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Improving the High Speed Internet Infrastructure in Santa Fe: Analysis of Potential Options

An Interactive Qualifying Project submitted to the faculty of the
Worcester Polytechnic Institute
in partial fulfillment of the requirements for the Degree of Bachelor of Science

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Abstract

The goal of the project was to research and recommend various options for upgrading the high speed Internet infrastructure in Santa Fe. After first recording and mapping information about the existing Internet infrastructure, we analyzed the current supply and potential demand for high speed Internet in Santa Fe. By surveying a sample of businesses, interviewing experts in the field, and reviewing existing information about construction activity, we explored options for upgrading the Internet infrastructure. The result of this work should assist the City of Santa Fe and its Telecommunication Advisory Committee in analyzing alternative solutions for future upgrades.

Executive Summary

As of 2010, 88 percent of Santa Fe County had access to wired Internet, with 63.5 percent of the population having a choice of three or more Internet providers.[1] Most Internet service is delivered through cable or DSL wires since there is limited access to fiber optic cable in Santa Fe. For local businesses in Santa Fe, Internet speeds range from 1.4 Megabits per second (Mbps) to 10.8 Mbps. The average Internet speed for New Mexico is below 4 Mbps, ranking it 45th among all states for the fastest speeds in America. Figure 1 is a graph that represents average connection speeds for downloading a 6 Gigabyte (GB) file in New Mexico, the United States, South Korea, and Worcester Polytechnic Institute (WPI).

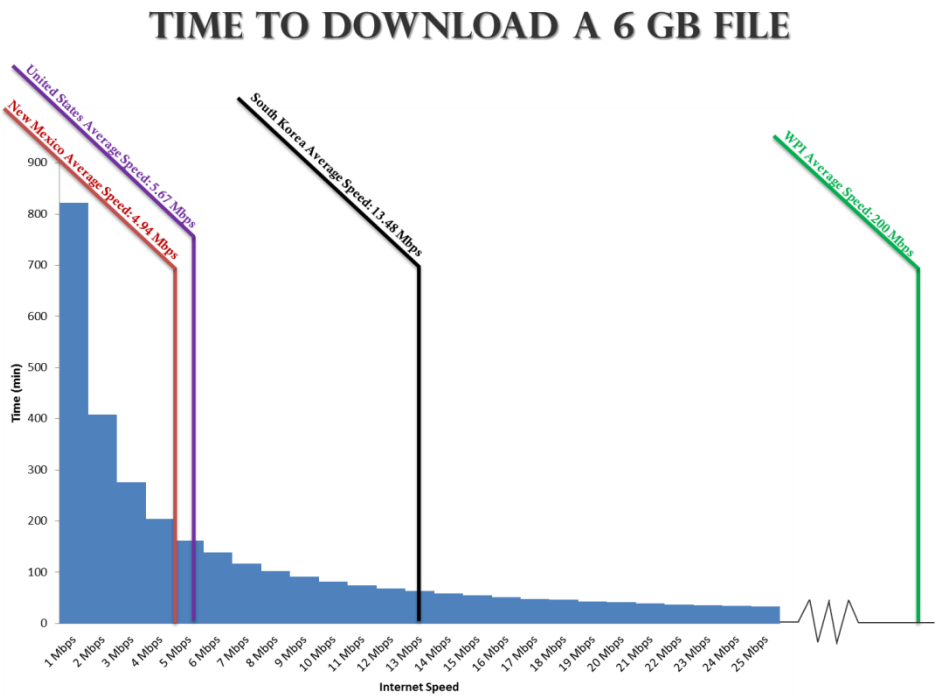

Figure 1: Download Times for Different Speeds with Relative Average Speeds

As illustrated, New Mexico significantly trails national and institutional averages for download speeds. Santa Fe is considered to be an "Info Mesa," a term coined to describe a high concentration of scientists who serve as a center for advanced technology. These scientists require faster Internet speeds for their work with vast amounts of information. In order to encourage more scientists to join the "Info Mesa," Santa Fe must provide the tools this scientific community requires, including high speed Internet access.

[1] (National Telecommunications and Information Administration 2010)

REDI Net, a government initiative fueled by the federal stimulus, recently was funded to bring faster Internet service to Northern New Mexico. This $10.6 million program will lay 150 miles of fiber optic cable, improving Internet connections for over 120 government institutions, schools, and hospitals. However, E-Cequia, the Santa Fe section of the REDI Net project, did not receive funding and therefore, Santa Fe remains without a proposed fiber connection.

The Economic Development Division (EDD), a subdivision of the Housing and Community Development Department of the City of Santa Fe, is interested in increasing Internet speeds to provide technologically dependent companies the resources needed to operate effectively. While there are three main fiber hookups for Internet connections, from Albuquerque and Rio Rancho, Los Alamos, and Lamy, fiber connection is still limited in the city. The goal of our project was to research and recommend the possible options for upgrading the high speed Internet infrastructure in the City of Santa Fe. This was accomplished by completing the following objectives:

1. To determine the current composition of the Internet infrastructure in Santa Fe
2. To identify the current and future high speed Internet demands
3. To provide possible options for the future of the Internet infrastructure

After speaking with experts in the field and gathering data about the location of fiber cables, we created a map on GIS Cloud. With the supply mapped, the current and future demand was established through survey responses from local businesses. We gathered information about their Internet service providers, connection speeds, overall satisfaction, and future needs. Once the need for an improved infrastructure was determined, we created a list of options to improve the Internet infrastructure. This list was evaluated against local business needs for speed, coverage, cost, and job creation.

With the City lacking a comprehensive map of all Internet infrastructure sites, we set out to create a map of the current infrastructure by piecing together information that we had uncovered. With large Internet service providers such as CenturyLink and Xfinity keeping their records confidential, there was no simple process to determine the exact locations of the infrastructure. Instead, experts in the field shared their proprietary information. Figure 2 shows the map of fiber optic cable

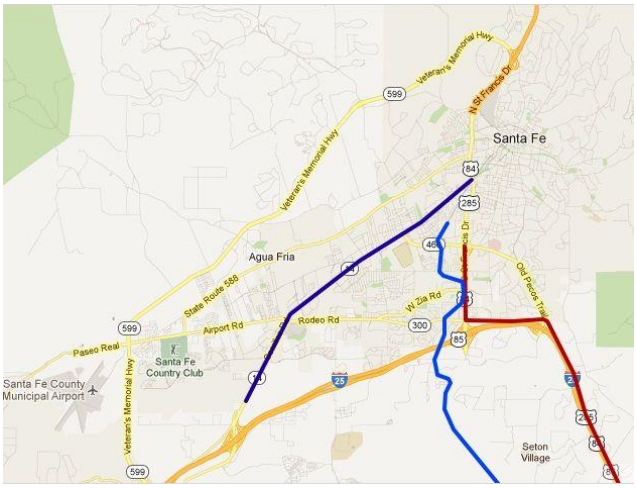

Figure 2: Underground Fiber in Santa Fe

located along Cerrillos Road that is owned by CenturyLink, as well as the fiber along the train tracks that belongs to Level 3 Communications. A field visit to ENMRs current dig site on St. Francis Drive unveiled the infrastructure that will be completed by June 2012, also shown in Figure 2.

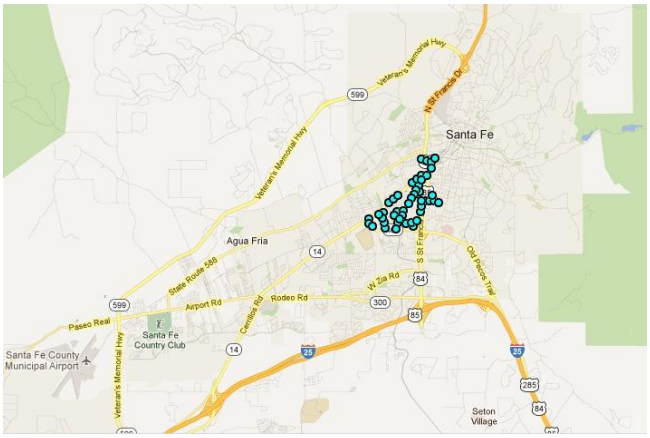

Figure 3: Above Ground Internet Markers

The next part of mapping the infrastructure involved an exhaustive cataloguing of the above ground fiber markers along the streets of a specific section of Santa Fe. As depicted in Figure 3, most of the markers indicated if they contained fiber or cable, along with the name of the company that owned it. Without these indicators, it was difficult to determine what each marker represented. Through tracking the coordinates of these markers, a tentative location of infrastructure was mapped.

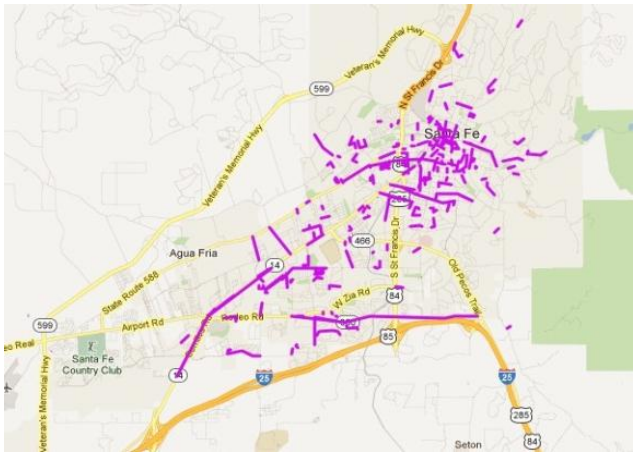

Figure 4: Street Cut Segments

The last part of the mapping effort involved street cut permits to determine more underground cable locations. Figure 4 is a map showing street cut segments. From these points, we selected only cable companies and mapped the locations of where the tentative infrastructure could be found.

Community Anchor Institutions, or CAIs, are schools, hospitals, and government buildings that can serve as hubs to which fiber can be connected and dispersed into the surrounding area. Figure 5 shows

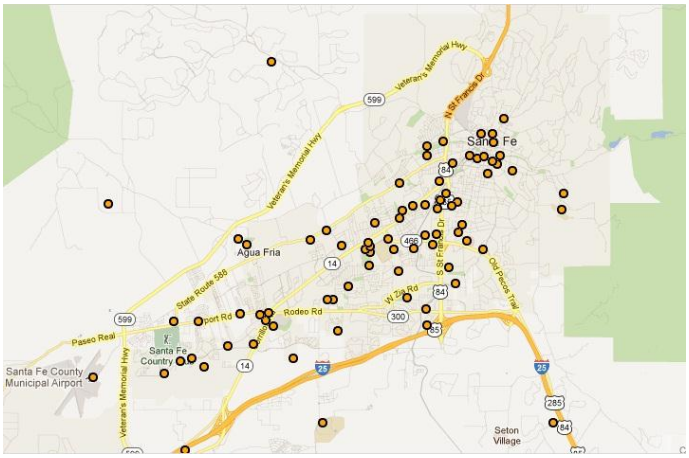

Figure 5: Community Anchor Institutions

140 CAIs throughout the city, currently without fiber optic Internet connection, that are potential locations for future high speed Internet. Along with these CAIs, businesses that require high speed Internet were pinpointed using the Chamber of Commerce business directory. Through surveys initiated with a total of 41 local businesses, we received six responses from the fields of Research, Insurance, Computer Services, Consulting, Accounting, and Marketing. Each provided insight into their Internet provider, connection speeds, cost, overall satisfaction, and future needs.

The information from these surveys indicated the existence of maximum connection speeds of 50 Mbps download and upload, and minimum speeds of 1.5 Mbps download and .007 Mbps upload. The cost per month for these services ranged from $65 to $3,200. In almost every case, higher speeds were needed either to increase business efficiency or to incentivize growth. The minimum desired download and upload speeds were 15 Mbps while the maximum desired download and upload speeds were100 Mbps. Although the sample size was small, it was apparent that higher Internet speeds could be beneficial for the City's economic development. Figure 6 identifies the current and future Internet demands of the businesses we surveyed.

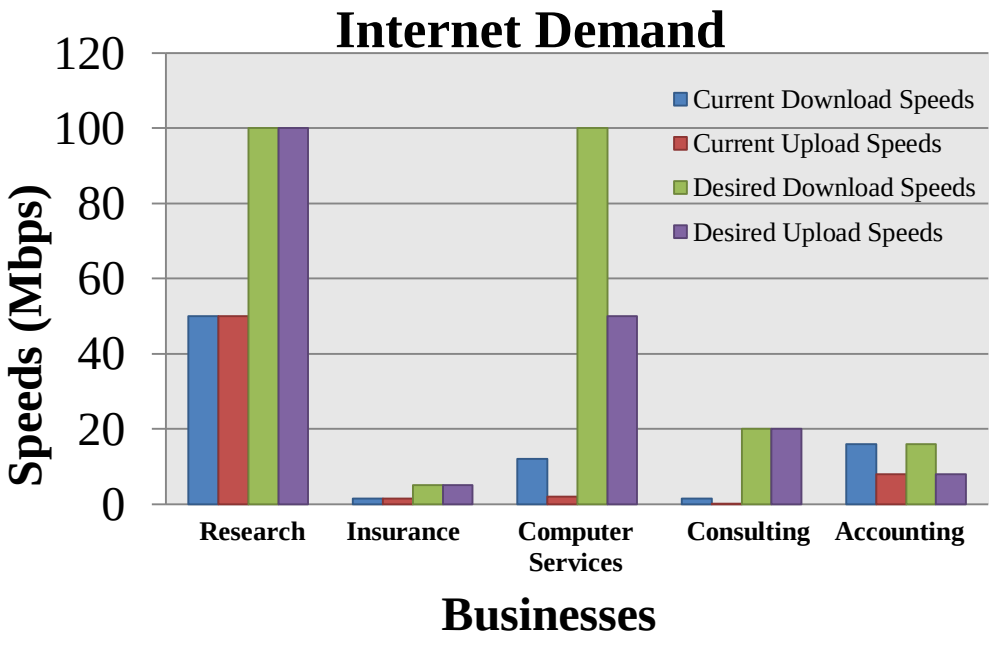

Figure 6: Surveyed Businesses Current and Future Internet Demands

With the demand for high speed Internet being apparent, we defined six options for the City to consider: Fiber to the Premise (FTTP), Fiber to the Node (FTTN), Fixed Wireless, Free Space Optics, Repeaters, and Doing Nothing. A comparison matrix was created to evaluate these options. Figure 7 is a matrix of variables that were used in the comparison of these options.

Categories	Jobs Created	Speeds Over 50 Mbps	Coverage Over 1 mile	ISP Participation	Inexpensive to Install
Do Nothing	✗	✗	✓	✓	✓
FTTP	✓	✓	✗	✓	✗
FTTN	✓	✓	✗	✓	✓
Repeaters	✓	✗	✗	N/A	✓
Free Space	✓	✓	✓	N/A	✗
Fixed Wireless	✓	✓	✓	✓	✓

Figure 7: Comparison of Each Infrastructure Upgrade Option

The option to keep the infrastructure as it currently exists today would not benefit the economy of Santa Fe. With the speeds of Internet constantly increasing and the demands for these speeds becoming ever present, there is pressure to compete by providing the most cost efficient high speed Internet to consumers and businesses. By undertaking one of these options, the City would be able to support faster speeds that, in turn, would be useful for satisfying the needs and demands of the surrounding area.

From the matrix in Figure 7, we observed that only Fixed Wireless satisfied all of the criteria. This Fixed Wireless signal is inexpensive to implement using existing antennae in the city. Certain Internet service providers, such as Cyber Mesa, stated that they would be willing to participate in a Fixed Wireless network in Santa Fe. Nearly half of the categories satisfied most of the options. Scores of N/A were applied in situations in which data were unknown, such as whether Internet service providers would participate in a free space optic network or install repeaters on streetlamps.

Finally, our analysis concluded with the evaluation of the concept of the Open Network, i.e. free Internet access. Essentially the opposite of a private network, the Open Network faces significant challenges, including difficulties surrounding control over the construction of the network and obstacles regarding how to manage the security risks inherent in an Open Network. For these reasons, our research focused on and recommendations were based on private network delivery.

The team trusts that the information provided will be of assistance to Santa Fe's Telecommunication Advisory Committee as it determines future actions regarding its Internet infrastructure.

Acknowledgments

We would like to thank the following individuals and organizations for their generous help and assistance during our project in Santa Fe. Without their help, this project would not have been as successful as it has been.

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1 Introduction

High speed Internet has increased the level of connectivity not only around the nation but also around the world. Today, two billion people are connected to the Internet, and together they transfer $8 trillion every year.[2] A 2010 study showed that South Korea has the fastest average Internet speed at 13.48 Megabits per second (Mbps), while the United States follows with average Internet speeds of 5.67 Mbps. The Northeast region of the U.S has relatively higher Internet speeds, with Massachusetts averaging 6.28 Mbps.[3] Worcester Polytechnic Institute, an educational institution whose engineering focus requires the highest quality Internet speed and capacity, rises far above that, with maximum speeds reaching 500 Mbps.[4] A 2010 U.S. population survey showed that 68 percent of households used broadband Internet, a form of high speed Internet.[5] In the past 12 years, broadband users in America have grown from 8 million to 200 million users, a 2,500 percent increase.[6] In 2009, the federal government funded a $7 billion grant to expand broadband cable across the United States.[7] This initiative coexisted with the National Broadband Plan, whose mission is to ensure that every American has access to broadband capability.

In 2010, most of the residents of New Mexico had Internet speeds below 4 Mbps.[8] For all of today's operations involving the Internet, the Federal Communications Commission (FCC) recommends a connection speed above 4 Mbps.[9] As of the 2nd quarter in 2011, New Mexico had an average connection speed of over 5.0 Mbps, a vast improvement over the prior average Internet speed of only 2.9 Mbps in 2007.[10] Recently, federal, state, and local officials in New Mexico had agreed to a project known as REDI Net, to bring faster Internet service to Northern New Mexico. Funded by federal stimulus dollars, this $10.6 million initiative will be used to lay 150 miles of fiber optic cable, improving Internet connection for over 120 government institutions, schools, and hospitals in Los Alamos, and Rio Arriba.[11] However, E-Cequia, the Regional Broadband initiative proposed by REDI Net in Santa Fe, was never funded and therefore, Santa Fe remains without the proposed fiber ring connection.

[2] (Pélissié du Rausas et al. 2011)
[3] (Akamai Technologies 2010)
[4] (Worcester Polytechnic Institute 2010)
[5] (Economics and Statistics Administration and National Telecommunications and Information Administration 2011, 72)
[6] (Federal Communications Commision 2012)
[7] (TRIP JENNINGS 2011, A.1)
[8] (Speedmatters.org 2012)
[9] (Federal Communications Commision 2012)
[10] (Akamai Technologies 2011, 3)
[11] (TRIP JENNINGS 2011, A.1)

In Santa Fe, there is limited access to fiber optic cable for the public sector.[12] Internet speeds range from 1.4 Mbps to 10.8 Mbps for local businesses.[13] The Economic Development Division (EDD), a subdivision of the Housing and Community Development Department of the City of Santa Fe, is interested in increasing Internet speeds to provide technologically dependent companies the resources needed to operate effectively. Most people are connected to the Internet with cable or DSL wires. While there are three main fiber hookups for Internet connections, from Albuquerque and Rio Rancho, Los Alamos, and Lamy, fiber connection is still limited in the city.[14]

As of 2010, 88 percent of Santa Fe County had access to wired Internet, with 63.5 percent of the population having a choice of three or more providers.[15] However, among all states, New Mexico is ranked 45th in fastest Internet speeds with the majority of states averaging speeds at least 1 Mbps faster. Santa Fe speeds have not increased enough compared to other state capitals such as Cheyenne, WY.[16]() A high speed Internet connection not only would allow for information to reach Santa Fe faster, but also would provide the City with a method to expand the private sector to increase revenue. There is a high concentration of scientists in the area and the City serves as a center for advanced technology, an "Info Mesa." This term was coined by author and educator Ed Regis, depicting the emerging technology-based companies and community in Santa Fe.[17] The lack of availability of fiber optics is hindering Santa Fe's growth and its ability to attract larger companies that require a higher level of broadband.

The goal of the project was to research and recommend the possible options for upgrading the high speed Internet infrastructure in Santa Fe. This was accomplished by mapping the existing Internet infrastructure in Santa Fe, concentrating on creating a physical map of the infrastructure for future records. We collected data about the demand for Internet services from businesses in Santa Fe through surveys. We gathered information about their Internet service providers, connection speeds, overall satisfaction, and future needs. With demand for higher speeds apparent, a list of options was prepared for the potential infrastructure upgrade. These options were evaluated and compared using variables specific to its installation within the City of Santa Fe. The information gathered through this project can assist the City in determining whether or not they should move forward with the project.

[12] (National Telecommunications and Information Administration 2010)
[13] (National Telecommunications and Information Administration 2010)
[14] (Clarke 2012, 1-1)
[15] (National Telecommunications and Information Administration 2010)
[16] (Speedmatters.org 2012)
[17] (Regis 2000, 7)

2 Background

Our project focused on the relationship between the Internet infrastructure and economic development within Santa Fe. A clear outline of the structure of the Internet on a national and global scale is provided in the background. The effects related to this economic development, including the Internet's effects on the economy and the Economic Development Division in Santa Fe, are included. The efforts to redevelop New Mexico and Santa Fe are also highlighted, mentioning the initiatives that are currently in the process of being completed.

2.1 The Structure of the Internet on a National and Global Scale

The **Internet** is an electronic communications network that connects computers, computer networks, and computer facilities worldwide using the standard Internet protocol.[18] This information can travel through underground pipes, over power lines, or wirelessly. To receive an Internet connection, an Internet Service Provider, or ISP, is required.[19] Internet service is supplied through the **Internet Backbone**, a high-speed line or series of connections that forms a major pathway within a network. The term is relative, as a backbone in a small network would likely be much smaller than many non-backbone lines in a large network.[20] Figure 8 shows an example of one company's Internet backbone. These

Figure 8: Internet Backbone

[18] (Merriam-Webster)
[19] (Enzer 2011)
[20] (Enzer 2011)

networks are usually all fiber. Many backbones around the country look similar to this one.[21]

Bandwidth and speed are similar terms expressing the transfer of data through cables. **Bandwidth** is the maximum capacity for data transfer of an Internet connection.[22] This differs from the speed of an Internet connection. **Speed** is the transfer rate of data. This means that your Internet speed can never be greater than your bandwidth and that an increase in bandwidth potentially can mean an increase in speed, yet this is not always true. Speeds can be described in terms of download and upload, measured in either kilobits per second (kbps) or megabits per second (Mbps).

Download speed is the rate of data transfer from another computer to your own computer.[23] High download speeds are important for activities such as streaming video, streaming music, and viewing images. Businesses that need high download speeds are the ones that draw heavily from the Internet. The following are businesses in these fields:

- Data Mining
- Education
- Media
- Graphic Design
- Investment Banking
- Cloud-Based Technologies
- Research Institutions

Figure 9 shows various download speed requirements for different Internet activities. Certain activities, such as sending email and instant messages, are not speed intensive. This is opposed to activities including watching video and sending medical transmissions, which require faster Internet speeds.[24]

Broadband Internet Speed Requirements

Application	Rate Required
Personal Communications, Instant Messengers	300 to 9,600 bits/sec or higher
E-mail transmissions	2,400 to 9,600 bits/sec or higher
Remote control programs	9,600 to 56 Kbits/sec
Digitized voice phone call	64,000 bits/sec
Database query	Up to 1 Mbit/sec
Digital audio	1 to 2 Mbits/sec
Access images	1 to 8 Mbits/sec
Compressed video	2 to 10 Mbits/sec
Medical Transmissions	Up to 50 Mbits/sec

Figure 9: Speed Requirements for Various Applications

[21] (Telecom Ramblings)
[22] (Enzer 2011)
[23] (Enzer 2011)
[24] (Salway 2012)

Upload speed is the rate of data transfer from your computer to another computer.[25] High upload speeds are important for posting pictures or videos on the Internet as well as sharing files. Businesses that need high upload speeds are ones that need to send a lot of information. These fields of business include:

- Media
- Data Mining
- Clinical Testing
- Cloud-Based Technologies
- Investment Banking
- Gaming
- Graphic Design

2.1.1 Broadband Internet

Broadband in its basic form commonly refers to high speed Internet access that is always accessible and faster than traditional dial-up access.[26] This means that it has a speeds around 1,000-11,000 kbps, which is faster than dial-up.[27] There are six types of broadband through which a user can gain access to the Internet. They are:

- Digital Subscriber Line (DSL)
- Cable Modem
- Fiber
- Wireless - Mobile and Fixed
- Satellite
- Broadband over Powerline (BPL)

DSL is a wireline transmission technology that transmits data over traditional copper telephone lines to homes and businesses. There are two types of DSL: Asymmetric DSL and Symmetric DSL. Asymmetric DSL, used primarily by residential consumers, typically provides faster download speed for receiving data than upstream speed for sending data. Symmetric DSL is intended to provide equal speed for sending and receiving data, and is standard for businesses that move large files among various users and between multiple sources.

Cable modem enables high speed Internet access using the cable television infrastructure, including coaxial cables that deliver cable TV programming. Users can access the Internet without disrupting TV signal.[28] These speeds are usually comparable to DSL.[29]

[25] (Enzer 2011)
[26] (Federal Communications Commision 2012)
[27] (Anonymous, 1)
[28] (National Telecommunications and Information Administration 2010)
[29] (Federal Communications Commision 2012)

Fiber optic technology converts electrical signals carrying data into light and sends the light through transparent glass fibers about the diameter of a human hair. It has the fastest connection speed, exceeding DSL and cable modem by tens of thousands of Mbps.[30] Figure 10 shows the different types of broadband Internet and their speed ranges and connection types. It is important to note that dial-up is not a broadband technology, but is shown for comparison purposes. Additionally, it shows that broadband Internet is much faster than dial-up, with fiber optic connections being extremely fast.[31](Salway 2012)

Broadband Technology and Speeds

Broadband Technology	Download Speed Range	Connection
Dial-up	Up to 56kbps	Phone Line
DSL	768 Kbps - 6 Mbps	Phone Line
Cable Modem	4 Kbps - 25 Mbps	Coaxial Cable
FiOS	up to 150 Mbps	Fiber

Figure 10: Internet Type Comparison

Wireless broadband connects a home or a business to the Internet using a radio link between the customer's location and the service provider's facility. The connection can be either mobile or fixed. Fixed Wireless requires two fixed locations, usually buildings connected by a wireless radio link, or a laser through a line of sight.[32]

Satellite broadband is another form of wireless broadband that is useful for customers in remote or sparsely populated areas. A few factors that affect satellite signal include the provider, the service package purchased, and the weather, as service can be disrupted in extreme weather conditions. A consumer should expect to have a download speed of about 500 kbps using this type of broadband.[33]

Broadband over Powerline (BPL) is the delivery of broadband over the existing low and medium voltage electric power distribution network. It can be provided to homes using existing electrical connections and outlets. BPL is an emerging technology that is only available in very limited areas. One benefit to BPL is the lack of need to build new facilities to accommodate new customers since power lines exist virtually everywhere.[34]

[30] (Federal Communications Commision 2012)
[31] (Salway 2012)
[32] (Federal Communications Commision 2012)
[33] (Federal Communications Commision 2012)
[34] (Federal Communications Commision 2012)

2.1.2 The Internet in Santa Fe

The City of Santa Fe supports a wide range of broadband Internet services including cable, copper, and DSL. 63.5 percent of the population has access to three or more providers in the area.[35] Some of the major providers are CenturyLink, Xfinity, and Eastern New Mexico Rural Telephone Cooperative (ENMR Plateau). Each provider owns partial sections of the communications infrastructure.

New Mexico ranks 45th in the nation in terms of Internet speed.[36] Figure 11 shows the speeds in New Mexico and the percentage of connected residents with those speeds. The majority of people at 58 percent have speeds of 4 Mbps or less, while only 5 percent of residents have the highest speeds between 10 – 25 Mbps. In the introduction, we stated that the average Internet speed in New Mexico was around 5.0 Mbps. In terms of national and international speeds, New Mexico lags by at least 1 Mbps. Figure 12 shows the download and upload speeds for each state.[37] New Mexico is one of six states that has an average download speed less than 4 Mbps. The United States has an average connection speed of 5.67 Mbps. In terms of state capitals, the City of Santa Fe has average speeds that are significantly lower than other state capitals, such as Bismarck, ND, or Cheyenne, WY, with download speeds of 3.06 and 3.86 Mbps respectively,

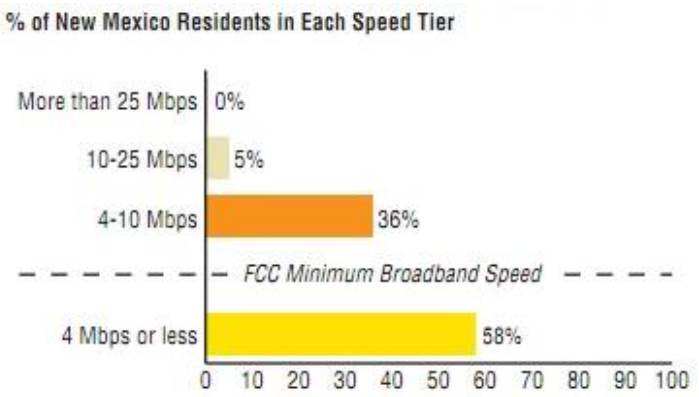


Figure 11: Percentage of Internet User Speeds

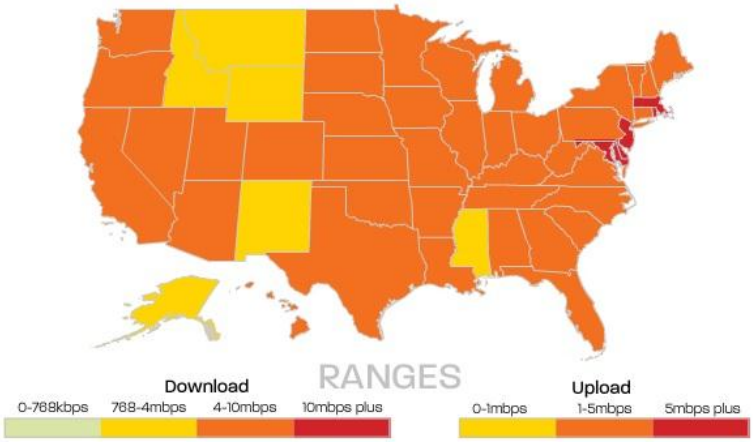
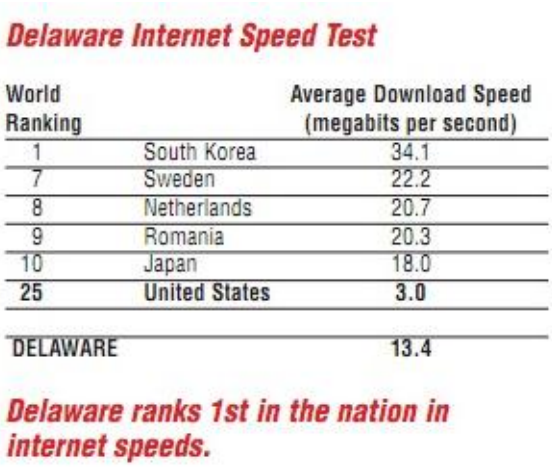


Figure 12: Internet Speeds by State

[35] (National Telecommunications and Information Administration 2010)
[36] (Speedmatters.org 2012)
[37] (Speedmatters.org 2012)

compared to Santa Fe, which has a download speed of 1.86 Mbps.[38] As shown in Figure 13, South Korea has the fastest download speeds at 34.1 Mbps. The United States averages a download speed of only 3.0 Mbps and an upload speed of 0.6 Mbps.[39]



Delaware Internet Speed Test

World Ranking		Average Download Speed (megabits per second)
1	South Korea	34.1
7	Sweden	22.2
8	Netherlands	20.7
9	Romania	20.3
10	Japan	18.0
25	**United States**	**3.0**
DELAWARE		13.4

Delaware ranks 1st in the nation in internet speeds.

Figure 13: World Ranking of Average Internet Speeds

2.1.3 Internet Service Providers in Santa Fe

As stated earlier, there are a variety of ISPs, also known as incumbent local exchange carriers and competitive local exchange carriers, or ILECs and CLECs that offer their services to customers in Santa Fe. The following is a list of those providers:[40]

- CenturyLink (formerly known as Qwest)
- Xfinity (also known as Comcast)
- Cyber Mesa Telecom
- Verizon Wireless
- AT&T
- Eastern New Mexico Rural Telephone Co. (ENMR)
- Oso Grande
- Paytec
- Level 3 Communications LLC
- Sierra Communications
- DIECA Communications, Inc.
- Frontier Navajo Communications
- La Jicarita Rural Telephone Cooperative
- Leaco Rural Telephone Cooperative

[38] (Speedmatters.org 2012)
[39] (Speedmatters.org 2012)
[40] (New Mexico Department of Information Technology)

These providers offer various Internet speeds, usually ranging from 3 Mbps to 50 Mbps**.** As compared to other parts of the country, these providers price their Internet services at higher rates. Figure 14 shows the prices of the Internet at different speeds in Santa Fe and Worcester. At low speeds, the two cities have similar prices, but at higher speeds the cost in Santa Fe increases at a faster rate.

Location	Company	Speed	Price (Non-cable, No phone)	Price
		12 Mbps	$29.95	$19.95
	Xfinity	20 Mbps	$72.95	$29.95
Santa Fe, NM		50 Mbps	$116.95	$99.95
	CenturyLink	1.5-3 Mbps	$29.99	$19.99
	Verizon	.5-1 Mbps	$24.99	NA
		1-3 Mbps	$39.99	NA
Worcester, MA		3 Mbps	NA	$19.99
		15 Mbps	NA	$29.99
	Charter	30 Mbps	NA	$39.99
		50 Mbps	NA	$49.99

Figure 14: Cost Comparison Matrix

This can be due, in part, to the lack of demand in the City in conjunction with the fact that Santa Fe's entire infrastructure is owned by only two companies: Xfinity owns all above ground infrastructure and CenturyLink controls everything underground. This oligopoly ensures little to no competition, allowing providers to charge whatever prices they desire. In addition, because they control the infrastructure, these providers can also ensure that there is no encroachment on their "turf," so that they do not have to compete with another provider that wishes to offer more competitive services in an area. Additionally, because Santa Fe's population base is small, Internet providers need to charge higher rates in order to recoup costs and earn profits.

While these providers control the infrastructure, they do allow smaller providers to lease their infrastructure to provide their services to customers. These arrangements create additional revenue streams and limit legal conflict. One of these smaller providers, Cyber Mesa, leases its infrastructure from CenturyLink and then provides its services, mostly Internet and telephone, to customers at competitive rates.

2.2 Economic Development in Santa Fe

Santa Fe has a culture rich in history and art. This has spurred the growth of tourism and education and brought them to the forefront of the City's economy. However, with the development of technology and communications, many companies, new and established, appear to need high speed Internet. In

response, the city government has undertaken an effort to increase residential areas and public housing, which in turn will support the current businesses, as well as encourage future companies to establish themselves in Santa Fe.

The mission of the City of Santa Fe's Economic Development Division is "…to achieve long-term sustainable and focused economic growth by building a diverse, innovative economy with high-wage, high-impact jobs that provide opportunity and prosperity for the City's residents, businesses and entrepreneurs."[41] In 2009, the Economic Development Division worked with the Santa Fe Regional Telecommunications Coalition (SFRTC) to submit an application for a grant to install a fiber optics network.[42] With this initiative, the network for high speed Internet in Santa Fe can expand.

2.2.1 The Market for High Speed Internet in Santa Fe

Our project's second objective was to identify current and future high speed Internet demands by determining the market for high speed Internet among businesses in Santa Fe. The markets that this project focused on included educational institutions such as the St. John's College, media companies such as HDNM Entertainment, and research organizations such as the Santa Fe Institute.

Strides have been taken to ensure that the Internet is fully understood and accepted in the New Mexican community. In 2011, federal, state, and local officials met in Española to start a $10.6 million initiative to bring faster Internet to Northern New Mexico.[43] This initiative, REDI Net, will lay 150 miles of fiber optic cable to more than 120 government institutions, schools, and hospitals in Santa Fe County, as well as others.[44] In order to encourage a greater use of high speed Internet, the state government started a program, Fast Forward New Mexico, to educate New Mexicans about the Internet.[45] This effort will be undertaken with the help of The University of New Mexico, the Global Center for Cultural Entrepreneurship, and the 1st-Mile Institute with the New Mexico State Library.[46]

2.2.2 Broadband Internet and its Contribution to the Economy

Numerous articles support the belief that "Internet-related consumption and expenditure is now bigger than agriculture or energy" and that the Internet "contributes 3.4 percent to GDP in the 13 countries covered by the research.[47] A study conducted by the OECD, Organization for Economic Cooperation and Development, determined there was a 0.9-1.5 percent increase in annual per capita

[41] (Economic Development Division 2008)
[42] (Economic Development Division 2009; Economic Development Division 2009)
[43] (TRIP JENNINGS 2011, A.1)
[44] (TRIP JENNINGS 2011, A.1)
[45] (TRIP JENNINGS 2011, A.1)
[46] (TRIP JENNINGS 2011, A.1)
[47] (Pélissié du Rausas et al. 2011)

growth in these countries after a 10 percent increase of broadband infiltration rate in places where broadband widths exceeded 256 kbps.[48] There has also been a 2.7-3.9 percent increase in gross domestic

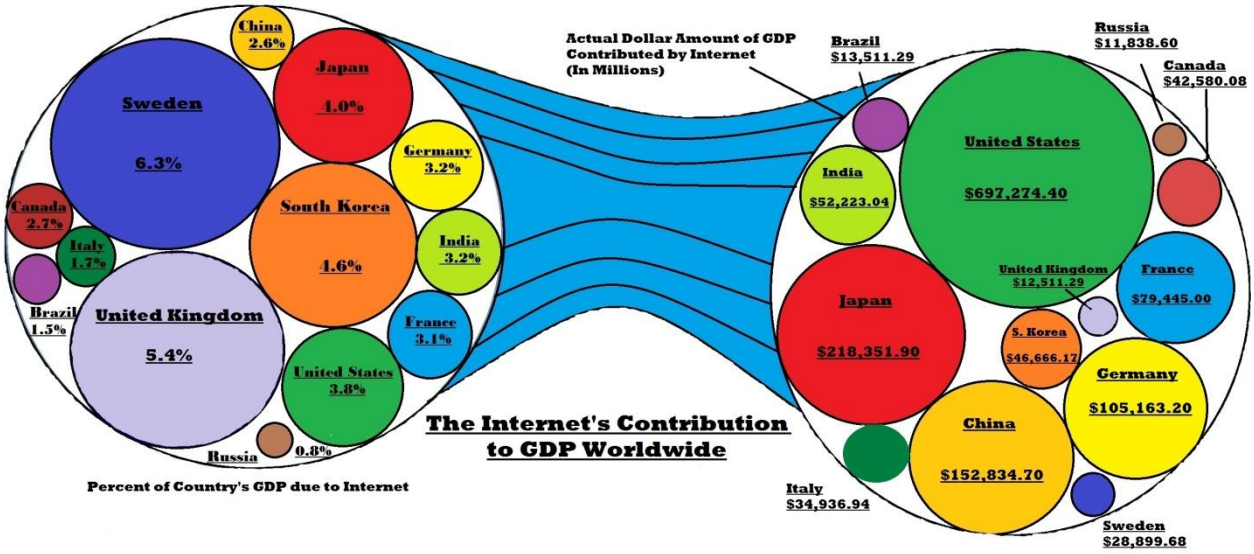


Figure 15: The Internet's Contribution to GDP by Country

product per capita with the introduction of broadband Internet.[49] Figure 15 shows the 13 countries in which the percent of total GDP related to the Internet is the greatest.[50] Sweden, the United Kingdom, and South Korea have the largest share of their GDP in the Internet, each being over 4.5 percent. The other side of the graph shows how much each of those percentages means to each country in millions of dollars.

The McKinsey Global Institute developed an index to gauge the capacity of countries on the four foundations of the Internet. Figure 16 offers

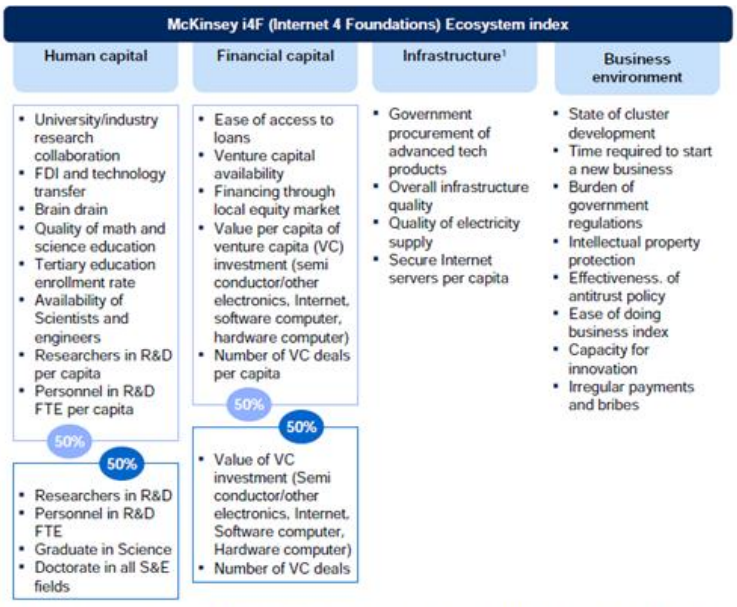


Figure 16: McKinsey i4F Index

[48] (Pélissié du Rausas et al. 2011)
[49] (Pélissié du Rausas et al. 2011)
[50] (Pélissié du Rausas et al. 2011)

insight into each of these foundations.[51]

Human Capital is the human element in the development of plans and actions regarding the Internet. It involves research and development as well as education about the Internet or education through the utilization of the Internet. This is strengthened by the amount and quality of education concerning the Internet granted to individuals.

In Santa Fe, there is a plethora of researchers who conduct studies for institutions such as the Santa Fe Institute. Our work involved the Santa Fe Complex, a research organization that conducts projects for undergraduate students to contribute to the betterment of the City.

Financial Capital is focused on the ability to easily and securely transfer funds. For countries to flourish within this foundation, they need ready access to loans and other capital transactions that are conducted over secure networks. The Internet, too, provides a broader market within which companies can find more capital and revenue.

There is a $1 million budget for the development of the high speed Internet infrastructure in Santa Fe.[52] A feasible plan would allow existing companies to have better access to electronic capital and for potential newcomers to relocate to Santa Fe and thereby increase its potential fiscal foundation through their commerce.

Infrastructure is founded on the strength of the established network. Our project focused on evaluating the feasibility of a high speed Internet infrastructure. The strength of this foundation was measured by the quality of the electrical and communications infrastructure based on power, area of connectivity, and strength of connectivity via speed and bandwidth.

This foundation had the most relevance to our project. We focused on the feasibility of a mass improvement to the infrastructure. The foundation of infrastructure supplies a backbone from which other foundations develop.

Business Environment is the final category of the index. The factor of marketability for companies to enter the economy because of the Internet's influence is critical here.

One goal of our project was to determine if improving the current infrastructure in Santa Fe would improve the business environment. Should the project result in future infrastructure development, there should be a correlated increase in future activity in the current business environment.

[51] (Pélissié du Rausas et al. 2011)
[52] (Moody 2012, 1-2)

In order to support the developing economy in Santa Fe, many improvements in the urban sector were made. These physical transformations supply a foundation for the economy to grow. This enables more businesses to enter Santa Fe and thereby increase its marketability.

2.3 History of Internet Redevelopment in Santa Fe

For the last several years, there have been plans to upgrade and improve the communication infrastructure in the city. A strategic plan has been presented to the U.S. Department of Housing and Urban Development to take place from 2008 until 2013. The Consolidated Plan has taken into consideration the needs of the city in terms of housing, homelessness, and economic development.[53] Guided by the Angelou Plan, the Consolidation Plan's action strategies are targeted to improve the overall economic development needs of the community.[54] These plans have revolved around the Internet providers in the city, as well as the debate over whether it is feasible to bring an improved high speed Internet infrastructure to the public. Because of this, many organizations and projects have been initiated to address the plan.

2.3.1 National Broadband Plan

In 2009, the National Broadband Plan (NBP) was developed by the FCC to ensure that every American has "access to broadband capability." Through the NBP, the gap between universal broadband availability and adoption will hopefully be filled. As previously stated, there are approximately 100 million Americans still without broadband connectivity. The initiatives created by the NBP will "stimulate economic growth, spur job creation, and boost our capabilities in education, healthcare, homeland security, and more."[55]

In early February 2010, the New Mexico Delegation to Congress sent a letter to FCC Chairman Julius Genachowski, encouraging that the NBP "clearly supports broadband for all."[56] Congress states that 20 of 33 New Mexico's counties are medically underserved. Internet is required in these areas to provide access to healthcare information and services. Chairman Genachowski replied that the NBP will develop a comprehensive strategy to provide a network of connectivity between all parts of the nation. This future communication network will transform the economy as well as society.

To improve the universal service programs, be they public, private, or cooperative efforts, short-, medium-, and long-term actions are being considered. The rural health care program has joined with NBP

[53] (Economic Development Division 2008)
[54] (Economic Development Division 2008)
[55] (Federal Communications Commision 2012)
[56] (FCC Chairman Julius Cenachowski 2010)

to assist in expanding affordable broadband connectivity more effectively. This will benefit areas such as New Mexico, where a majority of counties suffer from being medically underserved.

2.3.2 New Mexico Integrated Strategic Broadband Initiative

As stated earlier, New Mexico ranks in the bottom tier in terms of Internet access and speeds, compared to other states. In terms of connecting economic development and social needs, broadband is "the needed tie that binds".[57] The New Mexico Integrated Strategic Broadband Initiative was implemented around 2007 with the hopes of spreading high speed broadband throughout the state of New Mexico. There are a number of components in the initiative including:

- Help to substantiate planning
- Investment
- Cost-savings
- Ultimate economic benefits for statewide broadband improvements
- Strategically coordinating and leveraging support for separate state networking initiatives, limiting unproductive competition for limited state funds
- Dynamic vision for New Mexico's networked broadband future

Despite numerous plans of action, as of 2011, many rural New Mexico communities are still severely under-connected to even the most basic broadband (DSL) infrastructure and services.[58] The initiative made note of the failed attempts the City of Santa Fe has undertaken to bring fiber to the public.

2.3.3 REDI Net

REDI Net is the Northern New Mexico Regional Economic Development Initiative covering the counties of Santa Fe, Rio Arriba, Los Alamos, and Taos. Long term plans for Regional Broadband Initiatives, Economic Development Services, Cluster Strategies, and Public-Private Partnership have been prepared. Focusing on regional broadband, three applications were submitted by Northern New Mexico for federal stimulus funding. This initiative is under the Broadband Opportunities Technology Program, or BTOP, in the Department of Commerce and the Broadband Initiatives Program, or BIP, in the US Department of Agriculture. In August of 2010, the Plan received $74 million in funding. This funding was to be distributed among the three initiatives:[59]

- E-Cequia in the City of Santa Fe

[57] (Design Nine 2008, 12)
[58] (Design Nine 2008, 12)
[59] (Anonymous)

- North Central New Mexico Economic Development District in Rio Arriba, Los Alamos, northern Santa Fe counties, Española, and the Pueblos of Ohkay Owingeh, Santa Clara, San Ildefonso, and Tesuque
- Kit Carson Electric Cooperative and Telecom in Taos and Picuris Pueblos.

A closer look at the E-Cequia plan in Santa Fe or SFRTC, Santa Fe Regional Telecommunications Coalition, revealed that of a total request for $10 million, $7 million was requested in BTOP funding with an additional $3 million matched from the City of Santa Fe and Santa Fe County. The proposed plan called for a fiber ring to be installed to connect Santa Fe Studios, major business parks, Santa Fe Community College, the Santa Fe Indian School, the Institute of American Indian Arts, and Community Anchor Institutions (CAI). CAIs are schools, hospitals and government buildings that serve as hubs for fiber connections. There are 140 CAIs mapped in the City and County of Santa Fe. In 2009, the E-Cequia Plan was announced as a finalist in the first round of broadband funding. Unfortunately, it was not funded and therefore never completed. This has left an opportunity for an improved proposal to be made for an updated infrastructure. Figure 17 shows the fiber ring proposed in the E-Cequia plan.[60]

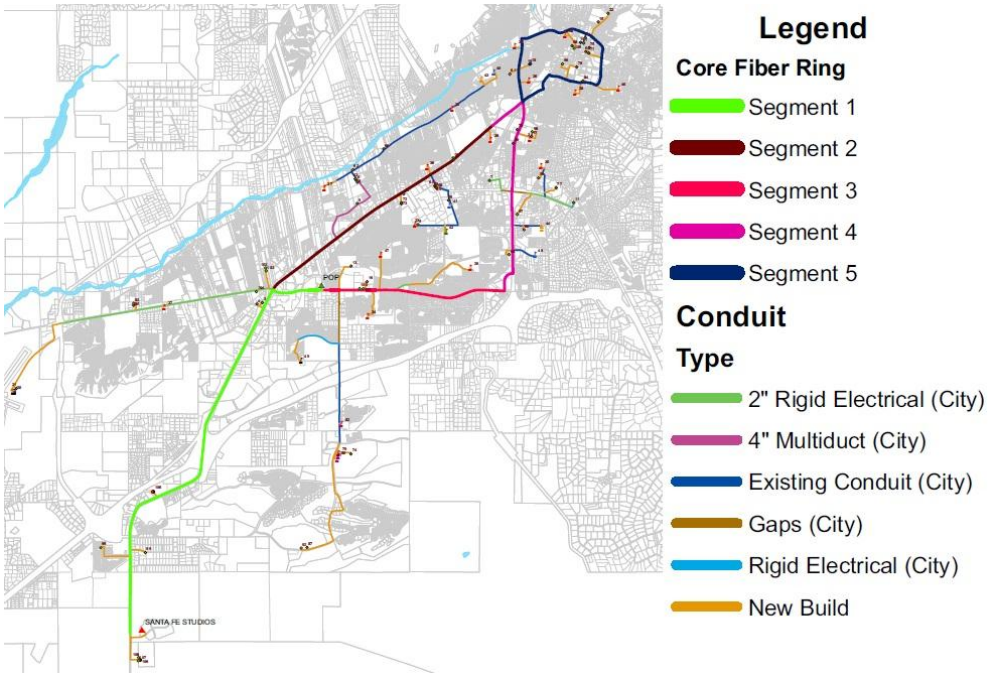


Figure 17: Santa Fe Proposed Fiber Plan

[60] (Torres 2010)

2.3.4 Capital Improvement Plan

The Capital Improvement Plan, or CIP, was created in 2011 after the Santa Fe's City Council passed a resolution to replace the last Telecommunication Advisory Committee (TAC). Essentially, the CIP is a telecom master plan to improve the Internet infrastructure in the city, primarily through high speed broadband. A request for a $1 million bond was approved to provide high speed Internet in selected areas of the city. Locations of potential interest are The Railyard, St. Michael's Drive, and Airport Road.

The biggest questions the CIP are looking to answer are whether there is a place for a publically owned infrastructure, whether there is a lack of high speed demand in the City that has led to ISPs not needing to compete for customers, and whether increasing the number of customers will translate into consumer cost savings. These questions are critical when determining the feasibility and success of a potential plan to improve the Internet infrastructure.

Looking first at the United States as the larger scale of the Internet infrastructure and then focusing in on the structure at the city level in Santa Fe, we were able to determine that Santa Fe lacks sufficient Internet infrastructure. While many initiatives, such as the New Mexico Integrated Strategic Broadband Initiative and REDINet were implemented to try to close the gap, the attempts have been unsuccessful, and our project's goal centered on trying to help the City find a way to close the gap.

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3 Methodology

Our project was to research and recommend various options for upgrading the high speed Internet infrastructure in the City of Santa Fe. Our objectives were as follows:

1. To determine the current composition of the Internet infrastructure in Santa Fe
2. To identify the current and future high speed Internet demands
3. To provide possible options for the future of the Internet infrastructure

In order to reach this goal, our team collected data and mapped the supply of the Internet in Santa Fe. Through surveys of businesses, we identified the demand for high speed Internet. Based on our findings about the current supply and future demand for high speed Internet in Santa Fe, we analyzed the data and created a list of potential options. The possible options for an improved infrastructure were evaluated and compared based on implementation in the City of Santa Fe.

3.1 Determined the Composition of the Internet Infrastructure in Santa Fe

Our first objective was mapping the composition of the Internet infrastructure in Santa Fe. We first contacted the main ISPs in Santa Fe for information on their infrastructure locations. These included:

- CenturyLink
- Xfinity
- Cyber Mesa

We then contacted anyone in Santa Fe who could help us gather information on the Internet infrastructure. These included:

- Sean Moody
  - Project Administrator, Economic Development Division, City of Santa Fe
- Gar Clarke
  - New Mexico Broadband Program Manager, New Mexico Department of Information Technology
- Merlyne Ortiz
  - Administration, Streets & Drainage Maintenance Division, City of Santa Fe
- Richard Lowenberg
  - Founder, 1st Mile Institute
- Ken Litton
  - Consultant, N-Com Experts
- Cristella Roybal
  - GIS Analyst ,GIS – ITT Department, City of Santa Fe

Sean Moody, our liaison, provided the overview of the Internet infrastructure in Santa Fe and the direction he wanted us to take. Gar Clarke offered information about the infrastructure in Santa Fe. Merlyne Ortiz provided information about street cut permits in Santa Fe. Richard Lowenberg provided us with information about the Internet, Internet infrastructure in Santa Fe, and the politics surrounding the decisions that have been made in Santa Fe to date. Ken Litton gave us a tour of the ENMR dig site in Santa Fe and provided information about the Internet infrastructure. Cristella Roybal provided us with the locations of the antennae in Santa Fe.

3.1.1 Long Haul into Santa Fe

For the first several weeks, we were unable to secure a definitive answer on where the long haul into Santa Fe was located and who owned it. The long haul is the term used to describe the transmission of Internet service over long distances, i.e. Santa Fe to Albuquerque. Sean Moody thought the location of the long haul into Santa Fe terminated at a small building beside the train tracks just south of the South Capitol Rail Runner station. To further research the long haul connection into Santa Fe, we biked along the path that runs parallel to the train tracks since that was the proposed long haul route. For approximately 2 miles along this path, poles were placed in increments stating where buried fiber optic cable lay underneath the poles. To convert the long haul into GIS Cloud as a layer of the map, we used Google Maps. By creating this custom map, we were able to follow the long haul. We then exported the long haul from Google Maps as a Keyhole Markup Language (KML) file. This file was uploaded to GIS Cloud and added to our Internet infrastructure map.

3.1.2 Above Ground Hubs

Above ground hubs mark where underground cable exists. We biked around highly congested sections of Santa Fe in search of above ground hubs. The area investigated was the triangle enclosed by St. Michaels Drive, Cerrillos Road, and St. Francis Drive. When a hub was spotted, the coordinates were recorded to mark its location, a description of the hub, and the company that owned the hub. The description included the type of hub we found. Some of the hubs explicitly stated that fiber was buried under them. We called these “poles”. Others simply indicated that cable was buried below. We called these “hubs”. Manholes and utility cabinets were also recorded. Utility cabinets are in-ground structures along the road that house cables are spliced together.

3.1.3 Street Cut Permits

We were given street cut permits by the Streets and Drainage Maintenance Division of Santa Fe. Street cut permits are required for any type of road cutting in Santa Fe. This is necessary for the City to

regulate the locations of underground infrastructures in order to avoid digging collisions, whether Internet, gas, electric, water, or sewage related. We received the street cut permit locations in an Excel spreadsheet. The street cut permits did not indicate what was being installed, but they did show the contractor who had applied for the permit. Using this information, we removed all of the street cuts that were irrelevant to our project. This narrowed the street cut permit universe specifically to those contractors who were installing cables. After narrowing down the spreadsheet, we mapped all of these locations on GIS Cloud. We took the Excel file, and using GPSVisualizer (http://www.gpsvisualizer.com), we converted the addresses into coordinates. We took the new Excel file with the coordinates and further converted that into a KML file using Earthpoint (http://www.earthpoint.us/ExcelToKml.aspx). The KML file was then uploaded to GIS Cloud, adding a layer to our Internet infrastructure map.

Some of the locations in the Excel file were a segment rather than a single point. However, there was no automatic way to create these segments. Therefore, we filtered out all of the point-only street cuts and mapped all of the road cuts in Google Maps. After all of the segments were mapped, we exported the Google Map as a KML file and uploaded that to GIS Cloud and added it to our Internet infrastructure map.

Appendix D has an example of the Excel file containing the street cut permits.

3.1.4 Antenna Towers

We were given the location of antenna towers around Santa Fe by the Santa Fe ITT Department in the form of a shape (SHP) file. We uploaded these to GIS Cloud and added them to our Internet infrastructure map. We learned that the fixed wireless signal would be strongest within a mile radius of the tower. There is a feature in GIS Cloud that allows for adding radius circles. We used this feature to add a mile radius circle to each antenna location. To ensure the accuracy of the radius circles, we zoomed in on a single point as closely as possible.

We also wanted to confirm that the towers were in the locations stated by the information provided to us. To do this, we used the Google Maps street view to see if we could locate each tower. Unfortunately, the Google Maps street view data was from 2007, so we were unable to verify the location of some of the towers. To locate the rest of the towers, we tried using the standard Google Maps program. When we found a tower using this method, we cross-referenced it against the GIS Cloud layer. We also found some of the towers by walking, biking, and driving around Santa Fe. When we found a tower in this way, we recorded its location and then compared the location on GIS Cloud.

3.1.5 ENMR

ENMR, New Mexico's oldest telecommunications company, is currently digging to install conduit pipes, within which fiber optic cable will be run. We were able to visit a few of their sites to observe the installation of an Internet infrastructure. The head engineer of N-Com was extremely knowledgeable, giving us information about where ENMR is currently digging and when they will complete the Santa Fe leg of their infrastructure upgrade. We took this information and mapped it in Google Maps. We then exported that information again as a KML file and uploaded it to GIS Cloud and added it to our Internet infrastructure map.

3.1.6 Community Anchor Institutions (CAI)

We gathered information about CAIs from the New Mexico Department of Information Technology. The data was contained in an Excel file displaying every CAI in the United States. First, we narrowed down the information to New Mexico only, and then further down to Santa Fe. We then found all of the coordinates for these locations. We converted the Excel file with the coordinates of the CAIs into a KML file. This file was then uploaded to GIS Cloud and added to our map.

3.1.7 Other Layers

We added additional layers to our analysis that were not part of the Internet infrastructure. These layers provided insight into the feasibility of the options we recommended to the City. These included:

- State Buildings
- County Facilities
- City Property
- State Property
- Federal Property
- Business Locations

Sean Moody provided access to files that detailed these locations. We were able to copy the layers and upload them to GIS Cloud for use in our Internet infrastructure map.

3.2 Identified the Current and Future High Speed Internet Demands

Our second objective involved collecting data about the demand for high speed Internet by businesses in Santa Fe. Using information from the Chamber of Commerce of Santa Fe, we created a list of businesses to survey. This list pinpointed businesses that relied heavily on Internet access for their business operations. We created a survey form to gather specific information from each business regarding their satisfaction with their Internet connection. The survey form shown in Appendix F, is

supplemented by a corresponding matrix, shown in Appendix G, in which the survey information was recorded and organized.

3.2.1 Determined the Businesses to Survey

We established a list of criteria in order to determine the list of businesses to survey. The first step in evaluating which businesses to survey was to establish types of business that required high speed Internet access. These fields were:

- Education
- Research Institutions
- Music
- Media
- Data Mining
- Clinical Testing
- Cloud-Based
- Investment Banking
- Gaming
- Graphic Design

We took this universal list of categories and customized it to those businesses currently in Santa Fe. Using the Chamber of Commerce business directory we cross-tabulated these fields to arrive at the final list and the subsections most relevant to our study:

- Advertisement and Media
  - Media
  - Graphic design
- Business and professional services
  - Entertainment
- Communication
  - Telecommunication
- Government and Education
  - Education
- Lodging, Travel and Tourism
  - Hotels
  - Motels
  - Resorts
- Computers, IT and Technology
  - Computer Consultants
  - Copiers/Digital Office MFP
- Finance and Insurance
  - Finance

With the relevant fields of business established, we cross-referenced Santa Fe with those fields and evaluated them by two criteria: the size of the workforce and the status of their website. Businesses

that had more than five employees and an up-to-date website were included. Below is the list of businesses we targeted to survey:

1. Best Western Inn of Santa Fe
2. Cisneros Design
3. Courtyard by Marriot
4. Davis Select Advisors
5. Desert Elements Designs
6. Dot Foil Computer Services
7. Eclipse IT Solutions
8. El Rey Inn
9. Genzyme Corporation
10. HDNM Entertainment
11. Heffter Research Institute
12. Hotel Santa Fe
13. Hyatt Place Santa Fe
14. Impressions Advertising
15. Inn on the Alameda
16. Integrative Enzymatic
17. Jemez Consulting Group
18. Lamplighter Inn of Santa Fe
19. Lensic Performing Arts
20. Mariah Media Group
21. Monsoon Design
22. National Center for Genome Resources
23. Nelson-Moore Associates
24. New Mexico Film Office
25. Northern Insurance
26. NXGEMS Marketing
27. Oralia Creative
28. Pacific Office Automation
29. Prediction Company
30. Qforma
31. Redfish Group
32. S.E.D. Medical Laboratories
33. Santa Fe Community College
34. Santa Fe Complex
35. Santa Fe Institute
36. Santa Fee Logo Design
37. Santa Fe Studios
38. Santa Fe University of Art and Design
39. Southwest Planning & Marketing
40. St. Michael's High School
41. Thornburg Funds

3.2.2 Developed the Survey Form

We created a survey form that was used to input the information gathered from each business. A survey was selected instead of an interview in order to ensure that consistent questions would be used. The questions covered the following topics for each company:

- Details about current service including download speed, upload speed, type of service, current provider, and cost
- Current satisfaction with their Internet connection based on the connection speed, cost per month, and provider
- Future desires in terms of speeds and costs if other options were available
- Impact that increasing Internet speed would have on their business
- Willingness to pay for increased Internet speed

The survey is shown in Appendix F.

3.2.3 Surveyed the Businesses and Compiled the Data

These surveys were conducted by phone. We developed a script for each phone call. The survey script is shown in Appendix H. Answers were recorded for each question. The survey form was created on Google Docs, from which the information was compiled into a matrix. The organized data can be seen in Appendix G. By analyzing the results of the matrix, we determined the degree of satisfaction these companies had with their Internet connection and their desires for faster speeds.

3.3 Provided Possible Options for Future Internet Infrastructure

Our third objective involved creating the possible options for future Internet infrastructure. These options were aimed at maximizing the economic growth of the City of Santa Fe. By researching these ideas, we determined the strengths and weaknesses of each based on cost, accessibility, viability, security, as well as environmental factors specific to Santa Fe. We evaluated these results in order to provide options with which the Telecommunications Advisory Committee could work.

3.3.1 Researched the Possible Options

We researched all possible options for Internet infrastructure upgrades. We investigated how various types of Internet providers, including ISPs, CLECs, and ILECs, provide their services to familiarize ourselves with the use of the infrastructure. We met with Cyber Mesa, a local ISP and CLEC in Santa Fe, which provided insight into the company's operations. We researched the different ways Internet services can reach residences and businesses. The research culminated in a list of options for infrastructure expansion:

- Fiber To The Premise
- Fiber To The Node
- Fixed Wireless

- Repeaters
- Free Space Optics
- Do Nothing

3.3.2 Compared the Options for Improving the Internet Infrastructure

Once possible options were identified, the strengths and weaknesses for each were evaluated and compared to one another. Additionally, these criteria were evaluated relative to their specific implementation in Santa Fe. The options were based on multiple variables: the cost to implement each option, the reach of their broadband signal, the speeds offered by each option, the willingness for ISP participation in the infrastructure expansion, and the likelihood that new jobs would be created. We created an options matrix in an Excel spreadsheet to help visualize which options would work best to improve the Internet infrastructure. Check marks were used to illustrate options that satisfied the requirements. “X” marks were used for the scenarios that did not meet the requirements. “N/A” was applied to cases in which the information was unknown.

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4 Current Internet Supply and Demand

This section contains our findings on the current supply and demand of Internet service and Internet infrastructure in Santa Fe. It includes a compilation of maps, those focusing on individual sections of the infrastructure, as well as a comprehensive map aggregating the findings. The results from the businesses surveys led to insight into the demand for high speed Internet throughout the City. Additional infrastructure maps can be found in Appendix J.

4.1 Composition of the Internet Infrastructure

The map in Figure 18 shows the information we gathered about the Internet infrastructure in Santa Fe. The elements that comprise this map are: Long Haul (light blue line), Cerrillos Road (dark blue line), Above Ground Hubs (light blue dots), Street Cut Permits (red dots and purple lines), Antenna Towers (dark blue dots), and ENMR (red line). Detail on each layer of this map is provided in the subsections that follow.

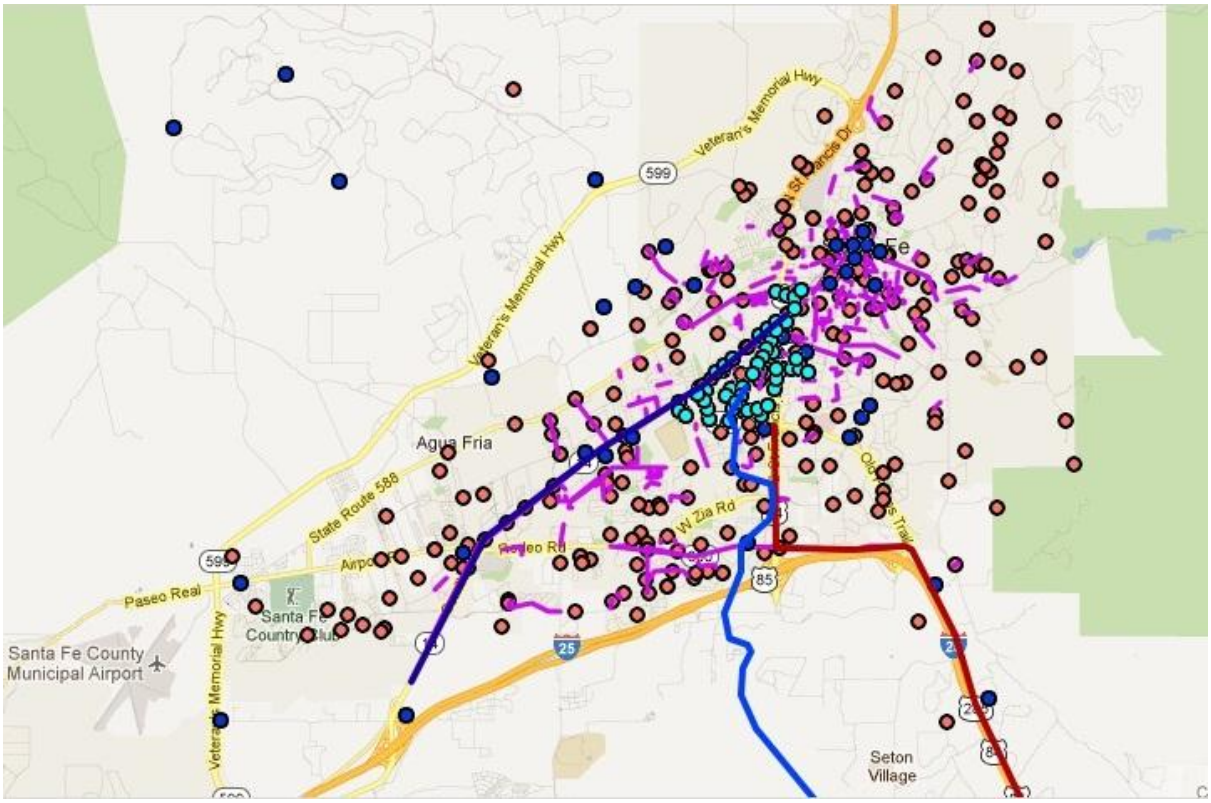

Figure 18: Existing Infrastructure

4.1.1 Long Haul

After searching through the long haul maps, we found two that we were able to map. They were the long haul maps of Level 3 Communications and Zayo Group. Both of these companies had long hauls that followed the train tracks into Santa Fe and stopped just short of the South Capitol Rail Runner station. In all likelihood, the housing structure Sean Moody showed us actually housed the end of the long haul into Santa Fe. Since these two companies had the same long haul into Santa Fe, we created one map to show the long haul. The long haul is illustrated by the map shown in Figure 19.

Figure 19: Long Haul into Santa Fe

4.1.2 Cerrillos Road

After contacting CenturyLink, Xfinity, and Cyber Mesa, we quickly learned that CenturyLink and Xfinity did not want to share their infrastructure data with us. We assumed this might happen given the highly competitive and proprietary nature of this business. Cyber Mesa does not own any infrastructure underground, but Jane Hill, the President of Cyber Mesa, was able to confirm that CenturyLink owns fiber optic cable under Cerrillos Road. This is shown in Figure 20.

Figure 20: Fiber Under Cerrillos Road

4.1.3 Above Ground Hubs

We mapped the 164 hubs we had logged, creating the map shown in Figure 21. It is important to note that due to time constraints, we concentrated our efforts in one area of Santa Fe. Further, along the path next to the train tracks, we found above ground poles which suggested that fiber optic cable was buried beneath them. Figure 22 shows examples of these poles.

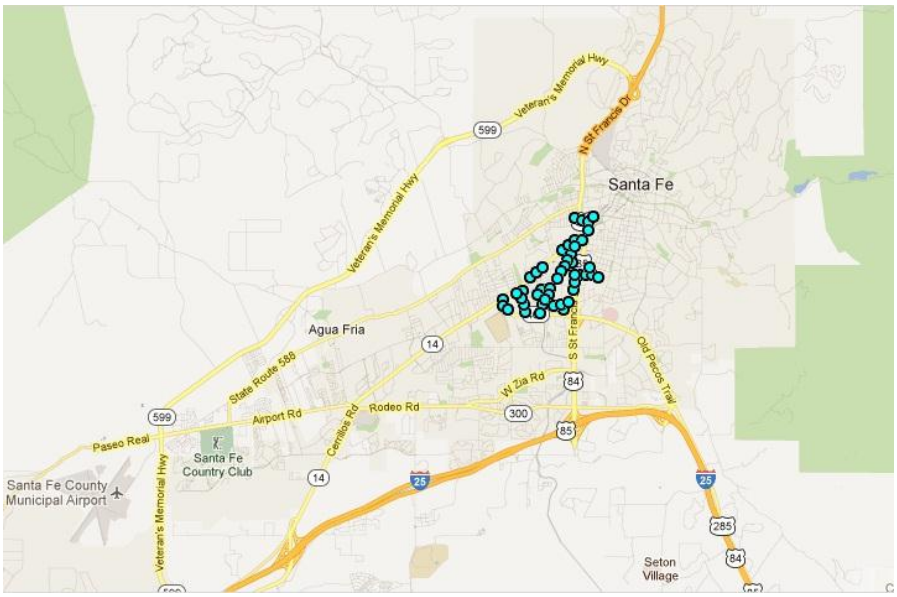

Figure 21: Above Ground Hubs

Figure 22: Buried Fiber Optic Cable Pole
Right image shows pole close up

Figure 23: Types of Hubs

The montage of pictures in Figure 23 shows some examples of various types of above ground hubs. Some of these hubs were either unmarked or poorly marked so we were unable to determine definitively if they were owned by an ISP. A list of the hubs can be found in Appendix E.

4.1.4 Street Cut Permits

Figure 24 shows all of the street cut permits in Santa Fe undertaken since the early 2000s.

This map represents the location of approximately 4,700 street cuts, including the locations of utilities (gas, water, electric, sewer). Since these were immaterial to this project, they were filtered out. Figure 25 demonstrates the filtered street cut points.

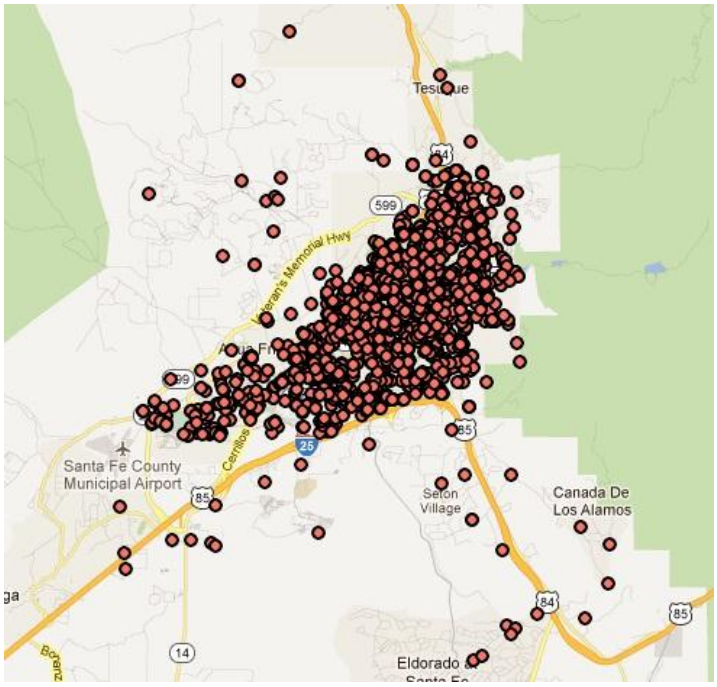

Figure 24: Street Cut Points

Many of the remaining street

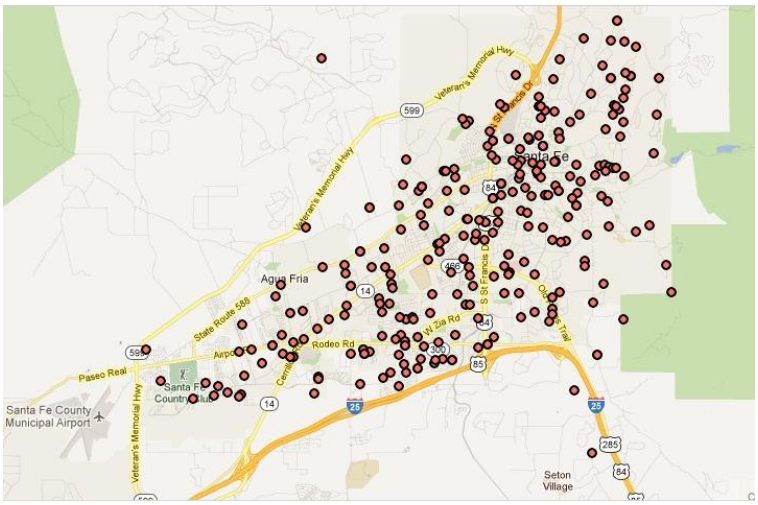

Figure 25: Filtered Street Cut Points

cuts were for the installation of broadband cables. They were somewhat evenly spread around Santa Fe, with a slightly larger concentration in the downtown area.

Some of the street cuts were not just point cuts, but along a segment of the road, so we added an extra layer for those cuts. To distinguish, a street cut point is a cut at a specific point in the road; a street cut segment is a cut that runs the expanse of the road. The cuts illustrated in Figure 26 have filtered out the utilities as shown previously in Figure 25.

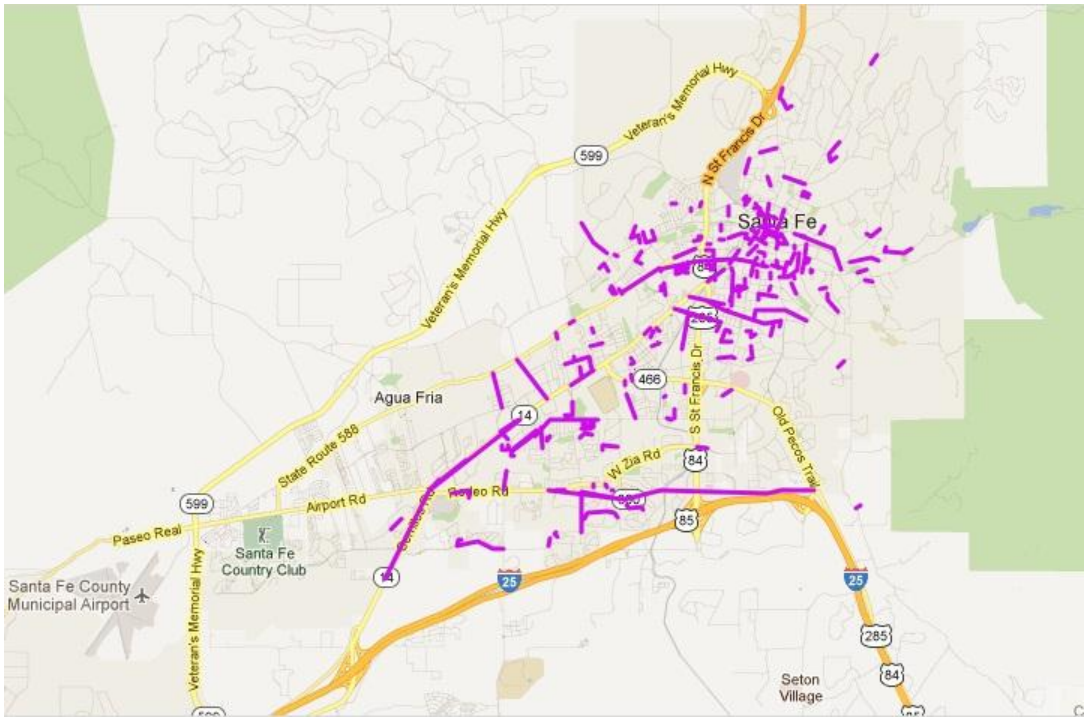

Figure 26: Street Cut Segments

This map shows 207 street cut segments. It indicates a heavier distribution of cuts in the downtown area, although there is still a somewhat even distribution of cuts throughout.

4.1.5 Antenna Towers

Figure 27 shows a map locating the antenna towers in Santa Fe. There are 77 antenna towers in and around Santa Fe, with a heavy distribution in the downtown area. Since these antenna towers are able to transmit a very strong signal within a mile radius of the tower, we added radii to the towers to demonstrate their broadcasting reach. Figure 28 maps the towers with their broadcasting radii.

The existing location of these broadcast towers, in conjunction with their broadcasting reach, enables Santa Fe to achieve nearly complete Internet coverage. The downtown area, with a proliferation of towers, has the densest coverage.

Figure 27: Antenna Locations in Santa Fe

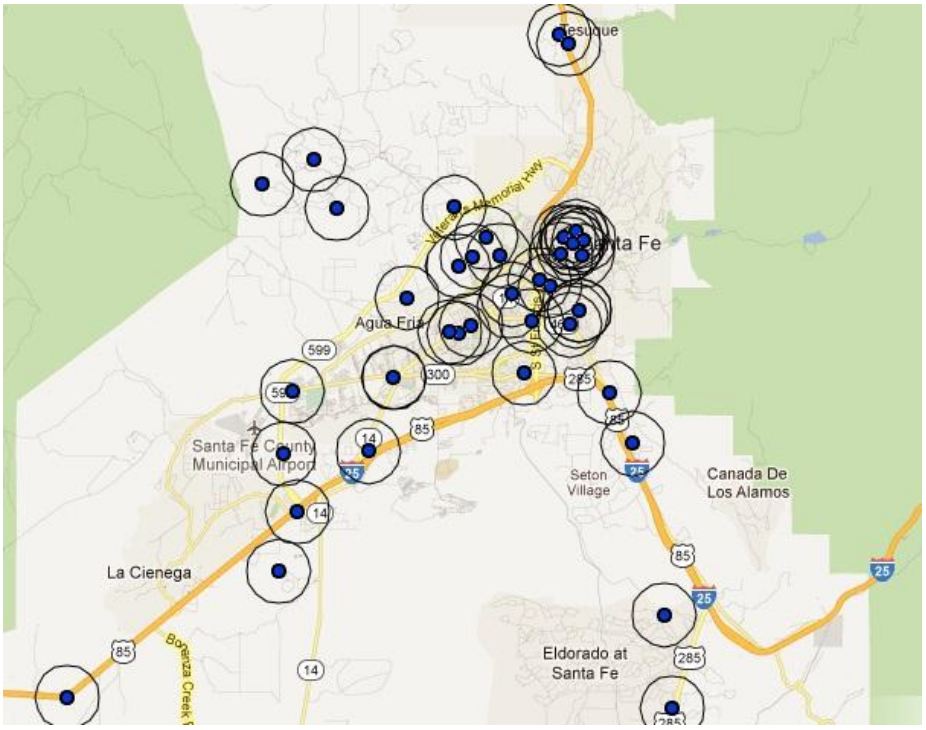

Figure 28: Antenna Towers with 1 Mile Radius

4.1.6 ENMR

Figure 29 shows the current trenching activity of ENMR. To expand their current Internet infrastructure, ENMR plans to lay 30 miles of fiber optic cable from St. Francis Road south out of Santa Fe on Old Las Vegas Highway. As a point of reference, it took ENMR approximately two weeks to trench out about 1.75 miles of land between the intersection of St. Francis Road and Siringo Road to the intersection of St. Francis Road and West Cordova Road. They have yet to install any fiber optic cable because they have not received the cables. They plan to start installation in June 2012.

Figure 29: ENMR Fiber Installation Route

4.1.7 Community Anchor Institutions

CAIs are schools, libraries, medical centers, police stations, fire departments, jails, and other government buildings that serve as hubs to which fiber can be connected. Figure 30 shows a map of the CAIs in Santa Fe, consisting of 140 locations; five of these are connected to the Internet by DSL and nine by copper wire. The other 126 CAI connections are unknown.

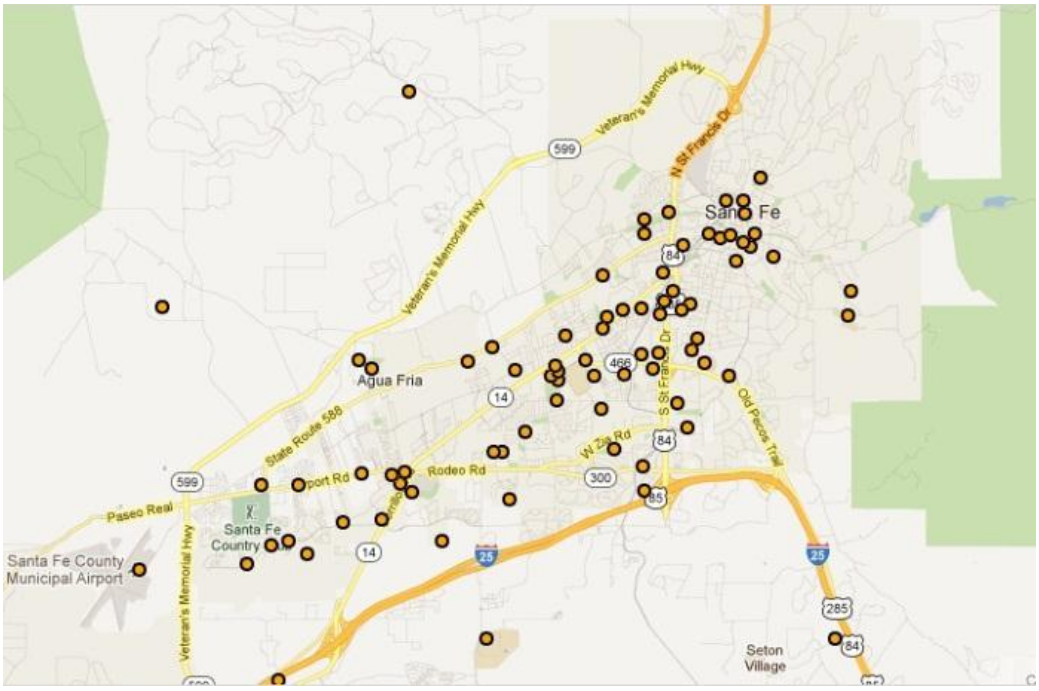

Figure 30: Community Anchor Institutions in Santa Fe

4.2 High Speed Internet Demand

Using the Chamber of Commerce business directory, we determined high speed Internet demand by surveying businesses that rely heavily on Internet access. We learned which ISPs they use, their satisfaction with the service, and their desire for faster speed. We also gathered insight into how the Internet affected their businesses.

4.2.1 Data Compilation

We encountered enormous difficulties when we attempted to contact businesses for their feedback, culminating in either no response or a refusal to participate. However, we were able to receive at least one response from a business in each field of interest. For those businesses that participated, we have fairly consistent answers from our surveys: many companies wanted access to higher speeds and were willing to pay more for it. The questionnaire and the answers are exhibited respectively in Appendix F and Appendix G. We developed our analysis from these answers to determine a definitive response to the economic question: "Is there a demand for higher speeds?"

The list of providers for these businesses is shown in Figure 31. This confirmed that CenturyLink and Comcast are the major ISPs. Their services were supplemented by smaller Competitive Local Exchange Carriers. Two businesses used Comcast as their provider; the other providers were used by only one business, further evidence that the large ISPs control a larger share of this business in Santa Fe.

Providers
CenturyLink
Comcast
Cyber Link
Oso Grande
Paetec

Figure 31: ISPs in Santa Fe, from Survey Results

Figure 32 references the current download and upload speeds as determined by our survey. Overall, the maximum speed for all businesses surveyed was 50 Mbps download and upload. Minimum speeds were 1.5 Mbps download and .007 Mbps upload. Of the six categories of businesses surveyed, the Consulting and Insurance firms had speeds of 1.5 Mbps. The Research business had the fastest speeds, 50 Mbps download and 50 Mbps upload. For the Marketing and Computer Services companies, speeds measured 15 Mbps. In almost all cases, download speeds were faster than upload speeds. When asked which speeds needed to be faster, three businesses responded download, two responded the same, and one responded upload.

Speeds		
	Download	**Upload**
Max	50 Mbps	50 Mbps
Min	1.5 Mbps	.007 Mbps

Figure 32: Internet Speeds, from Survey Results

Cost per Month	
Max	$3,210
Min	$65
Median	$100

Figure 33: Internet Costs per Month, from Survey Results

Figure 33 shows the cost per month for each business's Internet service. To obtain 50 Mbps, the Research company paid $3,210 per month; the Consulting firm paid $65 per month for 1.5 Mbps. The median cost per month was $100 for a download speed of 12 Mbps and an upload speed of 2 Mbps. With speeds slower than desired for such a technologically advanced city, the $3,210 per month for 50 Mbps upload and download seems unreasonable.

The most important result noted in our survey focused on the future Internet speed requirements of the businesses surveyed. The results showed in all but one case that future speeds must become faster. Figure 34 defines the maximum and minimum speeds that must be achieved as indicated by the companies surveyed. We concluded that faster speeds would benefit these businesses even if those speeds simply doubled. The Insurance firm cited that increased Internet speed would facilitate the expansion of their company. The Research company would be willing to pay nearly an additional $1,000 per month for double the speed. These businesses also indicated that increased speed would improve communications with their

Speed Needs		
	Download	**Upload**
Max	100 Mbps	100 Mbps
Min	15 Mbps	15 Mbps

Figure 34: Speed Needs, from Survey Results

customers and would make daily activities more efficient. Figure 35 summarizes the current Internet speeds and the future Internet requirements for the surveyed companies.

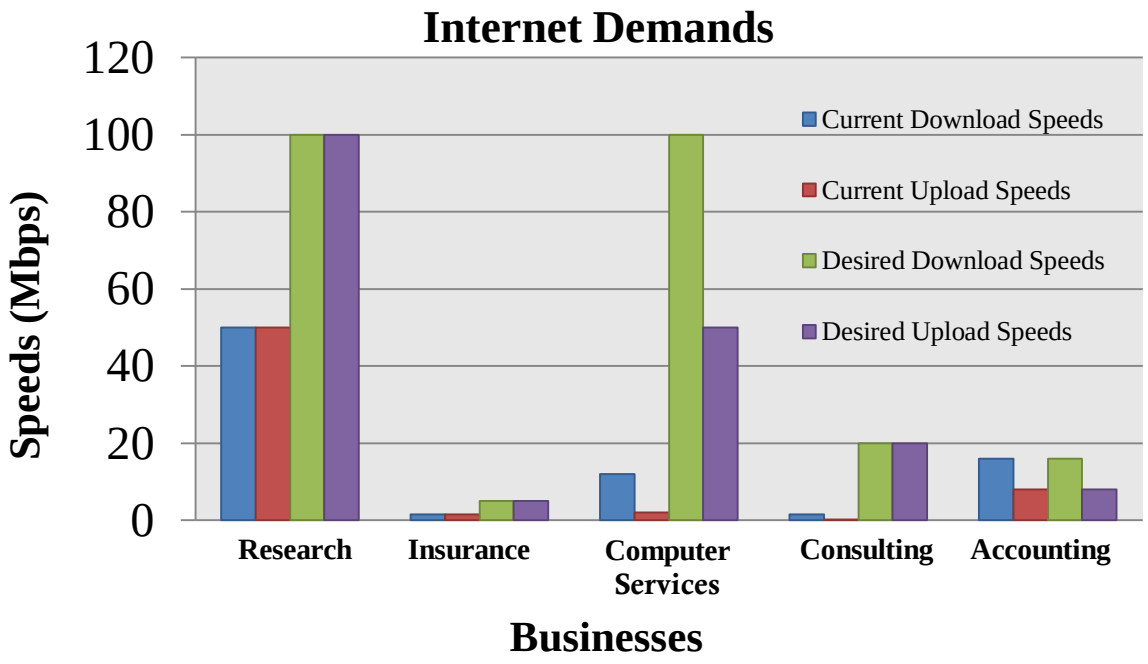

Figure 35: Internet Demands, from survey results
Previously shown in Executive Summary

4.2.2 Community Anchor Institutions

Community Anchor Institutions, CAIs, as previously mentioned consist of schools, hospitals, and government buildings. There are currently 140 CAIs located throughout the city and county of Santa Fe. These locations could serve as high speed Internet hubs. Currently nine buildings have copper connection and five buildings have DSL connection; the remaining 126 buildings could be available for possible high speed fiber connection. Through these fiber connections into the CAIs, high speed Internet could be dispersed into the surrounding area.

Figure 36 is a map showing the location of the CAIs throughout the City. It was noted that these locations are interspersed throughout much of the City, thereby facilitating the spread of high speed Internet into the surrounding areas.

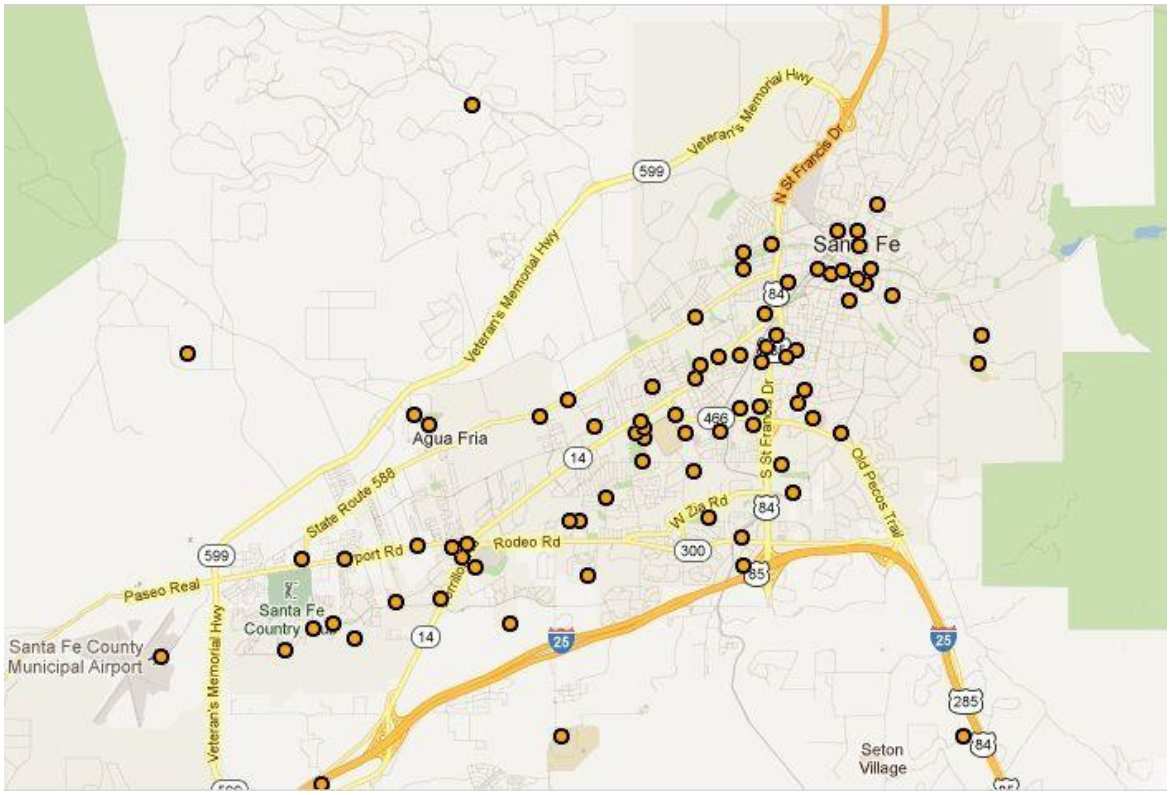

Figure 36: Community Anchor Institutions in Santa Fe

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5 Analysis of Potential Options

Our third objective consisted of identifying the possible options the city could implement to improve the Internet infrastructure. We then analyzed the options using specific variables that provided insight into each option. Details/notes about our options are provided in Appendix I.

5.1 The Options Comparisons Chart

Upon establishing the current supply of Internet service and determining that the demand for higher speeds was evident, we explored potential options the city could implement to improve its infrastructure. Our findings produced six options. These options are shown in Figure 37:

Categories	Jobs Created	Speeds Over 50 Mbps	Coverage Over 1 mile	ISP Participation	Inexpensive to Install
Do Nothing	✗	✗	✓	✓	✓
FTTP	✓	✓	✗	✓	✗
FTTN	✓	✓	✗	✓	✓
Repeaters	✓	✗	✗	N/A	✓
Free Space	✓	✓	✓	N/A	✗
Fixed Wireless	✓	✓	✓	✓	✓

Key:
✓ = Pass
✗ = Fail
N/A = Unknown

Figure 37: Options Matrix

5.2 Analyzing the List of Options

Upon creating the list of options, we analyzed each one using a number of criteria and examined its strengths and weaknesses. Starting with the Do Nothing option, we found that while it would save the City money, this option would not be suitable since it would hinder job growth. In addition, the current infrastructure cannot handle speeds of at least 50 Mbps throughout the entire city. Therefore, for the Jobs Created and the Speeds Over 50 Mbps criteria, the Do Nothing option does not qualify.

The second option we explored was Fiber to the Premise (FTTP). Figure 38 shows what a FTTP connection looks like. The building on the left is the main office of an ISP, the line coming out of the building is a fiber connection, and the taller building on the right is the residence and/or business. This option offers speeds of over 50 Mbps, and because it connects the optical fiber directly to homes and business, the network is secure. However, the negative attributes inherent in FTTP are twofold: the high cost of installing the fiber cables directly to the end-user (approximately $16 to $24 per foot inclusive of all costs), and the lack of widespread coverage from the central office to these premises. Thus, on our matrix, this option does not meet the criteria for Coverage and Inexpensive to Install.

Figure 38: Fiber to the Premise

Fiber to the Node (FTTN) was the third option analyzed. Figure 39 shows what a FTTN connection looks like. Fiber optic cable (red line) runs from the ISP main office to the node. In most instances, copper cable is installed between the node and the residence and/or business (orange line). Not only is this network less expensive to install than FTTP, but also since utility cabinets and CAIs can serve as nodes, it can be accessed by multiple users. It should be noted that due to the limitations of copper cable, the distance between the node and the end-user cannot extend beyond 1,000 feet, which causes a drop off in security. Although this distance is greater than FTTP, it is shorter in range when compared to the other potential options. Therefore, FTTN failed one of the criteria in our matrix: Coverage of over 1 Mile.

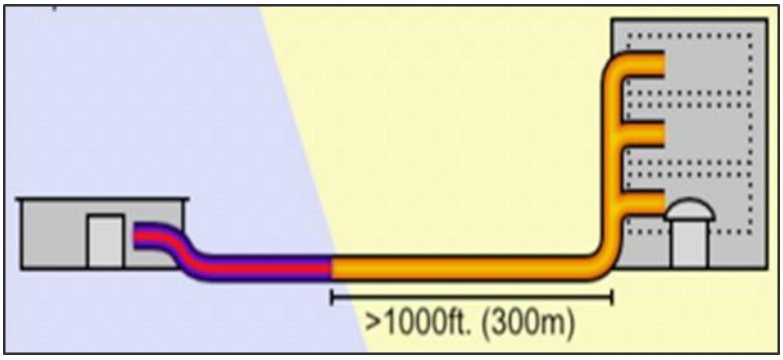

Figure 39: Fiber to the Node

The fourth option was Repeaters. Repeaters are boxes that are placed on street lamps to amplify a wireless signal so it can travel farther. Repeaters are inexpensive to install and currently are concentrated around the Railyard, a significant central hub for Santa Fe's economic development.

Because we were unable to determine if the ISPs would be willing to install these Repeaters, we could not assume the required number of Repeaters would be available and so we were not able to evaluate this option by the ISP Participation criterion. Without the Repeaters, depending upon the end-user's location, the signal would be greatly weakened or possibly non-existent. Even if repeaters were installed, if the antenna tower providing the signal goes offline, the repeaters that receive the strongest signal from that tower would be nearly useless. Repeaters, therefore, only satisfied two criteria: Jobs Created and Inexpensive to Install.

Following our analysis of Repeaters, we evaluated Free Space Optics. This laser-based technology makes the network very secure and also offers speeds of one gigabit per second. If this were to be installed, the initial end-users, according to our research, would be city and county governments. However, because Free Space Optics requires a direct line of sight to avoid signal disruption, this could become a problem during sandstorms, snowstorms, and other extreme weather conditions. Another negative aspect of this option is the very high cost of installation: transmitters can cost between $9,000 and $30,000.[61] Additionally, there are no assurances that any ISP would be willing to participate in the construction of this network. Therefore, Free Space Optics failed under the Inexpensive to Install criterion and could not be evaluated under ISP Participation.

Finally, we examined Fixed Wireless, a technology which uses transmitters installed on antenna towers to broadcast a wireless Internet signal. These transmitters are connected to the existing in-ground Internet infrastructure, be it copper or fiber. From these transmitters, the signal is spread within a mile radius. This signal can then be received by residences and businesses using wireless receivers. At approximately $4,000 per installation, it is relatively inexpensive to install. At least one ISP expressed willingness to participate in its construction. Another positive attribute of this technology is the speed of its signal, which can exceed 50 Mbps. The key weakness of Fixed Wireless is the impact inclement weather will have on the signal, similar to that faced by Free Space Optics. Of all the options explored, Fixed Wireless was the only one to satisfy all criteria in the matrix.

5.3 Analysis of the Open Network

As stated earlier, the Open Network option was placed in its own category because of the private versus public issue: private ISPs controlling delivery/access or local government offering the signal free of charge to the public. The goal of the Open Network would be to provide free Internet service to all of Santa Fe. The inherent obstacles to implementing this option include difficulty in determining who would operate the network, the cost to create an entirely new network, the quality of its operation, how it would

[61] (System Support Solutions)

be secured, how to maintain consistent Internet speeds, and how to determine whether this network could work as efficiently as a privately owned network.

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6 Conclusions and Recommendations

"Yes, America needs an upgrade, and that, yes, there are investors and innovators willing to step up to get it done"[62]

This comment from Blair Levin, executive director of Gig.U and lead author of the U.S. Federal Communications Commission's 2010 national broadband plan, on the most recent news about the funding of a gigabit-per-second broadband project, underscores the position that faces the City of Santa Fe. In turn, the City challenged our team to address three questions concerning the economic impact of the Internet on local businesses:

1. Is there a demand for higher Internet speeds in Santa Fe?
2. Will the Internet service providers participate in a city sponsored infrastructure?
3. Will the benefits of a newly sponsored infrastructure reach consumers and businesses?

The answers to these questions should aid the City in determining the potential impact a city-sponsored infrastructure project would have on developing the economy of Santa Fe. Our team was able to jump-start the process from which definitive recommendations could be made. Through our creative and exhaustive efforts, we were able to begin cataloguing Santa Fe's Internet infrastructure to provide a valuable blueprint for the City to use as it evaluates the six options we defined in our matrix.

6.1 Is there a demand for higher Internet speeds?

Our research concluded that not only is there demand among certain local businesses for higher Internet speeds, but also these businesses would be willing to pay more for it. Our survey's sample size, however, was small, which we believe can be attributed to two factors: the lack of knowledge local businesses have about their current Internet service as well as their future Internet needs, and apparent apathy within the community to address the topic: only 1 in 7 businesses responded to our survey and only 1 in 8 provided useful information. Of those who understood the implications of the Internet on their business, the interest in having faster speed access existed and was expressed. It seems reasonable to assume that if this Internet knowledge-base were expanded to a broader group, more companies would recognize the need for and value of faster speeds and would express similarly weighted responses to the ones we catalogued. We believe that there is a definite need for more education to the businesses in the

[62] (Gross 2012)

area about how the Internet supports and could expand their operations, and how speed is an integral variable in this equation.

6.2 Will the ISPs participate in a city-sponsored infrastructure?

We learned that there is some interest from service providers to participate in a city-sponsored infrastructure project. Cyber Mesa Telecom expressed such an interest. We believe the limited response to this question was driven by the highly competitive nature of this industry and the inherent layers of secrecy that surround the information each provider holds. Throughout the seven weeks of this project, we experienced an overall unwillingness from the service providers we interviewed to share information. Multiple service providers vie for business from a finite community in Santa Fe. This environment does not foster cooperation; it serves as a disincentive to that process. It seemed that they believed sharing this proprietary and confidential information would in some way negatively impact their competitive advantage. We believe that the next stage in this process would be to develop new approaches to promote and incentivize these companies to cooperate and work together for the greater good. This probably should involve coordination from the political sector to foster a secure environment for this information share.

6.3 Will the benefits of the infrastructure reach consumers and businesses?

We believe that the benefits of this effort will reach the end-users if the plan to expand the infrastructure is undertaken strategically in terms of geographic placement and if it is supported with a strong marketing program. This investment will be rewarded if it targets the areas currently lacking such infrastructure and if it enhances the capabilities of the current infrastructure. To determine accurately the areas in need, further mapping like the one already undertaken is required. We estimate it would take 240 man hours for one person to record the unmapped areas of Santa Fe on a bicycle. This time requirement could be significantly reduced if a car were used for transportation. In addition, it would take approximately 40 hours to input the data into a spreadsheet, to convert it into a correct format, and to upload the file to a GIS program. Continued data collection will ensure that the map is inclusive of all current and future investments committed to either by private entities such as the service providers or public ones such as the public works initiatives that we have discussed previously. Having this final comprehensive map will limit Santa Fe's investment in infrastructure that potentially would overlap existing architecture, which we believe would be a wasteful use of those funds.

If, once the map is complete, specific deficient areas can be highlighted, Santa Fe can earmark their funds for development in these key areas. Once incorporated into the system, this infrastructure will

augment the current structure and will be able to deliver the high speed Internet service that the local business community is demanding. Effective marketing to this existing group of businesses can be supplemented to reach out to and attract a universe of potential newcomers to the business community. Santa Fe, with this new widespread Internet infrastructure will be able to redefine itself to compete with other markets as a strong and viable business center. New businesses relocating to Santa Fe would translate into increased tax revenues and other economic booms generated by the influx of new people into Santa Fe.

One note of caution is in regards to the control over end-user pricing. If the City invests to supplement the current infrastructure and provides it at no or low cost to the ISPs for resale, the City might want to consider caps on the prices that can be charged to the end -user for these services. Santa Fe needs to be assured that their investment will translate into affordable services for its community and that price gouging of any type will be averted.

6.4 Recommendations

"It's time for a departure from the strategies of the past, strategies that merely looked a(t) fulfilling current demand"[63]

If we had to select one strategy that was best for Santa Fe to upgrade its infrastructure, we would choose Fixed Wireless. As mentioned in the above quote, this technology presents new ways of looking at satisfying demand. We think that not only would Fixed Wireless be one of the least expensive options to install, but also it would be easier to implement. On top of this, we know that at least one ISP that would be willing to participate in this form of infrastructure. A Fixed Wireless signal would be able to provide better Internet access to the areas with limited Internet connections in Santa Fe. While perhaps currently not capable of delivering Internet service at the highest speeds, it would provide faster speeds than currently available. Additionally, we believe it is the most feasible option in terms of cost, ease of installation, and reach. But to reiterate, we strongly recommend finalizing the mapping effort to obtain a comprehensive picture of the current infrastructure to make certain that this option is the most strategic.

6.5 Summary

To summarize, a demand and need for higher Internet speeds exist in Santa Fe among its business community. We have launched an effort to systematically and comprehensively map the existing

[63] (Gross 2012)

infrastructure, providing the skeleton for the evaluation of expansion options for this technology. This process needs to continue and should be supported and supplemented with an educational campaign aimed at local businesses to assist them in understanding their current Internet capabilities and how upgrades in technology would impact and could improve their business operations. The key to securing the remainder of this information will be to promote an environment of cooperation among ISPs to share and participate and at the same time to be guaranteed that their data will remain secure. Ultimately success will generate future revenue streams for the ISPs, the business community, and the City. All of this is underscored by the need for education to the businesses of Santa Fe, to compel them to understand that faster Internet speeds will translate into efficiencies in their operations, which in turn, could reduce costs and increase profits. Additionally, with higher quality Internet service in the area, the City will be able to meet the needs of local businesses that have an increasing dependence on technology. With more businesses purchasing faster Internet services and new businesses committing to expansion in Santa Fe, the economy of Santa Fe should grow.

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8 Appendices

Appendix A: Community Anchor Institutions

Rank	Name	Description	Latitude	Longitude
1	Wood Gormley Elementary	141 East Booth Street	35.67924585	-105.939425
2	New Mexico School For The Arts	275 East Alameda	35.68454261	-105.9348108
3	Carlos Gilbert Elementary	300 Griffin Street	35.69116089	-105.941887
4	Capshaw Middle	351 Zia Road	35.64687388	-105.9510678
5	Alameda Middle	450 La Madera Street	35.68465158	-105.9612587
6	Alvord Elementary	551 Alarid Street	35.68230607	-105.9523153
7	Santa Fe Public Schools	610 Alta Vista	35.66973238	-105.952322
8	Gonzales Elementary	851 West Alameda	35.68881065	-105.9556275
9	Monte Del Sol Charter School	4157 Walking Rain Rd	35.62498582	-106.0096564
10	Academy For Technology And The Classics	2395 Richards Ave	35.64234372	-105.9953682
11	New Mexico School For The Deaf	1060 Cerrillos Rd	35.67696598	-105.9570219
12	Salazar Elementary	1231 Apache Avenue	35.66485391	-105.9803239
13	Kaune Elementary	1409 Monterey Drive	35.67008866	-105.9620557
14	Tierra Encantada Charter High School	1501 Cerrillos Road	35.66986447	-105.9667294
15	Larragoite Elementary	1604 Agua Fria Street	35.67659234	-105.9713528
16	De Vargas Middle	1720 Llano Road	35.65690535	-105.9735703
17	Santa Fe High	2100 Yucca Road	35.65073045	-105.9716646
18	Chaparral Elementary	2451 Avenida Chaparral	35.64279055	-105.968743
19	Ser/Sfps Career Academy Alt	2516 Cerrillos Road	35.65772006	-105.9819992
20	Pinon Elementary	2921 Camino Caballos	35.63311189	-105.9935785
21	E. J. Martinez Elementary	401 N. San Mateo	35.66421229	-105.9488246

22	Capital High	4851 Paseo Del Sol	35.62253907	-106.042104
23	R. M. Sweeney Elementary	501 Airport Road	35.63585086	-106.0442605
24	Acequia Madre Elementary	700 Acequia Madre St.	35.68004757	-105.9304093
25	Atalaya Elementary	721 Camino Cabra	35.67335704	-105.9121077
26	Kearny Elementary	901 Avenida Las Campanas	35.64623179	-105.9900338
27	Pablo Roybal Elementary	1574 State Road 502	35.88128217	-106.065034
28	Pojoaque Intermediate	1574 State Road 502	35.88128217	-106.065034
29	Pojoaque Valley High	1574 State Road 502	35.88155016	-106.0666951
30	Pojoaque Valley Public Schools	1574 State Road 502	35.8709889	-106.2299341
31	Pojoaque Middle	1574 State Road 502	35.8903702	-106.026937
32	Francis X. Nava Elementary	2655 Siringo Road	35.65215778	-105.9821937
33	Agua Fria Elementary	3160 Aqua Fria	35.65991797	-106.0037688
34	Ramirez Thomas Elementary	3200 Calle Po Ae Pi	35.63797144	-106.0290112
35	Edward Ortiz Middle	4164 South Meadows	35.62852291	-106.0335951
36	Cesar Chavez Elementary	6251 Jaguar Drive	35.62498048	-106.0464671
37	Turquoise Trail Elementary	13-A San Marcos Loop	35.53634524	-106.0531946
38	El Dorado Elementary	2 Avenida Torreon	35.53890412	-105.9086204
39	Santa Fe Public Library	145 Washington St.	35.68852164	-105.9372382
40	College of Santa Fe Fogelson Library	1600 St. Michael'S Drive	35.66006335	-105.9753695
41	Oliver La Farge Public Library	1730 Llano St.	35.656889	-105.972306
42	Santa Fe Community College Library	6401 So. Richards Avenue	35.58713448	-106.0019038
43	Southside Library (Santa Fe Branch)	6599 Jaguar Drive	35.62417475	-106.050618
44	Pueblo of Pojoaque Public Library	101 Lightning Loop	35.89246418	-106.0166404

45	Vista Grande Public Library	14 Avenida Torreon	35.53737986	-105.9085281
46	Institute Of American Indian Arts Library	83 Avan Nu Po Road	35.58536178	-106.0134352
47	Physicians Medical Center of Santa Fe	2990 Rodeo Park Drive East	35.63473259	-105.9612517
48	Santa Fe Indian Hospital	1700 Cerrillos Road	35.66833888	-105.9704404
49	Saint Vincent Regional Medical Center	455 Saint Michaels Drive	35.65947918	-105.9468331
50	Santa Fe County Juvenile Detention Center	4250 Airport Road	35.63783479	-106.0217812
51	United States Marshals Service - Santa Fe	106 South Federal Place	35.69097706	-105.9375645
52	New Mexico State Parks Law Enforcement	120 South Saint Francis Drive	35.68796253	-105.9545287
53	Santa Fe Fire Department Station 1	200 Murales Road	35.69560493	-105.9336625
54	New Mexico Attorney General Investigators	408 Galisteo Street	35.68379296	-105.9430654
55	Santa Fe Fire Department Station 6	West Alameda Street	35.68734111	-105.9612623
56	Santa Fe Fire Department Station 4	1130 Arroyo Chamiso Road	35.656882	-105.9411187
57	Bureau of Land Management - Santa Fe Field Office	1474 Rodeo Road	35.63933611	-105.961736
58	Santa Fe Fire Department Station 3	1751 Cerrillos Road	35.66612514	-105.9715017
59	New Mexico Department of Transportation - Traffic Safety Bureau	604 West San Mateo Road	35.66152938	-105.9578744
60	Santa Fe County Volunteer Fire - Hondo District Station 2	645 Old Las Vegas Highway	35.55551922	-105.8760933
61	Santa Fe County Volunteer Fire - Pojoaque District Station 1	29 Ogo Wii	35.87803133	-106.0103721
62	Santa Fe County Volunteer Fire - Pojoaque District Station 2	302 State Highway 503	35.90435636	-105.9755388
63	Santa Fe County Volunteer Fire - Tesuque District Station 1	4 Senda De Fuego	35.75821299	-105.9334876
64	Santa Fe County Volunteer Fire - Tesuque District Station 2	444 State Highway 592	35.80848055	-105.9122242
65	Tesuque Tribal Police Department	5 Tesuque Pueblo	35.81620621	-105.9729615

		804		
66	Pojoaque Tribal Police Department	58 Cities Of Gold Road	35.88490615	-106.0148301
67	Pojoaque Pueblo Emergency Operations Center	58 Cities Of Gold Road	35.88472439	-106.0156344
68	Santa Fe County Volunteer Fire - Agua Fria District Station 2	6 Arroyo Calabasas Road	35.71228133	-106.0176147
69	Tesuque Pueblo Emergency Operations Center	State Highway 42	35.77640251	-105.9418629
70	San Ildefonso Pueblo Emergency Operations Center	State Highway 5	35.89193777	-106.1175593
71	Santa Fe County Detention Facility	4312 State Highway 14	35.56271319	-106.0507373
72	Penitentiary Of New Mexico - Level Two Unit	4311 State Highway 14	35.56651699	-106.0648575
73	Penitentiary Of New Mexico - Level Five Unit	4311 State Highway 14	35.56154248	-106.0682602
74	Penitentiary Of New Mexico - Level Six Unit	4311 State Highway 14	35.56877489	-106.068968
75	New Mexico Game and Fish Department - Law Enforcement	1 Wildlife Way	35.67041325	-106.0767158
76	Santa Fe Fire Department Station 5 - Santa Fe Fire Training Center	1130 Siler Road	35.662614	-105.9979179
77	La Cienega Volunteer Fire Department Station 2	136 Camino San Jose	35.56287076	-106.1251415
78	Santa Fe Fire Department Station 7	2391 Richards Avenue	35.64235032	-105.9974772
79	Santa Fe Fire Department Station 9	2512 Camino Entrada	35.63839456	-106.0186294
80	Santa Fe Police Department	2515 Camino Entrada	35.63596654	-106.019923
81	New Mexico Mounted Patrol - Troop 1	4491 Cerrillos Road	35.62924426	-106.0242663
82	Department of Public Safety - New Mexico State Police Department District 1	4491 Cerrillos Road	35.62924468	-106.0242632
83	Santa Fe County Volunteer Fire - Agua Fria District	58 County Road 62	35.66010266	-106.0295852
84	Santa Fe Fire Department Station 8	6796 Jaguar Drive	35.62049251	-106.0563653
85	Santa Fe Fire Department Station 10 -	Aviation Drive	35.61927988	-106.0821508

	Airport			
86	Homeland Security And Emergency Management Center	13 Bataan Boulevard	35.57121037	-106.0861896
87	Homeland Security And Emergency Management Mobile Unit	13 Bataan Boulevard	35.57122487	-106.0862015
88	Santa Fe County Volunteer Fire - La Cienega District	14 Fire Place	35.59792398	-106.0490356
89	Santa Fe County Volunteer Fire - El Dorado District Station 1	144 Avenida Vista Grande	35.53730873	-105.8907896
90	Santa Fe County Volunteer Fire - El Dorado District Station 2	167 Avenida Casa Del Oro	35.53936799	-105.9642583
91	Santa Fe County Volunteer Fire - Hondo District Station 1	21 Seton Village Road	35.6060387	-105.9157166
92	Santa Fe County Volunteer Fire - El Dorado District Station 3	28734 United States Highway 285	35.51073747	-105.8953673
93	Turquoise Trail Volunteer Fire Department Ambulance Station 3	3 Turquoise Trail	35.50166691	-106.0631247
94	Santa Fe County Volunteer Fire Administration	35 Camino Justica	35.56435206	-106.0488505
95	Santa Fe County Sheriffs Office	35 Camino Justicia	35.56437131	-106.0486369
96	Santa Fe County Emergency Operations Center	35 Camino Justicia	35.56433902	-106.0486564
97	Santa Fe County Volunteer Fire - Turquoise Trail District Station 2	3609 State Highway 14	35.46215905	-106.0703811
98	Santa Fe County Volunteer Fire - Penitentiary Of New Mexico District	4311 State Highway 14	35.56205622	-106.059502
99	Santa Fe University of Art and Design	1600 St. Michaels Drive	35.66006335	-105.9753695
100	Southwestern College	3960 San Felipe Road	35.63569961	-106.0530419
101	New Mexico Highlands University - Santa Fe Center	6401 Richards Ave, Room 302 D	35.6059291	-105.9990678
102	University of New Mexico - Santa Fe	1305 Luisa Street	35.67108958	-105.950376
103	University of Phoenix - Santa Fe Learning Center	130 Siringo Road	35.6516163	-105.9536087
104	Southwest Acupuncture College - Santa Fe	1622 Galisteo St	35.66191323	-105.9500608
105	St. John's College	1160 Camino De	35.66878538	-105.9126121

		La Cruz Blanca		
106	Southwestern College	P.O. Box 4788	35.63569961	-106.0530419
107	The College Of Santa Fe	1600 St. Michaels Drive	35.66006335	-105.9753695
108	Santa Fe Community College	6401 Richards Ave.	35.58638077	-106.0035834
109	DHI Office Court	4001 Office Ct	35.63449283	-106.0169839
110	Harold Runnels Building	715 Alta Vista St	35.67150836	-105.9567581
111	PHD D2 Santa Fe Letrado DO/HO	605 Letrado St	35.67141349	-105.9508287
112	PHD D2 San Mateo	810 W San Mateo Rd	35.6612413	-105.9619681
113	PHD D2 La Familia	2145 Caja Del Oro Grant Rd	35.6584165	-106.0267515
114	Paisaano Bulding	2968 W Rodeo Park Dr	35.63518025	-105.9618547
115	Siler ERD	1301 Siler Rd	35.65807339	-105.9924455
116	Henry Colgate Bulding	2040 S Pacheco St	35.65843914	-105.959285
117	Siler Pharmacy	1301 Siler Rd	35.65807339	-105.9924455
118	New Mexico State East Complex - PERA Building	1120 Paseo De Peralta	35.682237	-105.9360519
119	New Mexico State Central Complex - Concha Ortiz Y Pino Building	130 South Capitol Place	35.6829298	-105.9420171
120	New Mexico State Central Complex - Jerry Apodaca Education Building	300 Don Gaspar Avenue	35.6844217	-105.9409706
121	New Mexico State Central Complex - Joseph Halpin Records Center	404 Montezuma Avenue	35.6847291	-105.9461128
122	New Mexico State Central Complex - Bataan Memorial Building	407 Galisteo Street	35.6836141	-105.9410767
123	New Mexico State Paul Bardacke Complex - Villagra Building	408 Galisteo Street	35.6837949	-105.9430481
124	New Mexico State East Complex - Lamy Building	491 Old Santa Fe Trail	35.6830721	-105.9378812
125	New Mexico State East Complex - Lew Wallace Building	495 Old Santa Fe Trail	35.6832644	-105.9372365
126	State of New Mexico South Complex - Joseph Montoya Building	1100 South Saint Francis Drive	35.6734748	-105.9547162
127	State of New Mexico South Complex - Public Health Nurses Building	1105 South Saint Francis Drive	35.6726196	-105.9536103
128	Joe M Anaya Memorial Complex	1120 Cerrillos	35.6760416	-105.9575393

		Road		
129	State of New Mexico South Complex - Harold L Runnels Building	1190 South Saint Francis Drive	35.6720596	-105.9556755
130	State of New Mexico South Complex - Manuel Lujan, Senoir	1200 South Saint Francis Drive	35.6707151	-105.9561538
131	State of New Mexico South Complex - Wendell Chino Building	1220 South Saint Francis Drive	35.6691366	-105.9576783
132	New Mexico State Auditor Office	2113 Warner Circle	35.6574059	-105.9660707
133	West Complex - Doctor Timothy T Fleming Building	2500 Cerrillos Road	35.6591048	-105.9826689
134	West Complex - Human Services Field Office Building	2542 Cerrillos Road	35.6562572	-105.9820433
135	West Complex - Toney Anaya Building	2550 Cerrillos Road	35.6582643	-105.9825548
136	West Complex - Willie Ortiz Building	2600 Cerrillos Road	35.6584545	-105.9840059
137	State of New Mexico South Complex - John F Simms Junior Building	715 Alta Vista Street	35.6724351	-105.9566692
138	New Mexico Department of Game and Fish	1 Wildlife Way	35.6703394	-106.0767857
139	New Mexico State West Complex - Garrey Carruthers Building	1209 Camino Carlos Rey	35.657102	-105.9838579
140	New Mexico Corrections Department	4337 State Highway 14	35.5670781	-106.0540107

Appendix B: Street Cut Permit

Revised 8/18/10

CITY OF SANTA FE
STREETS & DRAINAGE
MAINTENANCE DIVISION

PERMIT #

1-800-321-2537

NM ONECALL (BLUESTAKE)

RIGHT-OF-WAY EXCAVATION & RESTORATION PERMIT

The undersigned hereby makes application to the City of Santa Fe Streets & Drainage Maintenance Section (SDM) to perform work, as described below, within a public place and agrees to abide by all City ordinances, regulations and instructions pertaining to advance notification, traffic control, safety, excavation backfill and surface restoration. The undersigned understands that he is responsible for furnishing traffic control in accordance with the Manual on Uniform Traffic Control Devices. Failure to comply with the Manual on Uniform Traffic Control Devices will void this permit. The undersigned agrees that all concrete work within any of the Historic Districts shall be a pre-approved non-gray color - SDM reserves the right to have non-compliant concrete redone at the permitee's expense. The applicant is duly licensed by the City of Santa Fe to do the work herein contemplated and agrees to render the city of Santa Fe harmless from any loss or liability by reason of injury to persons or property occasioned or caused by the work herein contemplated.

Print all information legibly. Illegible or incomplete permit applications will not be processed.

1. APPLICATION DATE: _____ 2. APPLICATION TYPE: ☐ ROUTINE ☐ EMERGENCY

3. APPLICANT/PRIMARY CONTRACTOR: _____ LICENSE NUMBER: _____

Bonding Company: _____ Insurance Company: _____ Exp. Date: _____

4. MAILING ADDRESS: _____ PH. OR CELL #: _____

Asphalt contractor: _____ License Number: _____

Concrete contractor: _____ License Number: _____

Material Testing Lab: _____ Subcontractors (Others) _____

5. **ACTUAL LOCATION OF WORK /STREET ADDRESS IF DIFFERENT**: _____

STREET SURFACE TYPE TO BE CUT OR REMOVED: ☐ ASPHALT ☐ CONCRETE ☐ DIRT ☐ GRAVEL ☐ SIDEWALK

PAVEMENT PENALTY APPLICABLE? ☐ YES ☐ NO

6. DESCRIBE IN DETAIL WORK TO BE COMPLETED: _____

_____

7. ESTIMATED DIMENSIONS: _____ _____ _____
(Length) (width) (area)

8. ESTIMATED WORK SCHEDULE: _____ _____
(TO INCLUDE SURFACE RESTORATION) (Begin) (End)

ACTUAL DIMENSIONS: _____ _____ _____
(Length) (width) (area)

ACTUAL START DATE: _____

FULL ROAD CLOSURE REQUIRED?: _____

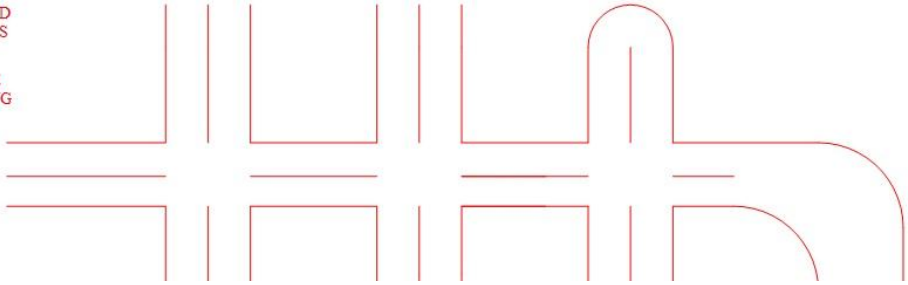
9. APPLICANT: _____ (PRINT NAME) _____ (SIGNATURE)

PERMIT ISSUE/APPROVAL DATE: _____ **PERMIT APPROVED BY:** _____

FEE CALCULATION	shaded areas for office personnel only
a. Permit 11001.421200 _____ b. New Pavement Penalty 11001.431150 _____ c. Other _____ d. Other _____ TOTAL $_____	* Excavation limited to 200' unless otherwise approved by the SMD Inspector * Primary contractor is responsible for quality of work and warranty work if needed * Please indicate below where street cut is to be made. Show measurements including those from corner of manhole where necessary. Note all appropriate information such as name of street(s), size and approximate location of excavation, location of sidewalk or drainage. PERMIT NOT VALID WITHOUT A RECEIPT FOR NON-FRANCHISE UTILITY CONTRACTORS.

A COMPLETE AND DETAILED MAP IS REQUIRED.

PLEASE INCLUDE ALL PRE- EXISTING PATCHES.



Appendix C: Street Cut Permit Bond

SURETY BOND

That we, _____, as Principal, and _____, as Surety, are held and firmly bound unto the **City of Santa Fe, NM** or to any of its officers, for the use of any persons, firms, or corporations with whom such Principal shall hereafter contract, in the penal sum of **Ten thousand and no/100 ($10,000.00)**, good and lawful money of the United States of America, well and truly to be paid, and for payment of which we and each of us hereby bind ourselves, our heirs, executors, administrators, and successors, jointly and severally, firmly by these presents.

The Conditions of this obligation are such that

Whereas, the above-named Principal desires to engage in the business of pouring, constructing, building, repairing and rebuilding curbs, gutters, sidewalks and driveways in the **City of Santa Fe, NM**, and has applied to the City Engineer of said City for a license to do such work.

Now therefore, if said Principal shall, during is continuance of said license, indemnify and save harmless the **City of Santa Fe, NM** and any person, firm or corporation with whom the Principal has contracted, from any and all damages of every character arising from, or caused directly or indirectly, from imperfect or inadequate work done by said Principal and maintain said work in good and workmanlike state of repair for and during a period of one (1) year from and after its completion and acceptance by the **City of Santa Fe, NM**, then this obligation shall be null and void, otherwise to remain in full force and effect; provided however, this bond is executed by the Surety on the condition that its liability shall be limited by and subject to the conditions and provisions herein contained.

Successive actions may be brought on this bond for successive breaches of its conditions or any of them; provided, however, that the sum total of all liability of the Surety on any one or all of such actions shall not exceed the sum of Ten Thousand Dollars ($10,000.00).

The liability of the Surety under this bond, if not canceled as hereinafter provided, shall cease and terminate of its own force and effect one year form the date hereon, saving and except for the maintenance of the work performed previous to the date of termination, for which work the liability of the Surety from maintenance shall continue for one year from and after the date of the completion and acceptance of said work by the City, but no longer.

Santa, Fe, NM five (5) days written notice of the Surety's intention to do so, and from and after said date the Surety will no longer be liable for any subsequent act, save and except as to maintenance as hereinabove provided.

In Witness hereof, the said Principal and the said Surety have set their hand and seal this ____ day of _____, _____.

_____
Principal

By:_____

_____
Surety

By:_____

Appendix D: Street Cut Permit Locations

	Permit Number	Company Name	Date Issued	Start/End Date	Date of Competion	Address	N - S - E - W	Street Name	Street type
2	99020050		22-Feb-99						
3	01080010	21st Century	06-Aug-01	8-6-01 - 8-11-01				Rosina	
4	00100045	A & J Const	19-Oct-00	10-21-00 - 11-4-00		925		Acequia Madre	
5	96040017	A-1 Plumb	24-Apr-96			220		Water	Street
6	01100050	AA Excavating	18-Oct-01	10-16-01 - 10-18-01		1530		5th	Street
7	97070044	AA Excavating	31-Jul-97					Canyon	Road
8	97120004	AA Excavating	08-Dec-97					Irvine	Street
9	98080031	AA Excavating	21-Aug-98			1170		San Acasio	
10	98120016	AA Excavating	15-Dec-98			1015		Hickox	Street
11	99110083	AA Excavating	29-Nov-99	11-26-99		523		Silva	Street
12	01070012	Abasto Utility	05-Jul-01	7-11-01 - 7-13-01				Rd, Pinon Dr,	
13	01080074	Abasto Utility	28-Aug-01	8-28-01 - 9-7-01				Siler	Road
14	96060039	Accent Landscaping	11-Jun-96					Jicarilla	
15	01020061	Accequia Plumb	23-Feb-01	2-26-01 - 2-28-01		745		Dunlap	Street
16	02080079	ACT	22-Aug-02	8-22-02 - 8-30-02	10-16-02			Callejon De Melinda	
17	00050008	ACT Utility	03-May-00	4-27-00 - 5-5-00				Ephriam	Street
18	00070056	ACT Utility	28-Jul-00	7-31-00 - 8-11-00		2923		Rufina	Street
19	00080061	ACT Utility	23-Aug-00	8-22-00 - 8-31-00				Rufina	Street
20	01030011	ACT Utility	02-Mar-01	2-28-01		320		Tesuque	Drive
21	01110034	ACT Utility	14-Nov-01	11-14-01 - 11-21-01				Agua Fria	
22	01110035	ACT Utility	14-Nov-01	11-14-01 - 11-21-01				Agua Fria	
23	02060039	ACT Utility	17-Jun-02	6-14-02 - 8-31-02	10-16-02			Camino La Canada	
24	02060040	ACT Utility	17-Jun-02	6-14-02 - 8-30-02	10-16-02			Calle Jon Melinda	
25	95090029	ACT Utility	20-Sep-95			2451		Ave Chaparral	
26	96010051	ACT Utility	26-Jan-96			1710		Alameda	Street
27	96020038	ACT Utility	22-Feb-96			2190		Alameda	Street

Address other	Street Name C	Cross Street	Street type B	Cross Street B	Fire Hydraunt #
and	Osage	and	Hopi		
and	Don Miguel				
and	Able Arjimo				
and	Dunlap				
and	Cir, Osage Ave				
	Siler Ct	Gallegos, Clark			
and	Calle Alvarado				
and	Irvine				
at	Ben Hur				
at	Calle Toijon				
and	Siler	Road			
and	Richards	Ave			
and	Laguna				
and	Hickox				
and	Hickox				
at	dead end of road				
at	Ben Hur	Drive			

Appendix E: Above Ground Hubs

Rank	Name	Description	Latitude	Longitude
1	CenturyLink	Hub	35.662319	-105.957855
2	CenturyLink	Hub	35.661739	-105.959915
3	CenturyLink	Manhole	35.661472	-105.962051
4	CenturyLink	Pole	35.662796	-105.9646
5	CenturyLink	Pole	35.663483	-105.964142
6	CenturyLink	Pole	35.663929	-105.963646
7	CenturyLink	Pole	35.664543	-105.963211
8	CenturyLink	Pole	35.66534	-105.96328
9	CenturyLink	Pole	35.665455	-105.962509
10	CenturyLink	Pole	35.665665	-105.962479
11	CenturyLink	Pole	35.665741	-105.962631
12	CenturyLink	Pole	35.665901	-105.96225
13	CenturyLink	Pole	35.666439	-105.962051
14	CenturyLink	Pole	35.667656	-105.961166
15	CenturyLink	Pole	35.669338	-105.959976
16	CenturyLink	Pole	35.670147	-105.959511
17	CenturyLink	Pole	35.670521	-105.959183
18	CenturyLink	Pole	35.671329	-105.958633
19	CenturyLink	Pole	35.671761	-105.958382
20	CenturyLink	Pole	35.672115	-105.95816
21	CenturyLink	Cabinet	35.672081	-105.957985
22	CenturyLink	Pole	35.673153	-105.957336
23	CenturyLink	Pole	35.673191	-105.957314
24	CenturyLink	Pole	35.673344	-105.957191
25	CenturyLink	Pole	35.674847	-105.95623
26	CenturyLink	Pole	35.675017	-105.955603
27	CenturyLink	Hub	35.676277	-105.954216
28	CenturyLink	Hub	35.671364	-105.956963
29	CenturyLink	Hub	35.67168	-105.957687
30	CenturyLink	Manhole	35.671707	-105.958084
31	CenturyLink	Hub	35.671211	-105.956017

32	CenturyLink	Manhole	35.671219	-105.956032
33	CenturyLink	Hub	35.668377	-105.956253
34	CenturyLink	Hub	35.667759	-105.956696
35	CenturyLink	Hub	35.667786	-105.956604
36	CenturyLink	Hub	35.667393	-105.95665
37	CenturyLink	Hub	35.667305	-105.957024
38	Unknown	Hub	35.666912	-105.956337
39	Unknown	Hub	35.667252	-105.956352
40	CenturyLink	Hub	35.666592	-105.956749
41	Unknown	Hub	35.666557	-105.957024
42	CenturyLink	Hub	35.66663	-105.957474
43	Unknown	Hub	35.666569	-105.957428
44	CenturyLink	Hub	35.666477	-105.956398
45	CenturyLink	Hub	35.665108	-105.956528
46	CenturyLink	Hub	35.664452	-105.95649
47	Unknown	Hub	35.66386	-105.966619
48	CenturyLink	Hub	35.661697	-105.959615
49	CenturyLink	Hub	35.660618	-105.959412
50	Unknown	Hub	35.65974	-105.95919
51	CenturyLink	Hub	35.660526	-105.959671
52	CenturyLink	Hub	35.660255	-105.959671
53	CenturyLink	Hub	35.659786	-105.965797
54	CenturyLink	Pole	35.662193	-105.964836
55	CenturyLink	Manhole	35.661633	-105.965225
56	CenturyLink	Manhole	35.661488	-105.965309
57	CenturyLink	Manhole	35.661419	-105.965385
58	CenturyLink	Manhole	35.661388	-105.965462
59	CenturyLink	Pole	35.661423	-105.965561
60	CenturyLink	Pole	35.660793	-105.965782
61	CenturyLink	Hub	35.660633	-105.974655
62	Unknown	Hub	35.661354	-105.976242
63	CenturyLink	Hub	35.662842	-105.976173
64	CenturyLink	Hub	35.662842	-105.976234
65	CenturyLink	Hub	35.664192	-105.972275

66	CenturyLink	Hub	35.664097	-105.972321
67	CenturyLink	Hub	35.664101	-105.97285
68	CenturyLink	Hub	35.663971	-105.973053
69	CenturyLink	Hub	35.664001	-105.971634
70	CenturyLink	Hub	35.663029	-105.970955
71	CenturyLink	Manhole	35.661671	-105.970398
72	CenturyLink	Hub	35.660076	-105.969986
73	CenturyLink	Manhole	35.660118	-105.96991
74	Unknown	Hub	35.66436	-105.971825
75	CenturyLink	Hub	35.664429	-105.97094
76	Unknown	Hub	35.664898	-105.970833
77	CenturyLink	Manhole	35.664978	-105.970843
78	CenturyLink	Hub	35.664959	-105.970863
79	CenturyLink	Hub	35.665333	-105.971077
80	Unknown	Hub	35.665264	-105.971138
81	CenturyLink	Hub	35.665001	-105.970749
82	Unknown	Hub	35.664719	-105.970665
83	CenturyLink	Hub	35.664398	-105.97036
84	CenturyLink	Hub	35.664146	-105.970169
85	Unknown	Hub	35.665936	-105.970284
86	CenturyLink	Hub	35.663204	-105.96597
87	CenturyLink	Hub	35.662991	-105.965561
88	Unknown	Hub	35.662636	-105.965263
89	CenturyLink	Hub	35.662209	-105.964912
90	CenturyLink	Pole	35.662323	-105.96489
91	Unknown	Hub	35.661232	-105.963066
92	CenturyLink	Hub	35.661186	-105.962204
93	CenturyLink	Manhole	35.661102	-105.961967
94	Unknown	Hub	35.66127	-105.961675
95	Unknown	Hub	35.661388	-105.960854
96	Unknown	Hub	35.661484	-105.960304
97	CenturyLink	Manhole	35.661566	-105.960083
98	CenturyLink	Hub	35.661594	-105.959633
99	CenturyLink	Manhole	35.661842	-105.958328

100	CenturyLink	Hub	35.661907	-105.95797
101	CenturyLink	Manhole	35.661894	-105.958061
102	CenturyLink	Hub	35.661884	-105.957558
103	Unknown	Hub	35.669079	-105.955513
104	Unknown	Hub	35.669235	-105.95565
105	CenturyLink	Hub	35.670155	-105.952316
106	Unknown	Hub	35.670006	-105.951431
107	Unknown	Hub	35.669987	-105.951202
108	CenturyLink	Hub	35.667824	-105.949699
109	Unknown	Hub	35.668224	-105.950974
110	Unknown	Hub	35.668404	-105.951569
111	Unknown	Hub	35.668434	-105.951576
112	Unknown	Hub	35.667995	-105.951569
113	CenturyLink	Hub	35.667744	-105.951572
114	Unknown	Hub	35.668316	-105.952011
115	CenturyLink	Hub	35.668003	-105.951931
116	CenturyLink	Hub	35.668381	-105.952255
117	CenturyLink	Hub	35.668564	-105.952744
118	CenturyLink	Hub	35.668417	-105.953308
119	CenturyLink	Hub	35.668499	-105.954033
120	CenturyLink	Hub	35.668522	-105.954811
121	CenturyLink	Hub	35.668392	-105.954842
122	CenturyLink	Hub	35.668385	-105.955452
123	Unknown	Cabinet	35.676731	-105.95359
124	CenturyLink	Manhole	35.678486	-105.952568
125	CenturyLink	Hub	35.681629	-105.951248
126	CenturyLink	Hub	35.68187	-105.951842
127	CenturyLink	Hub	35.681671	-105.952187
128	CenturyLink	Hub	35.681587	-105.952415
129	CenturyLink	Hub	35.681129	-105.952179
130	CenturyLink	Hub	35.68121	-105.952271
131	CenturyLink	Hub	35.680904	-105.952244
132	CenturyLink	Hub	35.680779	-105.952171
133	CenturyLink	Hub	35.680756	-105.952377

134	Unknown	Hub	35.680897	-105.952393
135	CenturyLink	Hub	35.680363	-105.952332
136	Unknown	Hub	35.679947	-105.9524
137	CenturyLink	Hub	35.679952	-105.953201
138	CenturyLink	Hub	35.679909	-105.953265
139	Unknown	Hub	35.679935	-105.953015
140	Unknown	Hub	35.679985	-105.953346
141	CenturyLink	Hub	35.680275	-105.953278
142	CenturyLink	Hub	35.680309	-105.953293
143	CenturyLink	Hub	35.680618	-105.953186
144	Unknown	Hub	35.680782	-105.953278
145	CenturyLink	Hub	35.680836	-105.95298
146	CenturyLink	Hub	35.680885	-105.952736
147	CenturyLink	Hub	35.680912	-105.953415
148	CenturyLink	Hub	35.680843	-105.953697
149	CenturyLink	Hub	35.680794	-105.954124
150	CenturyLink	Hub	35.681366	-105.956184
151	CenturyLink	Hub	35.680767	-105.955025
152	CenturyLink	Hub	35.680729	-105.954933
153	CenturyLink	Manhole	35.677251	-105.954468
154	CenturyLink	Manhole	35.676277	-105.956192
155	Unknown	Hub	35.675053	-105.95797
156	CenturyLink	Manhole	35.675103	-105.957993
157	CenturyLink	Manhole	35.674152	-105.959595
158	Unknown	Cabinet	35.670151	-105.96534
159	CenturyLink	Manhole	35.670124	-105.96537
160	CenturyLink	Manhole	35.669174	-105.966682
161	CenturyLink	Manhole	35.669044	-105.966789
162	CenturyLink	Manhole	35.667809	-105.968704
163	CenturyLink	Hub	35.665025	-105.9655
164	Unknown	Hub	35.662882	-105.965004

Appendix F: Survey Form

Interview Form

General Info

Interviewer(s): _____ Date: ___/___/_____
Company: _____
Address: _____
City: _____ Zip: _____

Contact Info

Email: _____ Phone: (_____) ____-_____
Other:

Questions

1. Who is your Internet provider?
2. How long have you been using this service?
3. Is it DSL/Cable/Fiber/etc…?
4. What speeds are you getting now (download and upload)?
5. Do you need more download than upload? Same amount? More upload?
6. How much are you paying per month/year?
7. How satisfied are you with your Internet connection? (1-10)
8. How much faster do you want the Internet to be? (A rate/ratio or speed)
9. How much more per month/year are you willing to pay to get those speeds?
10. How would the speeds affect your company? (New hires, higher revenue, etc…)

Appendix G: Survey Results

Timestamp	Company	Interviewer	Address	Email	Contact	Phone Number	Who is your Internet provider?
4/3/2012 17:20:57	National Center for Genome Research	Kyle	2935 Rodeo Park Drive East Santa Fe NM 87505			(505) 982-7840	Oso Grande
4/10/2012 15:38:17	Northern Insurance	Kyle	1219 Cerrillos Road Suite 1 Sante Fe, New Mexico 87505			(505) 982-9591	Paetec
4/10/2012 17:00:47	Dot Foil Computer Services	Claudia	851 Saint Michael's Drive Candyman Center Santa Fe, NM 87505			(505) 954-9955	Comcast
4/13/2012 12:40:34	Southwest Planning and Marketing	Kyle	128 Grant Avenue, Suite 114|P. O. Box 1506 Santa Fe, NM 87504			(505) 989-8500	CenturyLink
4/13/2012 14:03:33	Jemez Consulting Group	Claudia	NO PERSONAL INFORMATION			(505) 471-9890	Cyber link
4/17/2012 17:42:51	Impressions Advertising	Claudia	322 Paseo de Peralta, Santa Fe NM 87505			(505) 988-1402	Comcast

How long have you been using this service?	Is it DSL/Cable/Fiber/ etc..?	What speeds are you getting now (download/upload)?	Do you need faster download than upload? Same amount? Faster upload?	How much are you paying per month/year?	How satisfied are you with your internet connection on a scale 1-10?	How much faster would you like your Internet to be? (A rate/ratio or speed)	How much more per month/year are you willing to pay to get those speeds?	How would the speeds affect your company? (New hires, higher revenue, etc..)
2	Ethernet to Oso Grande, Oso Grande to Lambda Line or Quest Metropolitan Online (QMO)	50 each	Same Amount	3210	8	100 Mbps each	Max at $4200 per month	Faster transfer rates, upload to cloud servers, remote competing with other companys
2	T1	1.5 Mbps	Upload	400	2	5 Mbps	Contracted (higher speeds are provided for less)	Expansion
3	Cable	12 down 2 up	Download	100	7	100 down, 50 up	not much	not huge effect but more efficient
3	Fiber		Download	69	6	2x	0	Will be able to download large files.
10	DSL	1.5 down, 7kbps up	Download	65	8	20 Mbps	20-30	IT work, easier to download
1	Cable	16 down 8 up	Same Amount		10	Perfect		

Appendix H: Survey Script

- "Good morning/afternoon/evening,"
    - "I am part of a group of consultants working with the City of Santa Fe on the Capital Improvements Plan for Broadband."
- "This project entails discovering the current Internet services provided to businesses and determining the satisfaction and demands of high speed Internet for each business. We have questions that will cover your current services, you satisfaction or dissatisfaction with them, and if you would like faster speeds."
- "Company information will never be disclosed. However, if at any point you wish to withdraw from this study, we will immediately end your participation and terminate any and all information we currently have."
- "If you have the time, we would like to ask you some questions about your Internet Service."
- **Ask questions here**
- Thank you very much for your time. Have a wonderful day.

Appendix I: Strengths and Weaknesses of Upgrade Options

Fiber to the Premise

Pros:

- **Bandwidth Capacity**: optical signals can carry much more information than electrical ones. The most advanced copper cables can theoretically carry 1 Gigabit/second. Optical fibers, on the other hand, have a theoretical capacity of 350 Terabits/second or 350.000 Gigabits/second. Now that is the theory, what happens in practice? Current optical core networks (the backbone of telecom carriers) can already pack over 1 Terabit/second into a single optical fiber. The twisted copper pair (the cable that arrives to your telephone plug), instead, can transmit a maximum of 50 Megabits/second using the latest DSL technologies.
- **Signal reliability**: optical signals do not suffer electromagnetic interference and present a much smaller bit error rate compared to electrical systems. The signal loss (the amount of energy lost as the signal travels a medium) is also much lower in optical systems, meaning they can travel longer distances. DSL technology over the copper cable can cover up to 5 kilometers (18000 feet) before it needs regeneration while an optical network can reach over 200 kilometers.
- **Size and weight**: the core of an optical fiber goes from 10 to 50 micrometers (1/5 the diameter of a human hair) while some coaxial cables have diameters of half an inch. The weight of 1 kilometer of optical fiber is about 6 kilograms while the same length of coaxial cable could weigh as much as 1000 kilograms. When you need to roll-out networks long hundreds of kilometers having something light and thin can help.

Cons:

- **Cost per user**: optical networks are the rule for carrier's backbone because the huge amount of traffic justifies the economic investments. Deploying fiber to the home, however, is a different story. Telecom operators spend around $ 1000 per fiber subscriber. If you then consider that DSL technology offers up to 50 Megabits/second (a reasonable bandwidth even for coming years) at a fraction of that cost you get the reason why FTTH is advancing slowly.
- **Physical Constraints**: optical fibers cannot be bended too much or they lose some light reflecting properties. Additionally optical fibers can be damaged much more easily than copper cables, and the cost and complexity of the repair is significantly higher.
- **Switching**: current optical technology is very efficient for point-to-point data transmission. Unfortunately the same cannot be said for traffic switching. Optical switching technology is advancing fast but it still cannot match the flexibility and cost-efficiency of electrical switching solutions (read routers).

Wide Area Network (WAN)

Pros:

- Highspeeds and bandwidth - Frame Relay packet switch tech.
- Ease of Implementation - Service provider handles data tranport link.
- Scalable - Equipment cost (CPE) is the same independant of bandwidth.
- Multiple connections - Redundancy.
- Technology to choose - no one-size-fits-all solution.
    - Frame Relay, HDLC, PPP
    - ISDN (PRI,BRI), T1, T3, DSL, Dialup

Cons:

- Equipment is expensive.
- WAN connection handled by the provider. Provider must correct data transport link problems.
- Routing would be much more complex - determine exactly where each subnet would be advertised.
- More options - connectivity that would need to be considered.
- Expensive - bandwidth at a cost.

Fiber to the Node

Pros:

- Cost: fiber to the node is less expensive than fiber to the premise because it uses the existing coaxial or twisted pair infrastructure to provide last mile service
- Distribution: FTTN can cover more users/locations than FTTP, often hundreds at a time.

Cons:

- Speed: bandwidth potential is limited because it services consumers from up to a mile away (speeds decrease as distance increase)

Radio Towers

Pros:

- Fixed wireless signal can be distributed via cell towers, avoiding the telco companies who do not own the radio towers.
- Distance: signal can reach up to 1 mile, through air. Multiple towers in Santa Fe mean the signal can cover wide areas in downtown area, including the wealthy neighborhood and up the canyon region in Santa Fe.
- Cost: creating the infrastructure costs around $4000 per tower. Other upgrades to infrastructure
- Clean air means clear signal with little distractions (good weather 90% of the year in city).

Cons:

- Signal can be disrupted by weather patterns (rain, wind, fog, hail).

Free Space Optics

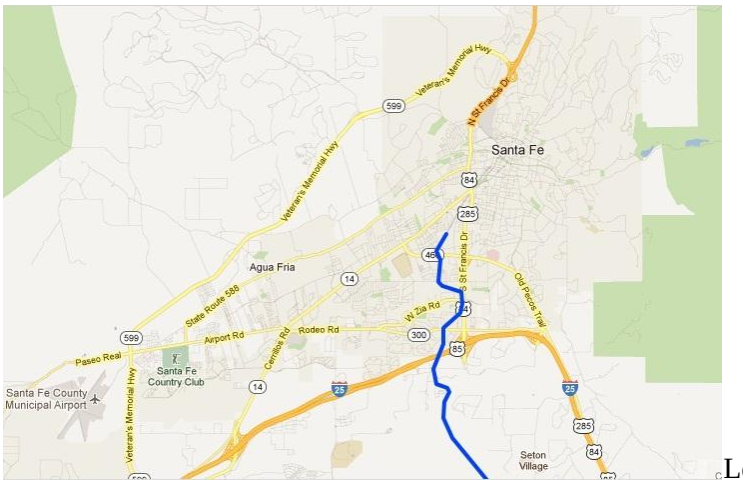
Pros:

- Ease of deployment
- High bit-rates (high speeds)
- Low bit error rates
- Signal travels over 1 mile (unlike fixed wireless which also operates over radio towers
- Very secure

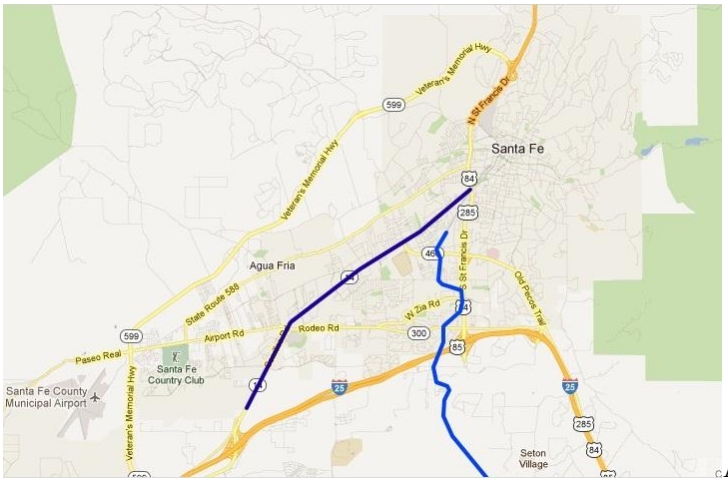
Cons:

- Weather: rain, wind, hail, dust can affect the signal
- Shadows can disrupt the signal

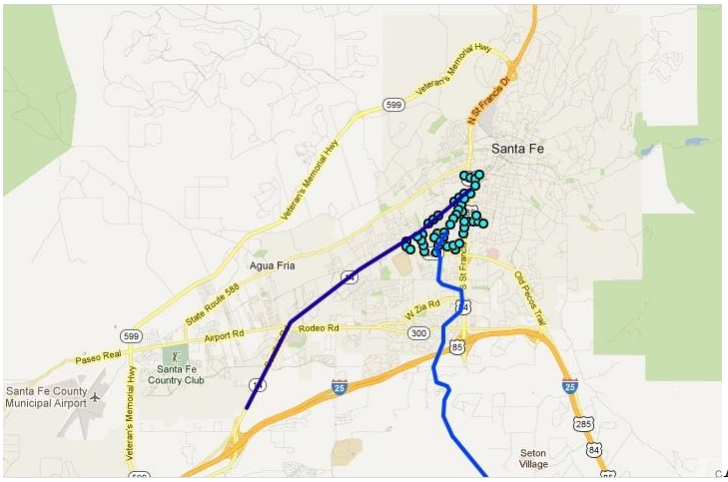
Appendix J: Infrastructure Maps



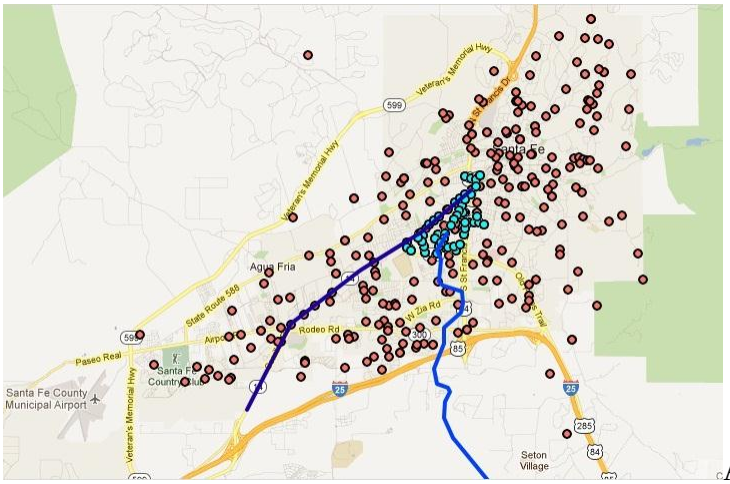
Long haul into Santa Fe



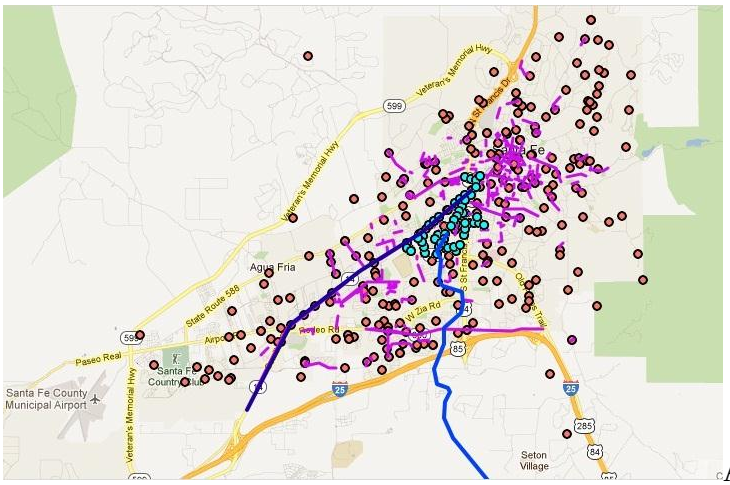
Added layer: Fiber Under Cerrillos Road



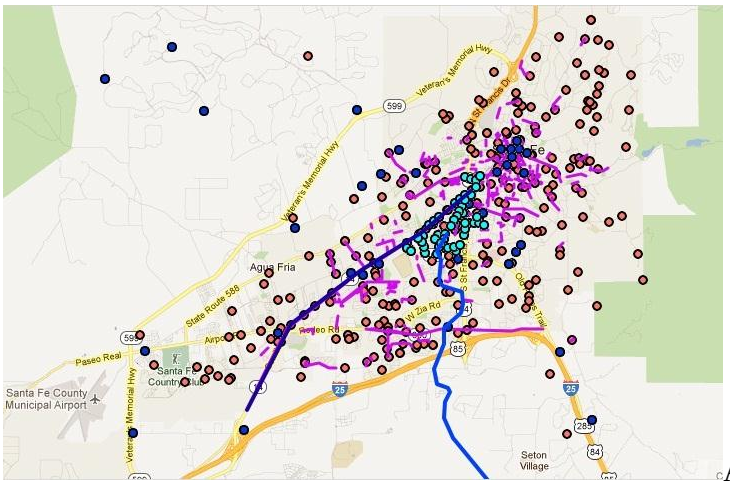
Added layer: Above Ground Hubs



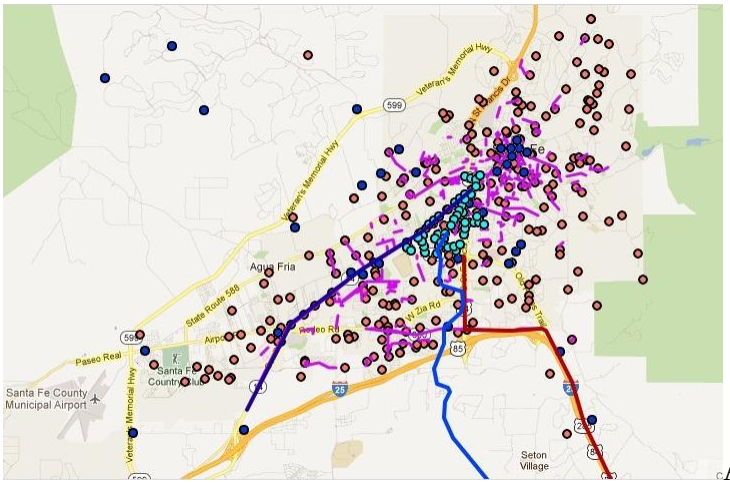
Added layer: Filtered Street Cut Points



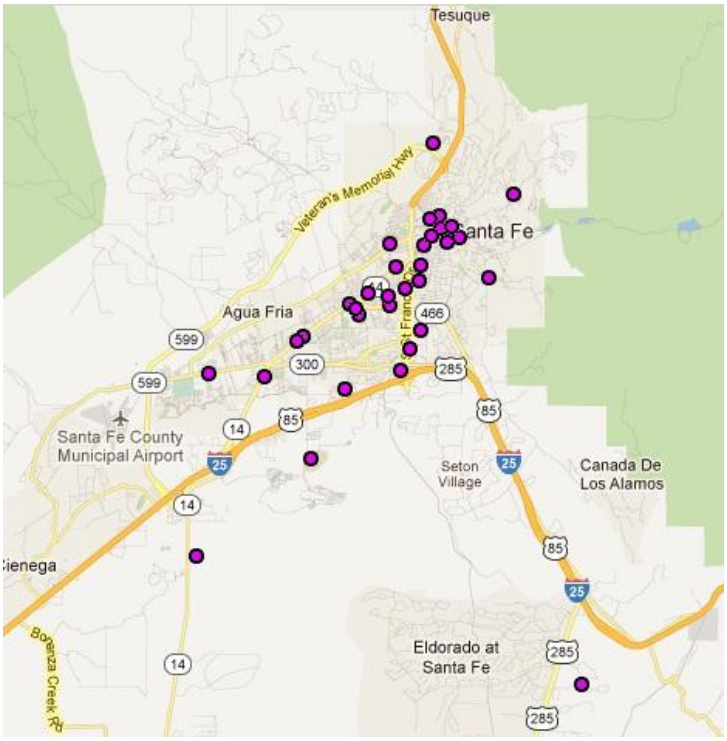
Added layer: Street Cut Segments



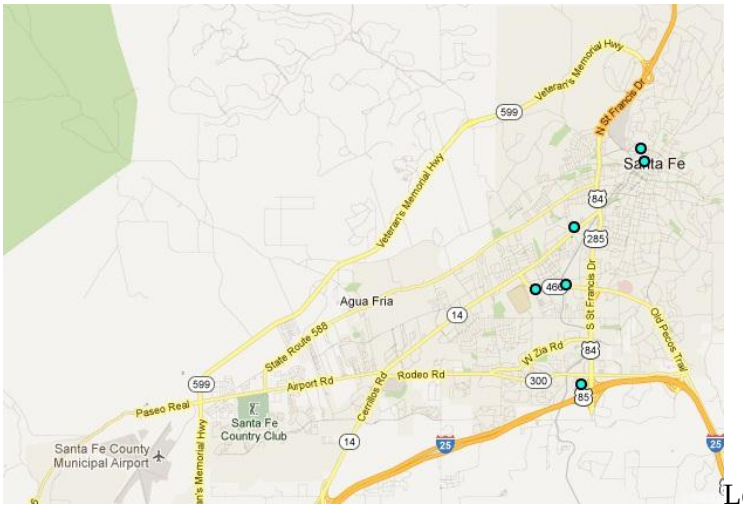
Added layer: Antenna Towers



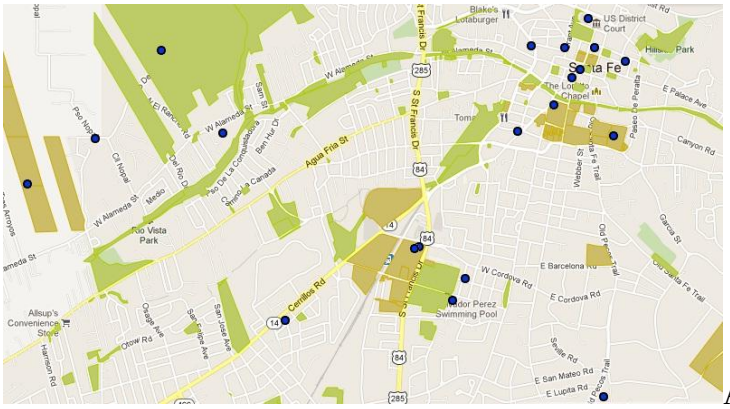
Added layer: ENMR Future Construction



Locations of Contacted Businesses

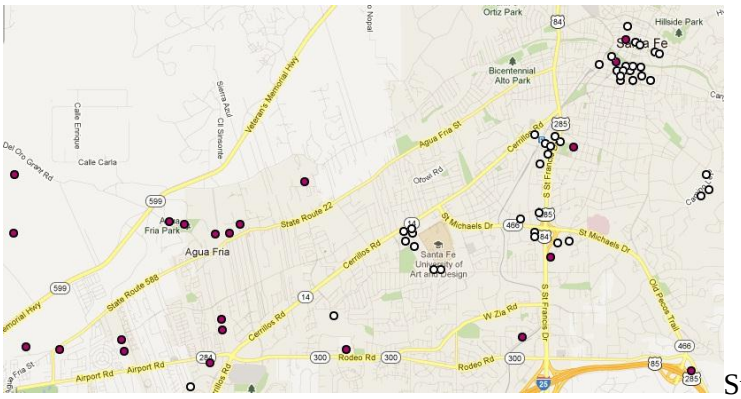


Locations of Surveyed Businesses

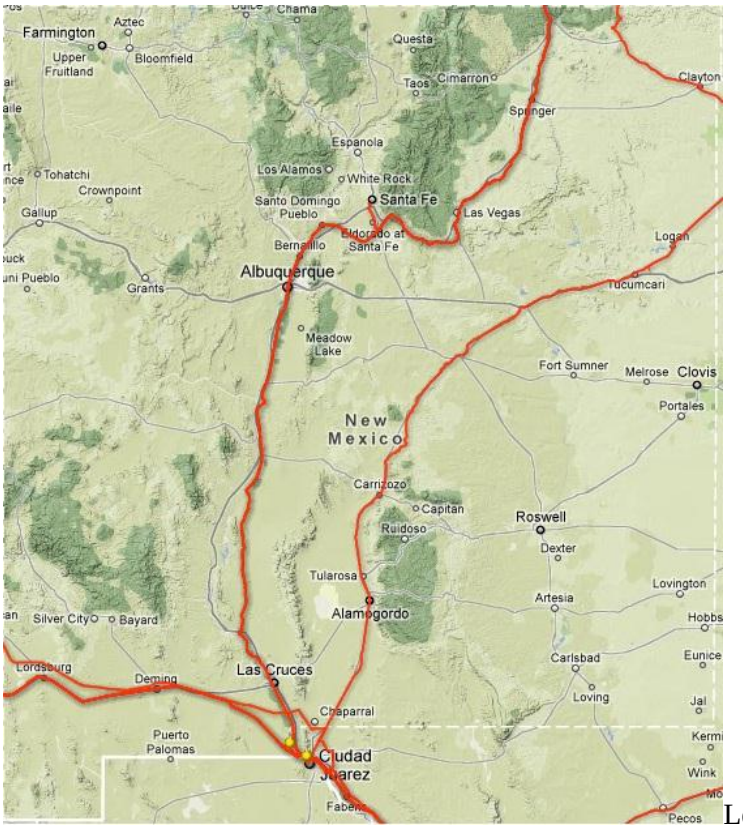


Antenna Towers and Government Land

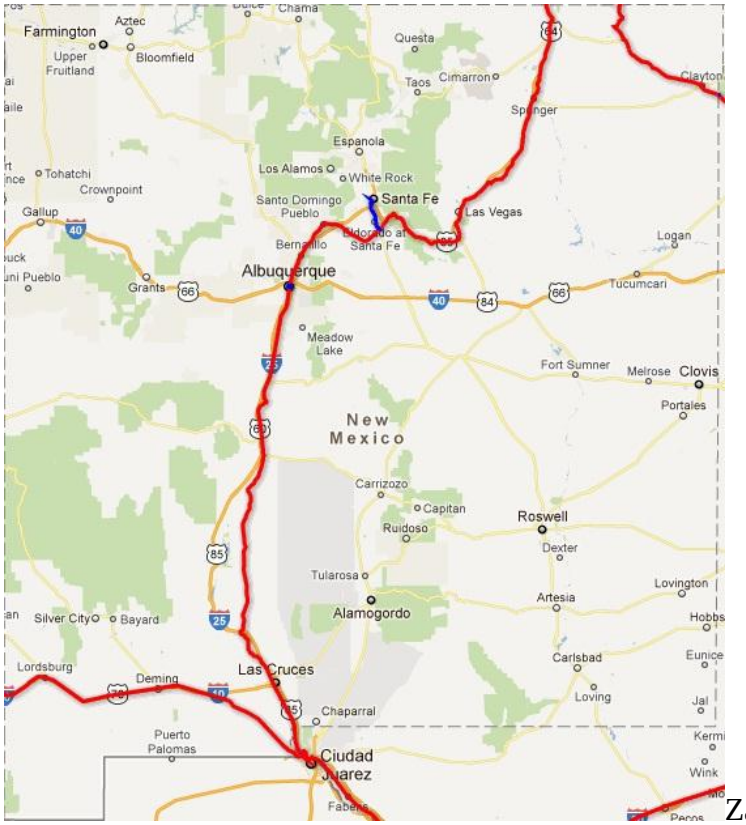
Level 3 Long Haul near Santa Fe



State and County Owned Buildings



Level 3 Long Haul in New Mexico



Zayo Group Long Haul in New Mexico