity of the Internet was characterized by a transition to digital modes of communications and higher demands for communications capacity. Consequently, copper telecommunications networks were retrofitted for transferring data as well, with an ongoing shift in the network architectures to support the growing demands.

Copper cabling is predominantly found in two forms: coaxial (coax) cables and twisted-pair cables. Coax cables were originally used for carrying video signals within cable television systems and radio frequency (RF) signals to and from antennas within wireless systems. Twisted-pair copper wire was developed from the invention of the telegraph, and was later used in the traditional telephone industry. Due to rising demands for Internet connectivity, cable TV companies and traditional phone companies adapted their infrastructure with new technologies , including cable modems and digital subscriber line (DSL), to begin offering higher speed data services than simple telephone lines could support.

Twisted pair cables are classified into Shielded Twisted Pair (STP) and Unshielded Twisted Pair (UTP), as shown in Figure 134. The difference between the two cable types is an extra sheath (or shield) present in STP that serves to eliminate cross-talk between two adjacent cables.

Coax cables, on the other hand, have one central conductor surrounded by a conductive shield that blocks interference electromagnetic interference (EMI) from outside sources. Insulating layers separates and protects each conductive component. Figure 135 shows a diagram for the coax cable.

Figure 134 Twisted Pair Cables

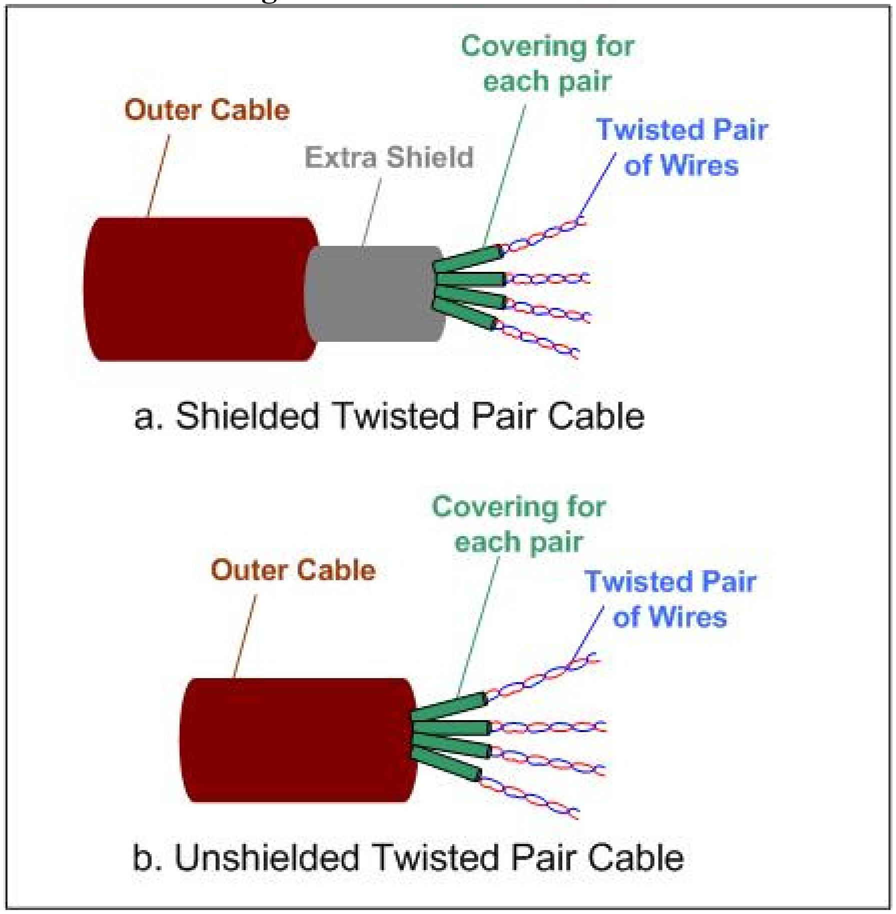
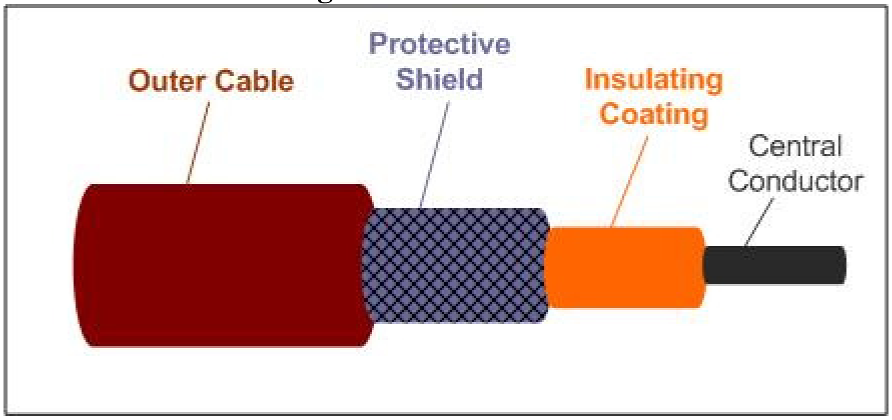
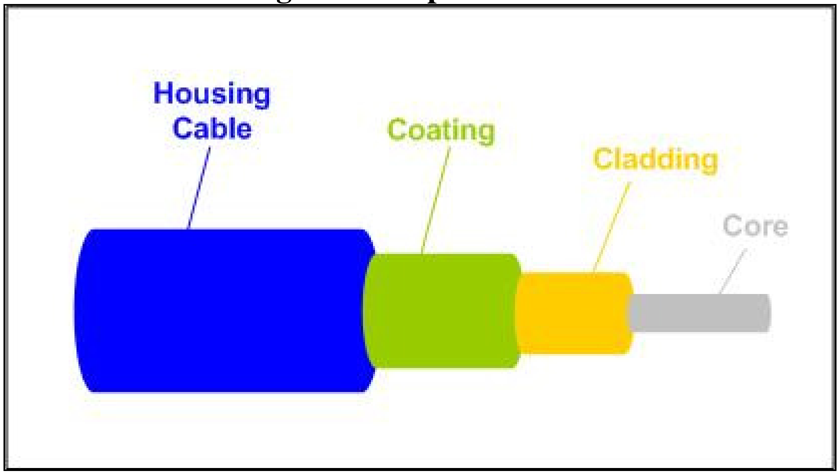


Figure 135 Coax Cable



All copper cables use electrical signals to transfer information between users. Optical fibers use light rays to transfer the same information through their glass cores. Figure 3 shows a simplified diagram of an optical fiber. The core is usually made out of specialized glass with low optical attenuation. The cladding, coating, and housing serve to protect the optical core and minimize the optical loss of the core.

Figure 136 Optical Cable



8.1.2. Optical Fiber Benefits

Optical fibers and copper cables have different physical compositions, which give the optical fibers inherent advantages over their copper counterparts. For a given expenditure in communications hardware, fiber optics can reliably carry many times more capacity over many times greater distances than copper wires of any type – far superior in both regards.

8.1.2.1. Bandwidth

The biggest advantage that fiber has over copper is the theoretically unlimited bandwidth that it can provide. This bandwidth is only restricted by the electronics at either end of the cable; modern fiber equipment is capable of speeds on the order of terabits per second over a single "strand". In addition, not only do fibers provide more bandwidth, they are able to do so over longer distances as compared to copper cables without necessitating regeneration or amplification, both of which can reduce signal reliability and capacity while increasing costs.

Bandwidth limits on copper cables are directly related to the underlying physical properties of copper. Copper conducts electrical signals at various frequencies, and higher data rates over copper require higher frequencies of operation. Twisted pair wire is limited to a few hundred megahertz in usable bandwidth (at most), with dramatic signal loss increasing with distance at higher frequencies. This physical limitation is why DSL service is only available within a close proximity to the telephone central office. Coaxial cable has a frequency bandwidth of approximately one gigahertz, or more; therefore its capacity is greater than that of twisted pair. Despite its higher capacity, coaxial cable does experience signal attenuation at higher frequencies similar to twisted pair. In other words, coaxial cable is incrementally more capable than twisted-pair wire, though it is still not comparable to the exponentially greater upper limits of fiber. In fact, fiber optics cables have a theoretically unlimited bandwidth, and today can support data rates of hundreds of gigabits per second in a practical sense.

Within a fiber optic strand, an optical communications signal (essentially a ray of light) behaves according to a principle referred to as “Total Internal Reflection” that guides it through the optical cable. Optical cables do not use electrical conduction, and thus do not require a metallic conductor, such as copper, as their propagation medium. Hence, optical communications signals do not experience the significantly increased losses as a function of higher frequency transmission experienced by electrical signals over copper cables. Further, technological innovations have allowed for the manufacturing of very high quality, low impurity glass that can provide extremely low losses within a wide range of frequencies, or wavelengths, of transmitted optical signals, enabling long range transmissions. Compared to a signal loss on the order of tens of decibels (dB) over hundreds of feet of coaxial cable, a fiber optic cable can carry a signal of equivalent capacity over several miles with only a few tenths of a dB in signal loss.

Both coax and twisted pair cables were originally designed to provide video and voice services, and were sufficient in early years of data communications when demand was relatively low. However, as demand for data capacity increased, networks built over copper have become increasingly insufficient to support high speed services. Even with technological advances, copper cables will not be able to live up to customer requirements. This is why communications carriers and cable operators are deploying fiber to replace large portions of their copper networks, and on an increasingly larger scale. Fiber optics is one of the few technologies that can legitimately be referred to as “future-proof,” meaning that they will be able to provide customers with larger, better and faster service offerings as demand grows.

8.1.2.2. Operations and Maintenance

Fiber is able to provide better signals over longer distances. This does not hold true for copper cables since copper is susceptible to cross talk, signal attenuation, and interference that degrade the signal quality. The length of the cable plays an important role in this, because longer cables result in greater losses at any bandwidth or frequency of operation. To compensate for this, electrical signal needs to be amplified or regenerated every few thousand feet using repeaters and amplifiers, whereas fiber optic signals can travel hundreds of miles without regeneration. This reduces the complexity and expense of operation and maintenance of networks comprised of fiber.

Optical fibers do not conduct electricity and are immune to other electromagnetic interferences. These properties allow optical fibers to be deployed where conductive materials would be prohibitive, such as near power lines or within electric substations. Moreover, the cables do not corrode in the way that metallic components can over time, due to weather and environmental conditions, further reducing maintenance costs.

8.1.2.3. Costs

One critique often directed at fiber networks is the cost involved in constructing and deploying the network. While optical fiber is often more expensive per foot than many types of copper wire, the costs over the last decade have become more on par. Despite the higher material cost of the fiber, new outside plant construction for copper and optical fiber is generally equivalent, since the vast majority of plant construction cost is due to the labor required.

8.1.2.4. Security

Copper cables transfer data in form of electrical signals. This makes the data less secure, since it is possible to physically "tap" in to the cables, especially twisted pair, and observe the data. Optical fibers are much more difficult to tap without breaking the connection, making the data they carry more secure.

8.2 Comparison Between Fiber and Coaxial (Cable) Technologies

Innovations in web-based services and multimedia technologies continue to drive a demand for higher speed connectivity, while most residential Internet connections struggle to meet the demand. As early as the mid 1990s, websites rich in high-resolution images pushed capacity demands beyond the limits of dial-up Internet connections. Multimedia content of all types, including audio and relatively low-quality video, became commonplace as the proliferation of cable modem and DSL broadband connections allowed Internet users to interact with web content in ways previously unprecedented. Today, on-demand and Internet-based delivery of high quality video, including high-definition (HD) content, are rapidly becoming popular modes for receiving entertainment, news, and educational content, testing the limits of these more traditional "broadband" networks in the US.

Other advanced services and applications, ranging from videoconferencing for teleworking and social networking to the transmission of increasingly larger video, data, and image files, also contribute to the growing capacity consumption of Internet users. Increased sources of streaming content and peer-to-peer technologies are necessitating more aggregate capacity in the backbones and distribution systems of networks compared to the primarily one-way, "bursty" use of network bandwidth characteristic of web applications of the past. Consequently, many Internet service providers (ISPs) are beginning to place caps on the monthly usage of broadband connections to contain the growth of capacity demand their networks are not yet capable of supporting.

With the evolution of web services and increased demand for capacity, network operators are being forced to re-evaluate their design models, both with respect to the "last-mile" customer access connectivity and the controlled oversubscription of shared backbone and distribution communications links. All types of communications network operators, whether telecommunications carriers, traditional cable television operators, or fiber to the premises

(FTTP) operators, are responding to this growing demand through the increased deployment of fiber optic technologies. Digital subscriber line (DSL) networks operated by telecommunications carriers offering high definition video services must deploy fiber optics "to the curb," leveraging their copper infrastructure for connecting only the last few hundred to few thousand feet to the customer. Cable television operators continue to build fiber optics closer to their customers, with the number of subscribers served by each individual fiber optic connection continuously being reduced.[91] FTTP networks represent the next step for future-looking communications providers, bringing fiber directly to each subscriber to remove the physical limitations to service offerings imposed by copper-based communications cabling.

As the individual customer demands reach the full magnitude of what is possible over copper wiring, network architectures in which the capacity of copper wiring is shared by multiple customers will evolve towards FTTP. Thus, HFC networks of today represent intermediate steps in their own evolution towards FTTP, with each substantial upgrade of their physical network cable plant an incremental step in this direction. The timeline for this evolution will vary among different markets and the degree to which individual network operators attempt to continue to leverage their existing copper network infrastructure to provide viable service offerings.

The remainder of this section provides an overview comparing the architectures of HFC and FTTP networks, and discusses specific areas of advantage offered by FTTP.

8.2.1. HFC and FTTP Architectures

Advances in HFC networks and technologies and the emergence of FTTP networks are a consequence of the attempts by service providers to deliver high quality, high-bandwidth service offerings to their customers. In many respects, the differences between these networks relate primarily to geographic scale of their components, rather than fundamentally different technologies or approaches to service delivery – both HFC (Hybrid Fiber and Coax) and FTTP networks use optical fibers as the primary physical medium to carry communication signals. Additionally, both HFC and FTTP networks leverage some degree of copper wiring for connecting the devices at the customer premises, such as television set-top boxes, computers, routers, and telephones. Both types of networks can carry broadcast analog or digital video signals, provide telephone services with guaranteed availability of network capacity to ensure quality of service (QoS), and provide Internet and data connections using standards-based Ethernet interfaces to the customers' equipment. The most significant distinction between these networks lies in how closely fiber carries the connection to the individual subscribers. A conversion to copper wiring occurs within the "last mile" between a provider and a customer for all HFC networks, while FTTP networks make this conversion at the customer premise.

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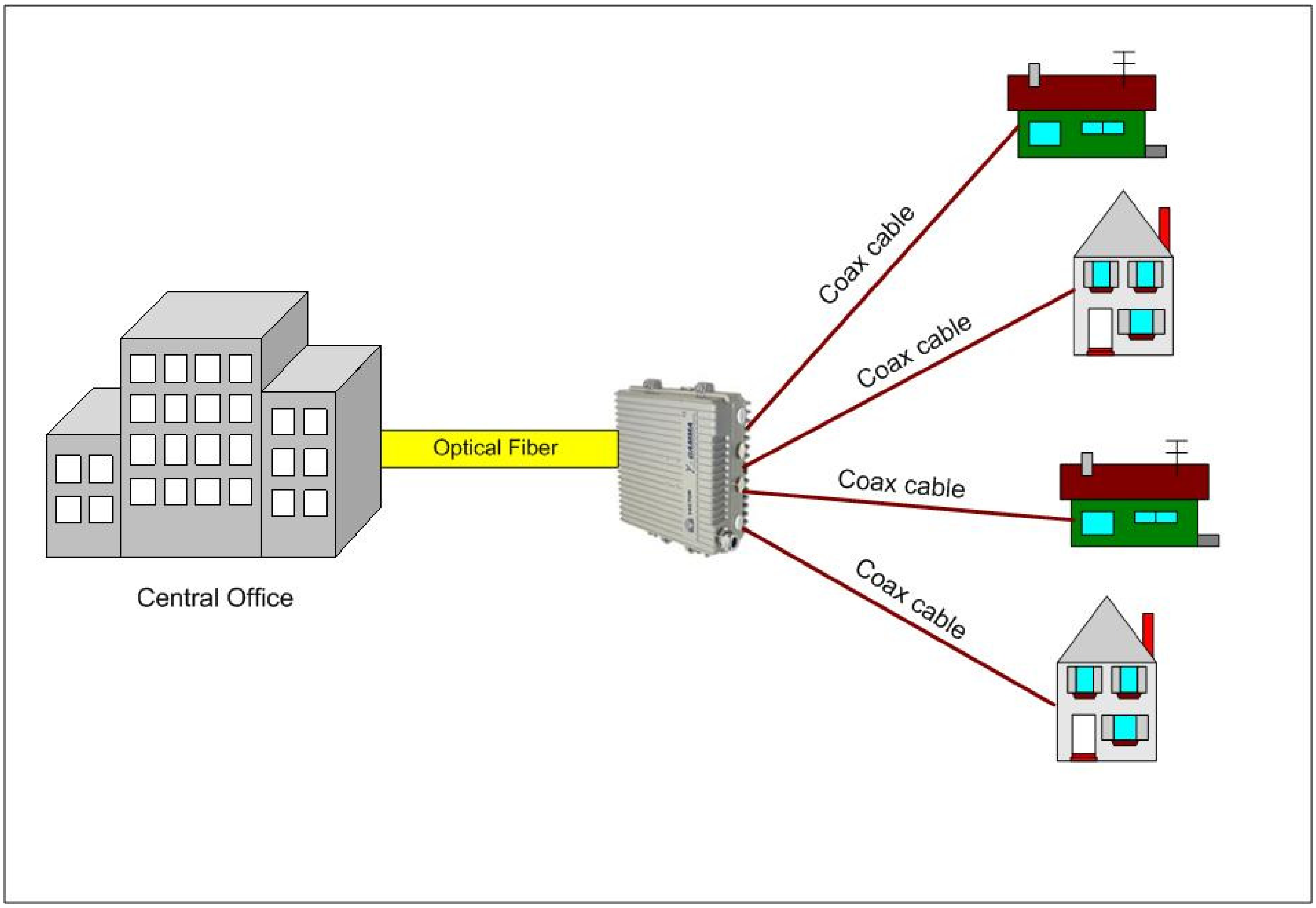
[91] Hybrid fiber-coaxial (HFC) networks in the late 1990s were typically designed to support between 500 and 1,000 customers per "node area," for which each node was provided connectivity by a dedicated fiber optic connection. In many markets today, nodes are segmented to serve fewer than 100 customers with each fiber connection, effectively increasing the total capacity available to each subscriber.

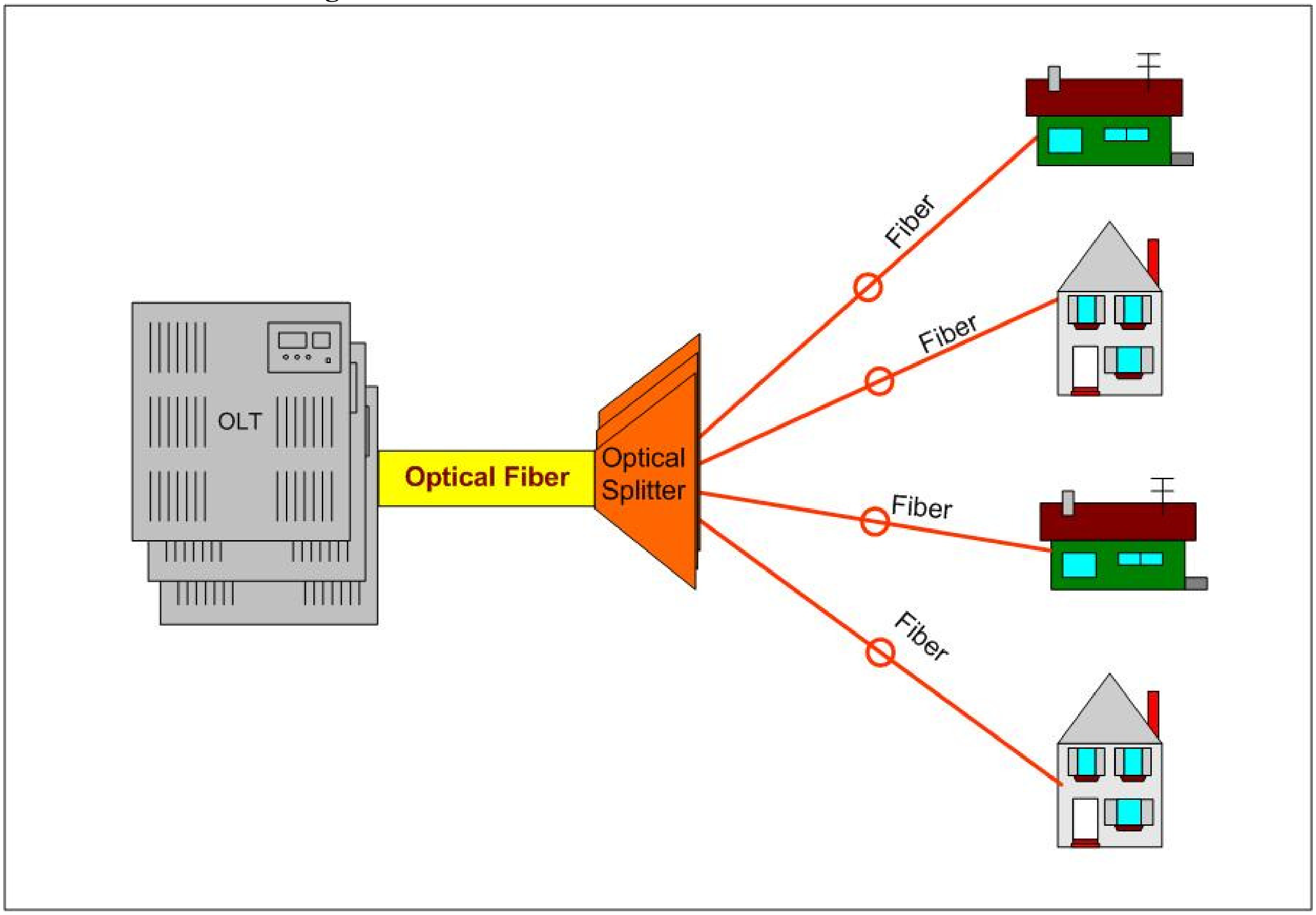
In case of the HFC network, one or more headend or hub locations house the core transmission equipment and components or connections necessary for the various service offerings. Fiber optic connections extend from these hubs to multiple "optical nodes," each of which serves a given geographical area, for example, a neighborhood. These optical nodes are electronic devices located outdoors, often attached to aerial utility lines, and make a conversion between the optical signals carried on fiber and the electronic signals carried over coaxial (coax) cables. From this point onwards, coax cable is used to carry the video, data, and telephony services to individual customer locations. This is depicted in the following diagram.

Figure 137 HFC Network Architecture



Similar to HFC networks, central equipment in a FTTP network is housed at a central office (CO) and/or video headend office (VHO). From the CO, fiber optics extend directly to each customer premises, often with some type of intermediate device located near the customer to split or aggregate connections, depending on the specific technology chosen. For example, a FTTP network using PON (or Passive Optical Network) technology would employ a passive optical splitter between the CO and the customer locations. The role of the splitter is to simply "split" the signal from CO into individual customer signals, typically supporting either 32 or 64 customers per fiber strand. This is depicted in the following diagram.

Figure 138 FTTP-PON Network Architecture



8.2.2. FTTP Benefits

While there is no doubt that FTTP is functionally superior to HFC networks, significant existing investments in HFC networks prevent cable operators from making an immediate leap to FTTP. Clearly, for new network deployments, FTTP is the only reasonable approach for fixed, wireline delivery of high-bandwidth connectivity and services.

From a physical perspective, fiber optics is a superior communications medium to any copper-based cable in nearly all respects. While fiber enables long range transmission of nearly limitless capacity over a single fiber strand (there can be hundreds of strands per cable), all copper wiring suffers from limited bandwidth that is inversely proportionate to the distance of the link. Thus, with the exception of very short-range connections, such as the wiring within an individual home, fiber provides vastly improved capabilities that equate to long-term scalability and, almost always, provides a much more cost-effective solution relative to copper wiring.

The remainder of this section discusses the specific areas of advantage for FTTP in more detail.

8.2.2.1. Bandwidth

Advances in electronics continue to increase the amount of video and data capacity over HFC networks, for which the most advanced systems currently available still provide only a fraction of the total capacity available from even the most common FTTP technologies in use. Although the fiber optics in an HFC network can provide vast amounts of capacity, the coaxial cable is driven by electronics designed to support approximately 1 GHz of total bandwidth. This limitation is a product of the tradeoff required between transmission distance and usable capacity over coaxial cable. Although slightly more total capacity is feasible, this represents the order of magnitude at which an HFC network is a viable technology choice – significantly reducing coaxial transmission distances to further increase capacity is analogous to building an FTTP network.

Beyond total available capacity, another major limitation of HFC networks is the fact that most of the capacity is utilized for broadcast television – of the 1 GHz (1,000 MHz) of total available bandwidth in the most advanced HFC networks, only 6 MHz is used for Internet connectivity in each direction. As markets increase demand for Internet capacity and on-demand video, this poses a significant challenge. The majority of advanced cable modem systems are capable of providing up to 38 Mbps of shared downstream capacity[92] (using a single 6 MHz channel) to all subscribers in a node area. Even for highly segmented systems, this could mean over 100 subscribers sharing 38 Mbps, which equates to less than 400 kbps available per subscriber on average if all subscribers are using their connections simultaneously. Unfortunately, this level of capacity is not suitable for carrying even one broadcast quality, standard-definition video stream per subscriber. Keep in mind that these cable modem services are usually advertised as providing data rates "up to" 10 Mbps (more than 10,000 kbps), or much more in many cases. Moreover, most networks have much greater than 100 subscribers per node area, further exacerbating the problem. While this level of oversubscription worked well in the past, it will not be able to sustain significantly increased usage of online video streaming or other similar applications that require constant amounts of bandwidth for each user simultaneously.

Conversely, the total capacity of an FTTP network is limited only by the electronics used to light the fiber, with fiber connected directly to each subscriber. Although deployment technologies vary even today throughout the world, PON-based systems are the most prevalent. In particular, GPON is one of the more commonly deployed technologies, including by Verizon to provide its FiOS service. Using this as a mid-level baseline for comparison, a GPON system can provide over 1 GHz for video broadcast, in addition to 2.5 Gbps for downstream data services. GPON systems split this capacity by no more than 64 subscribers (32 typically), supporting more than

[92] Assumes the use of DOCSIS 1.1 or 2.0 systems, which is the most commonly deployed, standards-based cable modem technology in the use by all major cable operators.

75 Mbps per subscriber even when fully utilized by all subscribers simultaneously. Because GPON and other FTTP technologies can leverage wave division multiplexing (WDM) to support multiple wavelengths, or "colors" of light over the fiber strand terminated at each customer's premises, FTTP networks can provide this level of data connectivity in addition to providing equivalent or greater capacity for broadcast video services simultaneously.

Beyond simply the amount of available capacity, the direction in which capacity is provided has become much more significant than ever before. HFC networks were initially built for delivering cable video services, and as such, are heavily biased to provide capacity from the cable operator headend to the customer (downstream). The RF transmission hardware used in HFC systems supports the relatively limited upstream capacity of approximately 50 MHz (about $1/20^{th}$ of the total capacity over the coaxial segments of the network). Advanced HFC cable modem networks typically utilize between 2 MHz and 6 MHz of this scarce bandwidth for upstream connectivity, which yields between 10 Mbps and 30 Mbps typically shared by 100 customers or more, (providing on the order of only 100 kbps to 300 kbps per subscriber if fully utilized). This has proven to be a serious disadvantage for HFC networks compared to the FTTP networks, which leverage WDM technology to carry upstream data over yet another dedicated wavelength of light. In the case of GPON systems, this enables 1.25 Gbps upstream connectivity, typically shared by no more than 32 subscribers (approximately 40 Mbps per subscriber even at full utilization).

8.2.2.2. Reliability

Figure 1 is a simplified depiction of a HFC network. For the signals to traverse the path shown in the diagram, from the CO to the customer locations, additional electronics is required so that the signal delivered has enough strength and quality such that the data reproduced for the end user is in a usable format. This includes equipment such as amplifiers which are required along the path to boost the signal due to cable attenuation. Such active electronics also imply that they be powered at all times to ensure service delivery. This feature of HFC network introduces more points of failure for the communication services, and lower reliability.

This is in sharp contrast to FTTP networks where the only electronics that must be powered are present at the CO and the customer premises. The splitter shown in Figure 2 is a "passive" component meaning that it does not need any electrical power to operate. There is no need for amplifiers to compensate for cable losses.

8.2.2.3. Deployment and Maintenance Costs

As mentioned above, HFC requires more electronics to support the communications network. This in fact increases the maintenance costs for the service provider who needs to make sure that the network is up and running at all times.

From a practical since, even installation costs between fiber and copper wiring are comparable, with material costs falling in the same range as coaxial cable, and labor costs mostly unaffected by the type of cable for most aspects of the installation. Equipment to connect via fiber continues to drop in price, with the hardware cost for a given interface speed typically no more than twice its copper counterpart. Of course, most of the cost of communications network hardware is not related to the particular interface type, and of course, copper is limited to speeds below 1 to 2 Gbps at best, above which fiber is the only viable option. Moreover, long distance communications using copper wiring requires amplifiers or digital repeaters at regular intervals due to the high signal loss, thus increasing hardware costs and reducing reliability compared to fiber.

8.2.2.4. Scalability

One of the biggest advantages that FTTP has over HFC comes from the ease with which new users can be added to both the networks. In case of FTTP, since the fiber has already been built to the users' premises, the only change required to add a new user requires that the customer premise equipment, referred to as the Optical Network Unit (ONU) or Optical Network Terminal (ONT) be installed at the customer location.

Moreover, in many cases, upgrading total HFC system capacity requires a costly replacement of all network electronics and passive devices (splitters, connectors, etc) used in the coaxial cable plant.

8.3 Comparison Between Fiber and Wireless Technologies

8.3.1. Advantages and Challenges of Wireless

Each network technology has its own distinct advantages and challenges (Figure 4).

Speed to Deployment and Flexibility. Once a wireless service provider begins offering services, it can provide services to fixed mobile customers. It can add capacity or coverage by adding base stations and antennas, and it can typically provide significant value without directly causing a high impact on miles of public right of way. As a result, the wireless service provider can typically act and respond more quickly than wired service providers newly entering an area.

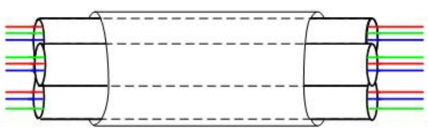
Figure 139: Wireless and Fiber Advantages and Challenges

Wireless Advantages

- Mobility
- Flexibility
- Speed to Deploy

Wireless Challenges

- Capacity limited by Spectrum
- Distance Limitations
- Building Penetration
- Control of Capacity
- Line of Sight
- Interference
- Towers/Monopoles Siting & Leasing
- Feeding capacity (Backhaul to system)
- Upgrade requires replacement of most Infrastructure



Fiber Advantages

- Almost unlimited capacity
- Resilience of cables
- Electronics only at endpoints
- Upgrade of electronics only (no need to replace fiber)
- Add cables in spare conduit capacity
- Hundreds of fiber strands per cable
- Low maintenance costs

Fiber Challenges

- Initial construction cost / disruption
- Use of right of way
- Fixed
- Vulnerability to digging
- Potential interference with electrical work space

Design Limitations. However, there are significant challenges in providing effective wireless service. Design limitations such as power levels, spectrum availability, and required data capacity require that individual antennas or base stations serve limited areas, such as one mile or less. This requires the provider to expend resources and time in placing the base stations.

In order for the network to be effective, each base station requires power, backup power (such as generators and batteries), a tall structure for mounting the antennas, coordination with other wireless providers for interference, aesthetic compatibility with the surroundings, connections to the Internet and core network, and secure access to the facility. The provider must address the concerns of the community and the zoning authorities. The provider must typically pay significant rental fees. Every time the provider desires to improve coverage quality or add capacity, it must face these challenges in placing new facilities.

To serve customers who are indoors, providers must increase the density of their base stations and/or add facilities inside buildings, such as microcells or picocells.

The challenge of deploying and managing a wireless network may be greater if an unlicensed technology, such as WiFi, is used. While the provider does not need to obtain an FCC license, it must operate lower-power equipment in accord with FCC requirements. This requires the use of significantly greater densities of antennas, typically one for each street block. In addition to the challenge of placing and powering the devices, the service provider must accept and cope with all existing and potential future interference from other users of the unlicensed frequency band. It must have a technique to ensure that sufficient data bandwidth is available at the many antenna points and to address the unique capacity and interference problems at each antenna site.

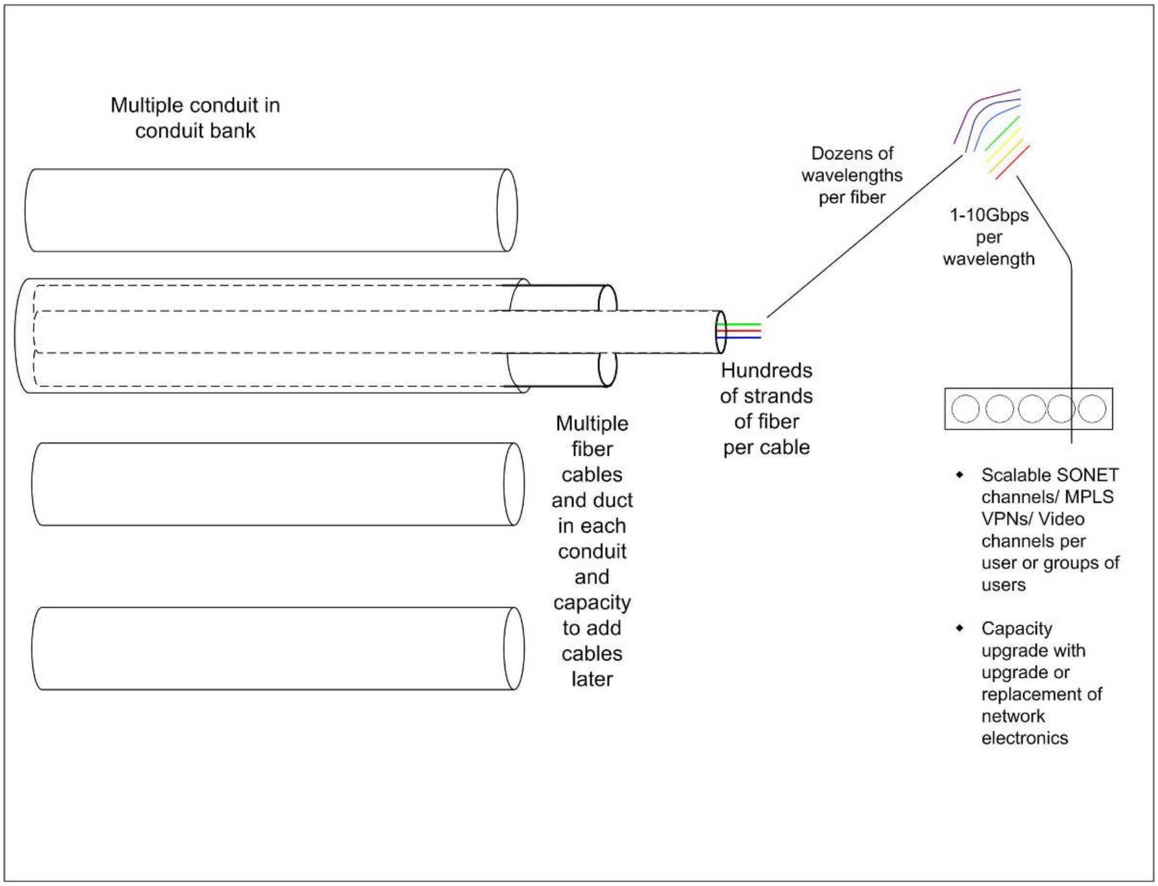
Costly Upgrades and Migrations to New Technologies. Finally, when a provider needs to migrate to a more advanced technology platform, it may need to re-engineer and redesign its entire system. Antennas, receivers, and transmitters may become obsolete, and spacing between base stations may need to be changed. Power and backbone connectivity may need to be upgraded. A thorough wireless upgrade, as may be required a few times per decade, may require the provider to replace a significant percentage of its capital investment.

8.3.2. Advantages and Challenges of Fiber

Capacity. Fiber optic technology provides almost unlimited capacity. One way to consider the potential of fiber optics is that each single fiber optic strand is theoretically able to duplicate the entire electromagnetic spectrum available to all wireless users. In a practical sense, the capacity limit is imposed by the capability of the electronics connected to the fiber.

Scalability. That capacity is constantly increasing as technology improves. At the current time, each fiber strand is capable of operating at hundreds of Gbps (gigabits per second) with off-the-shelf technologies (Figure 5). This is over 1,000 times the capacity of backbone wireless technologies and 100,000 times the capacity of the fastest, most sophisticated wireless services available to consumers on their PDAs and laptops.

Figure 140: Current Technologies Support over a Million Gbps in a Conduit Bank and Will Scale Further in the Future



Flexibility and Capability to Serve Multiple Providers. Each cable contains potentially hundreds of strands. Each underground cable conduit system has several cables, potentially dozens, located in separate conduits. As a result, many separate service providers can participate in a single conduit system. Even providers that do not own their own cables or fiber strands can lease discrete capacity from another service provider. Capacity is available in the form of separate wavelengths, channels, and virtual private networks (VPNs) and can therefore be secured from the other users and guaranteed at a particular quality of service.

Resilience and Reliability. Fiber optic cables can be armored and are resilient. They can tolerate falling from utility poles or being pulled laterally by out-of-control vehicles. Fiber electronics can be configured to operate in a fail-safe mode. If the fiber is installed in a ring or mesh topology, the communications can automatically and instantaneously fail over to another route.

Low-Cost Maintenance. Fiber optic capacity can be increased by upgrading the electronics at the endpoints. Depending on the technology and design need, electronic equipment may be dozens, hundreds, or thousands of kilometers apart and kept in secure indoor locations. There is typically no need to "touch" the outside fiber optic cables to add customers or capacity, and maintenance of outside plant is relatively undemanding and, on average, inexpensive.

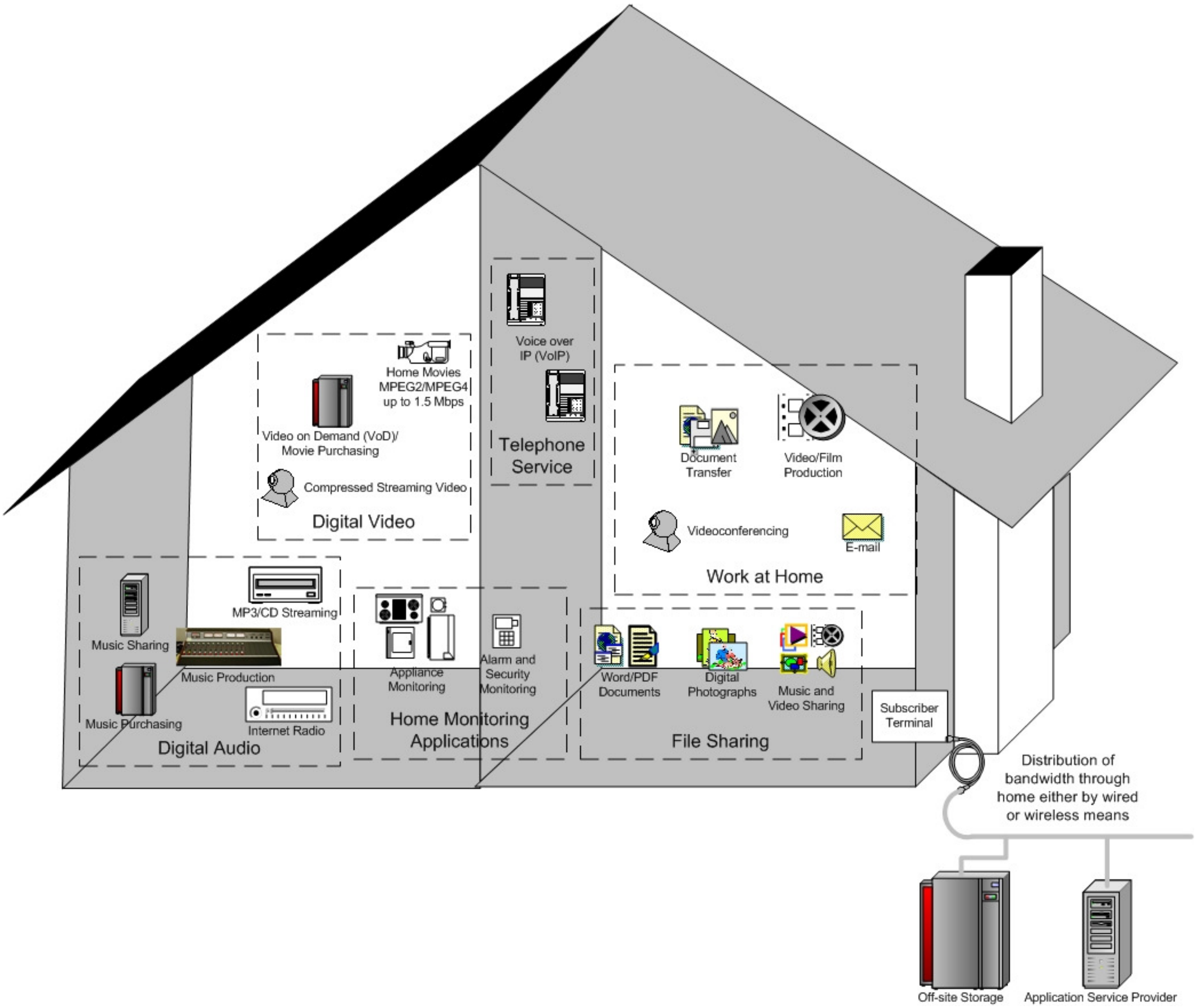
High Cost of Construction. There are significant challenges in fiber optic network technology, especially in the initial construction. Although lower impact construction techniques are emerging, there is still typically a need to perform boring or trenching to install fiber underground. Overhead installation requires space on utility poles. Fiber optic construction can be disruptive, especially if there is no underground conduit present and the area is served by underground communication utilities. Fiber networks must be permitted to be in the local right of way and use space in that right of way. In addition, fiber networks are vulnerable to underground digging, chewing by animals, fire, and damage in cable pathways, for example, in buildings or transit tunnels.

Service Limitations. There are limitations in the type of services that fiber can provide. Fiber connects only to fixed locations. It may not be cost effective to extend fiber to a location that will only be served infrequently or temporarily.

8.3.3. Capacity Needs are Constantly Expanding

The needs of communications users in residences and the workplace are constantly widening and increasing. A typical household has many more devices than were even conceived of in recent years (Figure 6). The diversity and needs of those devices will to grow as more people telecommute and require the capabilities of the workplace at home. This is true even as particular devices begin to use "compression" and other smart techniques to reduce the bandwidth needed for any particular use.

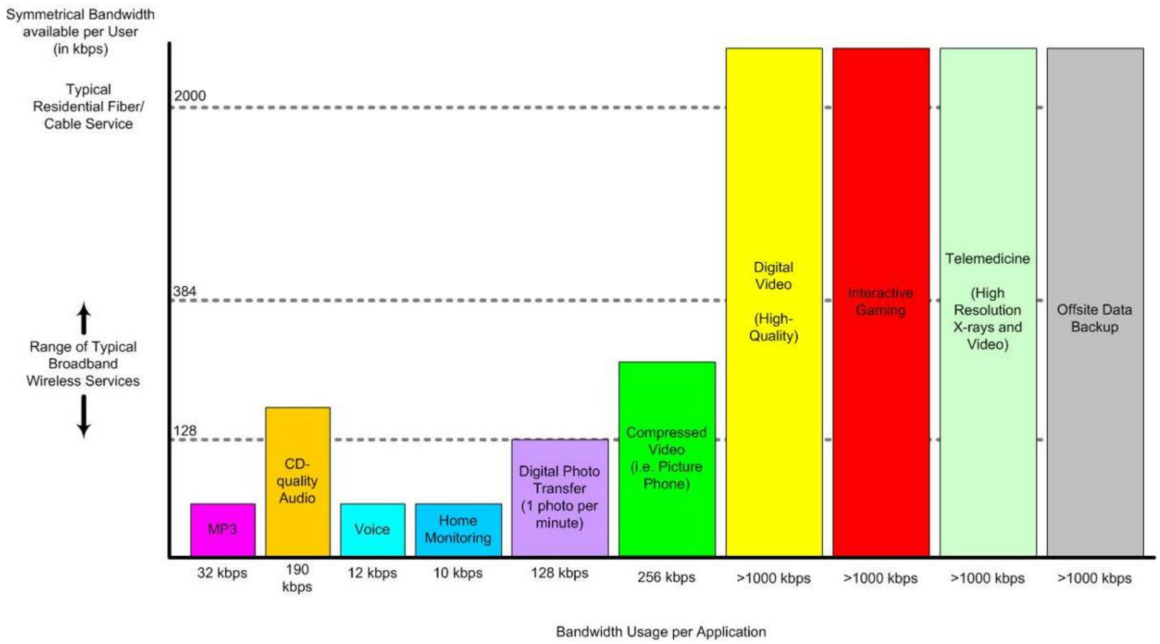
Figure 141: Current, Widely-Used, Home-Based Broadband Applications



Demand will grow as health care becomes more costly and people age, increasing the potential benefit of telemedicine to homes and remote clinics. It will grow as information and communications technologies become part of a strategy to save energy and reduce pollution.

Many of these applications require *symmetrical* (two-way) bandwidth of one or more million bits per second (Mbps). While some broadband wireless providers can provide this speed in the downstream direction (from the network to the user), broadband wireless technologies do not currently provide this stream in both upstream and downstream directions. As a result, interactive applications like telemedicine, digital video, gaming, and backup of files and data will perform poorly on most broadband wireless networks. In fact, some broadband wireless providers limit customers' ability to use these services on their networks.

Figure 142: Typical Symmetrical Bandwidth Requirements

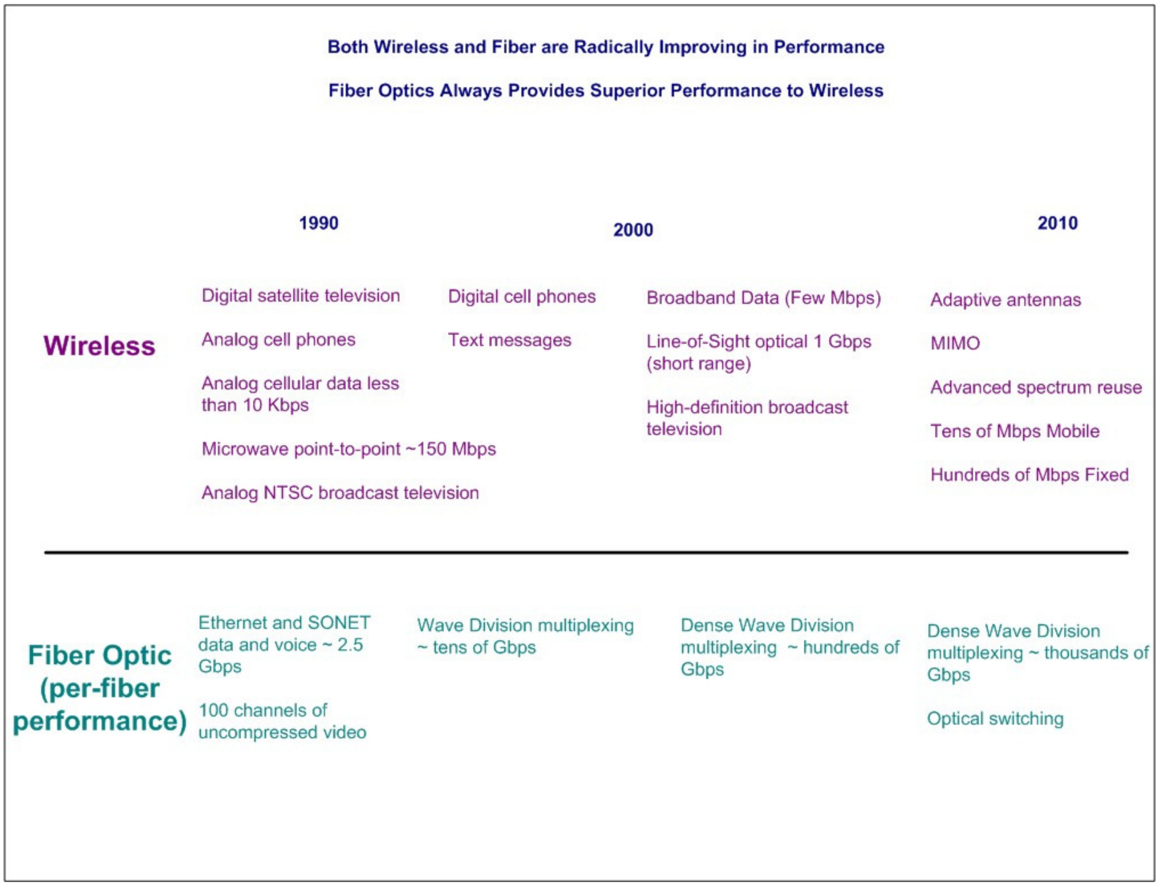


8.3.4. Both Wireless and Fiber Can Scale but Fiber Always Holds the Capacity Advantage

Communications equipment is big business, and researchers and manufacturers are constantly improving both wireless and fiber technologies. As a result, both can be expected to grow in their capability to offer more speed and capacity. In fact, it is likely that in future year's broadband wireless technology will provide sufficient bidirectional capacity for the applications in Figure 8.

However, fiber optic technology will also improve in performance in those years. A technology roadmap demonstrates the qualitative improvements in capabilities of off-the-shelf technologies since the early 1990s (Figure 8).

Figure 143: Wireless and Fiber Performance Roadmap

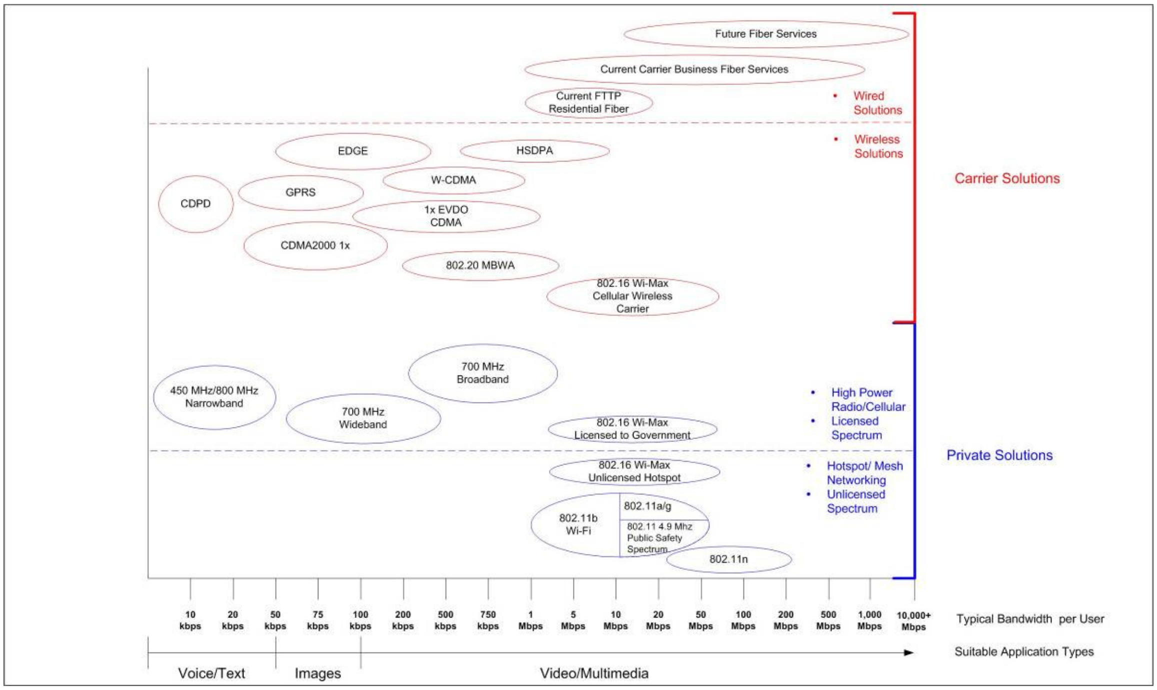


In all cases, the capacity of a service over a single pair of fiber optics was 50 or more times the capacity of comparable wireless links and services. This gap will likely remain. In coming years, we anticipate the development of advanced wireless technologies, including adaptive antennas[93], using multiple simultaneous wireless transmission routes, advance spectrum reuse techniques, and point-to-point laser optical technologies. At the same time, fiber optic advances will likely include faster electronics, a wider range of wavelengths, and optical switching.

The analysis is similar with respect to available wireless technologies. Figure 9 provides examples of broadband wireless and wireline technologies, including licensed, unlicensed, private, and carrier technologies. Because the actual capacity available to a user will vary according to specific circumstances, the capacity is shown as a range for each technology. Figure 9 also indicates the capacity required for typical applications, from text to advanced multimedia.

[93] Including multiple input multiple output (MIMO) antennas

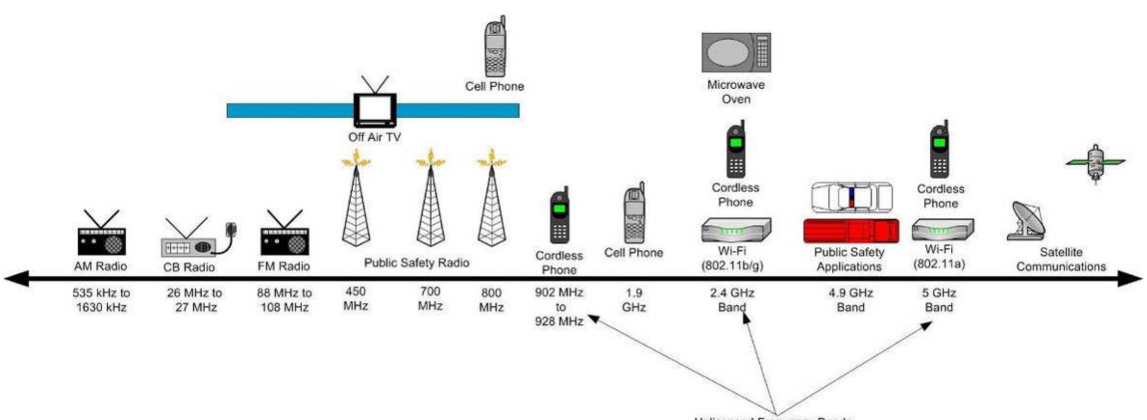
Figure 144: Wireless and Fiber Technology Roadmap



8.3.5. Wireless Performance is Physically Limited by Scarce and Costly Electromagnetic Spectrum

All wireless devices use the electromagnetic spectrum. The spectrum is shared by a wide range of users and devices. Most of the spectrum is assigned to particular uses by the Federal Communications Commission and by international agreement (Figure 10). Commercial licensed spectrum bands for voice and broadband services include 700 and 800 MHz, 1.7, 1.9, 2.1, 2.5, and 3.5 GHz. Popular unlicensed bands include 900 MHz, 2.4 GHz, and 5 GHz.

Figure 145: Spectrum Allocation



Higher speed services typically use the higher frequency spectrum. The higher frequency spectrum typically has broader channel widths and therefore is capable of providing more capacity. Lower frequency spectrum typically only has smaller channels available, but has the advantage of penetrating buildings and materials and not requiring as much of a direct line of sight.

Examples of wide channel widths are tens of MHz available in the Advanced Wireless Spectrum and former "Wireless Cable" spectrum. The actual capacity (speed) available will vary according to specific conditions and the technology used, but a reasonable estimate is that the maximum available speed from current technology is within an order of magnitude of the spectral width of a channel. Therefore, tens of MHz of spectrum in a particular large communications channel can conceivably, theoretically, provide the wireless users in particular area with hundreds of megabits per second of aggregate capacity.

The available speed can be increased by narrowing the wireless beam to smaller areas, and even particular users. Technologies can exploit multiple simultaneous paths between the two endpoints of communications. They can transmit in multiple senses of polarization. They can use sophisticated coding techniques to maximize spectral efficiency.

Depending on the outcome of a pending FCC proceeding, more spectrum may be opened up to unlicensed "secondary" broadband use through access to unused television channels (also known as "white spaces"). A new generation of ultrawideband wireless uses very large channels at high frequencies, but must operate a low power to not interfere with other users—which limits the technology to short range or point-to-point use.

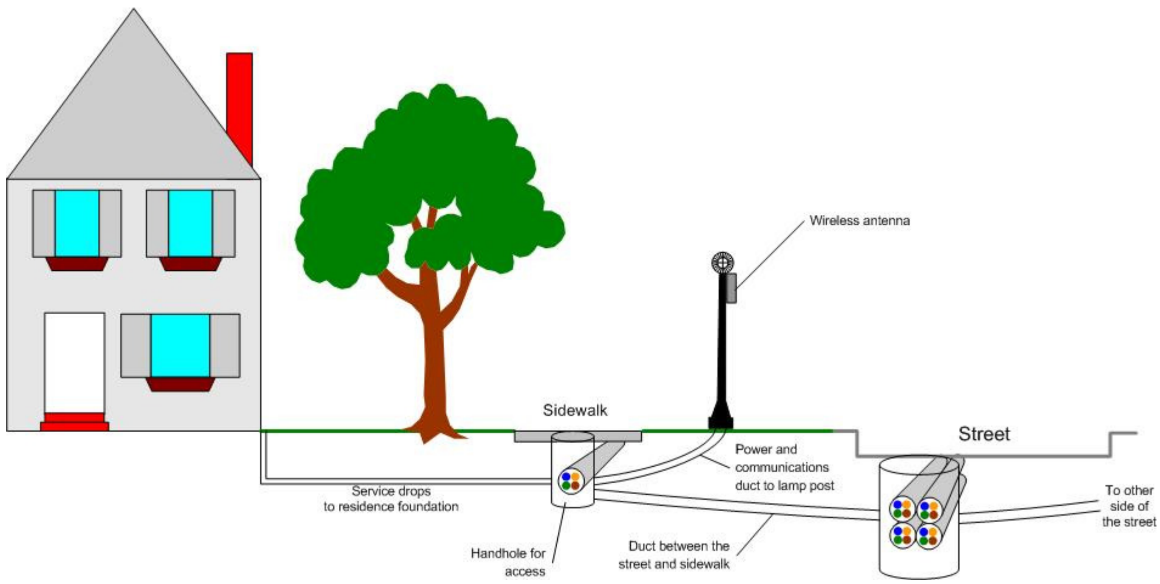
Nonetheless, even if the entire electromagnetic spectrum were to somehow simultaneously become available for particular wireless users, *the laws of physics dictate that this theoretical wireless capacity would still be less than the terabits per second (Tbps) currently available in one fiber optic cable with existing off-the-shelf technology*. Moreover, most of the wireless communication would be limited by range and by line-of-sight. In addition, substantial backbone fiber optic capacity would be necessary to connect the wireless communication system to its core and to other networks.

8.3.6. A Coordinated Fiber Optic Network Design Can Provide Capacity for Dozens of Separate Service Providers and Spare Capacity

There are many potential strategies for deploying a fiber optic network in the public right of way that maximize the long-term value and minimize the potential for future disruption. One is to construct a high-capacity conduit bank connected to manholes at regular intervals according to a standardized design (Figure 11). The primary manholes in turn connect to lower-capacity conduit connected to residential or business service drops or to wireless infrastructure. Small manholes or handholes can be managed by particular service providers for their proprietary access and service to particular customers.

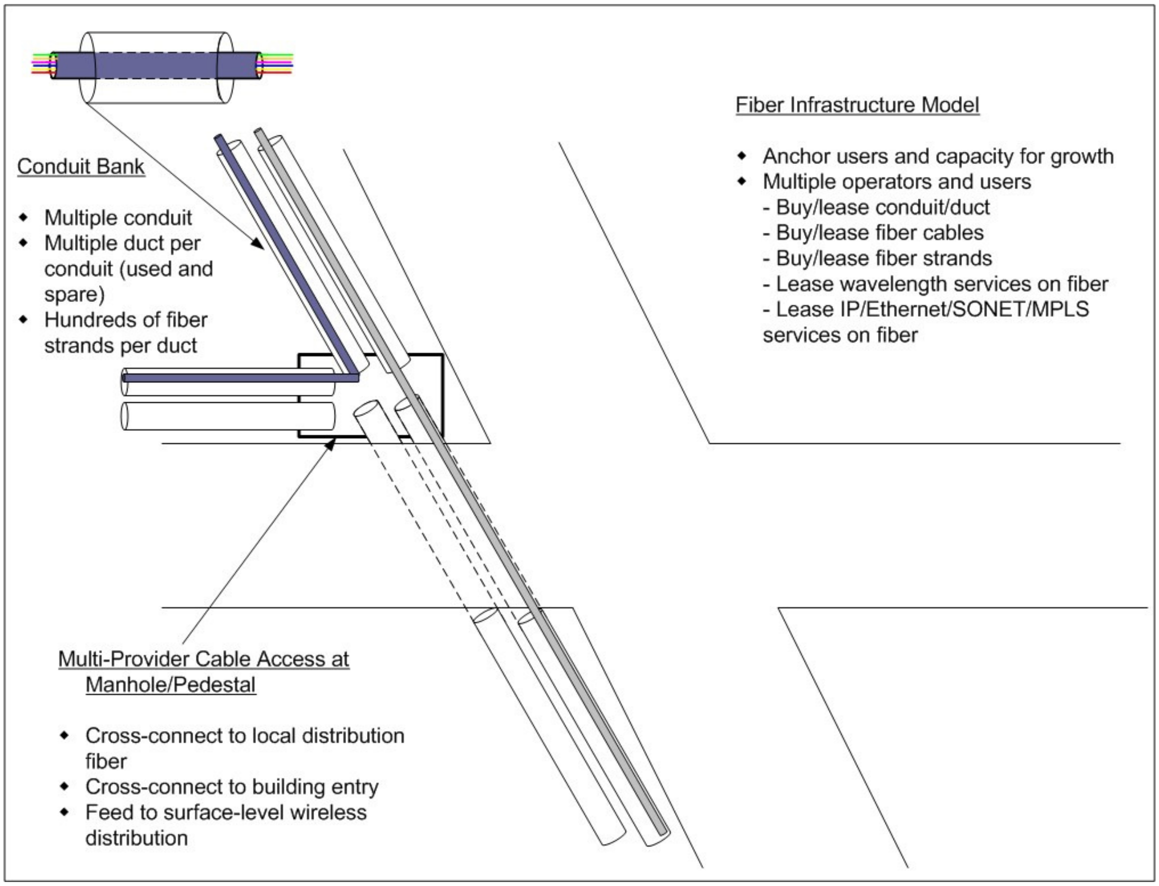
This type of strategy will enable several providers to leverage a single construction project. It will also provide capacity for other providers to enter at a later time at a relatively low cost and with minimal impact on the public right of way. To be effective, this strategy must be followed by all City departments, not just SCL.

Figure 146: Long Term Value Conduit Installation Strategy



A structured, standardized plan to install fiber optic infrastructure, either as part of a citywide strategy or as a required activity in coordination with road construction or maintenance, can create high value for residents and businesses. Each corridor could be reached by multiple wired or wireless service providers using a range of business models, from operation of conduit, to operation of fiber cables, to operation of fiber strands, to lease of services over the fibers (Figure 12). Government entities can obtain and provide value, using the fiber and conduit to connect traffic management infrastructure and manage utilities and mobile staff.

Figure 147: Structured Fiber and Conduit Design Provides Flexible Capacity Citywide



This type of strategy extends the level of raw communications capability in the most "wired" parts of the world to every served corridor. Wired and wireless service providers can serve a region without risk and difficulty of outside plant construction. There will not be a "last mile," because there will not be a physical bottleneck to extending communications services.

9 An Enhanced Passive Optical Network (PON) Model Cost-Effectively Provides Many Technical Advantages

Since the delivery of Columbia Telecommunications Corporation's (CTC's) original FTTP feasibility study, *Fiber Optics for Government and Public Broadband: A Feasibility Study*, in January 2007, FTTP architectures, construction methods, and costs have evolved. Given those changes, an enhanced passive optical network (PON) model now represents the best balance of network capacity and cost.

This section more closely estimates the construction and operational cost of an FTTP system in San Francisco. The most significant adjustments were to:

1. refine the original cost model to take into account prevailing trends in overhead construction costs, in particular, the increased cost of "make ready" construction to make space on utility poles;
2. include the cost of purchasing space on utility poles under the joint pole attachment agreement, as opposed to the lease model used in the previous report;
3. add a worst-case model where construction and make ready costs were the highest conceivable estimates, in order to explore the sensitivity of the model to unanticipated increases in these costs;
4. develop a new enhanced passive optical network (PON) model incorporating many of the technical advantages of both PON and home-run architectures at approximately the cost of a traditional PON; and
5. clearly define the network's ability to provide open access at the physical and electronic layers with wide ranging technical and financial models for FTTP deployment.

In the revised model, we find that CTC's most likely estimates of these adjustments result in fixed costs for both retail and wholesale approximately 6 percent higher than the previous model GPON fixed costs. Based on CTC's best estimates, these adjustments are measurable but unlikely to change the feasibility prospects for the project, as discussed in the detailed financial analysis.

We find that the worst-case model is approximately 50 percent more costly than the most likely estimate (Table 37). Therefore unforeseen problems with make ready and other aspects of overhead construction can pose a significant risk to the successful completion of the network. We recommend that the City further explore these risks before implementation of the citywide project by constructing a trial portion of the network in an area of the city with the strongest business case and with overhead utilities. We further recommend that the city closely monitor the costs and processes of the construction to better refine the estimate of cost and construction timeline.

We also find that the proposed enhanced GPON network provides a wide range of options for either a retail or wholesale "open access" network. There is only one option that enhanced GPON does not offer the city—which is that six percent is the maximum percentage of passings[94] in an area that can simultaneously have a dedicated fiber strand to their premises, and that the remainder will have their fibers connected through a passive splitter/combiner within 1,200 feet of their premises.

We do not believe that this architecture provides a significant barrier to open access or to the scalability of the network, because:

1. this architecture provides 2.5 Gbps downstream and 1.2 Gbps upstream shared between 32 passings. Equipment currently in trials (and likely to be available for the city's use at the time of construction) provides 10 Gbps downstream and 10 Gbps upstream, and WDM-PON equipment likely to be available in three to five years provides more than 10 Gbps upstream and 10 Gbps downstream to each subscriber.[95] The detailed financial model assumes the deployment of the state-of-the-art equipment at the time of the build and assumes replacement of electronics with the state of the art at seven year intervals, and therefore capacity and functionality will keep well ahead of demand;
2. GPON is now the most widely adopted FTTP architecture worldwide, and therefore there is a large existing and growing market that will likely lead to a growing choice of functions and features and keep costs low. GPON is used in most Asian networks, many European networks, by Verizon in the United States, and in most retail and open-access municipal FTTP deployments in the U.S.;
3. GPON equipment provides retail open access options at the router level (Layer 3) and at the interface level (layer 2). There are multiple scalable ways a retail service provider at the Internet or in the hub facilities can reach a customer over a dedicated secure path, over a range of speeds and service levels. Moreover, there is sufficient fiber in the proposed "enhanced GPON" to connect up to seven percent of the users directly over dedicated fiber and bypass the GPON equipment if desired. This percentage can be increased in the final design on an area by area basis; however a substantially greater percentage will increase construction costs;
4. any FTTP architecture, whether GPON, Active Ethernet, or "home run" requires the presence of a central infrastructure entity operating the network. Even if every user has a dedicated fiber to their premises, the physical maintenance of the fiber on the poles or in conduit will need to be centrally coordinated, the access to hub buildings would need to be coordinated, and the use of backbone fiber between the buildings would need to be coordinated; and
5. with FTTP it is possible to come reasonably close to an ideal model, where each premises has full, unfettered control to the global network. Given that there must always be a

[94] 29 of 500 subscribers, assuming 40% penetration

[95] WDM-PON equipment is expected to be available for commercial deployment in 2010. At the FTTH Council Europe Conference 2009, LG-Nortel announced that WDM-PON trials are currently underway with 10 service providers. During the Broadband World Forum Europe held in Paris in September 2009, LG-Nortel exhibited the prototype equipment to deliver the WDM-PON service. LG-Nortel is planning to have the WDM-PON equipment available commercially in the first half of 2010. The new products will include both 1 Gbps and 100 Mbps symmetrical Optical Network Terminals (ONT) and the NS161GCO Optical Line Termination (OLT) System. The new ONTs will be available in both indoor and outdoor units.

central coordinating entity, the success of open access always depends on the quality of the governance of the network. Success will depend on transparency, pricing and access models, and making available a wide range of retail options. In that light, the architecture and electronics must be sufficiently scalable and functional, but must also keep costs where the network can be feasible and successful.

The most likely and worst-case estimates are provided in Table 37.

Table 37: Summary Cost Estimates

GPON Retail Model

Fixed Costs	**Most Likely Estimate**	**Worst-Case Estimate**
FTTP Fiber Network	$307,029,000	$486,598,000
Core Network Equipment[96]	$8,600,000	$8,600,000
Headend Costs	$15,650,000	$15,650,000
Hub Costs	$12,000,000	$12,000,000
Total	**$343,279,000**	**$522,848,000**
Fixed Cost per passing	$890	$1,350
Average Subscriber Costs		
Drop Installation		$420
Core PON Equipment		$160
ONT		$460
Set Top Box		$300
VoIP Equipment		$21

GPON Wholesale Model

Fixed Costs	**Most Likely Estimate**	**Worst-Case Estimate**
FTTP Fiber Network	$307,029,000	$486,598,000
Core Network Equipment[97]	$8,000,000	$8,000,000
Headend Costs	$10,000,000	$10,000,000
Hub Costs	$12,000,000	$12,000,000
Total	**$337,029,000**	**$516,598,000**
Fixed Cost per passing	$870	$1,340
Average Subscriber Costs		
Drop Installation		$420
Core PON Equipment		$160
ONT		$460

[96] Includes billing software
[97] Includes billing software

This section outlines the primary design considerations and assumptions shaping the refined design and cost model for an FTTP network in the City and County of San Francisco. Many of these assumptions are based on industry practices and other FTTP deployment experiences; however, it is important to note that many of these assumptions cannot be verified until a detailed design is completed and bids are received from the applicable construction and equipment vendors.

9.1 System Architecture

Because of the large cost difference relative to a "home-run" architecture, the Department of Technology (DT) requested that CTC assess use of a passive optical network (PON) architecture for the FTTP network. CTC developed an enhanced PON model, a hybrid-passive optical network (PON) architecture to serve the specific needs of the City. PON was chosen due to:

1) falling cost of PON hardware due to the proliferation of the technology worldwide and within the U.S.;
2) increasing standardization of PON technologies potentially providing a lower-risk upgrade path than using less standardized technologies;
3) significantly lower cost of PON outside plant construction; and
4) reduced space requirements at each hub, enabling greater choices for locations and reduction of costs.

Although a home-run fiber construction architecture was recommended by the original CTC report, particularly with respect to the possibility of physical-layer models for open access, the 40 percent to 50 percent higher cost of home-run fiber optic construction in the San Francisco environment increases risk to the overall financial model.[98]

In San Francisco, PON costs are likely to be substantially lower than other techniques, owing to the suitability of overhead fiber construction in many areas where home-run or point-to-point architectures would create large cable bundles that would require underground construction. Instead, the City prefers a hybrid PON/home-run model in which the baseline fiber requirement for a PON network is augmented to allow only selected residential and business consumers to be served via dedicated ("home run") fibers, while still enabling the City to use aerial construction, in many areas.

For the purpose of developing a conceptual design, Gigabit PON (GPON) was chosen as the PON technology.[99] GPON is the most common technology for PON deployments in the U.S.

[98] The ability to use overhead cable construction for substantial portions of the network is the key reason why PON is substantially less costly in San Francisco, relative to European cities where the majority of utilities are underground, and relative to less urban environments where the cost difference between overhead and underground construction is less. An oft-quoted French government report claims that the construction cost difference between PON and home-run is less than 10%, but this assumes a "network entirely buried between the exchange and the foot of building or the entry of a house." http://www.telecom.gouv.fr/fonds_documentaire/rapports/rap_thd.pdf.
[99] For more information on GPON design considerations and details of the San Francisco GPON design, see the CTC report, "Fiber Optics for Government and Public Broadband: A Feasibility Study" prepared for the City and County of San Francisco in January 2007.

today, and is slowly replacing earlier BPON deployments. Hardware pricing for GPON today is most likely to be comparable to the cost of next-generation PON technologies[100] in the event that a deployment is not begun with this generation of equipment.

The proposed design is based on a 1:32 split, where one fiber from each hub serves up to 32 subscribers. Although GPON equipment can be purchased to split at ratios of up to 1:64 fibers to subscribers, this architecture uses a more conservative 1:32 to provide more flexibility and capacity per subscriber.

Using the 1:32 split and a 20-hub network architecture,[101] each hub connects to approximately 40 fiber distribution cabinets (FDCs), or a total of 800 cabinets citywide. This estimate is based on the housing and business statistics of San Francisco, and a cabinet serving approximately 500 customer passings. Each of these cabinets will have 1) feeder fibers that connect to the hub, 2) distribution fibers that extend to each passing. Assuming that every passing represents an actual customer, 16 feeder fibers would be utilized in a cabinet serving 500 passings. Figure 148 shows an FDC installed in an aerial location on a utility pole.

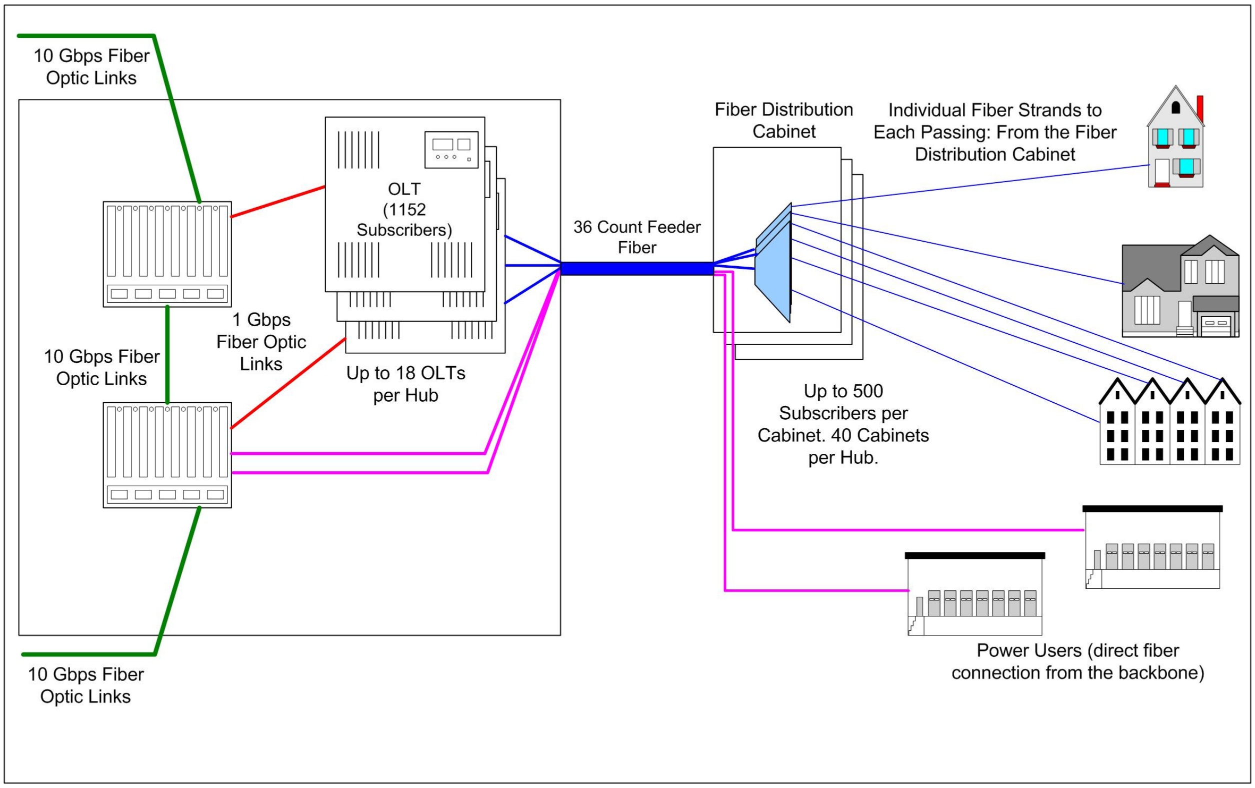
Figure 148: Aerial FDC Cabinet

In order to provide capacity for growth, including direct, home-run fiber connectivity to specific "power users," such as large business customers, the design includes a 36-count feeder fiber to

[100] Including 10 Gigabit PON (10GPON) and wave-division multiplexing PON (WDM-PON)
[101] Based on typical FTTP design of 20,000 passings per hub.

each cabinet. This would provide a minimum of 20 spare feeder fibers at each cabinet for future use, providing support for no less than 16,000 such direct connections citywide. This number of power users is a rough approximation corresponding approximately to half the number of businesses in the city. In addition, during the detailed design phase of an FTTP system, additional fiber capacity could be built in for specific sites, such as city facilities, schools, and known power users, in order maximize the number of spare fibers in the future.
Figure 149 provides a generic system level diagram of a GPON network.

Figure 149: GPON System Architecture



9.2 Service Delivery

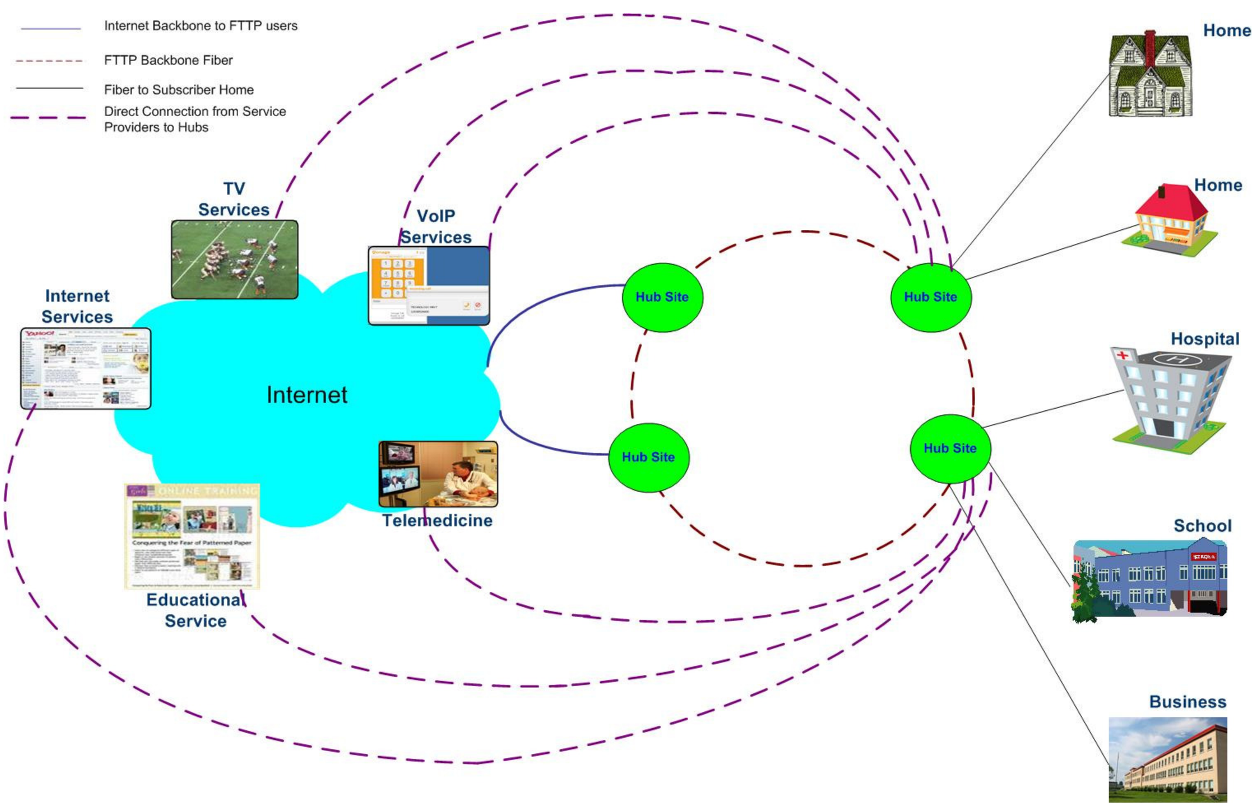
Given the technology trends in content delivery and the City's desire to maximize opportunities to support competitive open access service providers over the FTTP network, the proposed model places primary emphasis on providing open access and net neutrality through use of IP technologies. Some power users will be able to obtain direct dedicated fiber access as discussed earlier, but all users will be able to obtain dedicated capacity to and from their premises through the PON network, which has the ability to dedicated hard minimum and maximum capacity limits per subscriber, as well as guarantee connections through the PON network from the user to service providers located at the hubs or designated POP locations on the network.

Customers will be able to receive IP-based service delivery of Internet, dedicated data networks, Voice over IP (VoIP) telephony and IP television (IPTV) (Figure 150). As with current broadband networks, customers may choose to purchase VoIP or IPTV from their Internet provider or procure these services from third party vendors using their Internet connections for transport. In this service delivery model, the City (or its designated management partner) would construct and operate the GPON hardware. The City would then offer IPTV and VoIP services over the network and/or allow other third party vendors to offer services depending on the financial model chosen.

In order for this platform to effectively provide open access, the operator of this network architecture would need to configure the technology and its policies to:

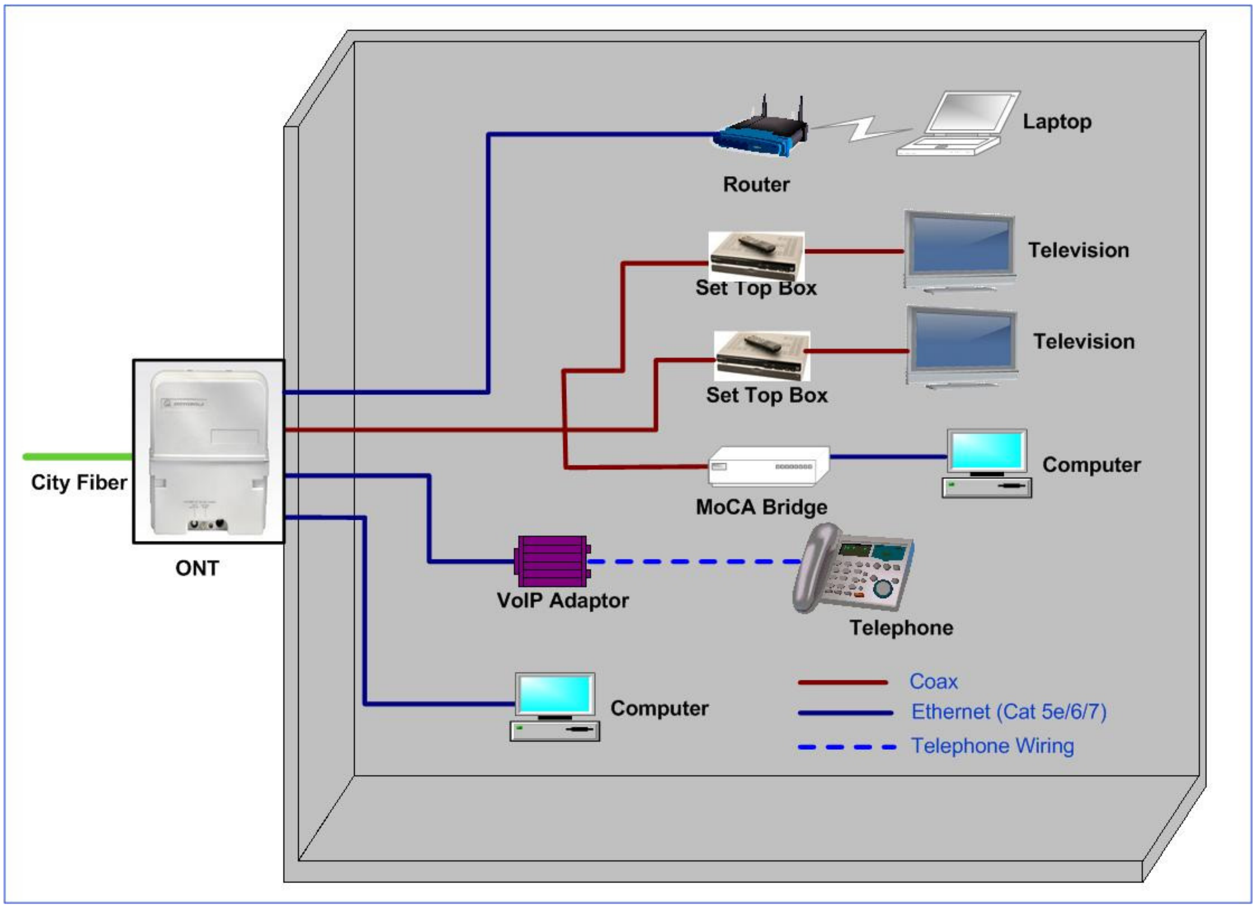
- make a wide range of services available over the PON platform, including small and large capacity offerings, and symmetrical capacity services;
- use fair and common standards for interconnection of customers with providers at hub sites and points-of presence; and
- provide customers and service providers with advanced traffic prioritization capability to enhance the delivery of services that are sensitive to network performance (voice-over-IP, video) and/or provide cost-effective best-effort capacity.

Figure 150: Service Delivery Model



By choosing an all IP-based delivery system, the cost of the ONT at each unit is reduced. The ONT hardware does not require RF video or traditional analog phone support. However, the cost of other customer premises equipment (i.e. TV set top box, VoIP phone adaptor) may increase depending on how the IP services are delivered. It is important to note that as the number of IPTV and VoIP deployments increase in the US, the cost of the CPE equipment will decrease. Figure 151 provides a subscriber level diagram of the connections within a residential unit. Existing internal wiring is used to minimize installation costs. VoIP adaptors interface with the existing Category 3 telephone wiring, while coaxial network media converters provide Internet and video streaming over coaxial cable. Two of the major data over coaxial cable standards include the Multimedia over Coax Alliance (MoCA) and the HomePNA (HPNA).

Figure 151: All-IP Delivery System



9.3 Multi-Dwelling Units

For the purposes of the network cost estimate we have assumed that every subscriber would require a separate ONT to receive service. In the case of MDUs, it may be possible to serve multiple subscribers from a single MDU-style ONT. The use of an MDU-style ONT would have to be determined on a building-by-building basis. Factors that may impact the ONT deployment in MDUs include:

- Number of units within a given building;
- Number of subscribers within a given building;
- Availability of a centralized location for an MDU-style ONT to be located;
- Existing internal wiring within the building;
- Existing internal wiring within the units;
- Availability of conduit for additional wiring within the buildings and units;
- Building owner negotiations and existing service agreements; and
- Aesthetic concerns of building owners and residents.

Given these unknown factors, we have taken the worst case/most common scenario in which each subscribing unit requires a separate ONT. The total cost of an ONT providing only data services is approximately $460 per unit, which includes the cost of an uninterruptible power supply (UPS), cabling, and software. In addition, the detailed financial model adds the incremental cost of ONT hardware required to support VoIP and IPTV, the fiber drop to the customer premises, television set top boxes and other consumer conversion equipment, and the addition of cabling to a computer location.

9.4 Outside Plant Construction

Outside fiber optic plant construction is the most time consuming and expensive component of the construction of an FTTP system. Because of the wide range of variables and unknowns of constructing in the public right of way, the overall cost of construction can be difficult to accurately estimate. The following sections outline the assumptions and design decisions made in developing a value-engineered PON FTTP network.

9.5 Overall Design Methodology

The overall GPON design methodology is described in Section 6.1.3.3 of CTC's original FTTP feasibility study, which remains the same for the enhanced PON model. The following serves as a summary of the design methodology used for determining the cost estimates for the PON FTTP network.

CTC initially developed a system level design based on the assumptions and parameters identified above. Once the system level design was completed, CTC developed cost estimates for the various outside plant components based on available industry pricing for fiber and facility construction. Using a sample aerial construction location and a sample underground construction location within the City, CTC generated detailed designs for each to determine the average construction cost per street mile for aerial and underground construction methods. The construction cost per street mile was then applied to the total street miles within San Francisco, using an assumption that 50 percent of the city will require aerial utility construction and 50 percent of the city has underground construction.

The following sections outline the various assumptions and external factors that can greatly impact the cost and design of a PON fiber optic network.

9.6 Facility Construction and Fixed Network Equipment Costs

The facility requirements for a PON network architecture are outlined in Section 6.3.1 of CTC's original FTTP feasibility study. The headend requires space for network electronics, servers to support a range of network management and service provisioning functions, and collocation space for potential third party providers. The estimated space requirement for the headend is 25,000 square feet. We assume that the space for the headend would reside in either an existing City owned building or on City owned land. The cost of building the facility with the required power, HVAC, security, and cable management is estimated at $400 per square foot, based on typical data center construction costs, for a total of approximately $10,000,000.

Hub sites located throughout the City are necessary to aggregate fiber connections and for housing FTTP transport electronics, which are necessary to increase network reliability and reduce costs relative to a single centralized headend location. The design model includes 20 hub locations, for which we estimate 1,500 square feet is needed within each to house the equipment for a PON network. These facilities would be unmanned facilities located within existing City facilities or on City-owned land. The cost of each hub is estimated at $600,000, or $12,000,000 for all 20 hubs.

If space within City facilities or land for new hub construction is not available, then the cost of facility construction could dramatically increase. Renting facility space in commercial buildings is an option, but would increase the operating costs of the network.

The headend and hubs will house central networking and application hardware necessary for the central operator to maintain and operate an FTTP system. The equipment includes core networking equipment, servers, and network operations and management equipment, incorporating all fixed costs for provisioning advanced VoIP telephony, Internet, and video distribution services comparable to competing services available today. We estimate that the cost of this equipment is approximately $8,000,000, not including costs associated with individual customers incurred as subscriptions are activated. The headend and hubs will also include space for other service providers to collocate their equipment.

9.7 Aerial Construction

Where space on utility poles exists, aerial construction is the preferred method of fiber optic construction. Aerial construction, where permissible, is typically far less expensive and time consuming than underground construction. Based on our review of the City and its existing utilities, we estimated that approximately 50 percent of the City has aerial utilities. CTC estimated unit costs for the various outside plant construction materials and labor needed in developing the sample design, itemized in Table 38.

While materials costs are fairly consistent, labor rates can vary greatly depending on the geographic region and the current demand for personnel to perform outside plant construction. Given that labor costs will vary substantially according to demand for services, it is difficult to calculate labor charges without receiving firm bids from fiber optic construction companies, thus it is necessary to examine labor costs within a likely range. Table 38 also provides the most likely and worst-case labor estimates used in calculating our cost estimates.

Table 38: Aerial Construction Unit Cost Assumptions

MATERIALS

ITEM	UNIT	COST
60 count fiber	Foot	$0.65
48 count fiber	Foot	$0.52
32 count fiber	Foot	$0.44
60 fiber splice case	Each	$338.75
48 fiber splice case	Each	$271.00
4 way tap 300 ft.	Each	$188.00
6 way tap 325 ft	Each	$231.50
8 way tap 225 ft.	Each	$275.00
12 way tap 200 ft.	Each	$365.00
FDC	Each	$13,000.00
Hardware	Foot	$0.50
STRAND	Foot	$0.27

LABOR ESTIMATES

ITEM	COUNT	Most likely COST	Worst-Case COST
Place Strand	Foot	$1.25	$2.00
Lash Cable	Foot	$1.80	$2.50
Splicing	Each	$30.00	$45.00
Place FDC	Each	$2,000.00	$5,000.00
Place Taps	Each	$15.00	$40.00

Using the sample aerial design and the pricing listed in Table 2, we developed a most likely aerial FTTP construction cost of approximately $93,000 per street mile, and a worst-case estimate of approximately $120,000 per street mile. These estimates do not include make ready costs, which are discussed below.

9.7.1. Make Ready, Permitting, and Pole Attachment Fees

Make ready is the process by which utility poles are prepared for new cable attachments, which are necessary to ensure that structural and safety requirements are met, often dictated by local and national codes. Prior to construction, the entire construction route, including all utility poles, must be surveyed to determine make ready requirements, generate permit applications, and develop pole attachment agreements with the utility pole owners. Pole attachments, in particular the make ready costs, represent the greatest degree of uncertainty and cost variance for aerial construction. Utility company requirements, condition of existing plant, City permitting requirements and local code are all unique to an individual community. In addition, some utility pole owners allow the new cable owner to survey and perform any necessary changes on their own, while others require that their own crews complete the make ready work.

During the make ready survey, each pole is visited and attachments on the pole are identified and recorded. The height of the pole, down guy size, anchor status, and location of pole attachments are drawn to scale. In addition, the proposed new cable attachment type and location is determined following utility pole owner and National Electrical Safety Code (NESC) requirements. Required changes in existing utility attachments are documented. Each utility company examines the requested changes and they submit an estimate for clerical, engineering, and inspection costs to the new operator. Typical make ready work on the aerial plant includes raising or lowering lines, adding ground bonds, changing down guys, adding anchors, adding guards and adding new attachment clamps. In some cases the entire utility pole must be replaced for the new operator to attach to the pole.

Once the make ready estimate is paid by the new operator, the utility or its contractor is permitted to complete the make ready. When construction is completed, the utility companies make a final inspection to ensure the plant was built according to plans. The utility companies then compare actual costs to estimated costs and reconcile the account. CTC estimates the average cost to complete make ready for an overbuilder in San Francisco to be approximately $25,000 per mile, with high-end costs of $65,000 per mile possible.

Monthly pole attachment fees are assessed to each operator on the pole, providing the owner with funding to support its maintenance. These fees can vary greatly depending on the requirements of the utility owners. The City of San Francisco is a member of the Northern California Joint Pole Association (NCJPA), which entitles the City to attach to other joint-use poles within the City. Thus, the City would be required to pay the ownership fee based on the NCJPA agreement. If the City were to attach to all utility poles throughout the City (18,000 poles, or approximately 40 poles per mile over 450 street miles) the City would pay approximately $8,100,000 in ownership fees ($450 per pole).[102]

9.8 Underground Construction

Underground fiber optic construction can vary greatly in cost depending on the type of construction, availability of space in the right-of-way, permitting requirements, and local ordinances in the areas of construction. In particular, traffic monitoring, lane closures, street and sidewalk repair, and existing underground utility locations can affect the overall cost of construction. Many of the unknowns of underground construction cannot be determined until the final detailed design and walk-out are performed. Table 39 provides the material and labor costs used in our preliminary budgetary estimates. Due to the range of labor rates associated with construction, we include both an average labor rate and a high- end labor rate for fiber optic construction.

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[102] Calculation based on the 2007 NCJPA. Assumes that on average poles are 15 years old ($29.84 per foot), the City will be the forth owner, each pole is 60 feet with 31 feet of common space, 9 feet assigned to the electric utility and the remaining space (20 feet) is divided equally between three communication providers. These assumptions yield a one-time per pole fee of $230 for the common space and $220 for the exclusive space.

Table 39: Underground Construction Material and Labor Rates

MATERIALS

ITEM	UNIT	COST
60 count fiber	Foot	$0.65
48 count fiber	Foot	$0.52
32 count fiber	Foot	$0.44
60 fiber splice case	Each	$338.75
48 fiber splice case	Each	$271.00
4 way tap 300 ft.	Each	$188.00
6 way tap 325 ft	Each	$231.50
8 way tap 225 ft.	Each	$275.00
12 way tap 200 ft.	Each	$365.00
Conduit	Foot	$2.00
Splice Vaults	Each	$450.00
Tap Vaults	Each	$75.00
FDC	Each	$13,000.00
Hardware	Foot	$0.50

LABOR ESTIMATES

ITEM	COUNT	Most Likely Cost	Worst-Case Cost
Place Conduit	Foot	$1.80	$3.00
Trench	Foot	$8.00	$20.00
Bore	Foot	$45.00	$75.00
Street Cut	Foot	$100.00	$175.00
Pull Fiber	Foot	$1.80	$2.50
Splicing	Each	$30.00	$45.00
Place FDC	Each	$3,000.00	$5,000.00
Place Tap Vaults	Each	$150.00	$500.00
Place Splice Vaults	Each	$650.00	$1500.00

Compared to many fiber construction projects targeting particular buildings or types of customers, complete FTTP construction is more costly on a per street mile basis. Since an FTTP network must be designed to serve all potential customers, construction is required on both sides of a street to serve homes on either side. This attribute further encourages aerial construction as the lower cost alternative, among other things, subscriber drops can be run over the street to serve both sides from distribution cables located on only one side of the street. Using the sample underground design detailed in our original FTTP feasibility study and the updated unit pricing listed in Table 3, we ascertained an average aerial FTTP construction cost of approximately $349,000 per street mile, and a high estimate of approximately $567,000 per street mile.

9.8.1. Use of Existing Conduit

San Francisco has considerable infrastructure that might be used to lessen the cost of FTTP construction. Existing underground conduit of which the City has unrestricted use is one such asset. These conduit assets are described in detail in Section 3.1.2 of our original FTTP feasibility study. During the detailed design phase and route walkout, opportunities to leverage these existing assets may be identified to reduce the cost of underground construction. However, since much of the underground fiber optic construction is required on both sides of the street, and much of the conduit in this part of the right of way (i.e. street light conduit) is in disjointed segments, there are not sufficient conduit resources to significantly reduce the budgetary cost estimates of an FTTP system, and the existing conduit, such as streetlight or MUNI, will mostly be suitable for backbone hub-to-hub segments only. For these reasons we have not included existing conduit resources into the budgetary cost estimates, and must assume that new underground construction is needed in all locations.

We note that cost estimates may be reduced considerably if the City forms a partnership with one of the utility providers in the right-of-way. For example, Pacific Gas & Electric (PG&E) has conduit to most residences and businesses in the City, and its conduit would significantly reduce costs. The same is true of Comcast and AT&T.

9.9 Open Access Considerations

Competitive providers can offer services within a fiber optic network via a number of different technical models. However, in any architecture there will be centralized roles (ie. bundled components) and roles that can readily be provided by competitive providers. Even in a fully home run architecture, the headend and hub facilities will still need to be maintained in common, as would all outside fiber cable, except potentially the drop cable from the customer to the street.

Regardless of the architecture, policies need to be adopted to ensure the greatest level of flexibility for open access is facilitated while maintaining an acceptable financial model for the City. For example, a central operator of a PON transport backbone would control and provision subscriber access for competitive service providers.

An open access model using PON would require the PON platform to be controlled by a central operator in a manner that would provide consistent technical capabilities and costs to all competitive service providers. This operator must have the means by which to allow customers equal access to any service provider, and more importantly, the desire to do so.

The proposed architecture establishes that there will be collocation space for the central operator and outside entities to provide services at the headend or hubs (e.g. IPTV, VoD, VoIP). The providers would connect to the PON and/or backbone transport equipment at the headend, hubs, or through the Internet; providers at the hubs would be able to connect directly to the "power users" purchasing the direct fiber connections and bypass the PON equipment.

Table 40 presents various network components and the options for ownership of the component.

Table 40: Owner, Provider and Operator of Components

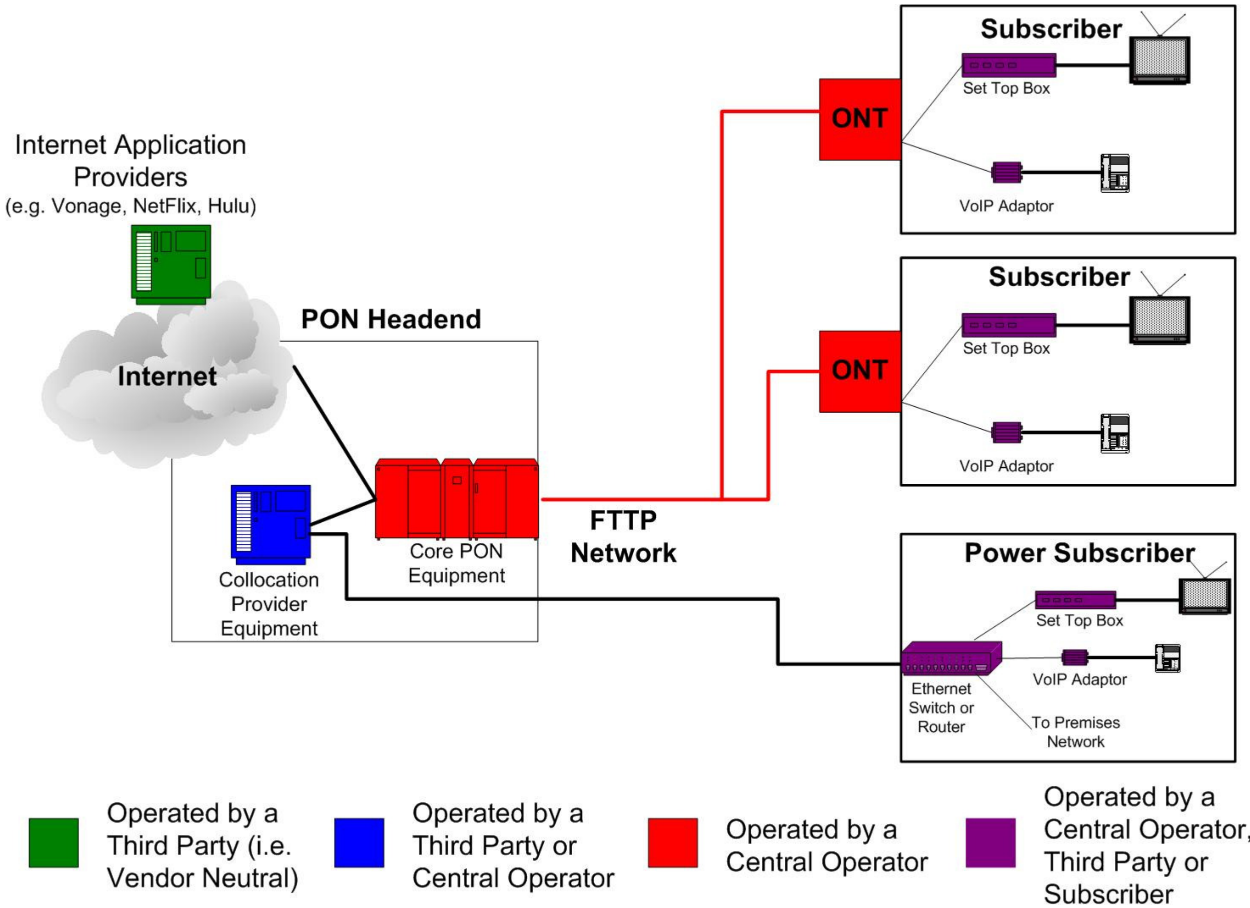
Component	Own	Operate and Maintain
Television/Computer/Phone	S	S
TV Set Top Box	S/ C/ P	S/ C/ P
Phone- VoIP	S/ C/ P	S/ C/ P
ONT	C	C
Drop Cable	C/ S	C/ S
Distribution Cable	C/ S	C
Hub Site	C	C
Backbone Cable	C/ P	C
Hub- PON Equipment	C	C
Network Application Equipment	C/ P	C/ P

Key to the table: S= Subscriber; C= Central Operator; P= Service Provider

In addition to competitive providers with a physical presence or connection with the FTTP network, subscribers can procure services from any provider that offers services over the Internet. As Internet use and broadband speeds have increased, there has been an increasing number of Internet application providers (Netflix, Vonage, Hulu) that offer video and voice services over the Internet. As long as particular types of Internet traffic are not intentionally hindered by the central provider or the retail Internet service provider, Internet-based providers can offer voice and video services similar to traditional facilities-based services over a plain Internet pipe. While this is still not the predominant mode for service delivery today, it is gaining traction as Internet connections and the technologies for service delivery improve. This trend is likely to continue, provided that ISPs are not allowed to adversely impact data traffic for competitive services traversing customer connections.

Figure 152 presents the recommended ownership and operational model for the proposed GPON network. The ownership of the identified optional components is examined in the detailed financial analysis.

Figure 152: Recommended Operational Roles for an Open Access Architecture



Appendix A: Overview of Broadband Services in San Francisco (February 2009)

10.1 Existing Residential and Small Business Products and Services

Marketing literature suggests that DSL and cable modem services are widely available in San Francisco. AT&T has a substantial footprint and most areas have DSL coverage.[103]

Service and availability gaps do exist. Sophisticated residential data users and businesses are requiring capabilities beyond those offered by cable modems and DSL.

A number of competitive telephone providers serve the business market and use AT&T's infrastructure. In addition, there are other alternatives to traditional telephone services, such as wireless (Verizon Wireless, AT&T, Sprint/Nextel), cable television (Comcast, Astound), Internet-based Voice over Internet protocol (VoIP) providers (Vonage, Skype, and others -- assuming a sufficiently robust Internet connection).

More than 45 local and national Internet service providers (ISPs) offer services in San Francisco, ranging from dial-up to high-speed connectivity (DSL, cable). There are also a number of higher capacity, higher cost options (ISDN, T1) available from providers, such as AT&T. Mobile wireless broadband options are also available from companies, such as AT&T, Sprint, and Verizon. Speeds and price vary greatly depending upon the level of service the user requires.

10.1.1. Internet Providers and Products

San Francisco businesses and residents have a number of options for high-speed Internet access, including DSL, cable, satellite, and wireless. In addition, there are a number of local and national dial-up Internet providers in and around the city. The dial-up service options range in price from $8 to $24.99 per month. There are seven companies in San Francisco that offer high-speed Internet access to residents through DSL with speeds ranging from 1.5 Mbps to 12 Mbps. The cost for the DSL service ranges from $14.95 to $64.95. A similar number of satellite and wireless Internet providers offer Internet service with download speeds ranging from 512 Kbps to 12 Mbps. The cost for this service ranges from $49.95 to $209.99.

A summary of some Internet providers, who may be considered direct competitors of a City Internet offering, and their available service options, is presented in Table 41.

[103] DSL coverage is difficult to project for a given location. A residence or business could be in an area where DSL is offered, but still not get service because of the quality of the existing circuit or because all DSL capacity has already been allocated.

Table 41: Internet Providers

Provider	DSL Facilities Based	DSL Reseller/ Added Value	Cable Modem	Cable Modem Reseller/ Added Value	Satellite	Dial Up Telephone	Wireless	EVDO/ UTMS	ISDN, Frame Relay, Other
Astound (RCN)			✓						
Internet Frontier		✓				✓			✓
Comcast			✓						
AOL		✓		✓		✓			
AT&T	✓					✓	✓		✓
*Speakeasy		✓							✓
Red Shift									✓
EarthLink					✓	✓			
HughesNet					✓				
Telepacific									✓
Suddenlink						✓			
Expert WildBlue					✓	✓			
Sprint PCS							✓	✓	
ACS									✓
Planeteria (for Mac)		✓				✓			✓
Sonic.net						✓			✓
localnet						✓			✓
cyberonic		✓		✓					✓
Cbeyond		✓							✓
*Verizon							✓		
DirecTV					✓				
Alltel							✓		
T-Mobile							✓		

The following tables provide further information on the Internet products offered by various service providers in San Francisco.

Table 42: Cable Internet Providers

Provider	Package	Price per month	Download/ Upload Speeds	CPE Cost	Installation	Misc.
Astound (formerly RCN)	Internet alone	$19.95 - $64.95 (depending on level of Internet service)	256 Kbps/128 Kbps 15 Mbps/256 Kbps 6 Mbps/1 Mbps 10 Mbps/1 Mbps 10 Mbps/1.5 Mbps	$3 - $5 /month rent[104] Buy own $4.95 - $15/month digital/HD/HD-DVR receivers[105]	Free[106]	
	Internet plus cable television	$25.00 - $55.00				
	Internet plus phone	$19.95 - $39.95				
	Internet plus phone plus cable television	$61.85 plus $127.90 (depending on level of service)				
Comcast	Internet alone[107]	$42.95[108]	6 Mbps/384 kbps	$99 buy $3/month rent	Self, one computer: $29.95 plus $9.95 shipping Professional, one computer: $99.99 Home networking (2–5 computers): $149.99	
	Internet plus digital voice		4 Mbps/384 kbps 6 Mbps/384 kbps 8 Mbps/768 kbps	$99 buy $3/month rent		
	Internet plus digital voice plus cable television	$139.15–219.13 (depending on level of TV service)[109]	6 Mbps/384 kbps 8 Mbps/768 kbps	$99 buy $3/month rent		

[104] Modem and Router available to lease for a monthly fee.
[105] Additional cable outlets have access to the Analog Cable channels (Limited & Basic channel tiers) included with the cable package. Digital cable, HD and HD-DVR costs vary for the 2nd to 4th TV/outlet.
[106] First four existing outlets free and more than 4 outlets cost $10 per outlet. New outlet installations cost $60 per outlet. Customers wanting more than four outlets need an amplifier installed at their cost to ensure a working picture on all televisions.
[107] Starter package: $19.99/month for 6 months.
[108] Package includes McAfee® Security Suite ($120 value) and the Comcast Toolbar, a comprehensive set of security tools to help protect when online. Also includes the Universal Address Book powered by Plaxo®, Rhapsody Radio PLUS®, Photoshow Deluxe 4.0, and more.
[109] Starter packages: $102–169.99 for one year.

Table 43: DSL Internet Providers

Provider	Package	Price per month	Download/ Upload Speeds	CPE Cost	Installation	Misc.
AT&T	Basic	$19.95[110]	768kbps/ 384kbps	$49.99 (buy Modem) $79.99 (buy Gateway)	$200.00	
	Express	$25.00[111]	1.5mbps/ 384kbps			
	Pro	$30.00	3.0mbps/ 512kbps			
	Elite	$35.00	6.0mbps/ 768kbps			

110 Promotional rate: $19.95 for first year for new customers, plus $19.99 shipping & handling.
111 Promotional rate: $29.95 for first year for new customers, plus $19.99 shipping & handling.

Table 44: Satellite Internet Providers

Provider	Package	Price per month	Download/ Upload Speeds	CPE Cost	Installation	Misc.
Dish Network (through Wild Blue)	Silver	$49.95	512 kbps/128 kbps	$199 lease	Free	
	Gold	$69.95	1 Mbps/200 kbps			
	Platinum	$79.95	1.5 Mbps/256 kbps			
Earthlink	Satellite	$69.95	1Mbps/200 kbps			
	Satellite	$99.95	1 Mbps/200 kbps			
HughesNet	Home	$59.99/$79.99	1.0 Mbps/128 kbps	299.98 (with $100 mail-in rebate)/None		
	Pro	$69.99/$89.99	1.2 Mbps/200 kbps	299.98 (with $100 mail-in rebate)/None		
	ProPlus	$79.99/$99.99	1.6 Mbps/250 kbps	299.98 (with $100 mail-in rebate)/None		
	Elite	$119.99/ $139.99	2.0 Mbps/300 kbps	299.98 (with $100 mail-in rebate)/None		
	ElitePlus	$189.99/ $209.99	3.0 Mbps/300 kbps	299.98 (with $100 mail-in rebate)/None		
Wild Blue	Value Pak	$49.95	512 kbps/128 kbps	$299 (special promo: $249)	$179.95 (special promo: free)	Threshold: 7,500 MB/2,300 MB[112]
	Select Pak	$69.96	1.0 Mbps/200 kbps			Threshold: 12,000 MB/3,000 MB[113]
	Pro Pak	$79.95	1.5 Mbps/256 kbps			Threshold: 17,000 MB/5,000 MB

[112] A threshold is the amount of data a user can upload/download within a 30-day period before WildBlue's fair access policy may reduce his or her speed.
[113] A threshold is the amount of data a user can upload/download within a 30-day period before WildBlue's fair access policy may reduce his or her speed.

Table 45: Wireless Internet Providers

Provider	Package	Price per month	Data Capacity	Miscellaneous
AT&T	DataConnect	$60.00	5GB per month	
Sprint	Mobile Broadband Connection Plans	$59.99	5GB per month	Or 300 MB per month for off-network roaming
Verizon	Wireless Internet Plan	$59.99	5GB per month	$0.25 per MB over allowance Average download speeds of 600 Kbps – 1.4 Mbps Average upload speeds of 500 Kbps – 800 Kbps. $35 activation fee
		$39.99	50MB per month	
Alltel	Wireless Internet Plan	$59.99 - $69.99	3.1Mbps per month	
	WiFi	$69.99		74 locations in San Francisco
T-Mobile	HotSpot[114]	$19.99		92 locations in San Francisco

114 Only available for nationwide plans priced at $39.99 or higher.

10.1.2. Video Providers and Products

Astound and Comcast are the cable systems operating in San Francisco. They offer analog and digital packages as well as a number of premium services. The basic and digital packages are summarized in Table 46 and Table 47.

Table 46: Comcast Residential Cable Television Packages[115]

Package	Basic Channels	Digital Channels	Music Channels	Premium Channels	Monthly Price
Broadcast Basic (analog)	24	0	0	0	$17.99
Standard Basic (analog)	71	0	0	0	$55.99
Digital Starter	0	47	45	0	$56.99
Digital Preferred with Starz	Includes Digital Bronze	69	45	1	$86.59
Digital Preferred Plus	Includes Digital Bronze & Silver	116	45	2	$104.94
Digital Premier	All channels are included (over 100)				$119.94
Broadcast HD	0	5	0	0	Free w/Digital Basic
HDTV	0	8	0	0	$7
Movie HD	0	0	0	4	Free with subscription
Sports PPV	0	0	0	6	Separate fee for each event

[115] Data obtained from http://www.comcast.com/default.html, accessed Aug. 4, 2008.

Table 47: Astound Residential Cable Television Packages[116]

Package	Basic Channels	Digital Channels	Music Channels	Premium Channels	Monthly Price
Limited Cable (analog)	Local channels	0	0	0	$21.95
Basic (analog)	Limited plus 62	0	0	0	$49.95
Enhanced Basic	Basic plus Free TV on Demand, free digital receiver	0	45	0	$52.95
Digital Basic Pack	Includes, Limited, Digital Access, On Demand, PLUS, Digital Basic	23	45	0	$57.50
Digital Cable Pack	Includes Limited Basic, Digital Access, On Demand, PLUS and Digital Sports	+12	45	0	$70.95
Bronze Pack	Digital plus Showtime Premium Movie Pack	+20	45	1	$75.95
Silver Pack	Bronze plus either Cinemax, Starz/Encore and HBO	+13 Cinemax +15 Starz/Encore +14 HBO	45	2	$87.50
Gold Pack	Bronze plus two premium channel packs	See above	45	3	$100.50
Platinum Pack	Bronze plus three premium channels		45	4	$110.95
Broadcast HD	0	5	0	0	Free w/Digital Basic
HDTV		20			$10
Movie HD	0	0	0	4	Free w/subscription
Foreign Language Channels	0	11 plus 13 Spanish Language Stations	0	0	Separate fee for each channel

Cable providers offer Internet and phone services along with cable television -- the pricing for which is summarized in Section 10.1.1.

[116] Data obtained from www.astound.com, accessed September 5, 2008.

There are 41 competing off-the-air channels at no cost- many of which offer uncompressed HD broadcasts. Table 48 lists the off-the-air channels that are available in San Francisco.

Table 48: Off-the-Air Television Channels[117]

Station	Channel No.	Channel Name
FOX	2.1 (56)	KTVUDT
FOX	2.2 (56)	KTVUDT2
MNT	4.1 (57)	KRONDT
MNT	4.2 (57)	KRONDT2
CBS	5.1 (29)	KPIXDT
ABC	7.1 (24)	KGOHD
ABC	7.2 (24)	KGODT2
PBS	9.1 (30)	KQEDHD
PBS	9.2 (30)	Encore
PBS	9.3 (30)	World
PBS	9.4 (30)	Life
PBS	9.5 (30)	Kids
NBC	11.1 (12)	KNTVDT
NBC	11.2 (12)	KNTVDT2
NBC	11.3 (12)	KNTVDT3
UNI	14.1 (51)	KDTVDT
IND	20.1 (19)	KOFYDT
AZT	20.4 (19)	KOFYDT4
PBS	22.1 (23)	KRCBDT
PBS	22.2 (23)	KRCBDT2
IND	26.1 (27)	KTSFDT
IND	33.1 (33)	KMTPDT
IND	36.1 (52)	KICUDT
IND	36.2 (52)	KICUDT2
SAH	38.1 (39)	KCNSDT
PBS	43.1 (43)	KCSMDT
PBS	43.2 (43)	KCSMDT2
CW	44.1 (45)	KBCWDT
IND	47.1 (47)	KTLNDT
TEL	48.1 (49)	KSTSDT
TEL	48.2 (49)	KSTSDT2
IND	50.1 (54)	KFTYDT
PBS	54.1 (50)	KTEHHD
PBS	54.2 (50)	KTEHVMe
PBS	54.3 (50)	KTEHDT
SAH	64.1 (62)	KTFKDT
ION	65.1 (41)	KKPXDT
Qubo	65.2 (41)	
ION Life	65.3 (41)	
Worship	65.4 (41)	
TFA	66.1 (34)	KFSFDT

[117] Data obtained from http://www.titantv.com/quickguide/quickguide.aspx, accessed October 22, 2008.

DirecTV and Dish Network offer cable television packages over satellites. Table 49 and Table 50 present a summary of the provider's pricing.

Table 49: DirecTV Cable Television Packages[118]

Package	Price Per Month	CPE	Installation	Miscellaneous	Add-ons per month
Basic	$ 9.99	Receiver $5 each (waived for first one)	Free (up to 4 rooms) Handling free ($20 value) HD/DVR receiver upgrade free ($99 value)		HD programming $9.99
Preferred Choice	$ 19.99				
Family	$ 29.99			Purchase of 18 consecutive months (24 months for advanced receivers) of any DirecTV base programming package ($29.99/mo. or above) or qualifying international services bundle required.	
Choice	$ 34.99			Purchase of 24 consecutive months (without interruption) of any DirecTV base programming package ($29.99/mo. or above) or qualifying international services bundle within 30 days of equipment lease. Offer valid for leased equipment only.	
Choice Extra	$ 39.99				
Plus DVR	$ 44.99				
Choice Extra plus HD	$ 49.98				
Plus HD DVR	$ 54.99				
NFL Sunday Ticket	$ 299.96 or four monthly payments of $74.99				
Lo Maximo (Spanish)	$ 104.99				

Local channels are also available over DirecTV and are included in the above packages. Premium channels can also be purchased individually for the prices listed in the table.

Table 50 presents a summary of Dish Network's pricing. The network also charges a set-up fee. Local channels are also available over Dish Network for an additional fee per month.

[118] Data obtained from http://www.directv.com/DTVAPP/index.jsp, accessed August 4, 2008.

Table 50: Dish Network Cable Television Packages[119]

Package	Price Per Month	CPE	Installation	Miscellaneous	Add-ons per month
Turbo HD Bronze	$24.99			Activation fee waived with 24-month commitment IR to UHF Pro Upgrade Kit - $39.99 Phonex Easy Jack - $39.00 Extra remote - $19.99 Activation fee waived with 24-month commitment IR to UHF Pro Upgrade Kit - $39.99 Phonex Easy Jack - $39.00 Extra remote - $19.99	Add-ons: Bronze HD - $10.00 Platinum HD- $10.00 Latino - $13.99 Latino Max HD Essential - $10.00 Latino Max HD Ultimate - $20.00 HBO - $14.99 Cinemax - $12.99 Showtime - $12.99 Starz - $12.99 Playboy - $14.99 2 movie packages - $22.00 3 movie packages - $31.00 4 movie packages - $40.00 5 movie packages - $50.00 DVRs available for rent
Turbo HD Silver	$ 32.99				
Turbo HD Gold	$ 39.99				
Dish Family	$ 19.99				
America's Top 100	$ 32.99				
America's Top 100 Plus	$ 37.99				
America's Top 200	$ 44.99				
America's Top 250	$ 54.99				
America's Everything Pak	$ 94.99				
Dish Latino	$ 27.99				
Dish Latino Plus	$ 32.99				
Dish Latino Dos	$ 39.99				
Dish Latino Max	$ 49.99				
Arabic Elite Super Pak	$ 44.99				
Chinese Wall	$ 32.99				
Greek Antenna Plus Ert	$ 32.99				
Polish Superpak	$ 39.99				
Brazil Elite Pak	$ 44.99				
Russian Mega Pak	$ 32.99				

10.1.3. Voice Providers and Products

10.1.3.1. Wireline Voice

AT&T is the Incumbent Local Exchange Carrier (ILEC). They offer communications services to residences, small businesses, and large businesses. Their residential services include local and long distance, Internet, and wireless cellular telephone service through a partnership with AT&T, Wireless. AT&T also offers complete network solutions for small and large businesses and wholesalers. Voice packages offered by AT&T are provided in Table 51.

[119] Data obtained from http://www.dishnetwork.com/, accessed August 5, 2008.

Table 51: AT&T Residential Voice Packages[120]

Service	Package	Monthly Price	Features
Local	Complete Choice	$26.00	Unlimited local calling; $40 activation fee, 14 phone features
	All Distance Select	$40.00	Unlimited long distance, 13 phone features
	Unlimited Flat Rate[121]	$10.94	Unlimited local calling no phone features

Astound and Comcast offer phone services over their HFC networks and their plans are summarized in Table 52 and Table 53.

Table 52: Comcast Cable Voice Services[122]

Plan	Price per Month (single line/double line)	Equipment/ Charges/Installation	Additional Features (charges apply)
Unlimited (for existing customers also subscribing to TV and Internet)	**$39.95[123]/$49.95**	• **Modem Lease fee: $3.00 for two lines** • **$5.00 for 4 lines** • **Installation: $99 per event** • **Service activation: $29.95 per event** • **Reconnect charge: $27.99 per event**	• **International Rates** • **Directory listing(s)/non-listing(s)** • **Additional line calling features**
Unlimited (for existing customers also subscribing to TV or Internet)	**$44.95/$54.95**		
Unlimited (for phone service only)	**$44.95/$54.95**		

[120] http://www.att.com/gen/general?pid=11107, accessed September 5, 2008.
[121] Not available in all areas.
[122] Data obtained from http://www.comcast.com/MediaLibrary/1/1/About/PhoneTermsOfService/PDF/DigitalVoice/StatePricingLists/Washington/Washington%20pricing%20list.pdf, Residential Pricing List (Effective: July 01, 2008), Western Washington, Version 16, accessed August 6, 2008.
[123] Promotional price: $33.00 for first 12 months.

Table 53: Astound Cable Voice Services[124]

Plan	Price per Month (single line/double line)	Equipment/ Charges/ Installation	Additional Features (charges apply)
Everything Pack	**$49.95 $39.95 with cable or Internet**	**Professional Installation $19.95**	
Enhanced Super Saver Phone	**$29.95 $19.95 with cable or Internet**		**Add voice mail - $4.95 Add call waiting - $3.50**
Super Saver Phone	**$13.95**[125]		**Add voice mail - $4.95 Add caller ID - $6.95 Add call waiting - $3.50**
Flat Rate Phone Line	**$10.95**[126]		**Add voice mail - $6.95 Add caller ID - $6.95 Add call waiting - $3.50**

In addition to wireline and wireless voice services, Voice-over-Internet Protocol (VoIP) is quickly becoming a competitor in the voice communications industry. VoIP providers, such as Vonage, are offering low priced packages that do not distinguish between local and long distance. Vonage, for example, offers unlimited calling anywhere in the United States and Canada for $24.99 per month. Vonage and other VoIP providers do not require a presence in the community since it is an application that resides over the Internet. The user (customer) simply needs a high-speed Internet connection.

10.1.3.2. Wireless Voice

There are a number of cellular telephone providers with coverage in San Francisco, including:

- AT&T
- Nextel

[124] Data obtained from www.astound.com, accessed September 5, 2008.
[125] Includes local calls (zone 1 and 2) and 100 minutes of zone 3 calls.
[126] Includes local calls (zone 1 and 2). Other rated calls (zone 3, intraLATA, intrastate long distance and interstate long distance) are billed at a la carte rates.

- Sprint
- T-Mobile
- Verizon

Many of these packages do not distinguish between local and long distance calling, and pricing is based on the number of minutes used per month.

10.2 Existing High-Capacity Business Providers and Products

During the course of our research, we identified 15 service providers in the San Francisco area that offer a range of services from dark fiber connectivity to data transport services, with speeds that range from 1 Mbps to 40 Gbps. The high-capacity providers in San Francisco are summarized in Table 54. The data transport services can be broadly classified by the technology used as Dark Fiber, Ethernet services, Wavelength services, and Synchronous Optical Network (SONET) services. Individual providers tailor these services to a customer's requirements, such as bandwidth required and configuration needed. Competitors in each service area are discussed in the following sections. The existing competitors for Ethernet (100 Mbps to 1 Gbps), SONET (OC-1 to OC-192), and wavelength (2.5 Gbps, 10 Gbps and 40 Gbps) services are listed in Table 54.

Table 54: San Francisco Existing Competitors

Sr. No.	Carrier	Dark Fiber	Ethernet (Mbps)			SONET	Wavelength
			100	1000	10000		
1	Abovenet	YES	YES	YES	YES	SONET over Ethernet	2.5 Gbps and 10 Gbps
2	AireSpring	NO	NO	NO	NO	DS-1/E-1, DS-3, OC-3–OC-48	NO
3	At&t	NO	YES	YES	YES	OC-3/OC-12/OC-48/OC-192	2.5 Gbps and 10 Gbps
4	Cogent	NO	YES	NO	NO	NO	NO
5	Comcast	NO	YES	YES	NO	NO	NO
6	IP Networks	NO	YES	YES	NO	NO	NO
7	Global Crossing	NO	YES	YES	NO	DS-3, OC-3 to OC-48	2.5 Gbps and 10 Gbps
8	Level(3)	YES	NO	YES	YES	DS-1 to OC-192	2.5 Gbps, 10 Gbps, 40 Gbps
9	Masergy	NO	YES	NO	NO	OC-3	NO
10	Paetec	NO	YES	YES	NO	NO	NO
11	Qwest	NO	NO	NO	NO	NO	YES
12	Sprint	NO	YES	NO	NO	NO	NO
13	Time Warner	NO	YES	YES	YES	YES	YES
14	Verizon	NO	YES	YES	YES	DS-1 to OC-192	8 Mbps to 10 Gbps
15	XO	NO	YES	YES	NO	OC-3/OC-12/OC-48	1G, 2.5G, 10G, 10 GbE LAN PHY

The range of pricing offered by existing competitors in San Francisco is shown in Table 55. The table shows the monthly recurring charges for Ethernet, SONET, and Wavelength services. The non-recurring charge for the services would vary based on the distance of the customer location from the closest point-of-presence of the service provider.

Table 55: Pricing Comparison Table

Service	Bandwidth Range	Pricing		
		Low	High	Unit
Dark Fiber	Variable	$17,000	$35,000	per mile per fiber pair for 20 year lease
Ethernet	1 Mbps to 10000 Mbps	$1,210	$6,734	monthly recurring charge*
SONET	51.84 Mbps to 10 Gbps	$1,100	$27,000	monthly recurring charge*
Wavelength	1.25 Gbps to 10 Gbps	$7,000	$62,800	for a 20-mile circuit

* Excludes non-recurring charge

10.2.1. Dark Fiber Services

Two service providers in San Francisco offer dark fiber services: AboveNet and Level 3.

AboveNet serves both national and local customers. Dark fiber can be leased by the month or procured using an Indefeasible Right of Use (IRU) for 20 years. Dark fiber lease costs approximately $2,500 per mile per fiber pair per month; a 20-year IRU[127] would be approximately $17,000 to $20,000 per mile per fiber pair. The fiber map showing the route of AboveNet fiber in San Francisco downtown and Bay are is available on their website and can be accessed at http://www.abovenet.com/products/maps2/index.html.

Level 3 Intercity Dark Fiber serves national customers as well as local ones. It charges approximately $30,000 to $35,000 per mile per fiber pair as part of a 20-year IRU. San Francisco is one of Level 3's Metro Dark Fiber markets. Level 3 is collocated at 37 neutral collocation sites in San Francisco. It is present in 30 carrier hotels and serves 47 ILEC Central Offices. Level 3 also provides collocation services; the pricing is typically a non-recurring charge of $2,200 and monthly recurring charge of $990 for a standard 19 inch 42-RU (rack unit) cabinet with a 20 amp power feed.[128] Level 3's Intercity and Long Haul dark fiber route in San Francisco is available on their website which can be viewed using their interactive map at http://www.level3.com/interacts/map.html.

10.2.2. Ethernet Services

Thirteen of the 15 providers offer Ethernet services with bandwidths ranging from 1 Mbps to 10000 Mbps (10 Gbps). The carriers who provide these services in the San Francisco region are: AboveNet, AT&T, Cogent, Comcast, IP Networks, Global Crossing, Level 3, MASERGY, Paetec, TW Telecom, Verizon, and XO Communications. Prices depend on the bandwidth, network configuration (i.e., point-to-point or point-to-multipoint), and whether the service is protected or unprotected, switched or mesh structure, or dedicated configuration.

AboveNet's Ethernet service is offered as a managed service at a bandwidth of 1 Gbps and 10 Gbps over a dedicated pair of fibers in the metro region. The 1 Gbps point-to-point Ethernet

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[127] http://www.abovenet.com/about/, accessed August 5, 2008.
[128] http://www.level3.com/brochures/e_brochures/Intercity_Dark_Fiber_e_brochure.pdf, accessed August 5, 2008.

service typically carries a monthly recurring charge of $5,565 to $6,734 for a three-mile circuit.[129]

AT&T has four different types of Ethernet products -- GigaMAN, DecaMAN, Opt-E-MAN, and EPLS-MAN. GigaMAN provides a native rate interconnection of 1 Gbps between customer end points. AT&T uses Coarse Wavelength Division Multiplexing (CWDM) to carry the traffic between end points; the handoff can be either single-mode or multi-mode fiber. DecaMAN connects the end points at 10 Gbps and is delivered over a wavelength division multiplexing system as well. The data is transmitted in native Ethernet format similar to GigaMAN, only 10 times faster. Opt-E-MAN service provides a switched Ethernet service within a metropolitan area. It supports bandwidths ranging from 1 Mbps to 1000 Mbps, and configurations such as point-to-point, point-to-multipoint, and multipoint-to-multipoint. A typical 100 Mbps Opt-E-MAN service would have a non-recurring price of $1,630 and monthly recurring price of $1,210 to $1,850 for a period of approximately one year. Similarly, a typical 1000 Mbps Opt-E-MAN service carries a non-recurring charge of $1,780 and a monthly recurring charge of approximately $2,040 to $3,540. The Ethernet Private Line Service-Metropolitan Area Network (EPLS-MAN) is a point-to-point, fixed-bandwidth Ethernet transport service within a metropolitan area, and is available at speeds ranging from 50 Mbps to 1 Gbps. The Ethernet data in this case is transmitted using SONET technology. For Gigabit Ethernet service, customers can choose from 50 Mbps, 300 Mbps, 600 Mbps, or 1 Gbps and have the option of single mode or multimode hand-off. For Fast Ethernet service, one can choose from 50 Mbps or 100 Mbps with electrical hand-off.[130] A fifth Ethernet service offered by AT&T is the Ultravailable Managed OptEring, which leverages the Resilient Packet Ring (RPR) SONET technology to provide optical Ethernet service supporting any-to-any LAN or MAN connection. Businesses can also get Internet access through this configuration. This technology is interoperable with Dense Wavelength Division Multiplexing (DWDM) technology and can support a mix of Time Division Multiplexing (TDM) technology as well as packet technology.[131]

Cogent has an extensive IP network globally. The two popular Ethernet products offered by Cogent are 100 Mbps Fast Ethernet and 200 Mbps Gigabit Ethernet solutions. Cogent is present at six data centers in San Francisco and is collocated with other providers such as Level 3.

Comcast offers the Ethernet Private Line and Ethernet network service products ranging to speeds up to 1 Gbps. The Ethernet Private Line is a point-to-point Ethernet service with dedicated Layer 2 capacity and the Ethernet network service is a switched Ethernet service between the desired locations. The switched Ethernet service allows exchange of VLAN configurations between customer locations and use of Class of Service (CoS).

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[129] http://www.abovenet.com/products/transport-metroenet.html, accessed August 5, 2008.

[130] http://www.business.att.com/service_overview.jsp?repoid=Product&repoitem=w_ethernet&serv=w_ethernet&serv_port=w_data&serv_fam=w_local_data&state=California&segment=whole, accessed August 5, 2008.

[131] http://www.business.att.com/enterprise/Family/eb_access_and_local_services/eb_ultravailable_managed_optering_service/, accessed June 4, 2008.

IP Networks, Inc. (IPN) operates a 400-mile optical fiber network throughout the San Francisco Bay Area. IPN's fiber network is installed in the existing electrical utility conduit system. The network is diverse from the existing ILEC networks as the fiber route is completely different. IPN's Metro Ethernet Transport Services provides bandwidth from 1 Mbps to 1,000 Mbps. The Metro Ethernet service uses MPLS-based Layer 2 Ethernet over fiber to connect customer locations. It is present in seven data centers in San Francisco.[132]

Global Crossing offers Ethernet service over SONET, WDM, or using MPLS. Its product, Ethersphere, provides point-to-multipoint and any to any services from 1 Mbps to 1000 Mbps, and is available globally. It offers another product, Etherline, which provides point-to-point services between its point-of-presence or between its POP and customer location, and speeds of 10, 100, and 1000 Mbps. The Bespoke Ethernet service product is where fiber is constructed by Global Crossing to the desired customer premises and uses either SONET or wavelength based on the customer requirements to transport its Ethernet data.[133]

Level 3's Ethernet Virtual Private Line (VPL) is offered in speeds ranging from 1 Mbps to 1 Gbps. It is an end-to-end Layer 2 switched Ethernet service delivered via a Multi-protocol Label Switched (MPLS) backbone. Fast Ethernet (FastE) and Gigabit Ethernet (GigE) interfaces are available, with virtual circuit bandwidths up to 600 Mbps in 1 Mbps, 10 Mbps, and 50 Mbps increments. Customers can allocate bandwidth by application, prioritize traffic into two different Classes of Service, and provision Virtual Circuits in point-to-point and hub-and-spoke configurations. The Level 3 Metro Ethernet Private Line and the Intercity Ethernet Private Line solutions provide Ethernet over SONET (EoS) service. Different bandwidths can be chosen in the Metro region with capacities ranging from 3 Mbps to 1000 Mbps and intercity service from 50 Mbps to 1000 Mbps. The backbone SONET ring is protected; however, the handoff to the customer is not.[134]

MASERGY's Intelligent Transport service carries Ethernet traffic, supports speeds of 1.5 Mbps to OC3, and is available nationally and internationally. [135]

Paetec has a national IP network over which it offers Ethernet services using MPLS. Target customers include those currently on Frame Relay or ATM circuits.[136]

Qwest provides point-to-point and point-to-multipoint service configurations for native Ethernet service over a pair of fibers to the customer's location. Speeds of 5 Mbps to 1 Gbps are offered over a meshed Ethernet network. The solution is based on a shared transport data bandwidth. A

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[132] http://www.ipnetworksinc.com/solutions/ethernet, accessed October 22, 2008.
[133] http://www.globalcrossing.com/enterprise/managed_ethernet/managed_ethernet_landing.aspx, accessed August 6, 2008.
[134] http://www.level3.com/brochures/e_brochures/Metro_Ethernet_Private_Line_e_brochure.pdf, accessed August 5, 2008.
[135] http://www.masergy.com/solutions_IntelligentTransport.htm, accessed March 19, 2008.
[136] http://www.paetec.com/data/mpls_vpn_overview.html, accessed August 5, 2008.

protected OC-12 SONET circuit is priced by Qwest at a non-recurring charge of $7,600 and a monthly recurring charge of $7,000 for a period of one year.[137]

Sprint offers Ethernet private line service called SprintLink Packet Private Line on an IP-network. Using Layer 2 Tunneling Protocol Version 3 (L2TPv3) technology, SprintLink PPL locks data between sending and receiving ports.

Time Warner (TW) offers Metro Ethernet with the choice of dedicated full-duplex 2 Mbps to 10 Gbps Ethernet service. Protected and Unprotected configurations are available.[138] Time Warner's office is located at 501 Second Street, Ste 200 in the city where it houses its staff that serves the San Francisco metro market. TW telecom owns a fiber network with approximately 26,000 route miles and has a 10 Gbps IP backbone nationally.[139]

Verizon offers Ethernet services under three different product categories -- Ethernet LAN, Ethernet Private Line, and Ethernet Virtual Private Line. The Ethernet LAN is a multipoint-to-multipoint bridging service at native Local Area Network (LAN) speeds. It is configured by connecting customer User Network Interfaces (UNIs) to one multipoint-to-multipoint Ethernet Virtual Connection or Virtual LAN (VLAN), and provides two Class of Service options -- standard and real time. The Ethernet Private Line is a managed, point-to-point transport service for Ethernet frames. It is provisioned as Ethernet over SONET (EoS) and speeds of 10 Mbps to 1 Gbps are available. The Ethernet Virtual Private Line (EVPL) is an all-fiber optic network service that connects subscriber locations at native LAN speeds; EVPL uses point-to-point Ethernet virtual connections (EVCs) to define site-to-site connections. It can be configured to support multiple EVCs to enable a hub and spoke configuration and supports bandwidths from 1 Mbps to 1000 Mbps.[140]

XO Communications offers Ethernet services at four different speeds -- 10 Mbps, 100 Mbps, 1 Gbps, and 10 Gbps (LAN/WAN PHY). The services support copper, single mode, and multimode interfaces.[141]

10.2.3. SONET Services

Nine of the 15 providers offer data transport using Synchronous Optical Networking (SONET) Technology. SONET services are available in speeds ranging from Optical Carrier-1 (OC-1) to OC-192, which is from 51 Mbps to 10 Gbps.

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[137] http://www.qwest.com/largebusiness/enterprisesolutions/products/ethernet/moe.html, accessed August 5, 2008.
[138] http://www.twtelecom.com/Documents/Resources/PDF/MarketingCollateral/2701NativeLAN.pdf, accessed August 5, 2008.
[139] http://www.twtelecom.com/cust_solutions/carrier.html, accessed October 21, 2008.
[140] http://www.verizonbusiness.com/products/data/ethernet/, accessed August 5, 2008.
[141] http://www.xo.com/carrier/transport/Pages/ethernet.aspx, accessed August 5, 2008.

AboveNet has an extensive Dense Wavelength Division Multiplexing (DWDM) network nationally and uses wavelengths to carry SONET traffic. The SONET services are priced in the same manner as the wavelength services.[142]

AireSpring is primarily a voice company and offers SONET services to carry mainly voice traffic and some data ranging from DS-1 to OC-48 over its fiber network.

AT&T's Dedicated SONET Ring Service (DSRS) provides a customized, dedicated self-healing ring network for two or more customer locations. The ring, with bandwidth levels of OC-3, OC-12, OC-48, or OC-192, supports voice, video, and data via DS-1 and higher interfaces. The ring architecture, including sub-rings, is designed to provide increased reliability and functionality. Dedicated SONET Ring Service provides Automatic Protection Switching which increases the availability of the services on the ring. The cost for an OC-12 DSRS network is approximately $1,325 to $1,350 per mile. AT&T also offers the Self-healing Transport Network (STN), which is an optical fiber service connecting two or more access nodes using optical fiber in a dual-ring structure. STN provides transport of various transmission bandwidths, allowing the use of voice, data, and video service on a single platform serving numerous locations. STN service includes self-healing characteristics, multiplexing, performance monitoring, and network supervision. AT&T's third SONET service, ACCU-Ring®, provides a reliable, cost-effective solution for customers that are spread out in many locations. ACCU-Ring® is a private network backbone that uses a dedicated high-speed fiber ring to carry all of a customer's network traffic. ACCU-Ring® service accommodates private line, switched, and enhanced services to carry local and long distance voice, data, and video traffic.[143]

Global Crossing offers SONET/SDH self-healing rings which employ four-fiber bidirectional line switched rings (BLSR). Customer access options include local loop, PoP interconnection, and metro service. The company offers bandwidths from DS1 to OC-48 over its global network, and targets more customers looking for international connectivity.

The Level 3 Metro Private Line service uses redundant local SONET rings to move data traffic between customer end points. The service supports speeds of DS-1 (1.544 Mbps), DS-3 (45 Mbps), OC-3 (55 Mbps), OC-12 (155 Mbps), OC-48 (2.5 Gbps), and OC-192 (10 Gbps). The transport can be in a point-to-point, hub, or Private Dedicated Ring (PDR) configuration depending on the customer's needs. The Level 3 Private Dedicated Ring (PDR) configuration provides a protected SONET service offered at ring capacity speeds of OC-48 (2.5 Gbps) or OC-192 (10 Gbps). The SONET equipment is dedicated for the customers' use and is provisioned over the Level 3 Metro network. With the Private Dedicated Ring service, the customer can configure the drop side, or lower bandwidth circuit capacity, at each of the nodes on the ring to enter and exit the ring in increments ranging from DS-1 to OC-48 or 50 Mbps, 150 Mbps, 300 Mbps, 600 Mbps, and 1 Gbps for Ethernet interfaces. Level 3 Private Line Hub service provides point-to-point, dedicated high bandwidth private line connections between a major data

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[142] http://www.abovenet.com/products/transport-wdm.html, accessed August 5, 2008.
[143] http://www.business.att.com/service_fam_overview.jsp?repoid=ProductSub-Category&repoitem=eb_accuring_service&serv_port=eb_access_and_local_services&serv_fam=eb_accuring_service&segment=ent_biz, accessed August 5, 2008.

aggregation point and an end site. The Private Line Hub service allows a customer to aggregate private line traffic at a Level 3 point-of-presence, from metro and intercity sites, and provides a single, high-bandwidth private-line connection to another location.[144]

In the San Francisco region, MASERGY's Intelligent Transport supports only an OC-3 SONET circuit.[145]

Time Warner offers different services using SONET technology. The Native LAN or Metro-Ethernet services include speeds of DS-1, DS-3, OC-3, and OC-12, and act as an extension of the organization's Local Area Network.[146] The Dedicated High Capacity service includes speeds ranging from 1.5 Mbps to 10 Gbps.[147] Both services are available in different configurations, such as point-to-point, point-to-multipoint, and multipoint-to-multipoint.

Verizon Metro Private Line SONET Service provides SONET handoff at speeds of OC-3 (155 Mbps), OC-12 (622 Mbps), OC-48 (2.5 Gbps) and OC-192 (10 Gbps). Verizon offers various configurations such as concatenated (full bandwidth) services and channeled services, point-to-point, point-to-multi-point, linear, and protected path. Verizon's Dedicated SONET Ring (DSR) has dual-fiber, dedicated ring architecture. It can carry traditional voice, data, and video applications, and supports SONET interfaces, such as Ethernet, DS-1 access, and Trans-Multiplexing. DSR is available at OC-3, OC-12, OC-48, and OC-192 bandwidths.[148]

XO SONET service provides customers with a secure, high-capacity customized network. The ring architecture of the SONET services provides the security needed for high-bandwidth transmissions. Bandwidths of OC-3, OC-12 and OC-48 are supported with this service and point-to-point, point-to-multipoint, and multipoint configurations are available.[149]

10.2.4. Wavelength Services

Eight of the 15 providers offer data transport using wavelength services with speeds ranging from 2.5 Gbps to 10 Gbps.

AboveNet has an extensive DWDM network in the United States. Their Metro WDM service supports speeds of 2.5 Gbps and 10 Gbps. It supports protocols, such as Gigabit Ethernet and SONET.[150]

Wavelength services from AT&T can be purchased under the WaveMAN service, the Metropolitan Optical Ring (MON) Service, or the Ultravailable Network Service. WaveMAN

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144 http://www.level3.com/brochures/e_brochures/Metro_Private_Line_e_brochure.pdf, accessed August 5, 2008.
145 http://www.masergy.com/solutions_IntelligentTransport.htm, accessed March 24, 2008.
146 http://www.twtelecom.com/Documents/Resources/PDF/MarketingCollateral/2701NativeLAN.pdf, accessed August 5, 2008.
147 http://www.twtelecom.com/cust_solutions/services/ded_hi_capacity.html, accessed August 5, 2008.
148 http://www.verizonbusiness.com/us/products/data/ring/#dsr, accessed August 5, 2008.
149 http://www.xo.com/carrier/transport/Pages/privateline.aspx, accessed August 5, 2008.
150 http://www.abovenet.com/products/transport-wdm.html, accessed August 5, 2008.

service is a point-to-point data transport service for interconnecting to interLATA, interstate networks. The service uses a Coarse Wave Division Multiplexing (CWDM) signal over fiber, connects intraLATA networks to long-haul services, and provides interconnection handoffs of intraLATA SONET and Interexchange Carrier Optical Wave service at SONET interface levels of 2.5 Gbps and 10 Gbps. The MON Ring Service provides optical transport using Dense Wave Division Multiplexing (DWDM) technology in a dedicated ring configuration. The Ultravailable® Network Service (UVN) is a managed, custom Dense Wavelength Division Multiplexing (DWDM) or SONET-based solution. It provides the communication path between a customer's premises and the nodes of AT&T's POP/AT&T Local Network Services (LNS) or a third-party fiber provider's.[151]

Global Crossing offers wavelength services at 2.5 Gbps and 10 Gbps in unprotected, bidirectional point-to-point links. Global Crossing's EtherWave Service provides point-to-point Ethernet connectivity over a 10 Gbps wavelength.[152]

Level 3 Intercity Wavelength is a point-to-point, unprotected wavelength service at 2.5 Gbps and 10 Gbps. It supports speeds between DS-1 to OC-192 and 10 GigE and 40 Gbps waves.

Qwest wavelength service, termed "QWave," is a managed private point-to-point service delivered over a dense wave division multiplexing (DWDM) network. Qwest provides an end-to-end solution with a wide range of transport bandwidths, including 1 Gbps, 2.5 Gbps, and 10 Gbps. A single-path 1.25 Gbps wavelength is priced by Qwest at a non-recurring charge of $14,600 and a monthly recurring charge of $14,000 for a period of one year.[153]

Time Warner Telecom offers wavelength transport services under its Dedicated High Capacity service. It offers speeds of either 2.5 Gbps or 10 Gbps. This is available in a point-to-point configuration.[154]

Verizon's Dedicated Wavelength Ring Service (DWR) is a Layer 1 transport technology that allows protocol-independent transport over a single fiber pair and eliminates the need for layered networks. The ring architecture operates as a single network and allows easy addition and drop of channels at desired locations. DWR also supports a broad range of protocols, with bandwidths ranging from 8 Mbps to 10 Gbps. Verizon also offers different types of protection depending on the customer's network needs.[155]

XO wavelength services support bandwidths of 1 Gbps Ethernet to 10 Gbps Ethernet or 2.5 Gbps to 10 Gbps (protocol-independent). The protocol-independent (XO Clear Channel)

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[151] http://www.business.att.com/service_overview.jsp?repoid=Product&repoitem=w_wavelength&serv=w_wavelength&serv_port=w_data&serv_fam=w_local_data&state=California&segment=whole, accessed August 5, 2008.
[152] http://www.globalcrossing.com/carrier/carrier_wavelength.aspx, accessed August 6, 2008.
[153] http://www.qwest.com/largebusiness/enterprisesolutions/products/ethernet/qwave.html, accessed August 5, 2008.
[154] http://www.twtelecom.com/cust_solutions/services/ded_hi_capacity.html, accessed August 5, 2008.
[155] http://www.verizonbusiness.com/us/products/data/ring/#dwr, accessed August 6, 2008.

accommodates multiple protocols including Ethernet, Asynchronous Transfer Mode (ATM), SONET, and Frame Relay.[156]

10.3 Potential Competition for a Municipal Network

The following providers and services are likely to compete with any FTTP project resulting from this initiative:

- **Internet Access:**
  Comcast
  AOL
  AT&T
  EarthLink
  HughesNet
  Sprint
  Speakeasy
  Other National & Local Providers

In addition to high-speed Internet providers, another key source of Internet competition includes national and local providers who offer a low-priced dial-up service. The cost of Internet access over a new or enhanced network will be higher. Customers are unlikely to switch unless they perceive a higher value with a high-speed connection.

Digital Subscriber Lines (DSL) and cable modems offer reliable and cost-effective Internet access. DSL and cable modem service are currently available in many locations.

T1, frame relay, and ISDN access is currently available in some areas. HughesNet and other satellite based providers offer an Internet service that does not require use of a telephone line.

Use of WiFi[157] for delivery of retail Internet services for the residential and small business market has received much attention over the past three years. However, results have been disappointing. For example, EarthLink once viewed deployment of WiFi as fundamental part of their strategy to move away from a fledging dial-up ISP business. EarthLink's venture into WiFi was unsuccessful, and is now liquidating all their WiFi investments.

Discussions regarding the use of WiMAX have accelerated over the past year. Sprint is looking towards WiMAX as a key strategy for their next generation mobile data products. WiMAX does have potential for the delivery of high-speed Internet access -- to potentially compete with cable modem and DSL. However, is not a solution for organizations looking for the next level of speed and reliability.

- **High-Speed Data Connection:**
  Comcast
  AT&T
  HughesNet

Fixed wireless services offering multi-megabit connectivity across unlicensed radio spectrum are extending high-speed data services to locations not served by traditional copper or cable networks. Relatively inexpensive to deploy, many of the systems deployed are built by smaller entrepreneurs not associated with any of the larger

[156] http://www.xo.com/carrier/transport/Pages/wavelength.aspx, accessed August 6, 2008.
[157] Either privately or publicly owned.

incumbent service providers.

AT&T and other Competitive Local Exchange Carriers (CLECs) provide T1 and other connectivity services.

AT&T has expanded it's footprint of Ethernet based services in California. Although AT&T's Ethernet services address the capacity issue, they are very expensive.

- **Long Distance Telephone (primarily for large business users):**
  AT&T
  Sprint
  Wireless Providers
  Others

Large users of telephone services are likely to pursue or have already pursued discounted long distance services. Given the competition, long distance services are a commodity with low gross margins. In addition, the applicability of Internet-based long distance service is increasing due to vendor and technology developments. In the next few years, long distance will become a no-cost or bundled service.

- **Local Telephone:**
  AT&T
  Sprint
  Competitive Local Exchange Carriers
  Wireless Providers
  VoIP Providers

The incumbent telephone company is not the only competition for local telephone service. The capability and reliability of wireless services is increasing, and Personal Communications Service (PCS) providers have a long-term objective of becoming an alternative local telephone provider. Incumbent telephone providers have already seen a decrease in services due to wireless options. In 2005, wireless telephone usage surpassed traditional landline telephone service and continues to grow. Today it is estimated that one fifth of adults in the U.S. do not have a traditional landline telephone and rely on a wireless or Internet connection.[158] This phenomenon is not limited to young adults. Over half of adults who only use a cell phone are over the age of 30.

To compete with AT&T and other competitive service providers, new entrants will need to obtain a large local or low-cost call area, and number portability will be essential. Otherwise, if a new entrant's local calling area is restricted to the city limits, the competition will have a perceived advantage. During the registration process and negotiation of interconnect agreements with the Incumbent Local Exchange Carriers (ILECs); new entrants will need to address issues related to the local call area and number portability. The bundling of local and long distance telephone services, as well as wireless service in some areas, allows providers to become "one-stop" services for business and residential customers.

[158] The Harris Poll #36, April 4, 2008.

Many business and residential users are looking to new alternatives to traditional landline local telephone service. Alternative service providers, such as Vonage and Skype, provide voice services over the Internet. These VoIP offerings require a robust Internet connection and quality of service (QoS) to provide adequate voice communications.

- **Cable Television/Video:**

  DBS (Dish Network and DirecTV)
  DSL Providers
  Comcast/Astound
  IP Video Providers (CinemaNow, Movielink, etc.)

Comcast and Astound (RCN) operate two-way Hybrid Fiber Coax (HFC) systems. They offer a Broadcast Basic and Expanded Basic cable lineup, two digital tiers of cable service, and several additional digital services, such as HDTV, movie channels, pay per view, and music. They also provide digital video recording (DVR), video on demand (VOD), and cable modem service.

Direct Broadcast Satellite (DBS) offers an alternative to traditional cable television. With a smaller dish than its predecessors, aesthetics are not as strong an issue as in the past. The cost of DBS continues to decline. With digital quality, near video-on-demand, and newly introduced two-way Internet access, we expect DBS to increase its share of the cable television market.

The provision of video programming over DSL should be able to compete with traditional cable television. Some independent telephone companies have successfully offered cable television services over telephone networks. AT&T has entered the cable television market. In selected communities, they are using a DSL-based video product. AT&T is also a satellite reseller.

IP (Internet Protocol)-based video programming competes with video-on-demand (VOD) programming offered by traditional cable providers. This service is becoming more popular due to its flexibility and convenience for users. IP-based services, such as CinemaNow and Movielink, offer movies and video programming that are downloaded from the Internet. These services allow customers to watch the programming at times and places that are convenient for the user. Cable television VOD programming does not have the mobility advantage that an IP-based service offers, since customers of cable VOD must watch the programming on a television connected to the cable system.