Los Alamos County

Community Broadband Network Design Report

September 14, 2012

Prepared for:
Los Alamos County, NM
Information Technology Division

CRESTINO
Telecommunications Solutions

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Executive Summary

As one of the top scientific communities in the world, Los Alamos is driven to meet the needs of the community for better, faster, and unencumbered broadband data access. Many County visionaries have studied the issue for over a decade[1], and have diligently challenged incumbent telecommunications providers to provide high speed broadband access commensurate with LAC's world class reputation. High speed broadband access for the entire community is necessary to meet current and continually growing demand. It will assist in growing the Los Alamos community and economy by supporting applications for public safety, education, business and telemedicine.

To further the commitment to build a Community Broadband Network, on April 19, 2011, the Los Alamos County (LAC) Council directed the Information Technology Division to "Develop a plan to provide an open and advanced broadband FTTP (Fiber to the Premises) network, with a target speed equal or greater than 1 Gigabit per second to each and every Los Alamos citizen and institution". A public survey showed the majority of residents (73%) feel this proposed network is a good idea for the community (a 4 or 5 on a 5-point scale), while very few (5%) feel it would be a bad idea for the community (a 1 or 2), and 13% have mixed feelings (a score of 3).[2] Further County Council reviews at the 30% and 60% design marks have kept the project moving toward the goal of completing the network design and business plan. Public meetings have been held to keep the citizens involved. These community discussions provided excellent feedback and resulted in an enhanced network design. The design discussions have also led to the involvement of the Department of Public Utilities (DPU) into the process, as they have committed to collaborating in the pursuit of grant funding for CBN.

The CBN Design Report delivers the plan for building a 1 Gbps, open access, FTTH network. It defines CBN design, and describes how it will be built, operated and maintained. A separate document, CBN *Business Plan* describes funding mechanisms that provide the capital to construct the network, and the revenue to operate the network. This report builds on the *2009 County Fiber Optic Network Expansion* study, which mainly addressed County facilities, extending coverage to all LAC residences and business.

"What is broadband? Why is it necessary?" There are many varying technical answers depending on to whom and how you ask these questions. These questions are being answered by each new application that comes on line; yesterday this couldn't be done, now it can. For fixed broadband network traffic is projected to increase by 50 percent every year, over the next three years. Mobile data network traffic is expected to experience even higher growth rates, increasing by 100% every year, over the next three years.[3]

Society has become accustomed to the use of the Internet, applications that require fast broadband services, and wireless information appliances in the home. Application requirements

[1] Spivak 1999, Atlantic 2003, Crestino 2009

[2] Research and Polling, Los Alamos County Broadband Network Survey Residents, May 2011

[3] International Data Corporation ,"Worldwide Internet Broadband Bandwidth Demand 2012-2015 Forecast

vary, from low speed e-mail (no attachments), to high-definition video applications requiring high speed data services.

During the 2012 NCAA basketball tournament the new iPad was introduced, and people used it to watch basketball games. If they used their local home connected Wi-Fi network, they were at the mercy of their connection speed and their Internet service provider (LAC high 12 Mbps download, 768 Kbps upload at this time). Many throughout the country used 4G commercial wireless services, (only 3G available in LAC at this time: high 1 Mbps), but quickly reached the caps on their data plans.

Some argue that the current incumbent providers should be providing service, and the County should not be involved. The current DSL and cable networks that are marketed as "high speed broadband" often cannot meet Customer demand during peak traffic times. These networks are shared between neighbors, and access is throttled to maintain a certain level of Customer satisfaction (less dissatisfaction). These networks offer upload speeds that are much lower than the download speeds. They are less than ideal for applications that need both high upload and download speeds, such as video conferencing. The farther your home is from the incumbent's service node, the slower the speed. CBN, with fiber all the way to the premises, will provide a superior user experience, delivering equally fast download and upload speeds that far exceed other options. Since LAC is considered to be a small, rural community, the incumbent providers tend not to make large capital investments for markets the size of LAC. The County is seeking to provide a fiber optic network that delivers 1 Gbps to all premises throughout the County, an open network that supports a level playing field for service providers, including the incumbents.

The road to establishing CBN is not perfectly paved. Current telecommunications incumbent providers may seek to impede the progress. They have indicated that their plans contain a fiber optic component for certain areas, but when pressed for a build out schedule, it has not been provided. Once again, it may be built to certain areas that are deemed most able to sign up for services. In these areas they will build fiber only to a neighbor node. Connections beyond this node consist of copper or coaxial cable to the premise, lowering the speed of the incumbent's service.

The design for CBN is a 1 Gbps network for both upload and download. The planning and design of CBN encompasses the entire County. All residences and businesses are part of the initial configuration. The network is sized to provide a 1 Gbps connection to the network for each user. At first users may request lower speed services to meet their current needs. But as pricing models improve, and user demands grow, the users will adjust their services to higher speeds.

Some argue that this is too much, too fast; it can be done with less. Can it? As you will see in this design, the cost for placing the (underground or aerial) fiber optic cable is the driving cost factor for the project. The fiber optic cable network speed is determined by the optical to electrical converters at the ends of the fibers. The cost of these devices is being driven down every day by market forces reacting to the increasing demand for network speed throughout the world. The fiber optic cable is a long term investment, as the electronics may change to increase the speeds further.

The design within the County is based on fiber optic cable between Point of Presence (POP) locations that connect to the Internet, Distribution Switch Facilities (DSF) located in the neighborhoods, and connections into homes, multiple dwelling units (MDU) and businesses. All network electronics are connected via fiber optic cable all the way to the Customer premises Ethernet switch, which interconnects with the Customer's computer, or other information appliance.

What is an open access network? The County Community Broadband Network is an open access network. This means that it offers a choice of service providers, who partner with CBN to provide services, such as Internet access, Internet Protocol Television (IPTV) or Voice over Internet Protocol (VoIP) services. These providers may range from local County providers to statewide, regional and national providers. Los Alamos County will provide the data transport across CBN at a wholesale cost to the providers, who in turn will market and sell their services to the community.

CBN will also support a basic data connection, even to premises that have not subscribed with a service provider. All premises in the County can be interconnected, forming a Metropolitan Area Network (MAN) that provides access to local services from LAC and other local organizations. This basic data connection allows the entire community to experience the benefits of CBN, experience that is vital for driving the growth of subscribed services.

Are there other municipalities that have completed a fiber optic network such as the one that is being proposed here? Yes, with the most successful ones being those that also provide electric utility service, such as Chattanooga, Tennessee and Chelan County, Washington. Working closely with DPU in Los Alamos allows the experience of building, operating and maintaining an electrical network to be leveraged towards CBN construction and operations. In return, CBN offers opportunities for enhancements to the electrical system, such as Smart Grid applications to improve the efficiency and reliability of the electrical utility system.

How will it operate? The operation of CBN involves people, processes and products. The people are CBN Network Operations and service provider personnel. They work together to execute the network operations processes, including service fulfillment, service assurance, billing, and maintenance. The processes result in the delivery of products to the Customers, products such as Internet access, IPTV, and VoIP. The network architecture provides a robust, high speed data network. The mechanisms to assure Customer satisfaction, retention and high-quality service must be clearly defined. Each role from the County from the service provider to the Customer must be established to provide superior Customer service.

CBN will provide a high level of automation to assure operational costs are minimized. A user will login to a web page, CBN Portal, and request desired services offered by the service providers. These service requests will be fed through CBN and service provider software systems which provision the network equipment to configure service.

This plan continues the commitment to build a Community Broadband network and addresses the need to serve Los Alamos County with advanced technology. The entire community will benefit from this $61M investment in the future, gaining an open and advanced broadband access for all 18,000 citizens, 9000 homes and businesses. It will enhance the discoveries of this community and meet the current and continually growing demand with one of the fastest broadband networks in the country.

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Section 1. Introduction

Los Alamos County (LAC) has engaged Crestino Telecommunications Solutions to design a Fiber To The Premises (FTTP) network. This network will provide open and advanced broadband internet service to all residential and business premises in LAC within Townsite and White Rock. It will support upload and download data rates of 1 Gigabit per second (Gbps) between LAC premises. This report covers the following topics:

- CBN Design, describing system components and their estimated costs
- Network Design
- Support Systems
- Network Operations
- Design Options
- Requirements

1.1 System Overview

CBN is an optical fiber network connecting all premises in LAC. Figure 1-1 shows an overview of the optical fiber cables within the two areas of LAC covered by CBN, Townsite and White Rock, and the fiber cable connecting the two areas. The Townsite and White Rock fiber consists of buried (also referred to as underground) and aerial (also referred to as overhead) construction. Buried construction uses both existing and new conduit pathways. Aerial construction uses only existing utility poles; no new poles are included in the design, except in cases where existing poles must be replaced to accommodate the addition of CBN fiber cables.

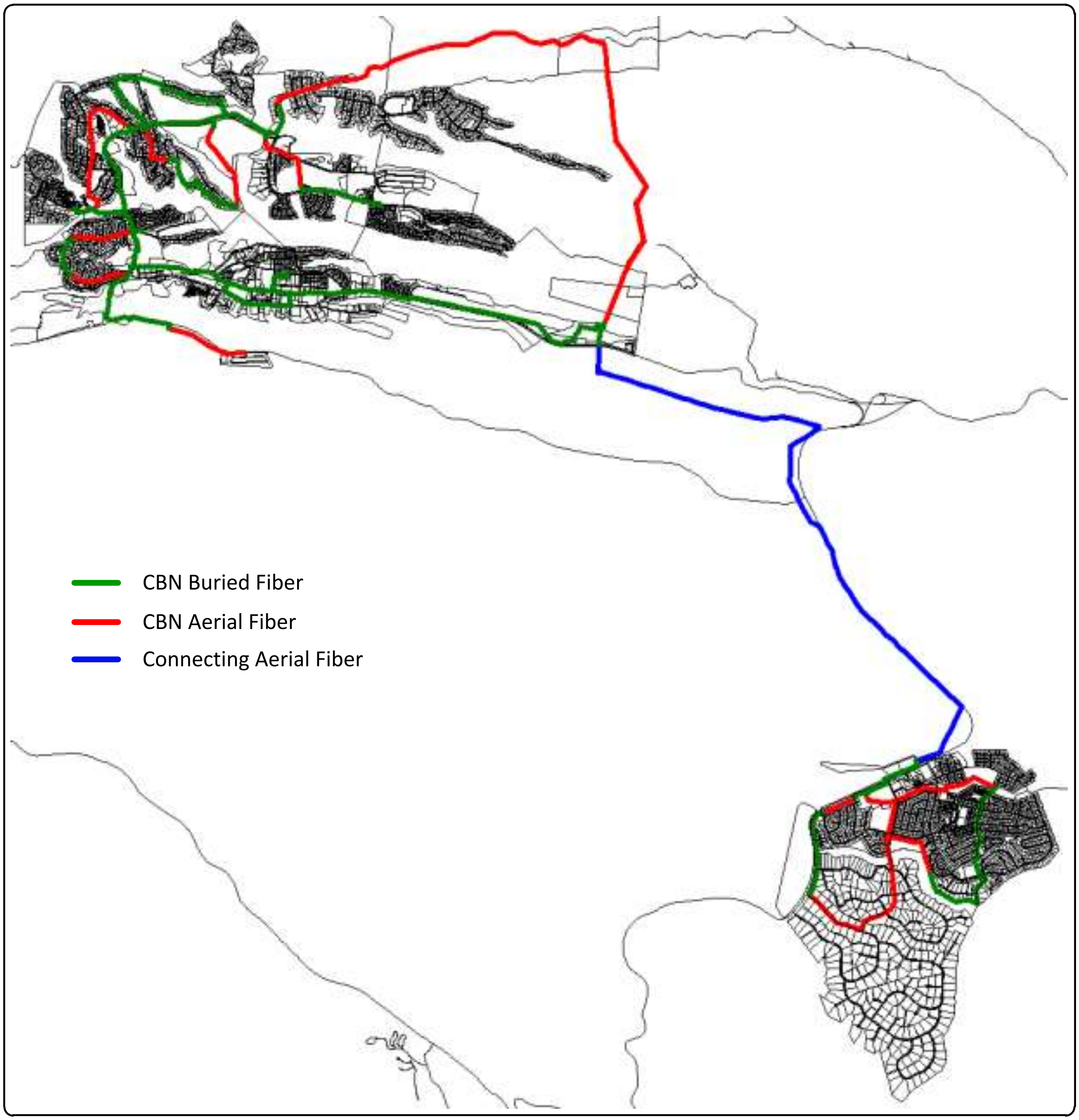

Figure 1-1. Fiber Cable Overview

Townsite and White Rock are connected by an aerial fiber that is being supplied to CBN, represented by the blue line.

1.2 Scope

This report provides an engineering design for a FTTH network for LAC and the associated estimated capital expenses for constructing the system. It provides a system operational concept. This report does not provide a business plan, operational expenses, or financial models; refer to CBN Business Plan for this information.

Section 2. CBN Design

On April 19, 2011, the LAC Council supplied seven CBN system requirements. These seven requirements, together with additional input from the LAC Information Technology Division and other LAC groups, were used to develop the full set of CBN requirements provided in Appendix B. Four of the requirements were especially significant in driving the engineered CBN design:

1. Develop a plan to provide open and advanced broadband communications access to all Los Alamos citizens and institutions
2. This purpose will be accomplished through building a fiber to the premises (FTTP) network
3. The target speed will be a minimum of 1 Gbps [symmetrical]. 1 Gbps reflects the speed of the local fiber network, and does not reflect the available speed to internet
4. The County will not generally be an overall content provider or a Service Provider. … Some County services may be provided through the new network infrastructure

The first and second requirements mean that CBN must be designed to provide every premises in LAC with a dedicated fiber optic cable. It also mandates that CBN shall be designed as an open access network, such that end users can subscribe to multiple services from multiple providers. Open Access is described in the Network Design section. The third requirement, mandating 1 Gbps data rates to Customers, drives CBN to an Active Ethernet (AE) design instead of a Passive Optical Network (PON) design; a comparison of AE and PON systems is in 0. The fourth requirement has effects across the entire system, including hardware, software, network operations, and the business model.

As an essential part of the design process, LAC identified network characteristics that are essential to providing ultra-high bandwidth services, choice of service and fair competition, as well as inherent flexibility so the network can support future services, uses and partnerships. The design criteria require a network that is scalable to grow with demand, flexible enough to integrate multiple applications on the same fiber infrastructure, and adaptable for other uses, such as wireless, government mobility, public safety, and automated meter reading services. The AE design offers qualities that are most complementary to those identified in the design process, and can be engineered to accommodate global standards that will provide a relatively easy interface for SPs. These qualities will accommodate services which can be identified today and provides an efficient and scalable transport layer for future applications.

2.1 System Components

A customer gains access to CBN FTTP network via a series of interconnected optical fiber cables running from the customer's premises all the way to the Point of Presence (POP) facility. A POP is the main hub of the network, the interconnection point between local facilities and to the outside facilities. Each connection is made via a series of fiber cabling connected by equipment, and installed with construction techniques tailored to each premises. Figure 2-1 shows a high-level overview of CBN architecture. It includes the following components:

1. Network Operations Center
2. Point of Presence
3. Core fiber
4. Distribution Switch Facility
5. Lateral fiber
6. Drop Closure
7. Customer Premises Equipment

The following sections describe each of these system components in turn, starting at the NOC and progressing through to the Customer premises equipment.

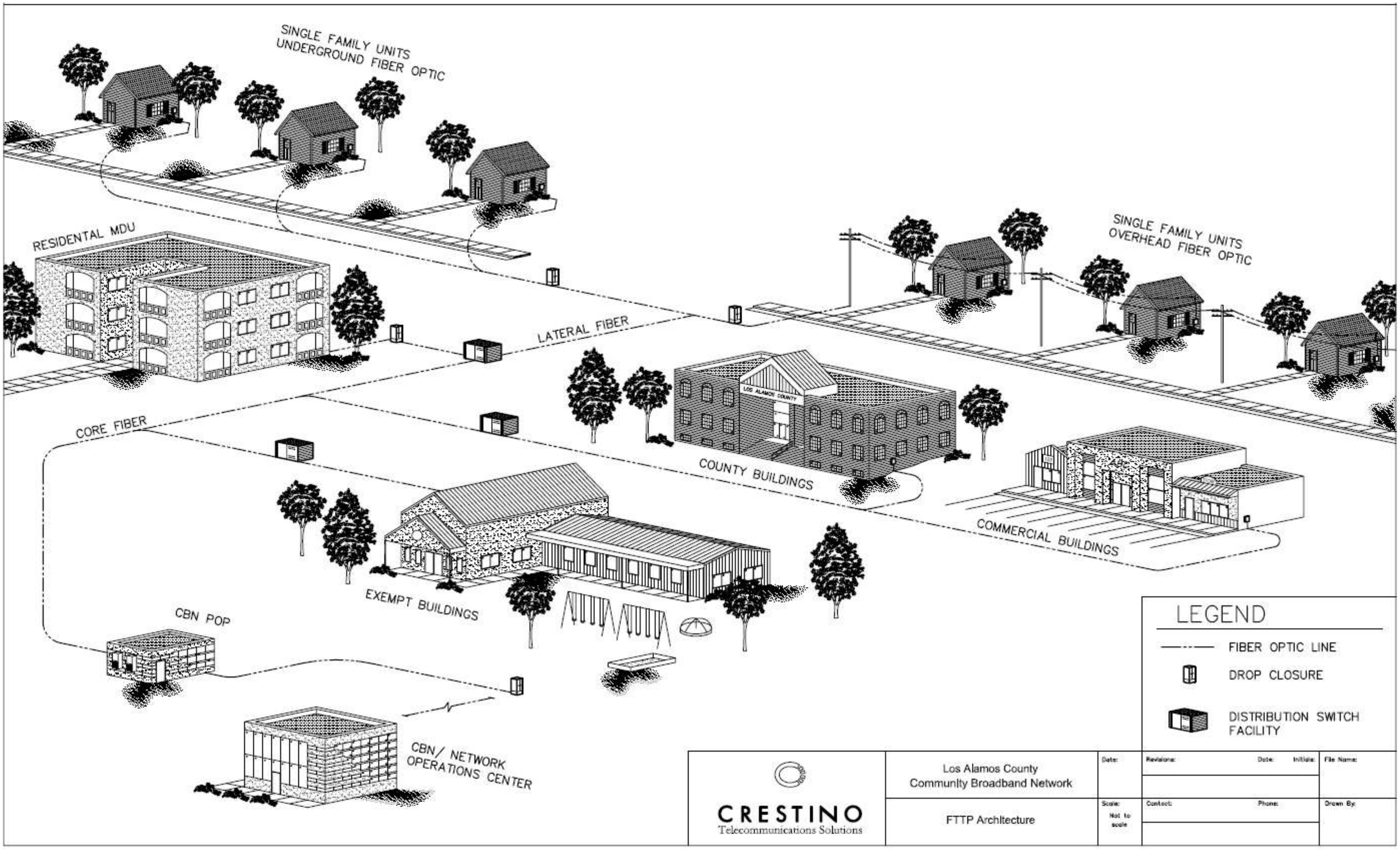

Figure 2-1. CBN Architechture Overview

2.1.1 Network Operations Center

The NOC is where the Network Operator personnel work, monitoring service delivery, Customer usage, and network performance. The NOC is priced in the budgetary cost estimate as a new building, designed to achieve a LEED (Leadership in Energy and Environmental Design) silver certification. It is approximately 2,044 square feet, with the floor plan shown in Figure 2-2. A site for the NOC has not been selected, as its location is very flexible; the only site selection criteria is the availability of two diversely-routed fiber connected to the network.

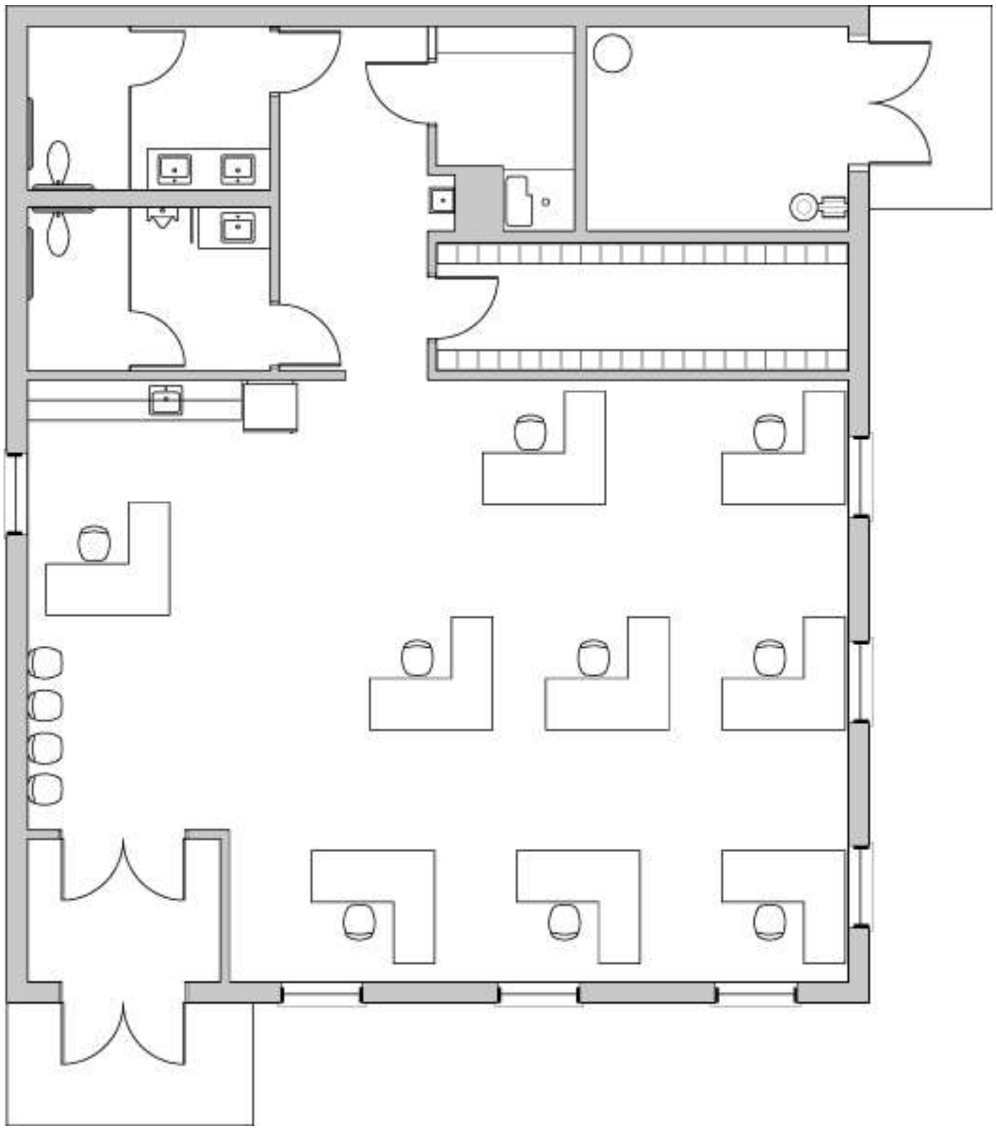

Figure 2-2. NOC Floor Plan

There are two alternatives to constructing a new NOC facility. The NOC may be retrofitted into an existing building, or if NOC operations are outsourced the NOC facility is omitted entirely. Outsourcing the NOC eliminates the capital expenses for the facility itself, but other NOC-related items such as software and a maintenance van would still be needed.

Table 2-1 lists the cost estimate for the NOC.

Table 2-1. NOC Cost Estimate

NOC					
	Item	Qty	Unit Price	Extended Price	Adjusted Price
Materials	Office space	1,317	185.00	$243,645	$251,685
Materials	Toilets/mechanical space	803	215.00	$172,645	$178,342
Materials	Generator	1	64,000.00	$64,000	$66,112
Materials	UPS - TVSS	1	23,000.00	$23,000	$23,759
Materials	Storm water storage	1	24,000.00	$24,000	$24,792
Labor	A&E Fees	1	80,000.00	$80,000	$88,683
Labor	LEED Expenses	1	90,000.00	$90,000	$99,768
Materials	Electrical service and transformer	1	45,000.00	$45,000	$46,485
Materials	Physical security	1	5,000.00	$5,000	$5,165
Labor	Physical security installation	1	5,000.00	$5,000	$5,543
Labor	Paving for parking, landscaping, grading, excavation and fencing	1	160,000.00	$160,000	$177,366
Labor	Geo-technical services	1	4,500.00	$4,500	$4,988
Materials	Furnishings for 8 staffers	8	4,000.00	$32,000	$33,056
Materials	BSS and OSS software and servers	1	350,000.00	$350,000	$361,550
Materials	Maintenance Van	2	40,000.00	$80,000	$82,640
		Sub-total		$1,378,790	$1,449,935

All estimated costs in this document follow the same format. The first column identifies whether the item is materials or labor. The second column describes the items. The third column identifies the quantity of the item. Lengths are in feet. The fourth column is the price per unit. The firth column is the extended price, which is the product of the quantity and the unit price. The sixth column is the adjusted price, which adds gross receipts taxes on labor, and converts the cost to projected 2013 dollars.

2.1.2 Points of Presence

A Point of Presence (POP) is a facility housing the network routing equipment that connects the DSFs with the SPs' equipment, providing access to the Internet, Voice over Internet Protocol (VoIP), Internet Protocol Television (IPTV), and LAC services. CBN includes three POPs:

1. South POP – located in Townsite at Lavy Lane
2. North POP – located in Townsite on the grounds of Fire Station 4
3. White Rock POP – located in White Rock on the grounds of Fire Station 3

These locations were selected based on the following criteria:

1. Located near the core fiber route
2. Located on LAC property
3. Near an electrical power source
4. Flat terrain

Figure 2-3 shows the connections between the three POPs, and the connections between the POPs and the internet. The Pajarito Cliffs Site POP is not a CBN facility. It is a future facility that planned for installation at within LAC property near the LAC airport. CBN may elect to use the PCS POP as a source of wholesale internet access.

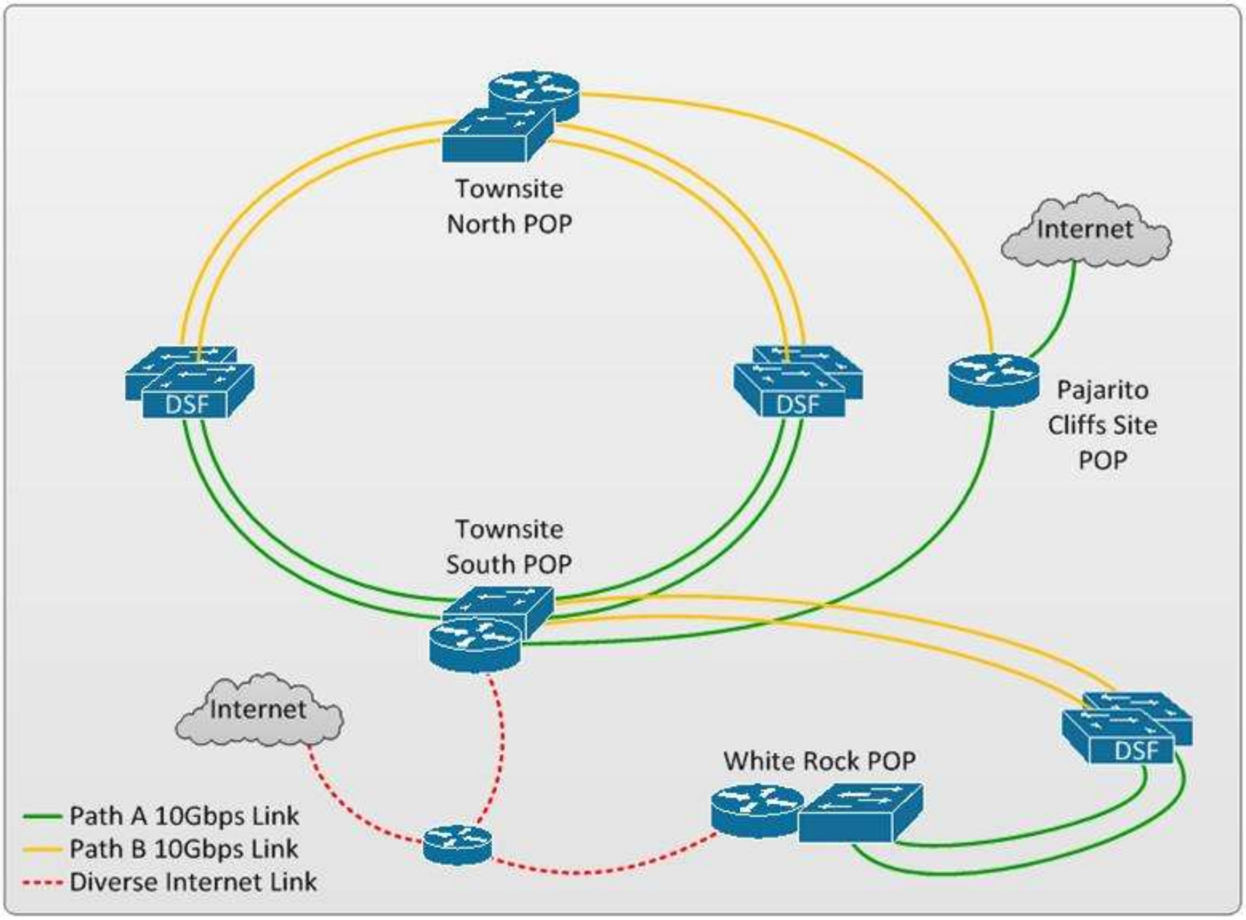

Figure 2-3. POP Connections

2.1.2.1 South POP

The south POP is the largest of the three POPs because it provides rack space for housing CBN routing equipment and colocation tenants' equipment. The south POP colocation facility will act as a "meet-me" location so that SP equipment may directly connect to the LAC network. This connection is accomplished through an Ethernet connection; the bandwidth and Quality of Service (QoS) parameters of the connection must be agreed upon through the contractual SLA between the LAC operator and the SP. Colocation tenants may include SPs who control the flow of data between customers and external networks including the internet. Colocation tenants may also include agencies that require dedicated equipment at the POP to implement specialized services over CBN, such as LAC Public Safety, LAC Utilities, or Los Alamos National Laboratory. Collocation tenants can access their equipment for updates, maintenance or equipment replacement as needed, subject to LAC access controls. The south POP is ~2750 square feet, with the floor plan shown in Figure 2-4.

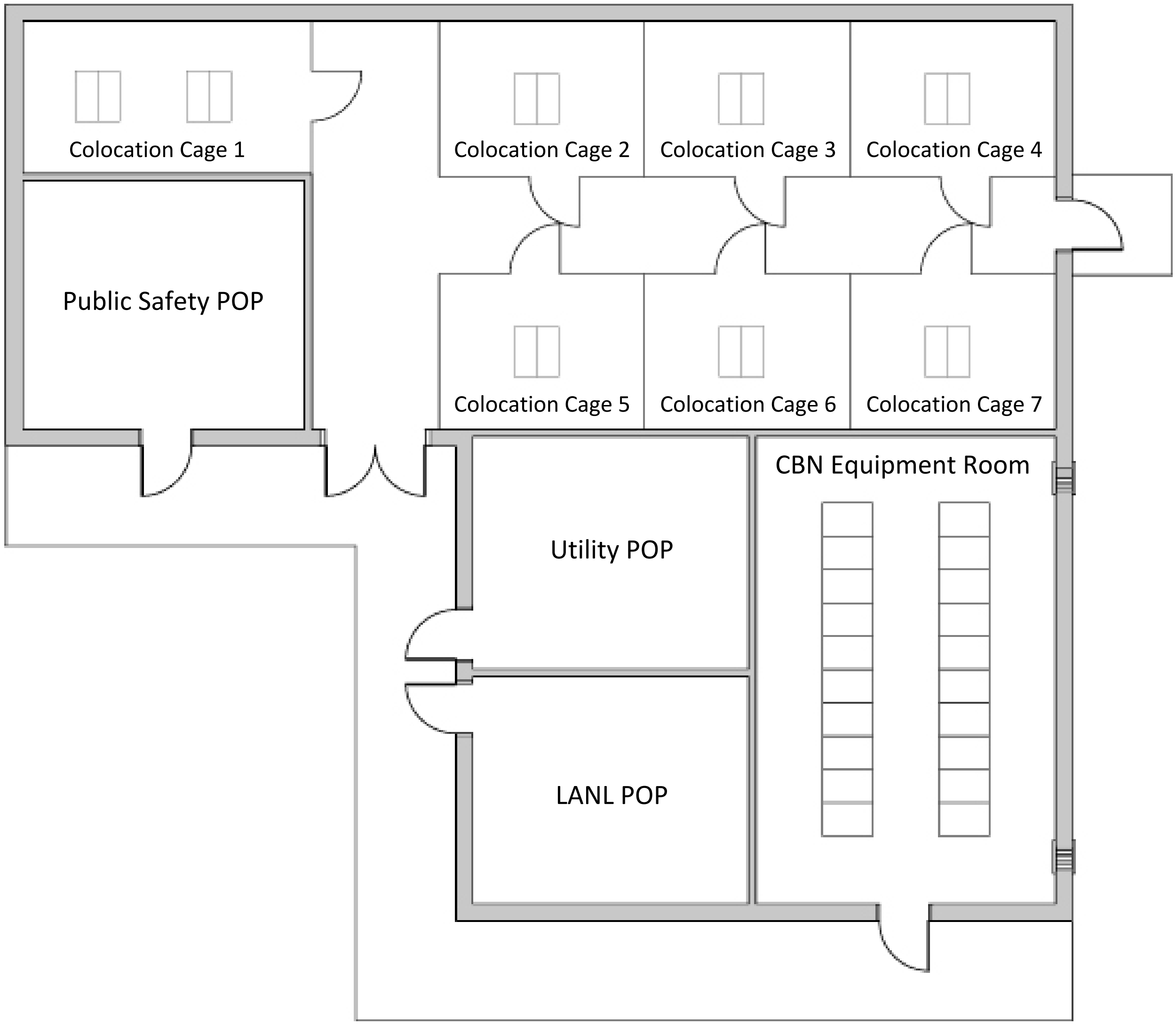

Figure 2-4. South POP Floor Plan

It has five separate rooms, capable of housing as many as 56 equipment racks:

1. CBN Equipment Room, capable of housing twenty 2’x3’ footprint racks. Nine racks are reserved for CBN use. Eleven racks are available for CBN use or for colocation tenant locking racks
2. Public Safety POP, capable of housing six 2’x3’ footprint racks
3. Utility POP, capable of housing six 2’x3’ footprint racks
4. LANL POP, capable of housing six 2’x3’ footprint racks
5. Seven lockable colocation tenant cages. Six colocation tenant cages can house two 2’x3’ footprint racks; one colocation tenant cage can house six 2’x3’ footprint racks

The south POP includes fiber management, power distribution, Uninterruptible Power Supply (UPS), security, fire detection and suppression, Heating, Ventilation, and Air Conditioning (HVAC) equipment, and an outdoor 75 kilowatt propane-fuelled generator. The PDU and UPS equipment covers only CBN equipment; tenants are responsible for supplying their own PDU and UPS equipment. It is unlikely that any colocation tenants will seek to install high density, high-power equipment, so the generator has been reasonably sized by estimating the power requirements of a partially populated facility holding primarily networking equipment. This results in a cost per square foot of $450. If additional tenant support equipment is desired initially or at a later time, additional costs will be incurred and may exceed $600 per square foot. Equipment racks for colocation tenants are expected to be supplied by the tenants and are not included in the budgetary cost estimate. The south POP equipment room notional rack configuration follows:

1. Racks 1-2: Fiber management panels
2. Racks 3-5: CBN routers and other network equipment
3. Racks 6-7 CBN power distribution and UPS
4. Racks 8-9: Reserved for CBN expansion
5. Racks 10-20: Reserved for colocation tenants

Table 2-2 lists the cost estimate for the south POP.

Table 2-2. South POP Cost Estimate

South POP					
	Item	**Qty**	**Unit Price**	**Extended Price**	**Adjusted Price**
Materials	Building	3,000	400.00	$1,200,000	$1,239,600
Materials	Generator, fuel tank, ATS (included in building price)	2	0.00	$0	$0
Materials	HVAC system (included in building price)	1	0.00	$0	$0
Labor	Power hookup	1	10,000.00	$10,000	$11,085
Materials	UPS for CBN equipment	10	1,300.00	$13,000	$13,429
Materials	Fiber entrance vault	2	1,500.00	$3,000	$3,099
Labor	Install fiber entrance vault	2	2,000.00	$4,000	$4,434
Materials	Fiber entrance cabinet	2	5,000.00	$10,000	$10,330
Labor	Splicing labor for tails at FEC, loose tube	1	10,800.00	$10,800	$11,972
Labor	Install Fiber Entrance Cabinet and conduit to fiber entrance vault	2	600.00	$1,200	$1,330
Materials	Cross-connect rack	2	22,000.00	$44,000	$45,452
Labor	Labor for cross-connect installation	2	5,000.00	$10,000	$11,085
Materials	Fiber trays	1	5,000.00	$5,000	$5,165
Labor	Fiber tray installation	1	1,000.00	$1,000	$1,109
Materials	Ladder trays	1	5,000.00	$5,000	$5,165
Labor	Ladder tray installation	1	1,000.00	$1,000	$1,109
Materials	Fire supression	1	30,000.00	$30,000	$30,990
Labor	Fire supression installation	1	10,000.00	$10,000	$11,085
Materials	Physical security	1	5,000.00	$5,000	$5,165
Labor	Physical security installation	1	5,000.00	$5,000	$5,543
Materials	Colocation tenant woven wire security cage	6	1,800.00	$10,800	$11,156
		Sub-total		**$1,378,800**	**$1,428,304**

Small South POP

An alternative design for the south POP provides a significantly smaller facility, ~672 square feet instead of ~2750 square feet. The size reduction lowers the cost of the south POP to

$478,819, a savings of $949,484. The small south POP is constructed from a pre-fabricated telecommunications shelter, with an overall size of ~24'x28', shown in Figure 2-5.

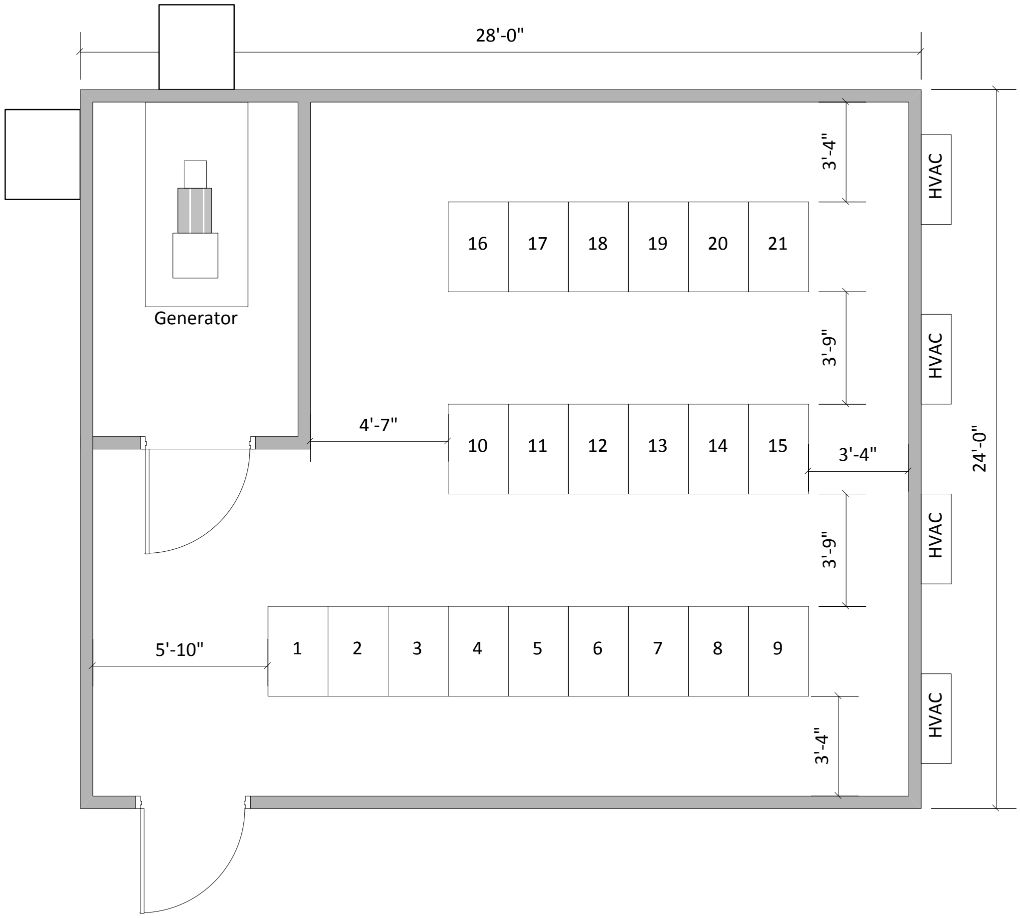

Figure 2-5. Small South POP Floor Plan

It holds as many as 21 equipment racks with a 2'x3' footprint, compared with the 56 racks in the larger south POP design. It contains a generator room with a 75 kilowatt propane-fuelled generator. The generator room is separated from the equipment room by a fire-rated wall. Like the south POP, it includes fiber management, PDU, UPS, security, fire detection and suppression, and HVAC equipment. The proposed facility is expandable; should additional POP space be required in the future, one or more additional pre-fabricated shelters may be erected next to the existing structure. The small south POP rack notional rack configuration follows:

1. Racks 1-2: Fiber management panels
2. Racks 3-5: CBN routers
3. Racks 6-7 CBN power distribution and Uninterruptible Power Supply (UPS)
4. Racks 8-9: Reserved for CBN expansion
5. Racks 10-21: Reserved for colocation tenants

The cost estimates for all of the POPs includes fiber management, fire suppression and physical security equipment, and Wavelength-Division Multiplexing (WDM) equipment. WDM equipment combines multiple optical signals, each at a different wavelength, onto a single optical fiber. WDM equipment is used to link the south POP with the White Rock POP. This link is designed to be implemented with a low number of pre-existing optical fibers supplied to CBN. The low number of fibers requires WDM to achieve the designed network capacity.

2.1.2.2 North POP

The north POP is smaller than the south POP because it does not provide colocation space, and is capable of housing six equipment racks. The north POP is ~330 square feet, shown in Figure 2-6.

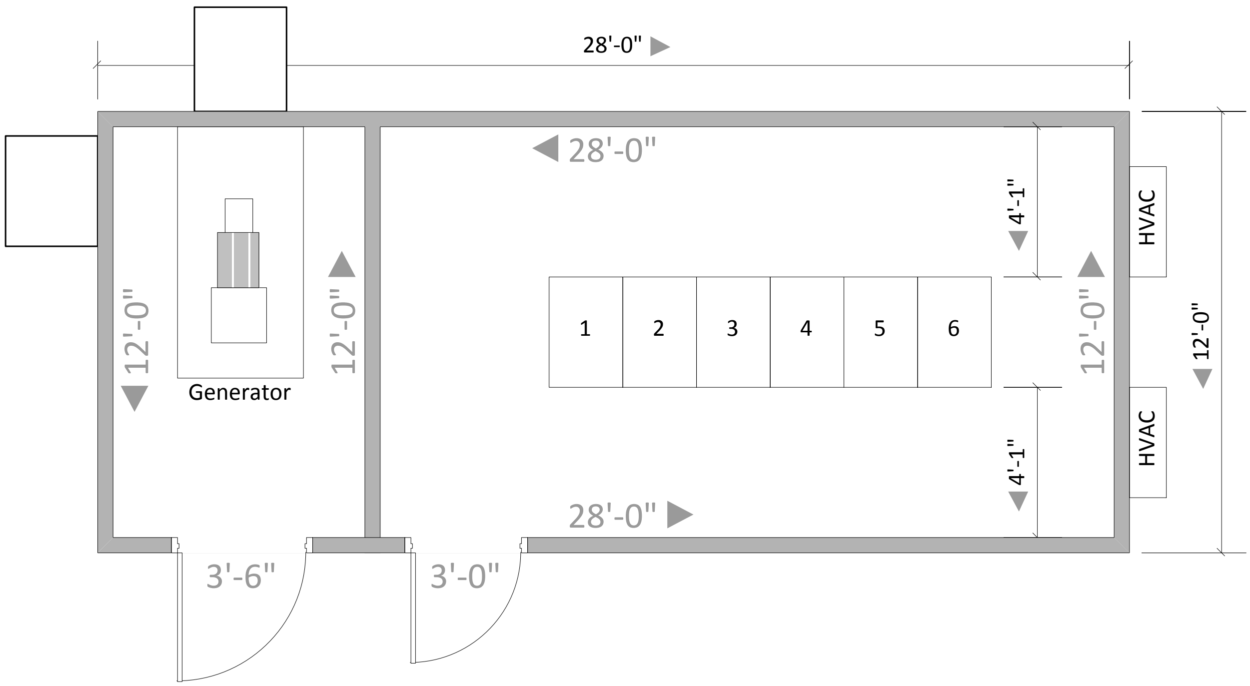

Figure 2-6. North POP Floor Plan

The north POP includes fiber management, power distribution, UPS, security, fire detection and suppression, HVAC equipment, and an indoor 75 kilowatt propane-fuelled generator. The north POP notional rack configuration follows:

1. Rack 1: Fiber management panel
2. Racks 2-3: CBN routers and other network equipment
3. Racks 4-5 CBN power distribution and UPS
4. Rack 6: Reserved for expansion

Table 2-3 lists the cost estimate for the north POP.

Table 2-3. North POP Cost Estimate

North POP					
	Item	**Qty**	**Unit Price**	**Extended Price**	**Adjusted Price**
Materials	Concrete prefabricated building	1	180,000.00	$180,000	$185,940
Materials	Generator, fuel tank, ATS (included in building price)	1	0.00	$0	$0
Materials	HVAC system (included in building price)	1	0.00	$0	$0
Labor	Power hookup	1	5,000.00	$5,000	$5,543
Materials	UPS for CBN equipment	10	1,300.00	$13,000	$13,429
Materials	Fiber entrance vault	2	1,500.00	$3,000	$3,099
Labor	Install fiber entrance vault	2	2,000.00	$4,000	$4,434
Materials	Fiber entrance cabinet	2	3,000.00	$6,000	$6,198
Labor	Splicing labor for tails at FEC	1	10,800.00	$10,800	$11,972
Labor	Install Fiber Entrance Cabinet and conduit to fiber entrance vault	2	600.00	$1,200	$1,330
Materials	Cross-connect rack	1	22,000.00	$22,000	$22,726
Labor	Labor for cross-connect installation	1	5,000.00	$5,000	$5,543
Materials	Fiber trays	1	2,500.00	$2,500	$2,583
Labor	Fiber tray installation	1	500.00	$500	$554
Materials	Ladder trays	1	2,500.00	$2,500	$2,583
Labor	Ladder tray installation	1	500.00	$500	$554
Materials	Fire supression	1	15,000.00	$15,000	$15,495
Labor	Fire supression installation	1	5,000.00	$5,000	$5,543
Materials	Physical security	1	2,500.00	$2,500	$2,583
Labor	Physical security installation	1	2,500.00	$2,500	$2,771
		Sub-total		**$281,000**	**$292,879**

The White Rock POP building is identical to the north POP. Table 2-4 lists the cost estimate for the White Rock POP. It is located near fire station 3 along state road 4.The cost for the White Rock POP is marginally higher than the cost of the north POP because it has electrical equipment supporting twice as much WDM equipment; one set of equipment to link with the south POP, and one set of equipment to link with the north POP.

Table 2-4. White Rock POP Cost Estimate

WR POP					
	Item	Qty	Unit Price	Extended Price	Adjusted Price
Materials	Concrete prefabricated building	1	180,000.00	$180,000	$185,940
Materials	Generator, fuel tank, ATS (included in building price)	1	0.00	$0	$0
Materials	HVAC system (included in building price)	1	0.00	$0	$0
Labor	Power hookup	1	5,000.00	$5,000	$5,543
Materials	UPS for CBN equipment	6	1,300.00	$7,800	$8,057
Materials	Fiber entrance vault	2	1,500.00	$3,000	$3,099
Labor	Install fiber entrance vault	2	2,000.00	$4,000	$4,434
Materials	Fiber entrance cabinet	2	3,000.00	$6,000	$6,198
Labor	Splicing labor for tails at FEC	1	10,800.00	$10,800	$11,972
Labor	Install Fiber Entrance Cabinet and conduit to fiber entrance vault	2	600.00	$1,200	$1,330
Materials	Cross-connect rack	1	22,000.00	$22,000	$22,726
Labor	Labor for cross-connect installation	1	5,000.00	$5,000	$5,543
Materials	Fiber trays	1	2,500.00	$2,500	$2,583
Labor	Fiber tray installation	1	500.00	$500	$554
Materials	Ladder trays	1	2,500.00	$2,500	$2,583
Labor	Ladder tray installation	1	500.00	$500	$554
Materials	Fire supression	1	15,000.00	$15,000	$15,495
Labor	Fire supression installation	1	5,000.00	$5,000	$5,543
Materials	Physical security	1	2,500.00	$2,500	$2,583
Labor	Physical security installation	1	2,500.00	$2,500	$2,771
		Sub-total		$275,800	$287,507

2.1.2.3 POP Network Equipment

Based on market research and sample service packages supplied by the service provider community, projected initial Customer demand for 1 Gbps service is expected to be very low. The average projected initial Customer internet bandwidth consumption is less than 100 Mbps, well below CBN's potential capabilities. CBN's network electronic equipment is designed to be installed in three stages. Adding the network equipment in stages avoids un-necessary spending on excess network capacity. It also allows CBN to benefit from network equipment prices falling over time, and to use future network technologies. Stage 1 is the initial build of network equipment. Stages 2 3 add more network equipment in the POPs and DSFs. Note that symmetrical 1 Gbps upload and download service is available across the network with every installation stage.

Stage 1

Stage 1 installs sufficient network equipment to service current and near-future Customer service. The stage 1 equipment needs were determined by using a very demanding Customer service package that can simultaneously deliver all of the following services:

- 40 Mbps Internet
- Four simultaneous VoIP conversations
- Two simultaneous High Definition (HD) multicast Moving Picture Experts Group (MPEG) -4 or MPEG-2 video streams
- Two HD unicast MPEG-4 video streams or one HD unicast MPEG-2 video stream

Note that this service profile is representative of an intensive service profile, but the actual services used by Customers may vary. The Stage 1 network has sufficient network capacity to deliver this service package to every one of the 8,994 connected premises. There are two factors in this calculation which ensure that the stage 1 capacity will be sufficient to meet current needs and provide excess capacity for future growth:

1. It is very unlikely that every premises in LAC will use CBN services. The actual percentage of Customers taking services will be significantly less than 100%
2. This profile assumes that the sustained Customer network load is identical to the peak load. In a network such as CBN, sustained network loads are always substantially lower than peak loads

The Stage 1 equipment includes Wavelength Division Multiplexing (WDM) equipment to link the north and south POPs with the White Rock POP. The WDM equipment is required to implement the links using a limited number of pre-existing optical fibers supplied by LAC. Table 2-5 lists the cost of the Stage 1 network equipment for the three POPs combined.

Table 2-5. Stage 1 POP Network Equipment Cost Estimate

Stage 1 POP Network Electronics						
	Item	**Qty**	**Unit Price**	**Extended Price**	**Adjusted Price**
Materials	POP Network Electronics: Switches, Routers, cards, configuration, installation	1	4,544,679	$4,544,679	$4,694,653
Materials	WDM Equipment	1	540,000.00	$540,000	$557,820
		Sub-total		**$5,084,679**	**$5,252,473**

Stage 2

Stage 2 installs additional network equipment in the POPs and DSFs to meet increased Customer demands. Stage 2 equipment may be installed at any desired time, based on network loading analysis and network operations-defined trigger conditions, funding availability, pre-scheduled date, or other considerations. It increases the network capacity to be able to simultaneously deliver all of the following services:

- 150 Mbps Internet
- Four simultaneous VoIP conversations
- Four simultaneous High Definition (HD) multicast Moving Picture Experts Group (MPEG) -4 video streams, or six simultaneous HD MPEG-2 video streams
- Four HD unicast MPEG-4 video streams or six HD unicast MPEG-2 video stream

1 Gbps Customer data rates continue to be supported across the network. Table 2-6 lists the cost of the Stage 2 network equipment for the three POPs combined.

Table 2-6. Stage 2 POP Network Equipment Cost Estimate

Stage 2 POP Network Electronics					
	Item	Qty	Unit Price	Extended Price	Adjusted Price
Materials	POP Network Electronics: Switches, Routers, cards, configuration, installation	1	2,080,786	$2,080,786	$2,149,452
Materials	WDM Equipment	1	680,000.00	$680,000	$702,440
	Sub-total			$2,760,786	$2,851,892

Stage 3

Stage 3 installs additional network equipment in the POPs and DSFs to achieve the maximum CBN capacity, providing any combination of network services up to 1 Gbps. As with Stage 2, Stage 3 equipment may be installed at any desired time, based on network loading analysis and network operations-defined trigger conditions, funding availability, pre-scheduled date or other considerations. If network monitoring indicates that the Stage 2 equipment is providing ample network capacity, the Stage 3 installation may be deferred indefinitely. Table 2-7 lists the cost of the Stage 3 network equipment for the three POPs combined.

Table 2-7. Stage 3 POP Network Equipment Cost Estimate

Stage 3 POP Network Electronics					
	Item	Qty	Unit Price	Extended Price	Adjusted Price
Materials	POP Network Electronics: Switches, Routers, cards, configuration, installation	1	5,374,535	$5,374,535	$5,551,895
Materials	WDM Equipment	1	2,380,000.00	$2,380,000	$2,458,540
	Sub-total			$7,754,535	$8,010,435

2.1.3 Core Fiber

CBN's core fiber network, commonly referred to by industry as feeder fiber, provides two redundant fiber routes between the DSFs and the POPs. As much as possible the two routes follow different physical paths, to mitigate the impact of a fiber cut along one route. The core fiber network extends to the Royal Crest community, crossing the Omega Bridge to get there. The Omega Bridge is owned by the Department of Energy, not LAC, and permission to install the fiber cable on the bridge needs to be obtained to proceed with construction to Royal Crest.

The nominal Townsite buried core fiber cable is a ducted all-dielectric cable with 432 fibers. The nominal White Rock buried core fiber cable is a ducted all-dielectric cable with 288 fibers. The buried core fiber routes use existing LAC conduit where possible, to minimize new underground construction. Existing Townsite conduit may restrict the allowable cable sizes to fewer than 432 fibers; in this case multiple cables may be used to achieve the required total fiber count. The nominal Townsite aerial core fiber cable is an All-Dielectric Self-Supporting (ADSS) cable with 432 fibers. The nominal White Rock aerial core fiber cable is an ADSS cable with 288 fibers.

The core fiber conduit is designed as three, 1.25" (HDPE) Standard Dimension Ratio (SDR) 13.5.conduits. SDR relates the outside diameter of the duct to its wall thickness:

SDR = outside diameter / wall thickness

Alternative conduit arrangements, such as a single 4" HDPE conduit may be used, or a lower SDR (thus a thicker wall and stronger conduit), with a minor cost increase. Figure 2-7 illustrates the core fiber conduit connecting a DSF with a POP. The specific conduit colors shown in the figure are not prescriptive, but three different colors are preferred.

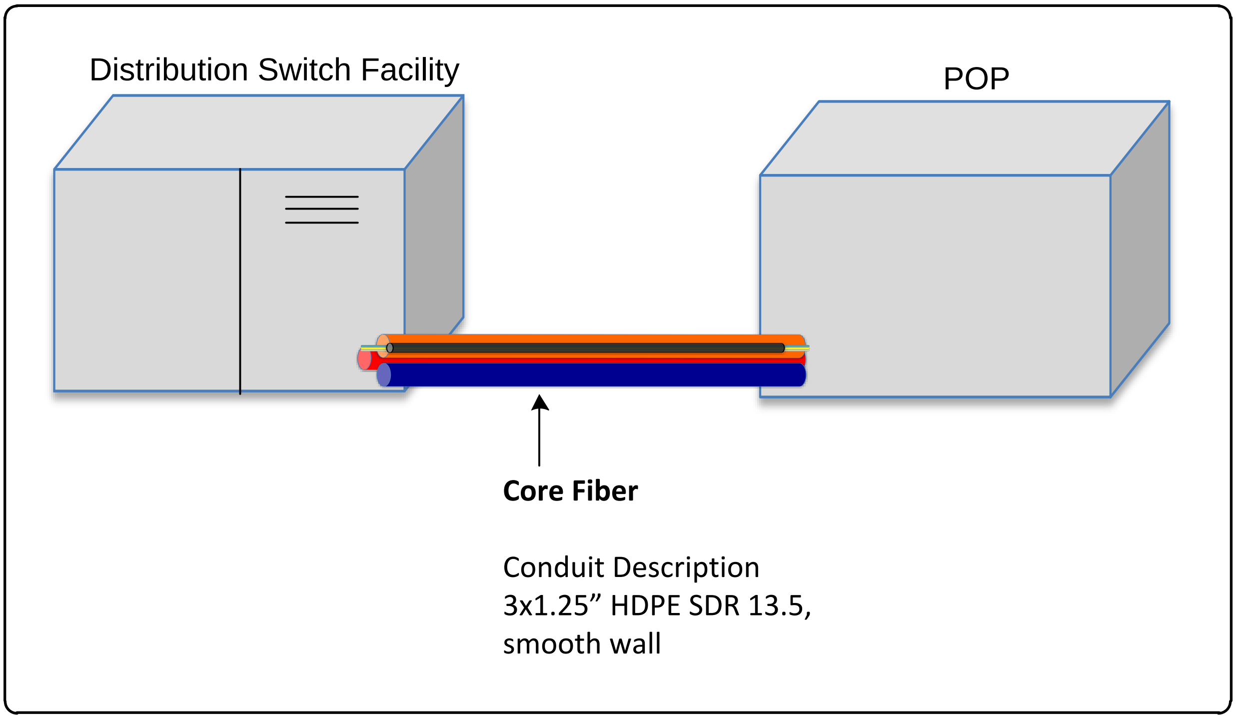

Figure 2-7. Core Fiber Conduit

Figure 2-8 shows the number of fibers required to support the maximum network capacity in each segment of the Townsite core fiber route. Figure 2-9 shows the number of fibers required to support the maximum network capacity in each segment of the White Rock core fiber route.

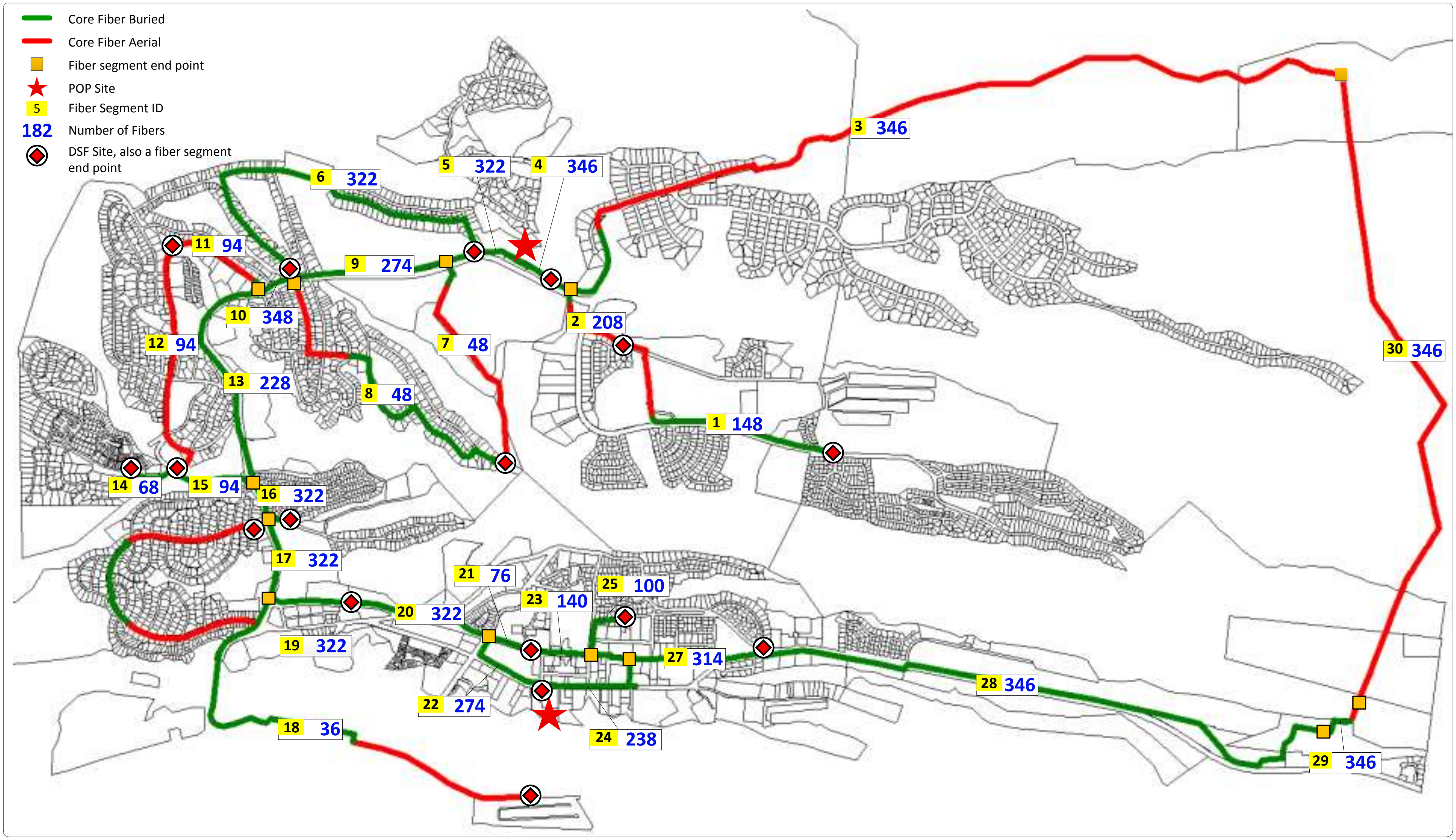

Figure 2-8. Townsite Core Fiber Counts

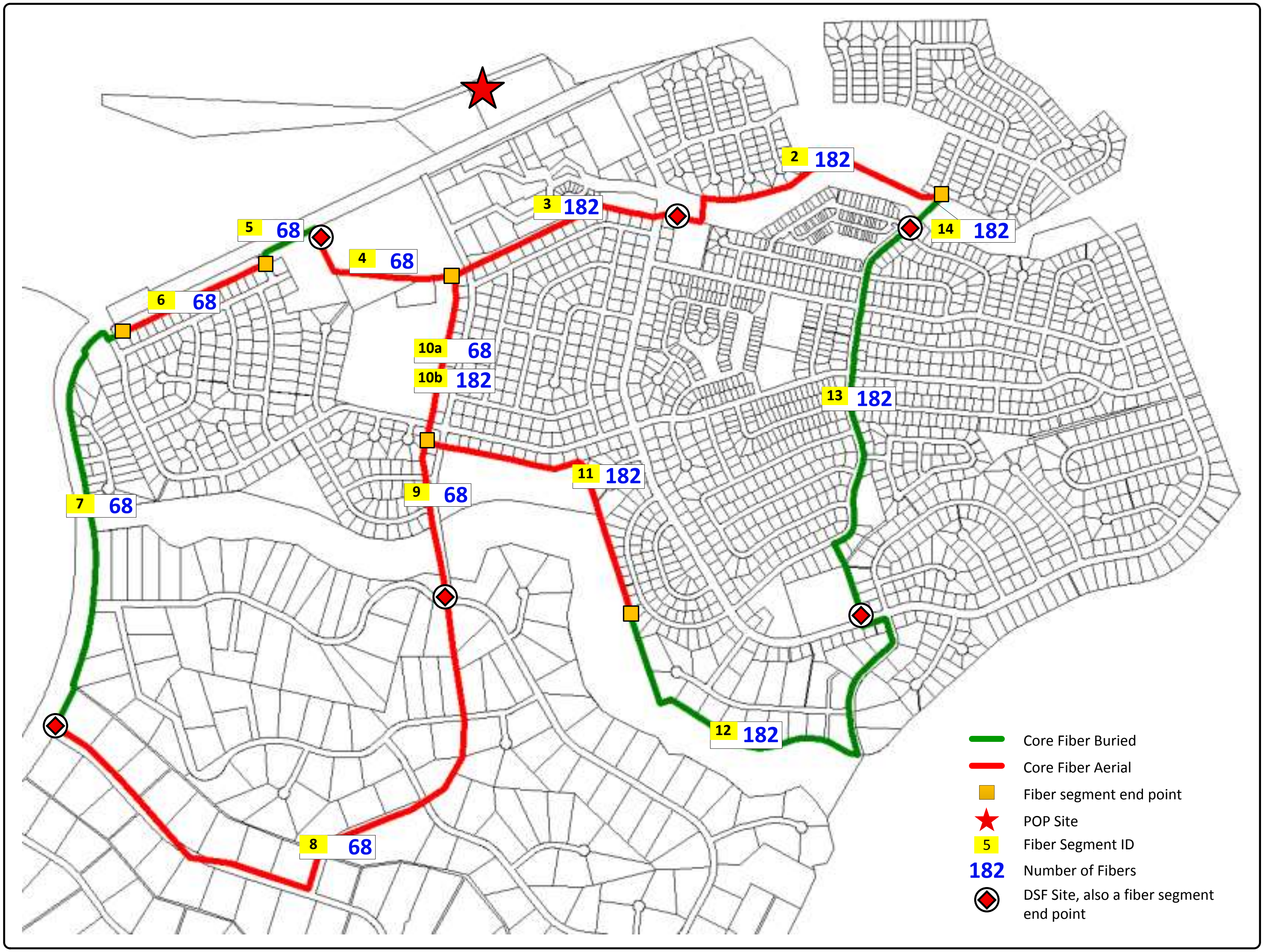

Figure 2-9. White Rock Core Fiber Counts

The fiber counts in the figure don't include spare "dark" fibers provided for future LAC use. Table 2-8 lists the proposed minimum number of spare core fibers.

Table 2-8. Spare Core Fiber Counts

ORGANIZATION	# SPARE CORE FIBERS
Utilities	24
Public Safety	24
Other LAC	24
LANL	12
TOTAL	**84**

Table 2-9 lists three attributes for each segment of the Townsite core fiber cable. The attributes are:

- # 10G Links: This is the maximum number of 10 Gbps links that would need to be carried over the segment
- # Fibers: This is the number of fibers needed to construct the 10 Gbps links; there are two fibers for each 10G link
- # Spare Fibers: This is the number of spare fibers available, calculated as the difference between the nominal aerial and buried core fiber counts and # Fibers. All segments exceed the minimum total spare fiber count from Table 2-10

Table 2-9. Townsite Core Fiber Characteristics

Segment	#10G Links	#Fibers	#Spare Fibers
1	74	148	284
2	104	208	224
3	173	346	86
4	173	346	86
5	161	322	110
6	161	322	110
7	24	48	384
8	24	48	384
9	137	274	158
10	174	348	84
11	47	94	338
12	47	94	338
13	114	228	204
14	34	68	364
15	47	94	338
16	161	322	110
17	161	322	110
18	18	36	396
19	161	322	110
20	161	322	110
21	38	76	356
22	137	274	158
23	70	140	292
24	119	238	194
25	50	100	332
26	54	108	324
27	157	314	118
28	173	346	86
29	173	346	86
30	173	346	86

Table 2-10 lists the attributes for each segment of the White Rock core fiber cable. Note that segments 10a and 10b are two separate fiber cables installed along the same route.

Table 2-10. White Rock Core Fiber Characteristics

Segment	#10G Links	#Fibers	#Spare Fibers
2	91	182	106
3	91	182	106
4	34	68	220
5	34	68	220
6	34	68	220
7	34	68	220
8	34	68	220
9	34	68	220
10a	34	68	220
10b	91	182	106
11	91	182	106
12	91	182	106
13	91	182	106

The Townsite and White Rock core fiber lengths are listed in Table 2-11.

Table 2-11. Core Fiber Lengths

CORE FIBER TYPE	LENGTH (miles)
Townsite Buried in Existing Conduit	9.9
Townsite Buried in New Conduit	3.7
White Rock Buried in Existing Conduit	0
White Rock Buried in New Conduit	2.7
TOTAL Buried	16.3
Townsite Aerial	11.1
White Rock Aerial	4.4
TOTAL Aerial	15.5
TOTAL Core Fiber (Buried + Aerial)	31.8

Table 2-12 lists the cost estimate for the buried core fiber construction. It is divided into four parts:

1. Townsite installation in existing LAC conduit
2. Townsite installation in CBN-installed conduit
3. White Rock installation

4. Rock contingency

The rock contingency is added to account for the higher cost of Horizontal Directional Drilling (HDD) through rock. The HDD construction method is described in Section 2.2.The geology of LAC is largely composed of tuff, a volcanic rock, so it has been estimated that as much as 45% of the buried construction will encounter rock.

The cost estimates for the core fiber cables (and for the lateral and drop fiber cables discussed in later sections) use cable lengths that are equal to $Actual\,Length \times 1.1$. Multiplying the actual length by 1.1 accounts for the additional cable length needed for slack loops, splicing, and waste. The value of 1.1 is calculated by adding 60' of cable for every pull box, with pull boxes nominally spaced 600' apart. Pull boxes are also used at locations where the fiber route makes small-radius bends. Pull boxes are used to limit the total bending angle that the fiber cables are subjected to, facilitating damage-free fiber cable installation. This 1.1 multiplication factor is also applied to the lateral and drop fiber cable lengths.

Table 2-12. Buried Core Cost Estimate

Townsite Core Fiber - Buried cable in existing duct with innerduct					
	Item	**Qty**	**Unit Price**	**Extended Price**	**Adjusted Price**
Materials	432 fibers	52,081	3.25	$169,262	$174,848
Labor	UG fiber pull, no splicing	52,081	1.00	$52,081	$57,733
Labor	Mass fusion ribbon splice	144	120.00	$17,280	$19,156
Materials	Vault 48x60x48	10	2,000.00	$20,000	$20,660
Labor	Install vault	10	12,000.00	$120,000	$133,025
Materials	Splice Closure	10	500.00	$5,000	$5,165
		Sub-total		**$383,623**	**$410,586**
Townsite Core Fiber - Buried cable, new 3 ea. 1.25" duct					
	Item	**Qty**	**Unit Price**	**Extended Price**	**Adjusted Price**
Materials	432 fibers	19,544	3.25	$63,518	$65,614
Materials	1.25" SDR 13.5 duct	58,632	0.45	$26,384	$27,255
Labor	UG fiber pull, no splicing	19,544	1.00	$19,544	$21,665
Labor	Mass fusion ribbon splice	144	120.00	$17,280	$19,156
Labor	Core HDD labor	17,767	21.00	$373,113	$413,610
Materials	Pull box 48x48x48	30	1,500.00	$45,000	$46,485
Labor	Install pull box	30	2,000.00	$60,000	$66,512
		Sub-total		**$604,839**	**$660,297**
WR Core Fiber - Buried cable, new 3 ea. 1.25" duct					
	Item	**Qty**	**Unit Price**	**Extended Price**	**Adjusted Price**
Materials	432 fibers	14,300	3.25	$46,475	$48,009
Materials	1.25" SDR 13.5 duct	42,900	0.45	$19,305	$19,942
Labor	UG fiber pull, no splicing	14,300	1.00	$14,300	$15,852
Labor	Mass fusion ribbon splice	144	120.00	$17,280	$19,156
Labor	Core HDD labor	13,000	21.00	$273,000	$302,631
Materials	Pull box 48x48x48	22	1,500.00	$33,000	$34,089
Labor	Install pull box	22	2,000.00	$44,000	$48,776
		Sub-total		**$447,360**	**$488,454**
Rock Contingency for Buried Installation					
	Item	**Qty**	**Unit Price**	**Extended Price**	**Adjusted Price**
Labor	Townsite Core (45% of new HDD)	7,995	30.00	$239,858	$265,892
Labor	Townsite Lateral (45% of new HDD)	66,217	30.00	$1,986,512	$2,202,124
Labor	White Rock Core (45% of new HDD)	5,850	30.00	$175,500	$194,548
Labor	White Rock Lateral (45% of new HDD)	38,712	30.00	$1,161,351	$1,287,402
		Sub-total		**$3,563,221**	**$3,949,966**
		Total		**$4,999,042**	**$5,509,303**

Table 2-13 lists the cost estimate for the aerial core fiber construction. All aerial construction costs are based on the recommended installation of optical fiber cable in the communications space. The core aerial cost estimate is divided into four parts:

1. Townsite excluding the segments along Rendija Canyon and south from Guaje Canyon
2. The Rendija Canyon segment
3. The segment from Guaje Canyon to the Pajarito Cliffs Site (PCS) POP
4. All of White Rock

Aerial construction costs are listed as a per-foot basis. The costs include adjustments to account for installation across canyons and other rugged terrain.

Table 2-13. Aerial Core Cost Estimate

Core Aerial: Townsite excluding Rendija - Guaje - PCS POP					
	Item	Qty	Unit Price	Extended Price	Adjusted Price
Materials	ADSS 432 fiber cable	30,395	4.00	$121,581	$125,593
Labor	ADSS installation	30,395	2.50	$75,988	$84,236
Labor	Fiber splicing	741	25.00	$18,525	$20,536
Materials	Vault 48x48x48	10	1,500.00	$15,000	$15,495
Labor	Vault placement	10	2,000.00	$20,000	$22,171
Labor	Pole assessment	818	50.00	$40,900	$45,339
Materials	Pole replacement 25%, Materials	205	1,000.00	$204,500	$211,249
Labor	Pole replacement 25%, Labor	205	4,000.00	$818,000	$906,784
	Sub-total			$1,314,494	$1,431,402
Core Aerial: Rendija - Guaje					
	Item	Qty	Unit Price	Extended Price	Adjusted Price
Materials	ADSS 432 fiber cable	13,860	4.00	$55,440	$57,270
Labor	ADSS installation	13,860	3.00	$41,580	$46,093
Labor	Fiber splicing	208	25.00	$5,200	$5,764
Materials	Vault 48x48x48	1	1,500.00	$1,500	$1,550
Labor	Vault placement	1	2,000.00	$2,000	$2,217
Labor	Pole assessment	39	50.00	$1,950	$2,162
Materials	Pole replacement 25%, Materials	10	1,000.00	$9,750	$10,072
Labor	Pole replacement 25%, Labor	10	4,000.00	$39,000	$43,233
	Sub-total			$156,420	$168,360
Core Aerial: Guaje - PCS POP					
	Item	Qty	Unit Price	Extended Price	Adjusted Price
Materials	ADSS 432 fiber cable	14,033	4.00	$56,131	$57,983
Labor	ADSS installation	14,033	4.00	$56,131	$62,223
Labor	Fiber splicing	208	25.00	$5,200	$5,764
Materials	Vault 48x48x48	1	1,500.00	$1,500	$1,550
Labor	Vault placement	1	2,000.00	$2,000	$2,217
Labor	Pole assessment	80	50.00	$4,000	$4,434
Materials	Pole replacement 25%, Materials	20	2,500.00	$50,000	$51,650
Labor	Pole replacement 25%, Labor	20	7,500.00	$150,000	$166,281
	Sub-total			$324,962	$352,102
Core Aerial: White Rock					
	Item	Qty	Unit Price	Extended Price	Adjusted Price
Materials	ADSS 288 fiber cable	22,923	2.25	$51,577	$53,279
Labor	ADSS installation	21,298	2.50	$53,246	$59,025
Labor	Fiber splicing	72	25.00	$1,800	$1,995
Materials	Vault 48x48x48	2	1,500.00	$3,000	$3,099
Labor	Vault placement	2	2,000.00	$4,000	$4,434
Labor	White Rock Pole assessment	393	50.00	$19,650	$21,783
Materials	Pole replacement 25%, Materials	98	1,000.00	$98,250	$101,492
Labor	Pole replacement 25%, Labor	98	4,000.00	$393,000	$435,655
	Sub-total			$624,523	$680,763
	Total			$2,420,398	$2,632,627

Detailed routes for the fiber construction in are contained in the *Townsite Fiber Construction and Route Design* and *White Rock Fiber Construction and Route Design* documents. These two documents illustrate not only the fiber routes, but the placement of most of CBN components:

- DSF locations
- Lateral fiber routes

- Pull boxes, which are installed approximately every 600’ in the buried conduit route
- Fiber splice points, which serve as locations for splicing fiber cables
- Drop closure locations
- Premises hand holes that serve as transitions between drop fiber conduits

The *Townsite Fiber Construction and Route Designs* and *White Rock Fiber Construction and Route Design* documents illustrate these component locations at a sufficient scale to see their placement in relation to property parcel boundaries. Verification of all fiber routes and component locations was completed using Geographic Information System (GIS) data sets, other mapping tools, utility service data, and field reviews. Buried and aerial fiber routes were verified to be in the existing utility right of way. POPs, DSFs, drop closures and hand holes were verified to align with LAC parcels, premises and buildings.

Figure 2-10 shows an example of a single sheet from the documents. The drop fiber paths are notional and do not dictate the exact path that may be selected during construction. All fiber splices in CBN, whether for core, lateral, or drop fibers, are fusion splices for individual fibers and mass-fusion splices for ribbon fibers. Mechanical splices or connectors are not used in CBN due to their inferior loss and reflection performance.

Figure 2-10. Example Mapbook Sheet

2.1.4 Distribution Switch Facility

A Distribution Switch Facility (DSF) is a telecommunications cabinet that houses Ethernet aggregation switches and fiber management systems. The aggregation switches connect the 1 Gbps Customer drop fiber links into a smaller number of 10 Gbps links to the POP. The aggregation of 1 Gbps links into 10 Gbps links reduces the required core fiber count by 10X. There are 17 DSFs in Townsite and 6 DSFs in White Rock. The number of Customers served by each DSF varies from as few as 134 to as many as 816, with an average of 391. The 1 Gbps Customer links are implemented with Small Form-factor Pluggable (SFP) modules. The 10 Gbps uplinks can be implemented with XFPs (10 Gigabit Small Form-factor Pluggable), or SFP+ (enhanced SFP) optics modules.

There are two sizes of DSF cabinets. The smaller cabinet is approximately 4 feet wide, 2 feet deep and 5 feet tall. It provides 25 Rack Units (RU) of interior space, and is used for DSFs with 480 or fewer Customers. Figure 2-11 shows an exterior view of this DSF cabinet.

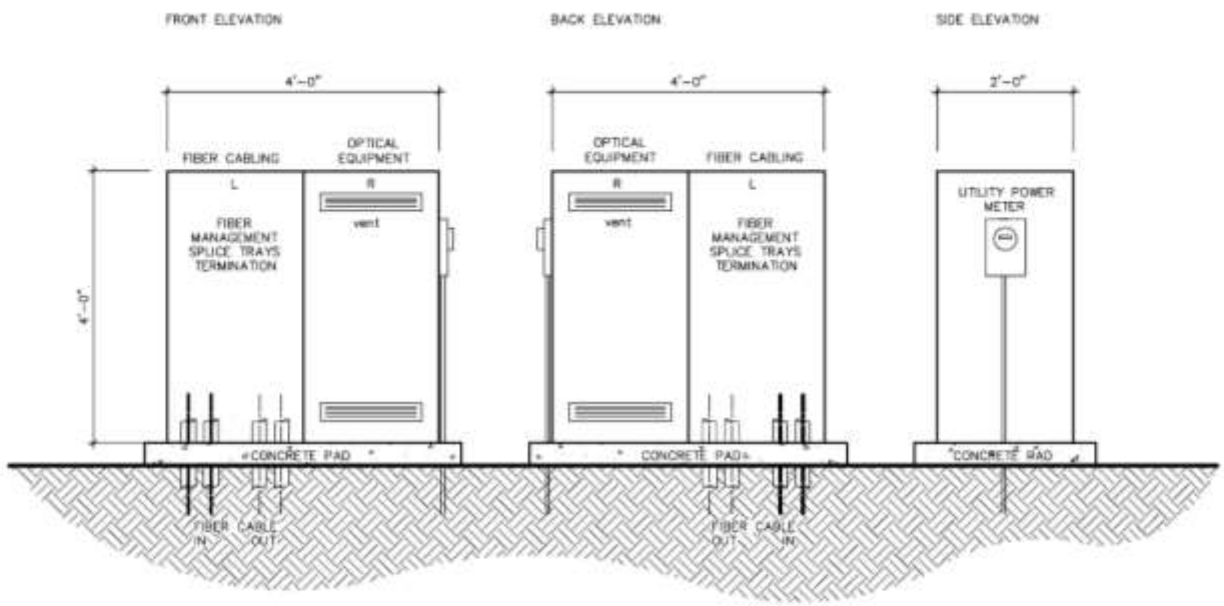

Figure 2-11. DSF Exterior View

Half of the space in each cabinet is reserved for electronic equipment. The other half is reserved for fiber management systems; Figure 2-12 is an interior elevation view of a DSF, showing this arrangement. The figure also shows the vault installed by the DSF, which may contain a splice closure. Pressurized splice closures may be used in flood-prone locations. Note that while this figure shows separate conduits for core and lateral fiber cables, these cables may be consolidated in a single conduit, depending on the type of buried construction selected.

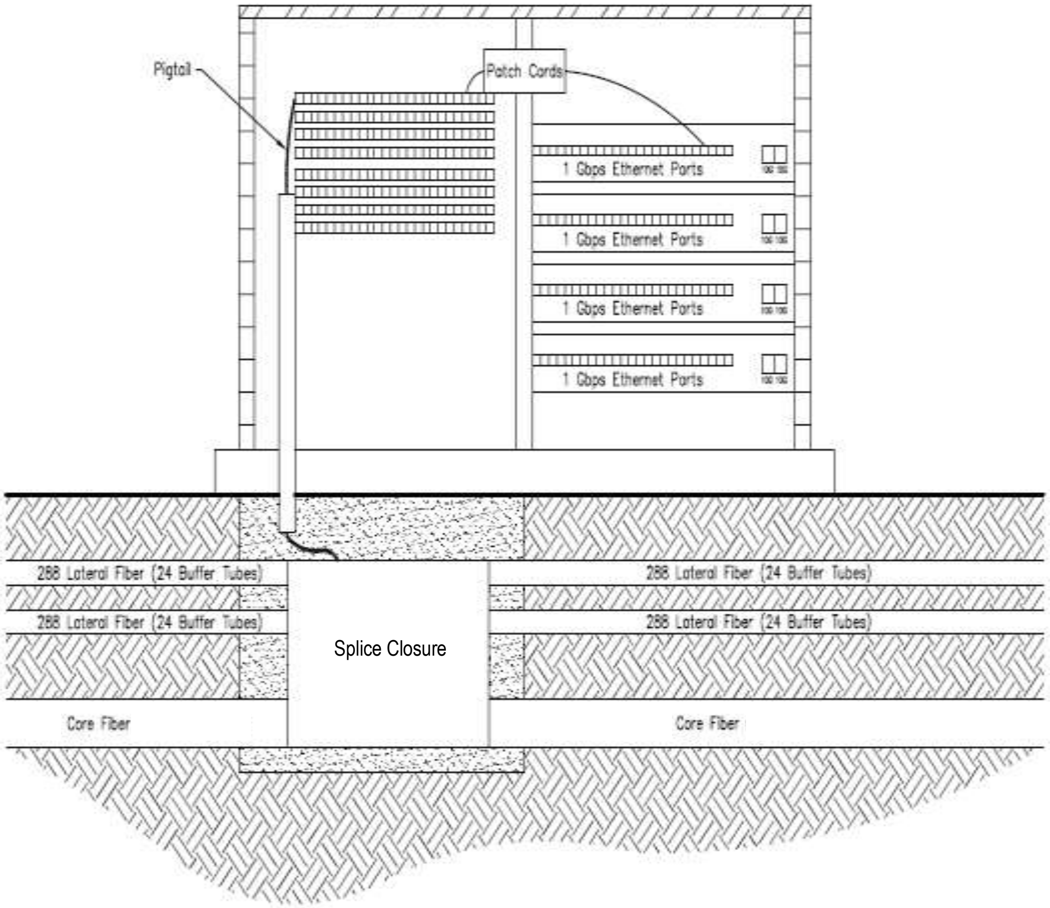

Figure 2-12. DSF Interior Elevation View

The larger cabinet is at least twice the size of the smaller cabinet, approximately 4 feet wide, 4 feet deep, and 5 feet tall, but vendors offer cabinets that are as wide as 8 feet. It provides 50 RU of interior space and is used for DSFs serving more than 480 customers.

Each DSF cabinet will be capable of connecting two optical drop fibers to every customer that it serves – one active fiber for CBN, and one spare fiber for future use. The spare drop fibers entering the DSFs will be stored un-spliced and un-connected. The DSF cabinets are sized to hold all CBN equipment and provide some empty rack space. When a use for the spare fibers is identified, and their equipment requirements are known, each DSF cabinet will need to be evaluated to determine if there is sufficient available rack space in the cabinet. Figure 2-13 shows a rendering of the smaller DSF cabinet with a cultured stone veneer applied as a possible aesthetic enhancement.

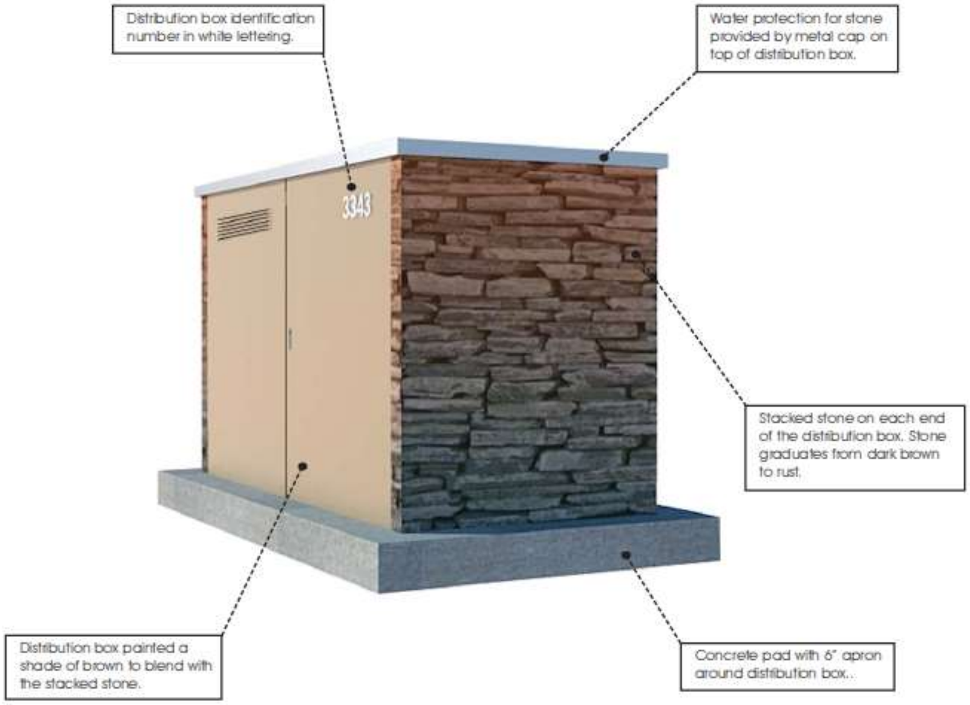

Figure 2-13. DSF Cabinet Rendering

Figure 2-14 shows this smaller cabinet at a simulated installation site.

Figure 2-14. Photo Simulation

Table 2-14 shows the cost estimate for the DSF cabinets. It is based on cabinets with heat exchangers, which are suitable for use with hardened electronic equipment. This cost estimate does not include the electronic equipment.

Table 2-14. DSF Cabinet Cost Estimate

Distribution Switch Facility Cabinet - 50RU					
	Item	**Qty**	**Unit Price**	**Extended Price**	**Adjusted Price**
Materials	50RU Cabinet	7	27,500.00	$192,500	$198,853
Materials	Rectifier	7	3,000.00	$21,000	$21,693
Materials	Fiber distribution and storage panels, fibers w/100' pigtails	35	4,600.00	$161,000	$166,313
Materials	Fiber jumper cables	4,500	30.00	$135,000	$139,455
Materials	Card to slot mapping and cabling	7	700.00	$4,900	$5,062
Materials	Battery string	7	2,000.00	$14,000	$14,462
Materials	Filler Panel	7	200.00	$1,400	$1,446
Labor	DSF Cabinet Installation: site prep, cabinet and components	7	3,000.00	$21,000	$23,279
Labor	DSF fiber splicing	4,950	25.00	$123,750	$137,182
Materials	Vault 48x48x48	7	1,500.00	$10,500	$10,847
Labor	Install vault	7	2,000.00	$14,000	$15,520
		Sub-total		**$699,050**	**$734,110**
Distribution Switch Facility Cabinet - 25RU					
	Item	**Qty**	**Unit Price**	**Extended Price**	**Adjusted Price**
Materials	25RU Cabinet	16	17,800.00	$284,800	$294,198
Materials	Rectifier	16	2,000.00	$32,000	$33,056
Materials	Fiber distribution and storage panel, fibers w/100' pigtails	39	4,600.00	$179,400	$185,320
Materials	Fiber jumper cables	4,510	30.00	$135,300	$139,765
Materials	Card to slot mapping and cabling	16	700.00	$11,200	$11,570
Materials	Battery string	16	1,000.00	$16,000	$16,528
Materials	Filler Panel	16	200.00	$3,200	$3,306
Labor	DSF Cabinet Installation: site prep, cabinet and components	16	2,000.00	$32,000	$35,473
Labor	DSF fiber splicing	4,961	25.00	$124,025	$137,486
Materials	Vault 48x48x48	16	1,500.00	$24,000	$24,792
Labor	Install vault	16	2,000.00	$32,000	$35,473
		Sub-total		**$873,925**	**$916,968**
		Total		**$1,572,975**	**$1,651,078**

2.1.4.1 DSF Network Equipment

Section 2.1.2.3 described the three stages for POP network equipment installation. The DSF network equipment is installed in three stages that occur at the same time as the POP stages. The cost estimates are based on the use of hardened electronic equipment suitable for use in cabinets with heat exchangers.

Stage 1

Stage 1 installs sufficient network equipment to service current and near-future Customer needs. 1 Gbps Customer data rates are supported across the network. Table 2-5 lists the cost of the Stage 1 network equipment for all of the DSFs combined.

Table 2-15. Stage 1 DSF Network Equipment Cost Estimate

Stage 1 Distribution Switch Facility Network Equipment					
	Item	Qty	Unit Price	Extended Price	Adjusted Price
Materials	Townsite Switch Chassis	173	895.00	$154,835	$159,945
Materials	Townsite Subscriber Card	334	5,395.00	$1,801,930	$1,861,394
Materials	Townsite Subscriber 1GE CSFP	3,273	225.00	$736,425	$760,727
Materials	Townsite Uplink 10GE XFP	84	1,700.00	$142,800	$147,512
Labor	Townsite Install DSF Network Equpment	17	1,000.00	$17,000	$18,845
Materials	White Rock Switch Chassis	64	895.00	$57,280	$59,170
Materials	White Rock Subscriber Card	125	5,395.00	$674,375	$696,629
Materials	White Rock Subscriber 1GE CSFP	1,226	225.00	$275,738	$284,837
Materials	White Rock Uplink 10GE XFP	28	1,700.00	$47,600	$49,171
Labor	White Rock Install DSF Network Equpment	6	1,000.00	$6,000	$6,651
		Sub-total		**$3,913,983**	**$4,044,881**

Stage 2

Stage 2 installs additional network equipment in the POPs and DSFs to meet increased Customer bandwidth demands. 1 Gbps Customer data rates continue to be supported across the network. Table 2-6 lists the cost of the Stage 2 network equipment for all of the DSFs combined.

Table 2-16. Stage 2 DSF Network Equipment Cost Estimate

Stage 2 Additional Distribution Switch Facility Network Equipment					
	Item	Qty	Unit Price	Extended Price	Adjusted Price
Materials	Townsite Uplink 10GE XFP	132	1,700.00	$224,400	$231,805
Materials	White Rock Uplink 10GE XFP	52	1,700.00	$88,400	$91,317
		Sub-total		**$312,800**	**$323,122**

Stage 3

Stage 3 installs additional network in the POPs and DSFs to achieve the maximum CBN capacity. Stage 3 may be considered optional; if network monitoring indicates that the Stage 2 equipment is providing ample network capacity, the Stage 3 installation may be deferred indefinitely. Table 2-7 lists the cost of the Stage 3 network equipment for all of the DSFs combined.

Table 2-17. Stage 3 DSF Network Equipment Cost Estimate

Stage 3 Additional Distribution Switch Facility Network Equipment					
	Item	Qty	Unit Price	Extended Price	Adjusted Price
Materials	Townsite Uplink 10GE XFP	452	1,700.00	$768,400	$793,757
Materials	White Rock Uplink 10GE XFP	170	1,700.00	$289,000	$298,537
		Sub-total		**$1,057,400**	**$1,092,294**

2.1.5 Lateral Fiber

Lateral fiber is the cable that connects the DSFs to the DCs. It is designed to accommodate the number of Customers serviced by the DSF with an additional spare amount of dark fiber added to accommodate future growth. Figure 2-15 shows a portion of the overview diagram where a lateral fiber cable connects a DSF with multiple DCs.

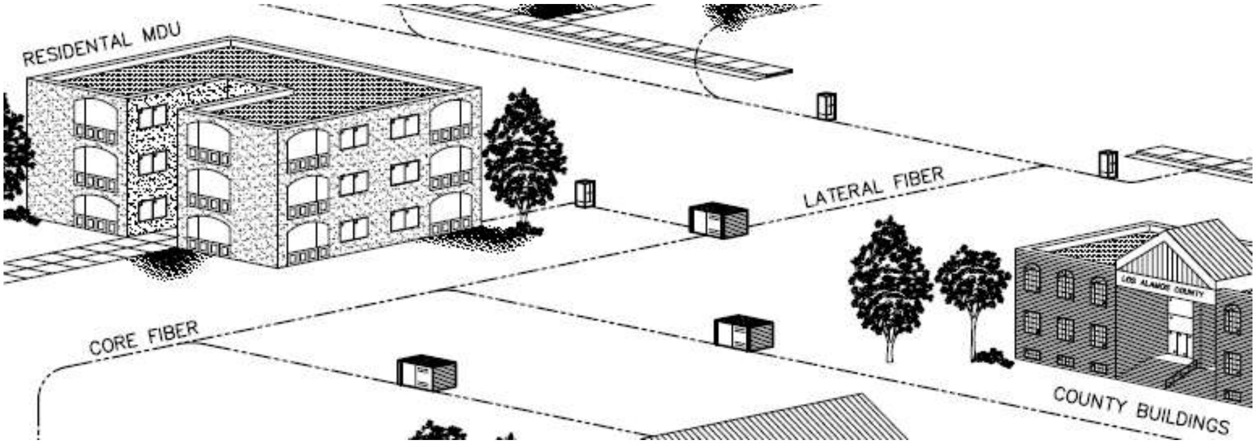

Figure 2-15. Lateral Fiber Rendering

Lateral fiber cables are sized to support one or more drop closures. With 24 fibers per drop closure, a 288 strand fiber cable can accommodate up to 12 drop closures. Since the maximum number of drops supported by each drop closure is 12, at most 12 of the 24 fibers will be used for CBN Customers; this leaves a minimum of 12 "dark" fibers at each drop closure. These dark fibers are reserved for future LAC use, possible by the LAC Department of Public Utilities for implementing a smart grid system. Few of the drop closures service the maximum number of drops, so there are additional spare dark fibers at most drop closures. Figure 2-16 shows a single pair of fibers from a lateral fiber cable running through a lateral conduit. One fiber, the active Customer fiber, shown in blue, terminates at fiber connection panels at both ends. The other fiber, the spare, shown in red, is coiled up and stored.

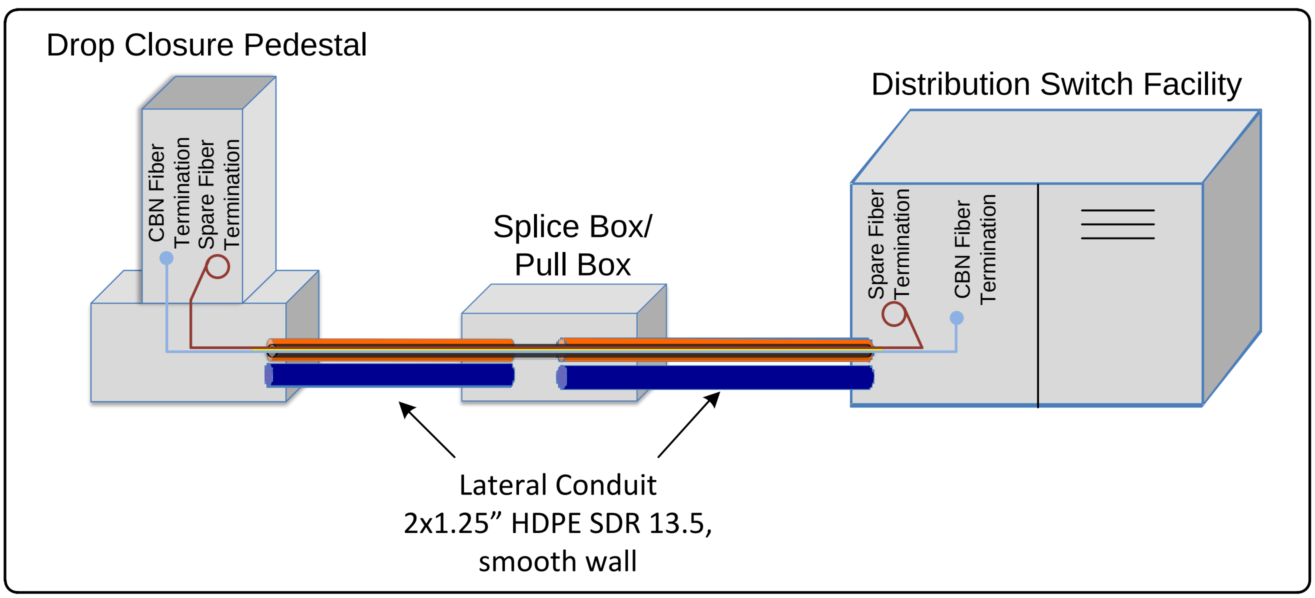

Figure 2-16. Lateral Fiber and Conduit

Table 2-18 shows the cost estimates for the buried and aerial laterals.

Table 2-18. Lateral Cost Estimate

Buried Lateral						
	Item	**Qty**	**Unit Price**	**Extended Price**	**Adjusted Price**
Materials	Townsite 288 fibers	225,578	2.25	$507,551	$524,300
Materials	Townsite 2 each 1.25" SDR 13.5 duct	325,543	0.45	$146,494	$151,329
Labor	Townsite Lateral HDD labor	147,149	18.00	$2,648,682	$2,936,165
Labor	Townsite Prepare existing conduit, place innerduct & fiber	48,847	2.50	$122,118	$135,372
Materials	Townsite Innerduct for existing conduit, 3 each 1.25" SDR 13.5	161,195	0.45	$72,538	$74,932
Labor	Townsite Fiber splicing	10,850	25.00	$271,250	$300,691
Materials	Townsite Lateral Splice Vault 48x48x48	114	1,500.00	$171,000	$176,643
Labor	Townsite Vault placement	114	2,000.00	$228,000	$252,747
Labor	Townsite Fiber splicing	5,425	25.00	$135,625	$150,345
Materials	White Rock 288 fibers	101,421	2.25	$228,197	$235,728
Materials	White Rock 2 each 1.25" SDR 13.5 duct	202,842	0.45	$91,279	$94,291
Labor	White Rock Lateral HDD labor	86,026	18.00	$1,548,468	$1,716,536
Labor	White Rock Fiber splicing	3,744	25.00	$93,600	$103,759
Materials	White Rock Lateral Splice Vault 48x48x48	46	1,500.00	$69,000	$71,277
Labor	White Rock Vault placement	46	2,000.00	$92,000	$101,986
Labor	White Rock Fiber splicing	1,872	25.00	$46,800	$51,880
		Sub-total		**$6,472,602**	**$7,077,979**
Aerial Lateral					
	Item	**Qty**	**Unit Price**	**Extended Price**	**Adjusted Price**
Materials	Townsite ADSS 288 fiber cable	89,060	2.25	$200,386	$206,999
Labor	Townsite ADSS installation	89,060	2.50	$222,651	$246,817
Labor	Townsite Lateral Fiber splicing	1,121	25.00	$28,025	$31,067
Materials	White Rock ADSS 432 fiber cable	69,923	4.00	$279,690	$288,920
Labor	White Rock ADSS installation	69,923	2.50	$174,807	$193,780
Labor	White Rock Lateral Fiber splicing	579	25.00	$14,475	$16,046
		Sub-total		**$920,034**	**$983,628**
		Total		**$7,392,636**	**$8,061,608**

2.1.6 Drop Closure

A drop closure is a weather-resistant housing containing one or more fiber management trays. It connects a lateral fiber cable to as many as 12 premises drop fiber cables. The drop closure protects the fiber management trays from the elements. Drop closures are available for installation in a pedestal or vault, or mounted directly to a pole or aerial cable strand. Pedestals are available where the pedestal itself serves as the drop closure housing. Representative examples of drop closures, including dome, pedestal, and in-line aerial styles, are shown below in Figure 2-17. All of these styles of drop closures are candidates for CBN.

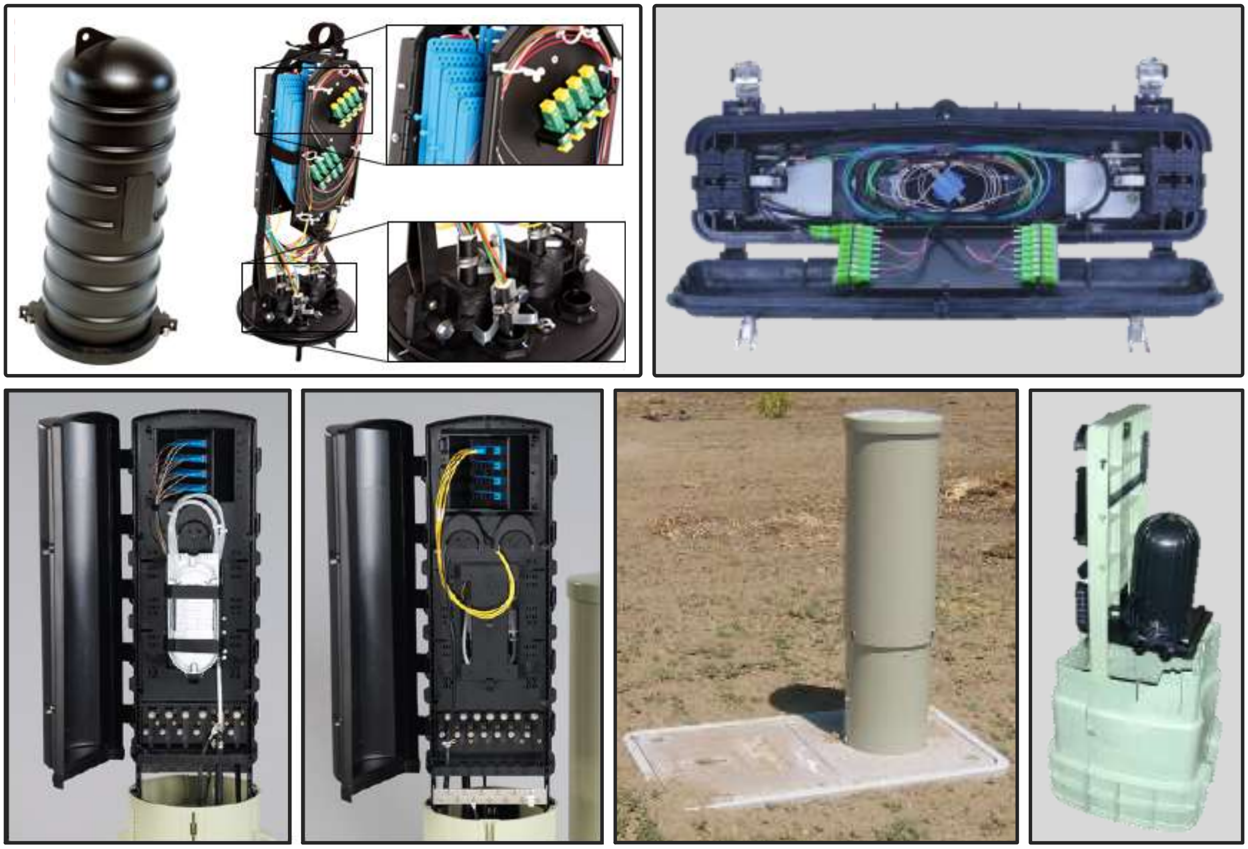

Figure 2-17. Drop Closures

Drop closures are available in a variety of exterior shapes, sizes, and fiber capacities. CBN drop closures have the capacity to contain as many as 24 lateral fibers and 24 drop fibers, using either SC/APC or LC/APC patch connections. Patch connections are preferred over spliced connections because they increase installation flexibility and can reduce restoration time for drop fiber cuts. The lit CBN drop fibers will be connected with lit CBN lateral fibers. The spare dark fibers will be stored unconnected in the drop closure. The dark fibers may be left bare without any connector fittings on them. When they are needed for a future use, they may be spliced or terminated with connectors at that time.

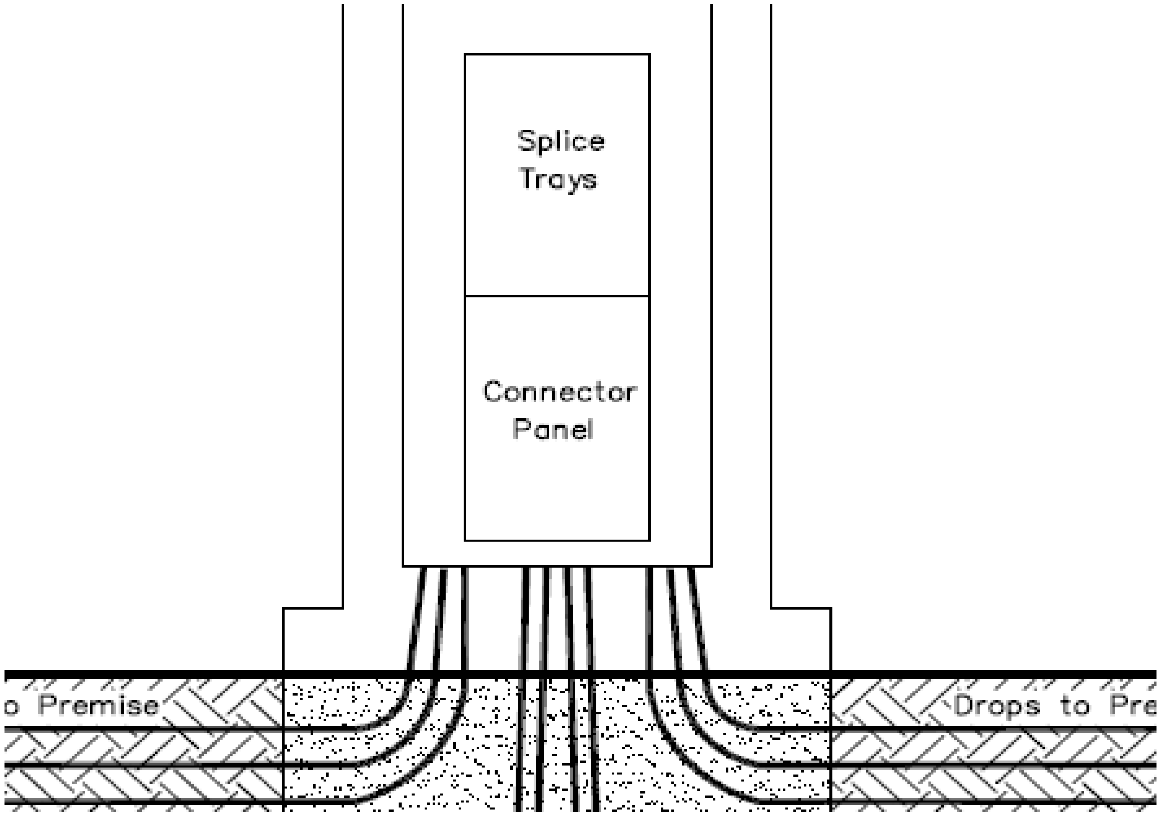

Figure 2-18. Pedestal Drop Closure

MDU and some commercial premises will have multiple Customers in a single building, perhaps 10 or more Customers. If such cases it may be appropriate to run the lateral fiber cable all the way to the premises and place the drop closure directly at the building, using one of the drop closures shown in Figure 2-17, or an exterior wall-mounted fiber termination box. If the building has a telecommunications room then an indoor fiber termination box can serve as the drop closure. Table 2-19 shows the cost estimate for the buried and aerial drop closure construction.

Table 2-19. Drop Closure Cost Estimate

Buried Drop Closure					
	Item	Qty	Unit Price	Extended Price	Adjusted Price
Materials	Townsite Pedestal mount drop closure	760	220.00	$167,200	$172,718
Materials	Townsite Pedestal 8" for drop closure	760	600.00	$456,000	$471,048
Labor	Townsite Install pedestal	760	200.00	$152,000	$168,498
Materials	Townsite Fusion Spliced Field-terminated Connectors at the drop closure	10,850	41.00	$444,850	$459,530
Materials	White Rock Pedestal mount drop closure	311	220.00	$68,420	$70,678
Materials	White Rock Pedestal 8" for drop closure	311	600.00	$186,600	$192,758
Labor	White Rock Install pedestal	311	200.00	$62,200	$68,951
Materials	White Rock Fusion Spliced Field-terminated Connectors at the drop closure	3,744	41.00	$153,504	$158,570
		Sub-total		$1,690,774	$1,762,750
Aerial Drop Closure					
	Item	Qty	Unit Price	Extended Price	Adjusted Price
Materials	Townsite Pole mount aerial drop closure	129	220.00	$28,424	$29,362
Labor	Townsite Install aerial drop closure	129	200.00	$25,840	$28,645
Materials	Townsite Fusion Spliced Field-terminated Connectors	2,242	41.00	$91,922	$94,955
Materials	White Rock Pole mount aerial drop closure	75	220.00	$16,421	$16,963
Labor	White Rock Install aerial drop closure	75	200.00	$14,928	$16,548
Materials	White Rock Fusion Spliced Field-terminated Connectors	1,158	41.00	$47,478	$49,045
		Sub-total		$225,013	$235,518
		Total		$1,915,787	$1,998,268

2.1.7 Drop Fiber

The drop fiber is the cable that connects the premises equipment with the drop closure. The fiber drop for residential and business Customers will have 2 fibers. One fiber will carry CBN network data – this is the "lit" fiber, i.e. it is illuminated by an optical light source, and one fiber will be a spare fiber for future use – this is the "dark" fiber, i.e. it is not illuminated by an optical light source. Installation of a spare fiber to all premises is an industry best practice that provides future expansion capabilities for a minimal cost.

Each CBN buried drop is designed with a ¾" conduit from the drop closure to a hand hole at the Customer's property. The hand hole is a buried plastic enclosure, 8-12 inches in diameter with a removable lid. It serves as a transition point from the ¾" conduit to 8-10 mm. microduct that completes the connection to the building. Microducts are available for use as an innerduct (which is a duct installed within a larger conduit), direct burial, or aerial applications. Multiple microducts can be run in the same path, such as a bore or trench. Their small diameter allows for faster and lower-cost installation methods, particularly for buried applications, such as:

- Microtrenching through paved surfaces
- Vibratory plowing through soil
- Shallow burial by hand through landscaping materials

Figure 2-19 shows a representative buried drop fiber installation.

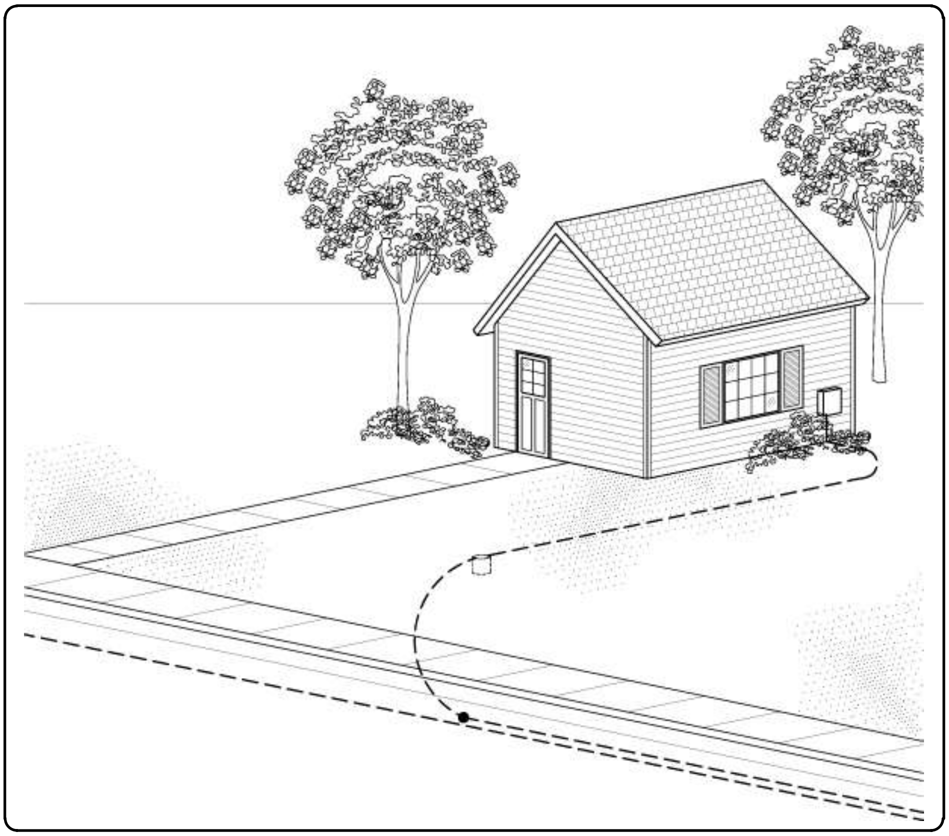

Figure 2-19. Buried Fiber Drop Rendering

Figure 2-20 shows a representative aerial drop fiber installation.

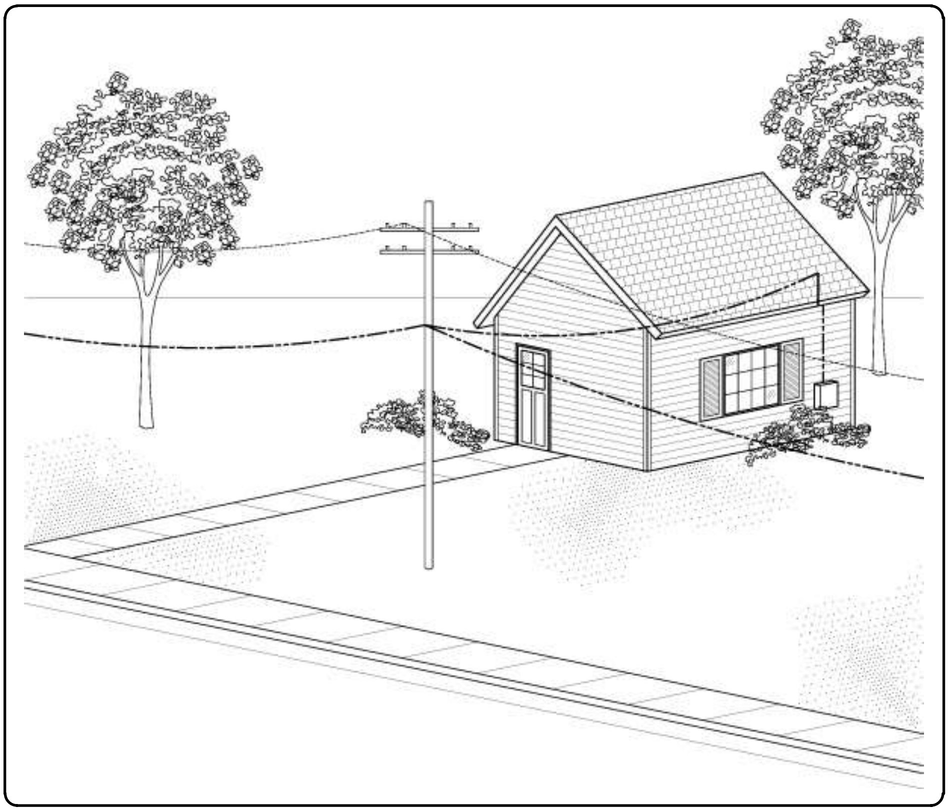

Figure 2-20. Aerial Fiber Drop Rendering

Table 2-20 shows the cost estimate for the buried and aerial drop construction.

Table 2-20. Drop Cost Estimate

Buried Drop					
	Item	Qty	Unit Price	Extended Price	Adjusted Price
Materials	Townsite Fiber, 2 strands, ducted, non-connectorized (spliced)	1,258,605	0.25	$314,651	$325,035
Materials	Townsite Buried drop microduct from handhole to fiber termination box	503,442	0.35	$176,205	$182,019
Labor	Townsite Install duct and fiber from handhole to fiber termination box	503,442	3.00	$1,510,326	$1,674,253
Materials	Townsite Handhole	1,869	15.00	$28,035	$28,960
Labor	Townsite Install Handhole	1,869	30.00	$56,070	$62,156
Materials	Townsite Buried drop duct from handhole to drop closure	755,163	0.45	$339,823	$351,037
Labor	Townsite Install duct and fiber from handhole to drop closure	755,163	3.00	$2,265,488	$2,511,380
Materials	White Rock Fiber, 2 strands, ducted, non-connectorized (spliced)	549,108	0.25	$137,277	$141,807
Materials	White Rock Buried drop microduct from handhole to fiber termination box	219,643	0.35	$76,875	$79,412
Labor	White Rock Install duct and fiber from handhole to fiber termination box	219,643	3.00	$658,929	$730,448
Materials	White Rock Handhole	912	15.00	$13,680	$14,131
Labor	White Rock Install Handhole	912	30.00	$27,360	$30,330
Materials	White Rock Buried drop duct from handhole to drop closure	329,465	0.45	$148,259	$153,152
Labor	White Rock Install duct and fiber from handhole to drop closure	329,465	3.00	$988,394	$1,095,673
		Sub-total		$6,741,373	$7,379,794
Aerial Drop					
	Item	Qty	Unit Price	Extended Price	Adjusted Price
Materials	Townsite Aerial drop cable self-supporting spliced	160,553	0.75	$120,415	$124,388
Labor	Townsite Install aerial drop fiber cable	160,553	2.25	$361,244	$400,452
Materials	Townsite Aerial Drop clamp	2,242	7.35	$16,479	$17,022
Materials	White Rock Aerial drop cable self-supporting spliced	108,089	0.75	$81,067	$83,742
Labor	White Rock Install aerial drop fiber cable	108,089	2.25	$243,201	$269,597
Materials	White Rock Aerial Drop clamp	2,242	7.35	$16,479	$17,022
		Sub-total		$838,883	$912,225
		Total		$7,580,256	$8,292,019

2.1.8 Customer Premises Equipment

Each Customer will be provided with “Customer Premises Equipment” (CPE) providing access to the 1 Gbps-capable CBN. The CPE consists of a fiber termination box outside the Customer’s premises that is connected to a gigabit Ethernet switch.

The fiber termination box connects the drop fibers to the in-building cabling. It typically mounts to the exterior wall of a building, and varies in size according to the number of customers it serves; smaller for single-customer premises and larger for multiple-customer premises. For a single customer premises, the fiber termination box is typically smaller than 10H”x10W”x3D”. It provides space to connect the drop and on-premises fibers with SC or LC plugs, and space to store slack fiber. Using connectors rather than splicing the drop and on-premises fibers provides the following benefits:

- During installation and maintenance troubleshooting it allows testing of the fiber before it enters the Customer premises
- Pre-fabricated premises fiber cables with factory-installed connectors can be used, at a lower cost than field-fabricated cables
- Faster restoration of a damaged drop or premises fiber cable

The active fiber is terminated with an SC/APC or LC/APC plug. The spare fiber is not terminated with a connector – it is left as a bare fiber and stored in the fiber termination box. Figure 2-21 shows two examples of small fiber termination boxes appropriate for a single family unit or small business premises. These two boxes are only suitable for use together with an interior Ethernet switch as they are too small to house an exterior Ethernet switch.

Figure 2-21. Small Fiber Termination Boxes

Figure 2-22 shows an example of an exterior Ethernet switch housed in a matching fiber termination box.

Figure 2-22. Small Fiber Termination Box with Exterior Ethernet Switch

Figure 2-23 shows examples of large exterior and interior fiber termination boxes. These boxes are approximately 12"Hx12"Wx6"D or larger. They are appropriate for MDU or large business premises that terminate drop fibers for multiple Customers.

Figure 2-23. Large Fiber Termination Boxes

Figure 2-24 shows an example of a multi-level MDU where a separate fiber termination box is used for each floor.

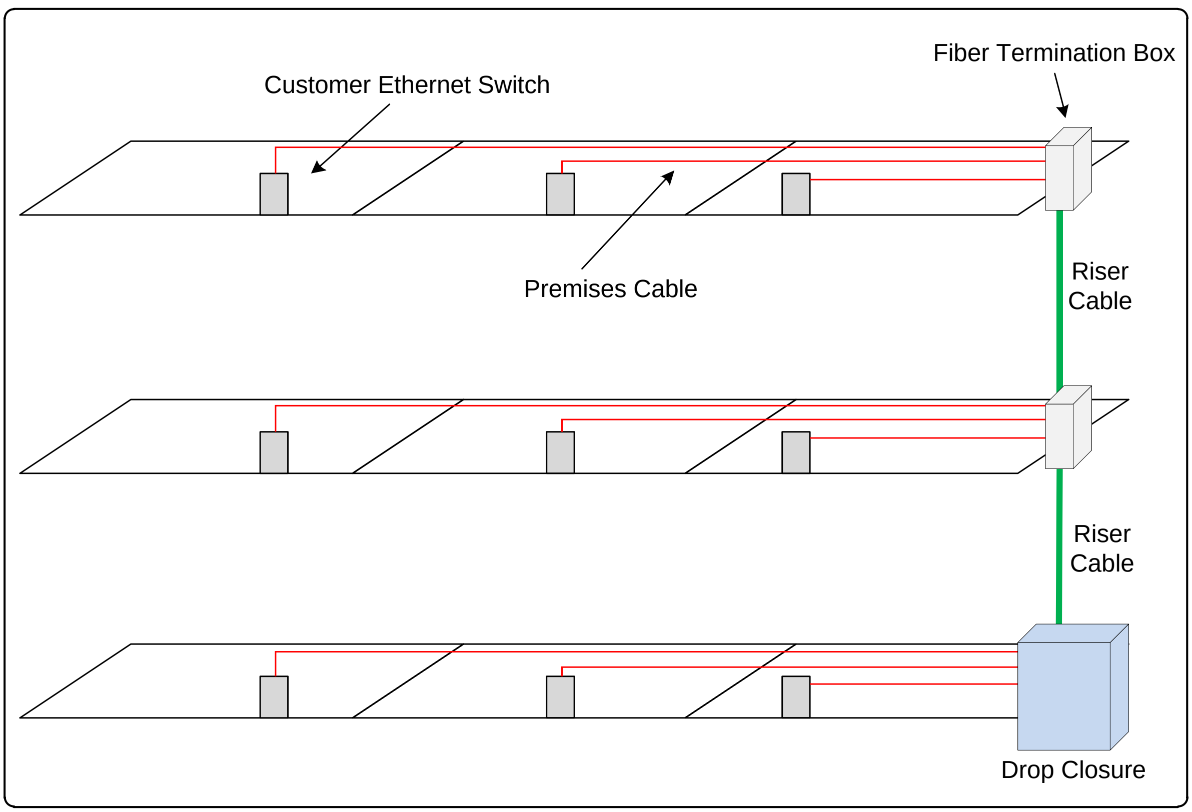

Figure 2-24. Multiple Dwelling Unit Drop

CBN uses an Ethernet switch with one or more Gigabit Ethernet ports, and holding an SFP (Small Form-factor Pluggable) transceiver module, which converts between optical and electrical signals. Products are available that offer telephone, video, and a variety of other interfaces in addition to Ethernet. These products were not selected for CBN, because they cost more, and may not be compatible with all SP equipment. This means that if a set-top box or similar device is needed to provide VoIP or other specialized services, the SP is responsible for providing this equipment to the Customer.

The Ethernet switch is available in outdoor and indoor versions. An outdoor Ethernet switch is installed directly into the fiber termination box. It requires installation of an electrical power cable through the wall of the building, and installation of an electrical earth ground. Because an outdoor Ethernet switch must operate over a wide temperature range due to weather exposure, it generally costs at least 30% more than a similar indoor version. In-building data cable installation may be simplified because copper cable is used instead of fiber. Outdoor Ethernet switches from any particular vendor typically require a matching fiber termination box.

An indoor Ethernet switch is installed in the interior of the building, sheltering the switch from weather, eliminating the requirement to provide power to the outside of the building, and providing ready customer access the gateway's data ports. While the switch itself is lower cost than the exterior version, in-building data cable installation may be more difficult because optical fiber is in installed in the building to connect the Ethernet switch with the fiber termination box. The interior Ethernet switch has been selected for its lower material cost, and because it eliminates the vendor-specific pairing of the Ethernet switch and fiber termination box.

Figure 2-25 shows three premises installation methods. The first is for the exterior Ethernet switch, connecting to the Customer's or SP's equipment over copper wires. The second shows an interior Ethernet switch connected by a short fiber patch cable to the fiber termination box. The switch connects to the Customer's or SP's equipment over copper wires. The third shows an interior Ethernet switch located further into the building, with a longer interior fiber cable used to connect the Ethernet switch to the fiber termination box. The switch connects to the Customer's or SP's equipment over copper wires.

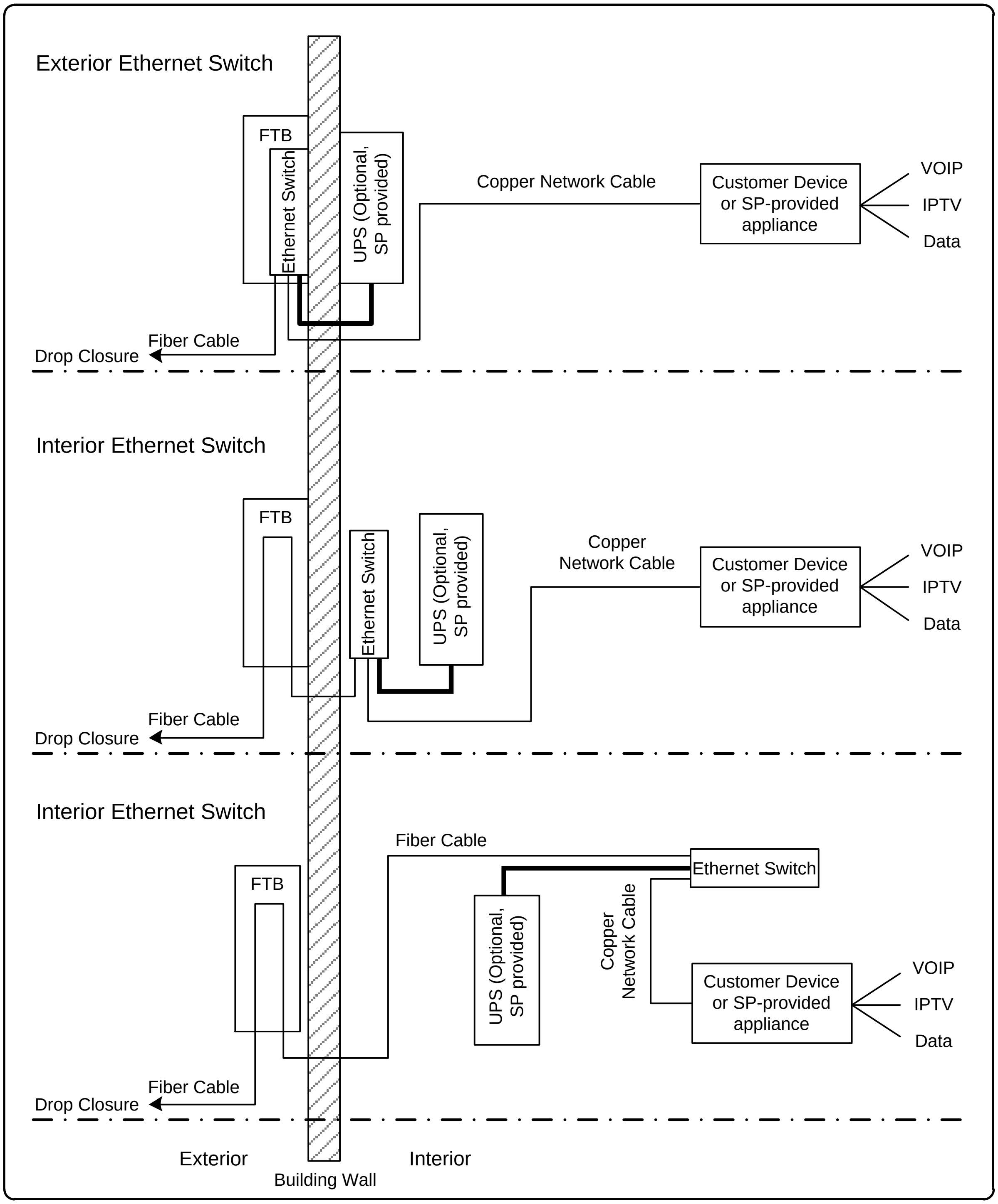

Figure 2-25. CPE Installation Methods

Table 2-21 shows the cost estimate for the installing interior Ethernet switches in 100% of LAC premises. CBN is designed to completely install the CPE to 100% of the premises in LAC, regardless of whether a Customer has purchased any services. The cost estimate does not account for premises that refuse the installation. The cost estimate includes material and labor for installing the Ethernet switch, the fiber termination box, connecting the drop fiber cable, and a 100’ ruggedized optical fiber in the building. The cost CBN design and the cost estimate do not include any premises UPS equipment. If a UPS is required for a specific subscribed Customer service such as VoIP, the SP providing the service is responsible for supplying and maintaining the UPS. For the cost estimate it was assumed that all premises use a small fiber termination box. While MDU and business premises may use the more expensive large fiber termination boxes, the per-unit cost increase is offset by combining multiple drops into fewer fiber termination boxes.

Table 2-21. CPE Cost Estimate

Customer Premises Electronics					
	Item	**Qty**	**Unit Price**	**Extended Price**	**Adjusted Price**
Materials	Indoor ONT with 3 FE 1 GE ports	8,997	300.00	$2,699,100	$2,788,170
Materials	ONT 1GE bidi SFP	8,997	60.00	$539,820	$557,634
	Sub-total			**$3,238,920**	**$3,345,804**
Customer Premises Materials and Labor					
	Item	**Qty**	**Unit Price**	**Extended Price**	**Adjusted Price**
Materials	Interior fiber pre-terminated cable = 100 ft/premises	8,997	60.00	$539,820	$557,634
Labor	Interior Fiber installation	8,997	125.00	$1,124,625	$1,246,690
	Sub-total			**$1,664,445**	**$1,804,324**
Customer Premises Fiber Termination Box					
	Item	**Qty**	**Unit Price**	**Extended Price**	**Adjusted Price**
Materials	Townsite Buried drop fiber termination box	5,425	30.00	$162,750	$168,121
Labor	Townsite Install fiber termination box	5,425	10.00	$54,250	$60,138
Materials	Townsite Fusion Spliced Field-terminated Connectors at the fiber termination box	5,425	16.00	$86,800	$89,664
Labor	Townsite Fiber splicing at the fiber termination box	5,425	25.00	$135,625	$150,345
Materials	White Rock Buried drop fiber termination box	1,872	30.00	$56,160	$58,013
Labor	White Rock Install fiber termination box	1,872	10.00	$18,720	$20,752
Materials	White Rock Fusion Spliced Field-terminated Connectors at the fiber termination box	1,872	16.00	$29,952	$30,940
Labor	White Rock Fiber splicing at the fiber termination box	1,872	25.00	$46,800	$51,880
Materials	Townsite Aerial drop fiber termination box	1,121	30.00	$33,630	$34,740
Labor	Townsite Fusion Spliced Field-terminated Connectors at the fiber termination box	1,121	41.00	$45,961	$50,950
Materials	White Rock Aerial drop fiber termination box	579	30.00	$17,370	$17,943
Labor	White Rock Fusion Spliced Field-terminated Connectors at the fiber termination box	579	41.00	$23,739	$26,316
	Sub-total			**$711,757**	**$759,802**
	Total			**$5,615,122**	**$5,909,930**

2.2 CBN Estimated Cost

The previous sections have identified the budgetary cost estimates for each CBN component. Table 2-22 lists the rolled-up costs for each CBN component. The component construction costs add up to $59M. Project management costs are estimated at $2M. The total estimated cost to build CBN is $61M.

Table 2-22. Total Estimated Cost

CBN TOTAL SYSTEM COST	
Item	**Adjusted Price**
NOC	$1,449,935
South POP	$1,428,304
North POP	$292,879
WR POP	$287,507
Stage 1 POP Network Electronics	$5,252,473
Stage 2 POP Network Electronics	$2,851,892
Stage 3 POP Network Electronics	$8,010,435
Buried Core Fiber	$5,490,147
Aerial Core Fiber	$2,632,627
Distribution Switch Facility Cabinets	$1,651,078
Stage 1 Distribution Switch Facility Network Equipment	$4,044,881
Stage 2 Additional Distribution Switch Facility Network Equipment	$323,122
Stage 3 Additional Distribution Switch Facility Network Equipment	$1,092,294
Buried Lateral	$7,077,979
Aerial Lateral	$983,628
Buried Drop Closure	$1,762,750
Aerial Drop Closure	$235,518
Buried Drop	$7,379,794
Aerial Drop	$912,225
Customer Premises Electronics	$3,345,804
Customer Premises Materials and Labor	$1,804,324
Customer Premises Fiber Termination Box	$759,802
CBN Components Sub-total	**$59,069,400**
Project Management	$2,043,257
TOTAL	**$61,112,658**

There are four significant cost options for the design. The options are listed in Table 2-23.

Table 2-23. Cost Options

CBN OPTIONS	
Item	**Adjusted Price**
Build the small south POP instead of the large south POP	($949,485)
Eliminate the NOC facility by outsourcing NOC operations	($1,263,995)
Omit Stage 3 POP and DSF network equipment build	($9,102,729)
Omit Stage 2 POP and DSF network equipment build	($3,175,014)
TOTAL	**-$14,491,223**

If all four cost options are exercised, the total cost falls to $46,621,434.

2.3 Construction Methods

Because aerial construction costs significantly less than most buried construction, the existing LAC Utility aerial system is used as much as possible. The cost estimate applies a 25% pole replacement rate for most aerial construction. This rate is based on recent real-world experience installing aerial fiber optic cables in multiple locations in and LAC and surrounding regions, with an added contingency factor to account for unknown issues. The 25% rate accounts for the age and condition of existing utility poles. It also accounts for cases where existing utility poles may be congested – existing communications cables may occupy the allowable communication space, leaving insufficient space to install an under-hanging CBN fiber optic cable with proper clearance to ground level. In this case the make ready process will address the issue, typically either through relocation of existing communication cables or pole replacement. It is recommended that a full pole assessment be performed prior to construction; the cost of this assessment is included in the pole replacement cost.

Certain conditions such as crowded easements and lack of capacity in existing systems can make underground the only practical fiber construction method. Because this option can be expensive, the following methods may be used to minimized underground contruction costs:

- Horizontal Directional Drilling
- Open-cut (trench)
- Vibratory plowing
- Unguided boring
- "Soft" excavation
- Microtrenching
- "Stitch" boring

The budgetary cost estimate assumes that *Horizontal Directional Drilling* construction is used for all buried fiber routes. HDD construction is a *drilling* method that bores a *horizontal* hole through the ground, called the pilot hole. The drilling equipment allows the pilot hole path to be varied as it extends through the ground. This *directional* control allows the pilot hole to follow dips and rises in the ground surface, follow bends in streets, and avoid obstacles such as buried pipelines. When the bore head and rod emerge at the planned end point, a special cutter, called a back reamer, is attached and pulled back through to enlarge the pilot hole. The back reamer is attached to one or more conduits being installed, and as the back reamer bores out the pilot hole it pulls the conduits along as well.

Since HDD method is generally the most expensive of the underground methods, the cost estimate represents an upper limit on the projected buried construction cost. When CBN proceeds to the construction phase, the construction contractor may select to substitute other construction methods where feasible, with a commensurate cost reduction.

Vibratory plowing uses a vibrating blade that is driven into the earth and cuts through the soil, pulling the conduit down into a narrow slot cut by the blade. While this method is fast and low-cost, it is only suitable for use in soils with minimal rocks. The geology of LAC may severely limit the application of this construction method.

Microtrenching is a useful buried construction technique for CBN. While this installation method is not widespread in the US, since 2003 the techniques have been improved and it has been used in some notable projects in Chicago and other municipalities. It offers precise installation with fast and low-cost restoration, and when properly installed does not experience issues with frost heaving or potholes. Using microtrenching would require close planning and cooperation with the LAC Department of Public Works. There may also be roadways in LAC with unusually thick pavement that may complicate or exclude microtrenching installation. Figure 2-26 shows a microtrench being cut and a microduct being installed in a microtrench.

Figure 2-26. Microtrenching

2.4 Permitting

Permitting will need to be conducted when the construction of CBN begins. Permits that may be applicable to CBN involve a number of entities.

2.4.1 Federal

EPA

The National Environmental Policy Act (NEPA) requires careful consideration of the environmental effects of Federal actions or plans, including projects that receive federal funds. Impacts on land uses and conflicts with state, regional, or local plans and policies are among the considerations included in the regulations. If Federal grant funds are considered for CBN, this act would apply.

http://www.epa.gov/compliance/nepa/index.html

US Forest Service

The US Forest Service (USFS) is responsible for the National Forest land that it manages. The Santa Fe National Forest may account for a portion of CBN project area, and fiber optic cable and equipment that is placed in these areas will require a permit.

Forest Supervisor:

Maria T. Garcia
11 Forest Lane
Santa Fe, NM 87508
505-438-5300

Department of Energy – Los Alamos National Laboratory

LANL will have direct jurisdiction over fiber optic cable and equipment placed on Laboratory property including the Omega Bridge. Los Alamos County personnel over the years have discussed fiber placement and its effects to the Laboratory. Areas of the Los Alamos community have been labeled as Potential Release Sites for Solid Waste Management Units (SWMU) that are of concern during construction.

2.4.2 State of New Mexico

Department of Transportation

New Mexico DOT will have jurisdiction over fiber optic cable placed in the right of way of State roads and highways. The permit regulations are attached in the Appendix.

Miguel Gabaldon, PE
District Engineer
Box 4127, Coronado
Santa Fe, NM 87502
505-476-4200

New Mexico Public Regulation Commission

The Service Providers may be required to follow rules as set forth by the New Mexico Public Regulation Commission.

2.4.3 Los Alamos County

Department of Public Utilities

A pole attachment agreement will be required from LAC DPU. This fiber optic cable will be available to entities in the County, such as DPU for their use.

County Public Works

The Public Works Department is responsible for Administration; Engineering and Surveying; Pavement; Fleet; and, Transportation, which is comprised of Traffic and Transit. Careful coordination and traffic planning with Public Works will be required for all construction activities on County property.

2.4.4 Private Property Owners

There may be cases where a preferred fiber route traverses private property. In such cases individual rights of way or other easements may be negotiated with the individual property owners.

Section 3. Network Design

CBN is a community network planned around an “Open Access” design principle, where separate entities provide the physical network infrastructure and content services. An open network design removes traditional barriers to entry caused by infrastructure costs and incumbent local providers who operate closed networks where they are the only service provider option. LAC will own CBN network infrastructure. Various SPs use CBN to provide services such as Internet, IPTV, and VoIP telephone service. This section of the report describes how network services are provided by CBN. Detailed logical and physical network design details, such as splice logic diagrams and Ethernet circuit diagrams are beyond the scope of the design report and will be completed leading in to construction.

3.1 Active Ethernet Network

An Active Ethernet (AE) design was selected for CBN due to its robust capacity meeting the 1 Gbps system requirement, wide adoption as a preferred medium for transport, and the ease with which any network element can be upgraded. This means that all nodes in CBN connect using Ethernet only. As described in CBN Design section, CBN uses AE equipment at the POPs, DSFs, and Customer premises. Figure 3-1 shows the physical core network topology for CBN, showing all three POPs, representative DSFs in Townsite and White Rock, and their interconnections.

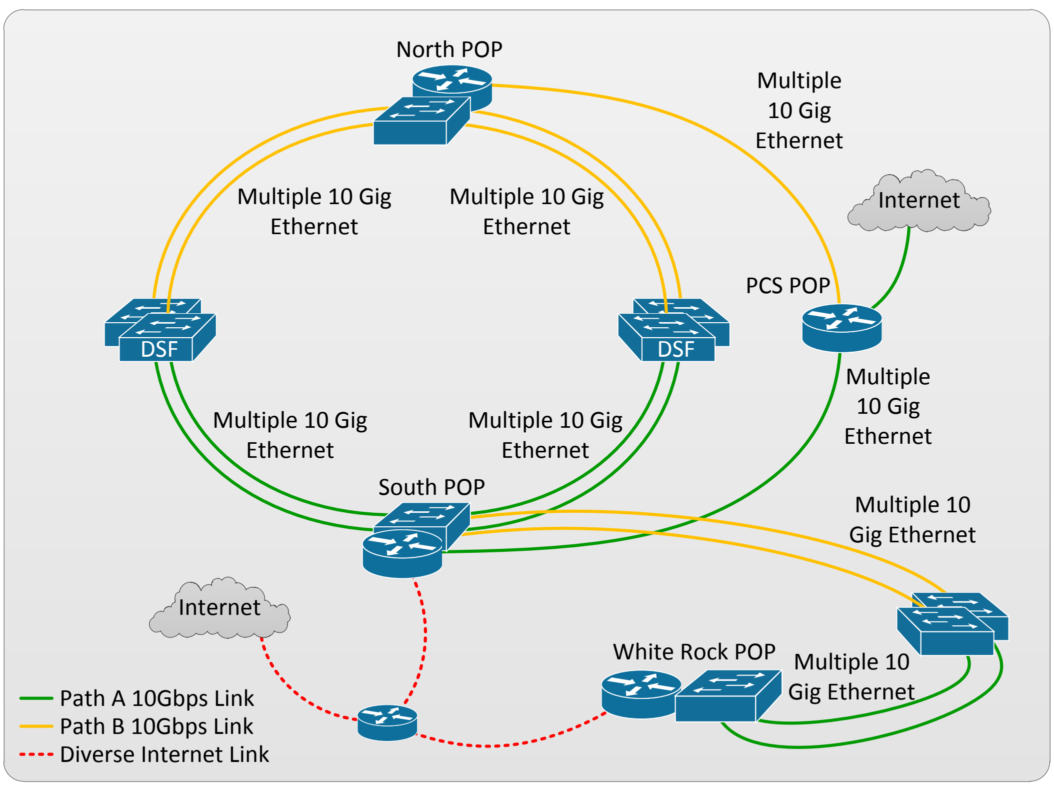

Figure 3-1. Physical Network Topology

Each DSF connects with two POPs over multiple pairs of 10 Gbps links. Each Townsite DSF connects half of its 10 Gbps links with the south POP, and the other half with the north POP. Each White Rock DSF connects half of its 10 Gbps links with the White Rock POP, and the other half with the south POP. Figure 3-2 gets into more detail on the network connections, illustrating the physical connections from the Townsite POPs all the way to the Customer Ethernet switches.

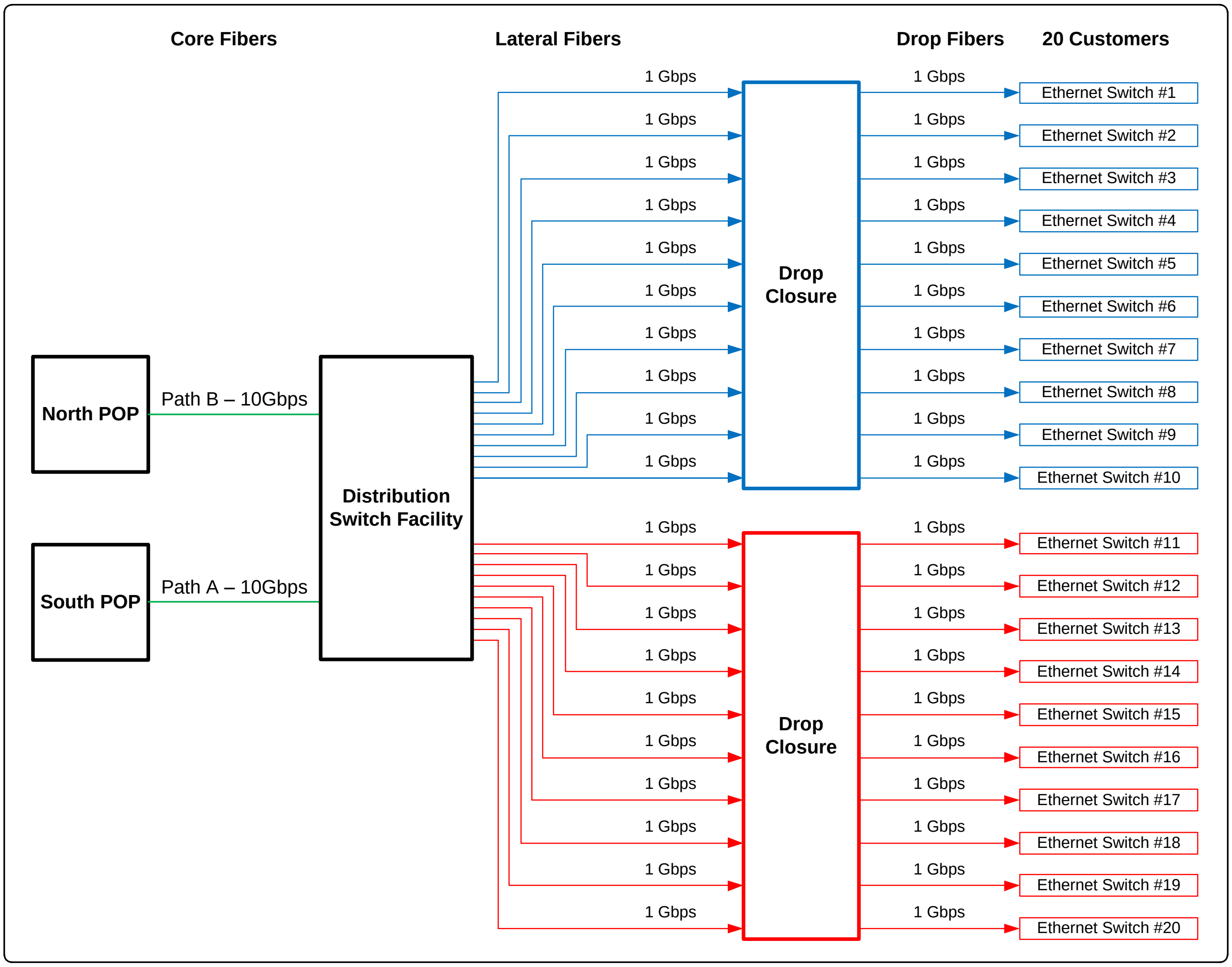

Figure 3-2. CBN Components

It shows how a single 10 Gbps core fiber link from each of two POPs combine at a DSF to provide the two redundant paths. The pair of 10 Gbps links fan out over lateral fibers to two drop closures servicing a total of 20 Customer Ethernet switches with 1 Gbps links. This figure only shows the installed Customer links from the DSF; the additional 4 spare 1 Gbps Customer ports at the DSF are not shown.

3.1.1 Commercial Services

Commercial services are provided by SPs that have partnered with CBN. The SP provides the service content, and CBN delivers it to the County premises. There are three main commercial services: Internet, IPTV, and VoIP. CBN can deliver Internet services directly to CBN Ethernet switch. The Customer is responsible for connecting their own device to the Ethernet switch to complete the service connection. IPTV and VoIP services may require add additional set-top box or other information appliance to interface between the Ethernet switch and a television or telephone.

3.2 CBN Routing Overview

CBN provides Ethernet transport to SPs so that SPs may provide retail network services to the residents and businesses of Los Alamos County. An SP's router acts as the Internet gateway for Customer equipment connected to CBN. The SP router performs the routing lookup and forwards the data traffic either locally within the SP network (for services provided directly by the SP, such as IPTV or VoIP) or to an interconnect provider when accessing the Internet. Alternatively, CBN can act as the Internet gateway, providing transport service for SPs. In this case, CBN router will perform the routing function for the SP Customer's traffic.

Beyond CBN Internet gateway case, there are instances where CBN equipment performs routing functions, as outlined in the following sections. These are mainly in support of providing Ethernet transport services (invisible to the Layer 2-based services), and also on-network CBN services, including access to the community Portal.

3.2.1 Multiprotocol Label Switching Core Network

Multiprotocol Label Switching (MPLS) is deployed in CBN core network. Some benefits of MPLS include robust Quality of Service, multi-service delivery, scalability, and fast network recovery/resiliency. MPLS requires a Layer 3 routing protocol (Open Shortest Path First) to run on each router, as well as a signaling protocol (Label Distribution Protocol) to establish MPLS tunnels. As such, within the context of MPLS, CBN core routers do perform routing and MPLS functions.

However, the Ethernet transport services are implemented using Virtual Private LAN Service (VPLS), where the actual services between the customers and SPs are delivered as Layer 2-only (within CBN) across the MPLS core. The MPLS operation is essentially transparent to an Ethernet transport service.

3.2.2 SP Interconnect

CBN provides common fiber interconnection points for SPs to interconnect with the network, allowing them to use CBN as a seamless extension of their own network. Services are provided to the Customers by the SPs, and Customers can subscribe to multiple services from different providers. Figure 3-3 provides a high-level overview of the network architecture, showing network nodes and interfaces, stakeholder organizations, and a flow of services across the network.

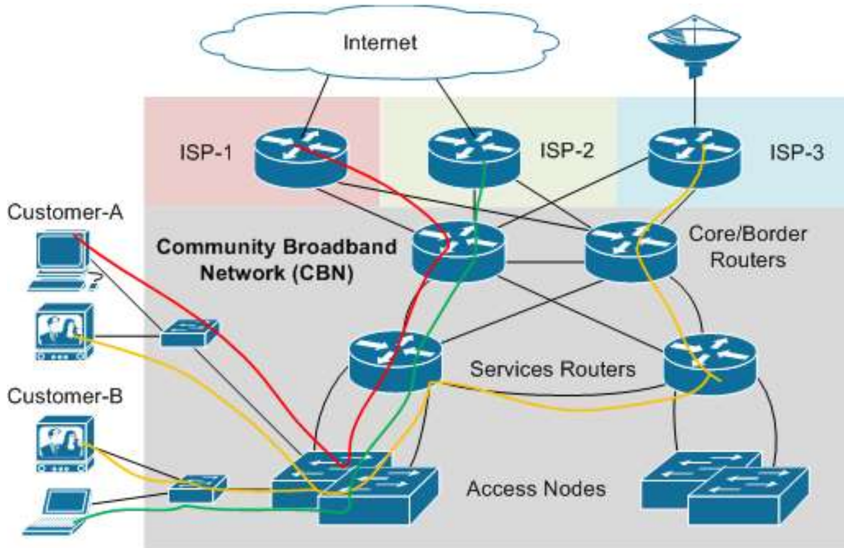

Figure 3-3. Network Architecture Overview

This figure shows two Customers receiving Internet services from different Internet Service Providers (ISPs). Customer-A receives Internet service from ISP-1 (represented by the red line) and Customer-B receives Internet service from ISP-2 (represented by the green line). Both Customer-A and Customer-B receive IPTV service from ISP-3.

The initial SP Interconnect model is to hand-off Virtual Local Area Networks (VLANs) between CBN border router and the SP border device. This reflects the Ethernet transport model, where CBN acts as a Layer 2 domain between the end-customer and SP, and also requires the lowest level of interoperability and complexity in implementing the interconnect. This approach is augmented through the use of access control lists to ensure that only traffic from agreed to IP addresses is passed at the interconnect.

Though not the initial model for SP interconnection (due to complexity and interoperability concerns), MPLS may be utilized to provide VPLS services across the interconnection. This allows the benefits of MPLS to be realized between CBN and SPs. In this scenario, Inter-Autonomous System VPLS would be deployed, where the VPLS instances are created crossing both CBN and SP network. This requires the Border Gateway Protocol routing protocol between CBN and SP routers.

3.2.3 CBN Internet Gateway

In this scenario, CBN router provides the routing and IP transport to the interconnect provider on behalf of a retail SP. This model supports SPs who perform all of the retail operations, such as defining services, marketing the services, and handling Customer care, but CBN performs the IP transport to the Interconnect provider without the need for SP routers. The CBN router implements the routing interface for each SP, and acts as the next-hop Internet gateway for all end-users customers to the SP’s service. The traffic is then routed to an interconnect provider.

3.2.4 On-Network Services

CBN is a significant investment of infrastructure, providing fiber optic connections to every premises in LAC. The weak link can many times be interfacing with other networks with lower performance, or inefficient traffic flows, where traffic leaves CBN to the SP, then re-enters CBN to reach the destination. To take advantage of the fiber infrastructure, on-network services may be created, and traffic between the Customer and service remains completely on CBN. On-network services could include:

- Community Portal services
- LANL applications
- Public Safety applications
- Library services
- Los Alamos Public Schools applications such as remote learning
- Department of Public Utilities – automated meter reading and smart grid services
- Municipal wireless

The traffic between the end-user and the on-network service provider should not leave CBN. To accomplish this, CBN must support some degree of routing for on-network services. When a resident or business initially connects a computer to CBN, the resident/business does not have an Internet provider established at this point and has yet to access the self-service Portal to choose an SP. Or, the resident or business chooses to not use an SP on CBN for Internet services, but still connects to CBN Portal for local community services. In this case, CBN acts as the next-hop router for the end devices, to provide connectivity between the end devices and community Portal. A private IP is provided to the end device through DHCP, which is routable only within CBN, for the sole purpose of accessing CBN Portal (this is different than in the wholesale Internet case, where public IPs are used and are routable to the Internet).

Once a resident/business selects an Internet provider, the network is reconfigured as that CBN performs Ethernet transport between the end device and SP, and all IP allocation and routing is performed by the SP. Once a customer selects an Internet provider, as previously mentioned, the SP router is the Internet gateway and acts as the next-hop router for data traffic (with the exception of the wholesale Internet gateway case). The CBN on-network services are on a subnet different from the end-user devices. Traffic to and from the on-network services is not forwarded from CBN to the SP, but remain on CBN. To support this, proxy Address Resolution Protocol and/or policy based forwarding should be implemented in CBN core routers to enforce this forwarding decision.

3.3 Network Routing Protocols

The network configuration and routing protocols determine what kinds of services can be offered on the network. At a minimum, CBN will assign a VLAN-per-service or VLAN-per-Customer, such that a Layer 2 connection is made between the port on a Customer Ethernet switch and the SP infrastructure. In the Layer 2 environment, the SP builds routing interfaces for its services on its routers (which exist in the SP network). The network segment is extended into the LAC network over a VLAN. The VLAN extends through the LAC network and terminates on the

Customer Ethernet switch. In this environment, the end-user's device(s) are constrained to only receive services from the single SP at a time.

3.3.1 Layer 2-based Network

CBN can provide services using a Layer 2, VLAN-based pipe created between one or more Customers and the SPs. The VLAN-based service delivery designs allows for both VLAN-per-service and VLAN-per-customer models. In a VLAN-per-service model, multiple Customers share a VLAN, and the VLAN terminates into a routing interface on the SP's router. Figure 3-4 shows this configuration. Note that in this figure and through this section of the document, *Access Node* refers to the DSF switch equipment, *Aggregation Switch* refers to CBN POP switch equipment, and *Services Router* refers to the SP router that connects with the internet.

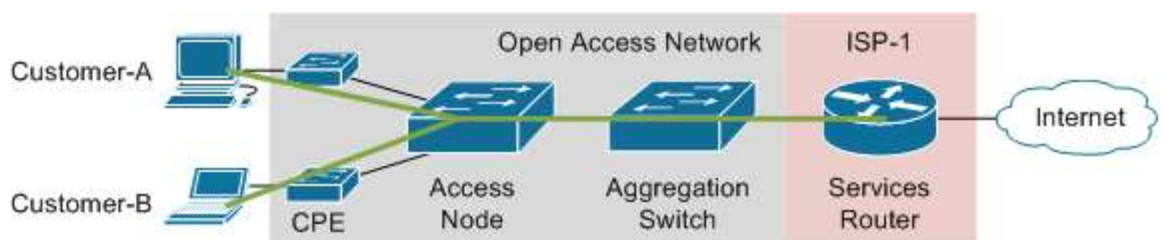

Figure 3-4. VLAN-per-Service

This model simplifies provisioning of the network, in that the service VLAN can be created throughout CBN, and is simply added to a port on the Customer's CPE device. The most significant disadvantage is that, absent specialized features, all Customers' workstations are on the same broadcast domain – as though they are all connected on the same Local Area Network. This leaves the workstations vulnerable to attack, hacking, privacy issues, etc. Split horizon features may be implemented to force packet flows between only workstations and the access router. Note that these concerns are limited when using VLAN-per-service to delivery IPTV and VoIP services, as these services utilize service-specific devices which are the only devices active on the service VLAN.

The VLAN-per-customer indicates that a dedicated VLAN is created on a per-Customer basis for data services. When a Customer signs up for service, the VLAN is provisioned between the Customer's CPE device, through the Access and Metro networks, and terminating on the SP's router. Note that modern access routers allow multiple VLANs to map into a common IP interface, eliminating earlier concerns of excessive subnetting.

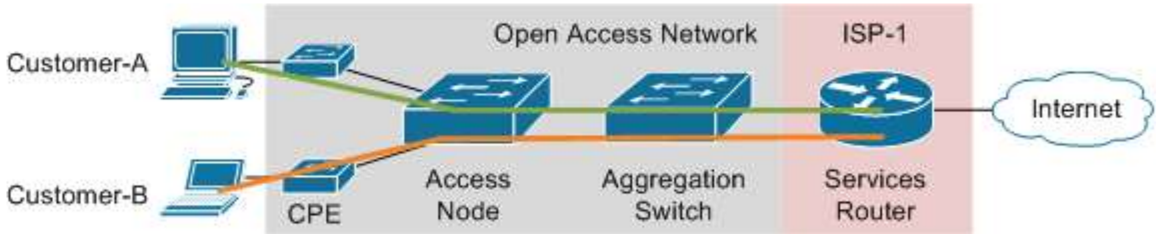

Figure 3-5. VLAN-per-Customer

This model eliminates many of the security concerns of the VLAN-per-service model, and provides the SP with full control of packet forwarding. A disadvantage is that additional provisioning is required, as a VLAN must be configured throughout the network on a per-Customer basis – in both CBN and SP networks. Options include creating the VLAN when the service instance is created, or pre-configuring a set of VLANs, and assigning one to a service instance when the instance is created.

3.3.1.1 Double VLAN Tag

Another challenge with the VLAN-per-service model is the limited number of VLAN IDs. The VLAN tag is a limited to up to 4,096 unique VLANs. This has obvious scalability issues, given that a VLAN is assigned per-Customer. This issue is exacerbated due to the Open Access nature of CBN, since multiple services will be provided by multiple SPs, and each SP may require its own VLAN ID space/range to assign VLANs.

Double VLAN tagging is useful in increasing the VLAN space. In this model, an Ethernet frame includes both an "inner-tag" and "outer-tag". The "inner-tag" is assigned on a per-Customer basis, and is applied at the Customer CPE device. The "outer-tag" is applied at the access node or in the Metro network, indicating the SP and/or segment of the SP's service area. Once the "outer-tag" is applied, all forwarding decisions are based on the "outer-tag". Of course, this can further complicate the provisioning model, as a service instance is then associated with a set of VLAN tags.

In the Double VLAN tagging scenario, both tags could be forwarded to the SP at the interconnect point, or the "outer-tag" could be popped. This depends on the needs and capabilities of the SP network and access router.

3.3.1.2 Resiliency

A VLAN-based architecture is capable of providing resiliency within the network. Layer 2 Ethernet protocols exist to repair network failures such as link failure and element failure. Common protocols include:

- Link Aggregation Groups (LAGs) – link protection
- Spanning Tree Protocol (STP) – including Rapid and Multiple STP – link/element protection
- Ethernet Ring Protection Switching (ERPS) – link/element protection

A weakness with a Layer 2 architecture is the risk of switching loops. This occurs when multiple switching paths exist between two network elements. Each element thrashes in learning the port a particular workstation is located, and traffic is continually forwarded in a loop, potentially exhausting network resources. The aforementioned Layer 2 protocols prevent Layer 2 switching loops from occurring. Despite this, misconfiguration of the protocols could result in a loop, resulting in denial of service across the entire network.

The Layer 2 model can be augmented with use of MPLS technology to provide network resiliency, particularly in the Metro network. In this architecture, the Access network remains Layer 2/VLAN-based. The Access nodes are aggregated by MPLS-capable access/service routers. In this model, the service VLANs are mapped into a VPLS instance. At the SP interconnect the VPLS instance is mapped back to the service VLANs. The VPLS instance allows Layer 2 connectivity across the MPLS cloud, but with the benefits of MPLS, such as traffic engineering, fast re-route, etc. MPLS inherently prevents switching loops with VPLS, due to split horizon rules. Switching loops could still occur in the Access layer, but at least this would be limited to a segment of the network.

3.3.1.3 Service Provider Integration

SP interconnects exist so that Customer traffic may pass between the SPs' networks and CBN. Being an Ethernet interconnection, it will support Ethernet VLANs. The VLANs will provide a Layer 2 connection directly between the Customer and SPs.

CBN and each SP must agree upon a service delivery method, such as VLAN per service, VLAN per customer, and double tagging. VLAN per customer will likely require use of double tagging. A set of VLANs must be reserved and associated with a particular SP. The VLANs are then exchanged in the trunk link between CBN border router/switch and the SP network element. It is the SP's responsibility to terminate these VLANs into its own services router, to provide an IP routing interface.

When a service is activated, the VLAN must be configured on the Customer's CPE port. Ideally, this will be accomplished through the use of Automated Provisioning Systems – where the SP system requires that CBN system perform the configuration. In addition, in the case of VLAN-per-customer, the VLAN must be added through CBN; but, the preferred approach is likely to pre-provision the VLANs once they are identified between the SP and CBN.

Redundant connections pose some complexities in a pure Layer 2 environment, especially when using redundant border network elements. Using a single set of border network elements, Link Aggregation can be used to provide redundancy over multiple links.

When using sets of redundant network elements, a Spanning Tree Protocol will like be necessary to support failovers. Since STP will operate over both CBN and SP domains, it will be necessary to isolate the STP domain on a per-SP basis in CBN.

3.3.2 Service-Aware Model

The Service-Aware model implies that the LAC Community Broadband Network has additional knowledge of the services provided in the network, and has additional capabilities in determining the forwarding of the packet flows. The ability to support these features depends upon appropriate support in the selected network equipment and support systems. Most of these features are considered value-plus features, meaning that CBN will function as a robust, competitive Open Access network without them; they just open avenues to additional services and revenue. Each feature described likely can function without the precondition of another feature – meaning that that they are independent.

Some features of a Service-Aware CBN include –

- Per-destination bandwidth and prioritization
- Time-based bandwidth
- On-network community services – such as Portal, Local Video Streaming, etc.
- Aggregated bandwidth
- SP per workstation

Many of these features could be implemented in the SP infrastructure. But, the features become much richer and CBN becomes more powerful and profitable if CBN can support these features. In order to support these features, CBN infrastructure likely needs to support some traditional and/or policy-based routing capabilities, and the provisioning systems will likely need to support provisioning multiple network elements when activating services.

3.3.2.1.1 Per-destination bandwidth and prioritization

The Per-destination bandwidth and prioritization feature implies that on a per-destination-basis (for instance, to a particular web site, download service, etc.), traffic is given a unique bandwidth limit and priority through the network. For instance, general Internet traffic is given one bandwidth limit and treated as best-effort traffic, while traffic to a cloud server is given higher bandwidth and priority.

3.3.2.1.2 Time-based bandwidth

The time-based bandwidth feature allows bandwidth to be increased at a particular time of day and/or for a particular period of time. Examples include a data service whose bandwidth increases at night in order to access a backup service or a "bandwidth-boost" service that allows increased download speeds during the weekend.

3.3.2.1.3 Aggregated bandwidth

A data/Internet service is typically given a single bandwidth profile. As previously mentioned, it is desirable to allow bandwidth profiles on a per-destination basis. To augment this feature, it is desirable to implement aggregated bandwidth limits. In this model, a data service may be given 5 Mbps, but traffic to a cloud server is given 8 Mbps, outside of the data service bandwidth. The aggregate bandwidth of both services at any given time might be 10 Mbps.

3.3.2.1.4 Service provider per workstation

Typically, a Customer selects a SP for data services, and all workstations at the Customer's premises receive the same service. The SP is tied to a particular port on a CPE device. In the Service-Aware model, services could be selected on a per-workstation(s) basis. Consider the case of an apartment with two roommates. One roommate could subscribe to a particular data service on his/her workstation, while the other could select a different service (and both would be billed separately).

3.3.2.2 Routing

In order to implement feature that impact forwarding decisions of the data traffic in CBN – such as On-Network Services, CBN must have the capability to participate in the routing of traffic, to an extent. In the VLAN model, CBN is only responsible for switching frames by examining the Ethernet header – usually the Ethernet addresses of the workstation and next-hop router.

With routing in the Service-Aware model, CBN services route looks at the destination (and source) IP addresses of the packets, and makes routing decisions, in supporting on-network services. This allows traffic to be redirected to local infrastructure providing on-network services, without the need for traversing the SP network. For instance, CBN must determine that a destination IP address is that of the Community Portal, and forward the packets directly to the Portal without entering the SP network.

A couple approaches for implementation potentially exist –

- Traditional routing – a routing IP interface is created on an OAN services/access router per-service. It acts as the next-hop for all workstations using the particular SP's service. IP addresses are allocated by SP
- Policy-based routing – perhaps there is a means to use policy-based routing and/or access control lists to redirect Layer 2 traffic. This might allow the next-hop IP interface to exist on a SP router, but traffic is redirected on-net, as necessary, prior to reaching the SP router

Some source-based routing function is also required to support the *SP per workstation* feature. In this context, the routing decision is made dependent upon both the Source and Destination IP addresses of the packet; the packet flows exist in a common VLAN to the Customer.

This functionality is likely not available in the access node equipment, as these nodes typically function solely as Layer 2 switches. Therefore, it likely will require a services/access router in CBN that aggregates the Access nodes.

3.3.2.2.1 Service Provider Integration

SP Integration depends upon the method for implementing this capability in CBN services routers. If the services routers act as the next-hop router for the SPs' services, then a virtual routing-forwarding (VRF) instance is created in CBN. This VRF becomes a routing peer with the SP network, using static routes, or in the case of redundant connections with the SP, a routing protocol, such as Border Gateway Protocol (BGP).

If another means for redirecting On-net service traffic is identified in the selected network equipment (through access list, etc.), then it might be possible to implement the feature without the need for CBN to participate in a full routing function for SPs' services. This is platform-dependent in the services router, and requires further research. In this case, the implementation of the feature would essentially be invisible to the SP.

Absent support for this feature within CBN, actions can be taken to ensure efficient delivery of On-net services. First, the SP routing function could be performed on the border network element in the SP network, effectively looping the traffic immediately back to CBN. This solution isn't optimal, as it requires all On-net services traffic to "hair-pin" to/from the SP network; but the services will still benefit from the high-speed optical CBN network without any degradation, assuming the SP router operates at line rate. Alternatively, the on-network service could include IP addressing and interfaces so that it acts as a client directly on each SP's service VLAN. This adds additional requirements to the equipment providing the services, such as a Portal, but the requirement certainly isn't burdensome.

3.3.2.3 Quality of Service

CBN must support Quality of Service mechanisms to support per-destination prioritization. Most modern networks have QoS support to ensure proper prioritization of traffic – typically within the context of a particular service. The Service-Aware model extends this so that packet flows with a service instance may be given different priority depending upon the IP Destination, Transmission Control Protocol/User Datagram Protocol (TCP/UDP) port, etc. This requires equipment to set Ethernet Class of Service (CoS) and IP Differentiated Services Code Point fields depending upon the flow parameters. The services router and/or access node likely will support the ability to assign the priority value depending on the flow specification.

3.3.2.3.1 Service Provider Integration

When defining the service between CBN and the SP, the parameters for the Quality of Service marking are defined – flow/IP destination to Class of Service mapping, etc. Once defined, a QoS profile is created in the services router and/or access node within CBN. When the service is provisioned for a particular Customer, the profile is applied to the Customer. If the SP is able to identify traffic flows in its network, ideally it will also perform a similar QoS remarking, as soon as possible, in its network. Otherwise, the traffic could be remarked once entering CBN from the SP.

Ideally, the SP will recognize and act in this service, meaning that it will recognize CoS markings in Ethernet frames, and mark the CoS fields when sending traffic towards CBN. If this is the case, CBN can view its interface to the SP as "trusted" and act on the CoS markings. CBN and the SP will share common CoS-to-priority queue mappings, so that prioritization of packets is consistent between networks.

3.3.2.4 Policing

CBN must support traffic policing to support per-destination bandwidth. As with QoS, this augments the typical policing model where all traffic with a service instance is given a total bandwidth. In the Service-Aware model, traffic flows are identified by IP destination, and TCP/UDP port, and the flow is given a unique bandwidth profile. The services router and/or access node likely will support the ability to assign the priority value depending on the flow specification.

A data service instance will typically have a bandwidth profile associated with it. For instance, an Internet service may allow 10 Mbps download and 10 Mbps upload speeds. The bandwidth limit is typically implemented through a traffic policer. The policer will typically apply a token bucket algorithm to limit the bandwidth, allowing for some traffic bursts. The policing occurs close to the Customer, at the customer Ethernet switch and/or Access node, depending on the needs of the service. This prevents network resources from be overwhelmed by a Customer who attempts to transmit traffic flows exceeding their service-level agreement.

Typically, each service instance for a particular Customer has its own bandwidth profile, and the bandwidth limits are not interrelated. For instance, for a business Customer, the data/Internet connection has a bandwidth profile and a Virtual Private Network (VPN) service has a separate bandwidth profile. There is no way to limit an aggregate of bandwidth to or from the Customer.

When defining the service between CBN and the SP, the parameters for the policing are defined, such as flow/IP destination to bandwidth mapping. Once defined, a Policer profile is created in the services router and/or access node within CBN. When the service is provisioned for a particular Customer, the profile is applied to the Customer. A key difference with the Policing vs. QoS prioritization feature is that this can be implemented in a single location in CBN – as close to the Customer as possible. This will handle Policing in both directions. Because of this, the SP network has no other requirements to support his feature.

3.3.2.5 Hierarchical QoS

Hierarchical Quality of Service allows for QoS parameters to be applied to services in a hierarchical manner. This provides flexibility in how bandwidth can be offered to a Customer in mixing a set of services. As previously mentioned, this allows a bandwidth limit to be applied as an aggregate for a Customer, and also apply a bandwidth limit to various services within this aggregate. For instance, a Customer could have Service X, with a bandwidth limit of 4 Mbps, and Service Y, with a bandwidth limit of 3 Mbps, but have an aggregate limit of 5 Mbps total. Furthermore, this feature allows aggregate bandwidth to a particular SP's service to be applied, i.e. all Customers for a particular service are limited to an aggregate bandwidth in a particular part of the network, or the entire network. The latest generation services routers typically will support the ability to apply hierarchical QoS rate limiting and shaping.

3.3.2.5.1 Service Provider Integration

When defining the service between CBN and the SP, the parameters for the policing are defined, such as flow/IP destination to bandwidth mapping. Once defined, a hierarchical policer profile is created in the services router within CBN. When the service is provisioned for a particular Customer, the profile is applied to the Customer. Similar to regular policing, this is implemented in a single location in CBN, as close to the Customer as possible. This will handle policing in both directions. Because of this, the SP network has no other requirements to support his feature.

Section 4. Support Systems

CBN is designed as an Open Access network, and as such, Operational Support Systems/Business Support Systems (OSS/BSS) must be considered as a dual set of systems that work in tandem between CBN and the SPs. CBN must support the ability for SPs to accept and fulfill service orders, while configuring the services on CBN. Also, if a Customer has an issue and contacts the SP, the SP likely needs some exposure to CBN in order to troubleshoot the problem in real time. Therefore, CBN OSS/BSS should have some integration ability with the SPs' OSS/BSS.

The OSS/BSS allows LAC to manage, maintain, and electronically provision access through CBN in real-time. The software can isolate and identify individual application data streams and program them into the interactive Portal that will allow the individual end user to make changes to the selected services and/or SP with the click of a mouse.

The framework of the business plan and design operations model follows the TeleManagement Forum's enhanced Telecom Operations Map (eTOM) framework. The TM Forum is a global, non-profit industry association focused on simplifying the complexity of running a SP's business through a wealth of knowledge, intellectual capital, collaboration and standards. It provides the critical operations functions required, realizing the interaction of People, Processes, and Products. The following operational functions are performed in CBN:

- Service Fulfillment – taking orders, provisioning, managing resources
- Service Assurance – help desk, ticketing, network monitoring & troubleshooting
- Billing – Customer billing and SP billing

Different OSS/BSS systems likely will exist to support these various functions. Both the Network Operator and SP will have systems to support each of these functions, each focused on their own, unique resources that provide the services on CBN. The following sections provide an explanation of the OSS/BSS functions that are needed for CBN.

4.1 Community Portal

The community Portal allows an easy way for Customers to access services and communications from SPs and LAC. The Portal provides a platform for SPs to offer their services by providing a menu of service and SP options to the Customers. These services include Internet, Voice, and Video services, as well as other Community-based services. The Portal allows the Customer to compare services and instantly activate the service (assuming the location is in the service area, the service doesn't require additional equipment, such as a set-to-box, etc.). Figure 4-1 shows a conceptual Portal screen capture. The actual Portal design will depend upon vendor selection and customization.

Figure 4-1. Conceptual Portal Web Page

When the LAC user logs onto the network, the user is taken to the welcome page of the Portal. The welcome page can give some background regarding LAC, the network, the region – whatever is important for LAC. The LAC user can then browse through the available CBN services. Each SP can create its own Portal page listing all of the services available. The Portal page may be marked up by the SP, in order to customize according to the SP's marketing program.

The Portal consists of server(s) connected to CBN at the south POP. It is the Customer's entry-point into CBN. When a Customer first connects to CBN, they are taken to the Portal and given an overview of the services available through CBN. The Portal allows Customers to select and activate services; this capability requires the Portal system to have some integration with the SPs. There are two ways that the SPs can interact with the Portal:

- The SPs have limited administrative access to publish services in the Portal, update services marketing information, etc.
- The Portal has integration with the SPs' systems to notify the SPs when a service is selected by a Customer, and potentially provision the service instantaneously

In the first interaction, the Portal may provide a web interface that each SP can use. This interface restricts each SP's capabilities to only the required functions specific to each SP. The second interaction, which provides automated provisioning, requires software integration between the Portal and the SPs' OSS/BSS. Each SP will provide a software interface, likely SOAP/XML-based, which the Portal can utilize to notify the SP of service activation requests. An alternative is a non-automated provisioning case, in which the Portal could send an email or similar notification to the SP when a service is selected by Customer. Figure 4-2 shows the interfaces described above.

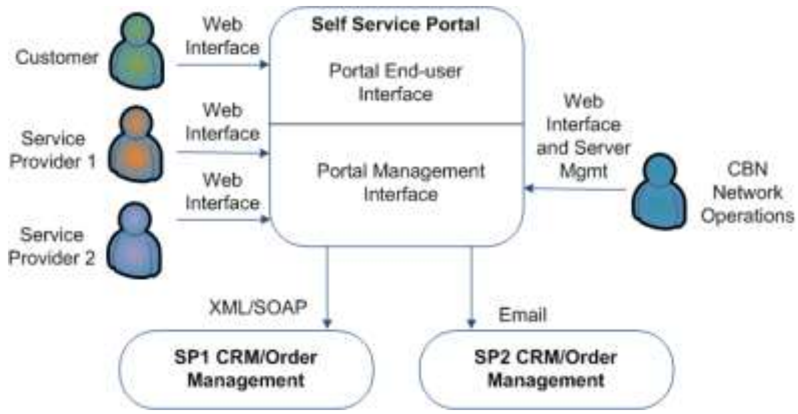

Figure 4-2. Service Provider Integration

This figure depicts the following interactions:

- A Customer accesses the Portal Customer interface from a networked device (PC, STB) within their premises, using a web interface/browser. Through the Portal, they can view CBN community and SP services
- Network Operations is responsible for the Portal administration (including maintenance of servers), for creating and publishing community CBN services, and for creating management "views" for each SP. These functions may be accomplished through direct (CLI) access to the servers as well as web interface/browser
- The SP interface provides each SP with the ability to modify characteristics for their services, including marketing and pricing information. This is done through a web interface/browser
- For SP1, when a Customer subscribes to the SP's service, the activation uses a SOAP/XML API within the SP's OSS/BSS order management systems to receive the activation. This allows for a fully automated activation for applicable services
- For SP2, when a Customer subscribes to the SP's service, an activation request is sent to the SP through email. The service activation is processed manually by the SP's Order Management staff. This does not allow for fully automated service provisioning

The level of integration between CBN Portal and the SP will fully depend upon the capabilities of the SP's OSS/BSS systems. CBN may select to specify a reference order management system for SPs, especially smaller ones with limited/no existing order management systems. The SP would be responsible for the expense of the system.

4.2 Service Fulfillment

Service fulfillment is the process of taking a Customer order, processing the associated workflow, provisioning the service, and managing the resources associated with the service. A combination of systems likely will be required to support all the aspects of service fulfillment, and the systems must work in tandem across both CBN systems and SP systems.

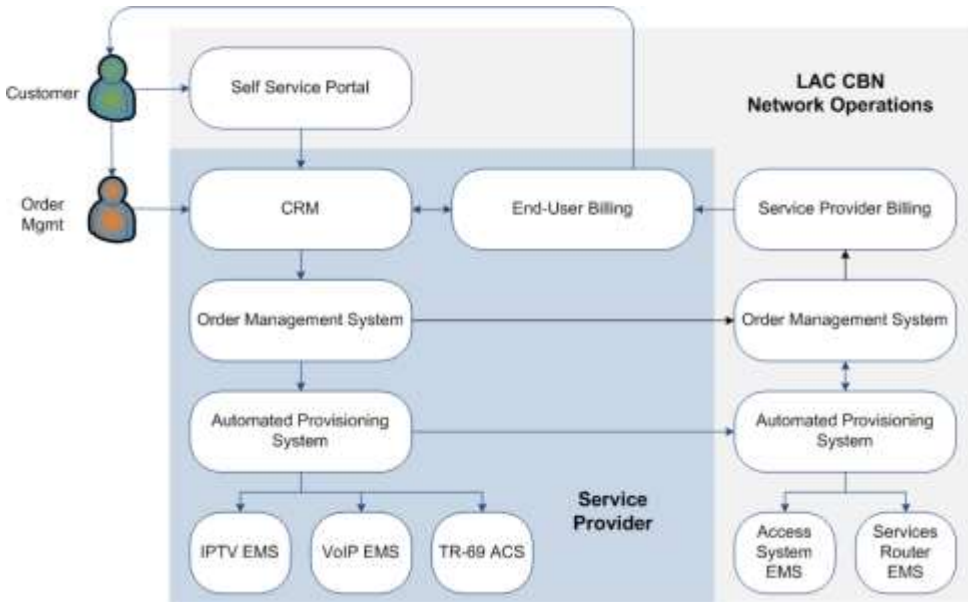

Figure 4-3. Service Fulfillment Process

A high level of automation is preferred for service fulfillment. This begins with the Portal, which allows households and businesses in LAC to directly choose from a menu of services and SPs, and instantly active the service. Even in the case of orders taken through human contact, automation is desirable to increase Customer satisfaction on lead times. Automated support is critical for minimizing Network Operator staffing requirements.

4.2.1 Order Management

The order management system is responsible for receiving Customer orders and handling the workflow necessary to activate the service. This includes scheduling network installation, equipment shipment/installation (set-top boxes, etc.), local number portability, etc. Once all prerequisites are completed for service activation, the order management system may then active the service.

Both the SP and CBN Network Operations have roles in order management, and ideally the systems will have some level for integration. For instance, the SP's order management system must know whether a port is available at a Customer's premises on CBN (or whether the premises is even serviceable on CBN). If a Customer changes SPs, CBN's order management system must broker the deactivation of the old service (from old SP) to the new one. When a service is finally activated, CBN system should be able to receive the activation and automatically activate it.

Consider a case where CBN is available at a premise, and the Customer connects their computer for the first time. They are taken to the Portal, and choose an Internet service. The Internet service doesn't have prerequisites, such as the need for a set-top box or local number portability, so it can be instantly activated. The activation workflow can complete quite quickly (perhaps just an instance credit check), and the service is activated in the network equipment providing the service. This activation likely will require activation on CBN network equipment. Unless the provisioning system is fully automated and integrated between SP and CBN, the Customer may have to wait for CBN Network Operator to manually process the service activation – which could take hours or days, as opposed to instantly.

4.2.2 Automated Provisioning System

The automated provisioning system provides the necessary service activation automation in CBN. As previously discussed, automation is crucial, as it increases Customer satisfaction through service selection flexibility and immediate service connection. Automation also provides a platform to efficiently support increased numbers of Customer, services, and SPs, while controlling operational costs to the Network Operator.

Ideally, both CBN Network Operations and SPs will have automated provisioning systems to provision all resources that provide a service. For instance, for an Internet service, activation likely will require configuration on CBN to configure the network connection between the SP and traffic policer, as well as activate the service within the SP's router/DHCP service. In the case of an IPTV service, the service must be activated on CBN to deliver the multicast into the Customer's premise, as well as setup the channel package in the SP's IPTV middleware server. The automated provisioning system must balance robustness with support for network equipment. Effective provisioning systems will typically have adapters to support the various resources (network equipment, IPTV head-end, VoIP softswitch).

The SP automated provisioning system receives order activation notifications from the SP's order management system. It then sends the activation notification to the local SP resources through CBN and SP Element Management Systems (EMSs). The CBN Network Operations automated provisioning system receives activation requests from either CBN's internal order management system and/or the SP's automated provisioning system.

4.2.3 Element Management Systems

Element Management Systems provide provisioning to the network elements and resources that provide the services in the OAN. For instance, an EMS will likely exist in the SP's environment to provision the VoIP softswitch. Likewise, an EMS will exist in CBN Network Operation's environment to provision the Access and Services Router network elements. An EMS is typically tightly integrated with the network/service resource it supports, and provided by the same vendor.

Ideally, the EMS will not be touched by human during service activation. The EMS typically will provide an open interface for OSS/BSS integration, using CORBA, XML/Web Services, etc. This is the interface that is used by the automated provisioning system through an adaptor developed for the particular EMS.

4.2.4 Inventory Management

Services on CBN are provided by a set of network resources working in tandem – for instance, a DSF, Customer Ethernet switch, services router, and gateway router to the Internet, using an IP address and a certain amount of bandwidth. The resources are inventory – both for the Network Operator and the SP. An effective inventory management system will manage hardware/element resources. An ideal inventory management system will manage all resources to effectively manage the network.

4.3 Service Assurance

Service assurance aspects of the operational model ensure that the service-level agreements between the SP and Customers are met. This category includes a wide range of activities, including help desk, ticketing, networking monitoring, network troubleshooting, and proactive service assurance systems. Within CBN, services are provided, in tandem, over SP and CBN equipment, and multiple SPs provide services on common CBN equipment. SPs need a method to receive basic fault information about CBN, and have access to networking monitoring and configuration information in order to troubleshoot Customer issues.

Providing the service assurance information (network monitoring and troubleshooting) from CBN to SPs is complicated by the fact that Network Operator desires to minimize the amount of information available to the SPs. There are numerous reasons for this: security, network demarcation/control, and competitive considerations. Regarding competitive considerations, it is critical that one SP cannot obtain information regarding service offering and Customers of competing SPs.

4.3.1 Technical Assistance Center

A Technical Assistance Center (TAC) is typical in any broadband network. In CBN, TAC support is provided from the SPs to their Customers, and also by Network Operations to the SPs. Network delivery issues may occur in CBN, and therefore, CBN and the SPs must have processes in place to support technical assistance. Both SP and CBN Network Operator will implement a multi-tiered support system.

The end Customer always calls the help desk of the SP offering the service. As such, the SP employs a Tier 1 TAC center. The SP will also have Tier 2 and 3 TACs, in order to troubleshoot network and service issues, etc.

CBN Network Operator must also implement TAC to support the SP. The expectation is that CBN TAC will not be contacted until the issue has been escalated to at least Tier 2 support at the SP, therefore CBN Network Operations will support Tier 2 and 3 TAC.

In order to increase the efficiency of troubleshooting Customer issues – resulting in increased Customer satisfaction and controlled operation costs – CBN Network Operations should provide systems to the SPs in order to obtain monitoring and troubleshooting information from CBN. This is further discussed in the following sections.

4.3.2 Network Monitoring

Network monitoring is crucial for ensuring that the network is performing properly and service delivery is meeting service level agreements. Network monitoring may occur for various purposes, including –

- Network element failure
- Link/fiber failure
- Bandwidth utilization
- End-to-end service verification

The monitoring information may be used for various purposes – to trigger action on fiber and element failure, to plan network resources for peak utilization, and to proactively ensure that services are being delivered on an end-to-end basis.

In CBN, both the SP and CBN Network Operations will implement network monitoring systems. Clearly, the SP will be responsible for acting on network and service degradation resulting from failure in its own equipment. But, the open access nature results in complications in receiving monitoring information from the common equipment, managed by CBN Network Operations.

4.3.2.1 Service Provider Integration

In this scenario, network monitoring will occur on CBN by CBN Network Operation systems. But, since the SP will handle first-level Customer issues, it must have the ability to receive a minimal set of network monitoring information from CBN equipment. For instance, the SP should receive a link state trap when the CPE port of one of its Customers goes Up or Down. Also, the SP should know when a network element goes down, resulting in loss of service to Customers, or when fiber links go down, resulting in service degradation.

4.3.3 Network Troubleshooting

CBN Network Operations is responsible for troubleshooting CBN equipment through direct access to the network elements, EMSs, etc. The SPs will have limited or no access to these systems and associated troubleshooting information. SPs will receive notification of service degradation from either a Customer (reactive) or from network monitoring (proactive). Once service degradation is identified, the SP must have means to troubleshoot the issue. The SP is responsible for troubleshooting issues with the systems it owns. The SP's TAC staff has the ability to directly access the SP's network elements and EMSs, in order to troubleshoot the issues.

The SP and CBN Network Operations must agree to the minimal set of troubleshooting information available, including:

- Ability to retrieve CPE port information for ports related to SP's port attachments – including port status, statistics, MAC tables, service attachment information
- High-level network element in-service information – such as node uptime
- Network/link availability information – such as knowledge of isolated network equipment due to fiber/link failure

Information beyond this may allow the SPs to interpolate the current service offerings on the network, which creates competitive and security concerns. Ultimately, the SP needs enough information to know 1) whether the service is provisioned, 2) the Customer is attached to the network, and 3) CBN equipment is "on-line". If the SP has this visibility, it can provide the Customers the proper information and expectations regarding issue resolution. In addition, it allows the SP to intelligently troubleshoot Customer issues, and contact CBN Network Operations TAC only when necessary.

4.4 Billing

There are two levels of billing for CBN: Customer billing and SP billing. Customer billing is the process for SPs to directly bill Customers for delivered services. SP billing is the process for the

Network Operator to bill SPs for their use of CBN. The following two sections describe each of these processes.

4.4.1 Customer Billing

The SP is responsible for billing Customers for each service provided to the Customer from the SP. Aggregated billing is conceivable between SPs, but this is outside the scope of CBN; it would be an agreement directly between SPs.

CBN does not add requirements to the billing systems of SPs. When services are activated or deactivated, CDRs are created within the SP systems, and can be processed by a conventional Billing system to create the proper billing. It is up to the billing system to support the various service tiers and packages that the SP decides to offer. For usage-based billing (such as total Gigabytes in a month), SP equipment should be able to collect this information and associate with the particular Customer.

4.4.2 Service Provider Billing

The Network Operator is responsible for billing the SPs. The Network Operator requires a system to provide aggregate billing for all services associated with each SP. For instance, the Network Operator needs to bill a SP for each instance of an internet service subscription. CBN must keep track of Service Description Records (SDRs) related to service activation and deactivation, and provide an aggregate bill each month. CBN does not associate the SDRs and service instance with the end-Customers – it has no knowledge of the Customer billing information, payment method, etc. It only associates the total services instances with the SP.

This Billing method could be complicated by additional factors. Tiered billing – where the SP pays varying rates depending on number of service instance, combinations of service instances, etc., should likely be supported, in order to support flexibility in service agreements between the SPs and CBN. In addition, outage-based credits must be supported. In this context, when a network outage occurs that is within CBN, CBN Network Operations must have a means for crediting the SP for the duration of the outage.

Note that SP Billing likely doesn't have "real-time" implications that Service Fulfillment and Assurance have. It is unlikely that a SP will need to have access to real-time updated billing information from the Network Operator, as the SPs will have their own billing information as they activate/deactivate services. Furthermore, while innovative services may be supported by the network infrastructure, the billing systems must support the ability to monetize the services. This adds additional requirements to a robust billing system.

4.4.3 Automation

Full automation from Portal to SP to CBN decreases cost for both the SP and CBN, while allowing greater scalability. Given that initial costs for integration (absent a pre-integrated solution) may be a barrier-to-entry for small/medium SPs, manual operation may be preferred in some circumstances. In considering this option, several sub-options are considered, primarily around the level of automation in the system. The three areas of automation and integration relevant in this option are:

1. SP Order Management / CBN Order Management System

2. SP Automated Provisioning System / CBN Automated Provisioning System
3. CBN Automated Provisioning System / Network Equipment/EMSs

The first two options are considered as an either/or case, where, depending upon the systems selected, the SP systems could integration with either the CBN Order Management system or the CBN Automated Provisioning System (assuming the CBN Automated Provisioning System notifies the CBN Order Management system of provisioning activity for reporting/billing). It is important to note that the CBN systems could be loosely or tightly coupled, depending upon the product selected; nonetheless, for automation between the SP and CBN, integration must occur between the SP and CBN systems (and each have a similar cost involved). This area of automation directly impacts the number of NOC / Order Management staff required.

The third area of automation, CBN Automated Provisioning / Network Equipment/EMSs, allows all network services to be provisioned when a service is activated or deactivated, as well as auto-provision equipment when it is deployed or replaced. This area of automation directly impacts the number of NOC / Operations & Maintenance & Network Engineering staff required.

4.4.3.1 Order Management

Automated Order Management allows service activation / deactivation requests to be passed from SP systems to CBN systems and have the service provisioning automatically fulfilled by CBN. This allows CBN to minimize NOC staff focused on Order Management / Order Entry processes, associated with supporting SP requests.

4.4.3.2 Automated Provisioning

Automated Provisioning refers to the automation of network provisioning in two scenarios – 1) when an order activation / deactivation request is received from a SP and 2) when deploying or replacing network equipment in the field. This case considers the in-house NOC option only, as the decision and costs for automation within an outsourced NOC are outside the scope of consideration for CBN, as it is an internal decision to the NOC provider. The first case impacts the number of In-house NOC / Operations staff required and the second impacts the number of network engineers required on staff, most notably during years 1-3, when CBN is built. Based on prevailing costs, initial cost for the Automated Provisioning system is $127,000, plus another $125,000 in cost for adapters to the access and services routers deployed.

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Section 5. Network Operations

This section describes the operational concept for the proposed Community Broadband Network in Los Alamos County, New Mexico. The operational concept was developed by considering the operational processes, the systems supporting these processes, and the people who execute the processes and use the systems. The following sections detail the operational concept and the underlying operational model.

CBN is designed to provide community fiber-to-the-premises services to all households, businesses, educational, and government facilities in Los Alamos County. This network will serve approximately 9,000 premises. CBN will operate as an "open access" network, where Los Alamos County owns the fiber network, and retail services (such as internet, voice, and video) are provided by external third-party Service Providers (SPs). Los Alamos County may provide community-based services over CBN (such as a community portal, bulletin boards, calendars, multimedia, etc.), and the local utility may use the network for automated meter reading and smart grid services. Los Alamos County could operate the network themselves, or outsource network operations to a contractor.

5.1 Operational Roles

The operational roles for CBN are defined below.

- **Customers**: the households and businesses in Los Alamos County who purchase services on the network from one or more SPs. In addition, they will have access to the community Portal as a government service
- **Network Owner**: Los Alamos County is the Network Owner, providing the Metro and Access Networks to all premises in LAC. This network provides connectivity from the Customer premises to interconnect points with the SPs' network
- **Network Operator**: works with the SPs to deliver services to Customers. Responsibilities include service fulfillment, assurance, and SP billing. Throughout this document the Network Operator is considered to be separate from LAC. This separation allows LAC the option to act as an in-house Network Operator directly, or outsource the Network Operator role
- **Service Providers**: provide data services on CBN, perform Customer Relationship Management (CRM), order entry, frontline support, service help desk/troubleshooting, and Customer billing. The network may include several SPs, each with competing services. SPs have service agreements with LAC, and are billed by the Network Operator (on behalf of LAC) for use of network. SPs may operate their own equipment to provide their services, including border routers for upstream internet access, IPTV head-ends and set-top boxes, VoIP softswitches, and other service-specific systems

5.2 Operational Model

The Network Operations Center (NOC) will be staffed 24/7/365 to monitor and manage CBN operations. NOC personnel activities include monitoring all network equipment, conducting routine testing of circuits, diagnosing problems, responding to trouble reports from SPs, installing software and equipment firmware upgrades, and provisioning new services.

Network personnel will take calls only from SPs, not from customers. SPs are responsible for first line Customer support. NOC personnel will prepare monthly billing reports and invoices for SPs, listing all services active and subscribed to during the billing period.

NOC personnel will provide information to the CBN Outside Plant (OSP) maintenance field team. For CBN, the term OSP refers to all of the physical fiber cabling and supporting infrastructure, including conduit, vaults, and cabinets, located between the POPs and the Customer premises. NOC personnel identify field equipment problems, diagnose the problems, coordinate with maintenance personnel to repair, replace, or reconfigure defective equipment, and ensure that the problem is fixed.

5.2.1 NOC Activities

- Provide day-to-day network operations, maintenance, and repairs
- Diagnose and troubleshoot problems reported by SPs
- Diagnose network faults and coordinate repairs with the OSP maintenance personnel
- Provide oversight and quality assurance of network operations
- Provision network services for SPs including:
  - Ethernet Transport
    - Bandwidth
    - QoS Provisioning
    - VLAN/VPLS segregation
  - Internal DNS (Domain Name System)
- Modify existing network services
- Install network management software upgrades
- Install network equipment firmware upgrades
- Prepare monthly billing reports and SP invoices

5.2.2 Outside Plant Activities

- Coordinate with NOC for repair/replacement of:
  - Defective network equipment
  - Fiber / OSP failure and damage
  - Network upgrades
- Fiber maintenance

5.2.3 Systems Activities

- Portal design, development, and maintenance
- OSS (Operations Support System)/BSS (Business Support System) deployment, support, and maintenance

5.3 Network Operations Systems

This section details CBN Network Operations systems. A high degree of network automation limits operational expenses and provides scalability in operations. Some of the systems described may be consolidated in single products, depending on the vendor.

5.3.1 Systems Summary

The following table summarizes the relevant systems to CBN operations. Each is explained in further detail in the subsequent sections.

Table 5-1. Network Operations Systems

System	Party	Notes
Order Management System	Network Operator & SP	Separate, Possible Integration
Self Service Portal	NetOp	SP uses NetOp's
Ticketing System	NetOp & SP	Separate
Help Desk/Troubleshooting	NetOp & SP	Separate
Network Management/Assurance	NetOp & SP	Separate, SP has limited view of NetOp's
Automated Provisioning	NetOp & SP	Separate, Possible Integration
Element Management	NetOp & SP	Separate
Inventory Management	NetOp & SP	Separate
SP Billing	NetOp	Sends bills to SP

The 'Party' column describes whether CBN and/or SP will be required to deploy each relevant system. Each Party may deploy similar systems that act as peers or operate completely 'Separate'.

For instance, each Party will deploy an Order Management system; the SP Order Management system handles Customer orders, and CBN Order Management system handles SP orders (resulting from Customer orders). In a fully automated deployment the SP Order Management system would send an automated order request to CBN Order Management system, and the service provisioning request would flow through to the lower layer systems, activating the service in an automated manner.

Conversely, each Party would deploy Element Management and Inventory Management systems, but these systems have no interaction with each other. The SP EMSs will control only SP equipment, as CBN EMSs will only control CBN equipment.

The following sections detail each of the systems relevant to CBN, and the operations performed by each.

5.3.2 Order Management System

- Contains service activation/deactivation records, according to service location
- Provides interface (API and/or Web) to SPs for serviceability and order entry
- Network Operations order management enter orders from SP
- Integration with workflow/ticketing

5.3.3 Self Service Portal

- Includes community Portal as well as lists of SPs, their respective services, and provides a Web interface to each SP to publish marketing info about services
- Walled garden for new Customers
- Notifies SPs of service activations
- In a fully automated environment, triggers full service provisioning (in conjunction with SP and CBN systems)
- Otherwise, notifies SP of activation for manual provisioning
- Managed by Network Operator

5.3.4 Ticketing System

- Ability to create tickets for service provisioning and network issues
- Tie to workflow system for reassigning and escalating/ issues and requests
    - Email notifications within CBN and to SPs
    - Prioritization and timeline/reminders for ticket resolution
- Include a Portal for SP to enter and/or view tickets

5.3.5 Service Desk/Troubleshooting

- System for CBN Help Desk troubleshoot the network
- Viewing only, no ability to change network configuration
- Web interface to SPs, so SPs can view a very limited set of information about their Customers only
    - CPE port status
    - CPE port statistics
    - MAC addresses of clients connected to CPE
    - Current service configuration (only if it's the SP viewing the status)

The Web interface to SPs is a desirable option available in out-of-the-box solutions.

5.3.6 Network Monitoring/Assurance

- Detection of network alarms through reception of SNMP traps from network elements
- Alarm notification to CBN NOC staff through email and SMS
- Alarm escalation depending on severity
- Alert acknowledgement to track responses to alarms
- Automated responses to alerts, such as automatic reboots
- Monitors and reports network availability, alerts, alert responses, and bandwidth utilization

5.3.7 Automated Provisioning

- Performs flow-through provisioning of service activation/deactivation

- Receives service activation from CBN Order Management system or SP Automated Provisioning system
- Dispatches configuration activation/deactivation to network devices required for the service
- Utilizes an adaptor for each network element type, which could communicate with an EMS or directly to the network equipment (depending upon the adaptors capabilities)
- Supports automated provisioning of the common services, custom services require manual configuration
- Alleviates the need for additional NOC staff to provision services

5.3.8 Element Management

- Provided by vendors' of network elements/devices
- Allows provisioning and monitoring of network elements
- Automated Provisioning System is integrated with the EMSs for provisioning
- In a non-automated case, CBN NOC staff may directly use EMSs for provisioning
- In some cases it may be more desirable to directly access network elements, depending upon cost/scale

5.3.9 Inventory Management

- Required for asset management and resource management/forecasting
- Complete database of all network equipment
- Full configuration – chassis, line cards, power supplies, fans
- Port counts
- Transceivers
- Serial numbers
- MAC addresses
- Support contracts
- Physical location
- Network location / addressing
- Software version
- Location of CPE devices provides serviceability information to premises

5.3.10 SP Billing

- Collects service activation/deactivation events from Order Management and/or Automated Provisioning systems
- Provides an aggregated bill for each SP at a regular interval (monthly)
- Aggregate bill for period
- Aggregate service counts – for each service, a count of the number active for the period
- EDRs showing service activations/deactivations during time period

- Provides ability to do service rating (for tiered pricing) and crediting
- Tiered pricing reflect SLAs (Service Level Agreements) between CBN and SPs
- Credits for service outages and degradation

5.4 Operations Process Framework

The following terms are relevant in defining the Operations Model:

- People – Customers, NOC personnel, SP Staff
- Processes – Service Fulfillment, Service Assurance, Billing
- Products – Operational systems including Self-service Provisioning, Automated Provisioning, Ticketing, Network Monitoring & Troubleshooting, Ticketing, Billing/Billing Mediation

Processes are defined to support CBN Operations. The Processes are implemented through People and Products/Systems. The following sections define the relevant Processes to CBN, and describe the People and Products specific to CBN.

People, Processes, and Products can be considered in the context of the eTOM framework.

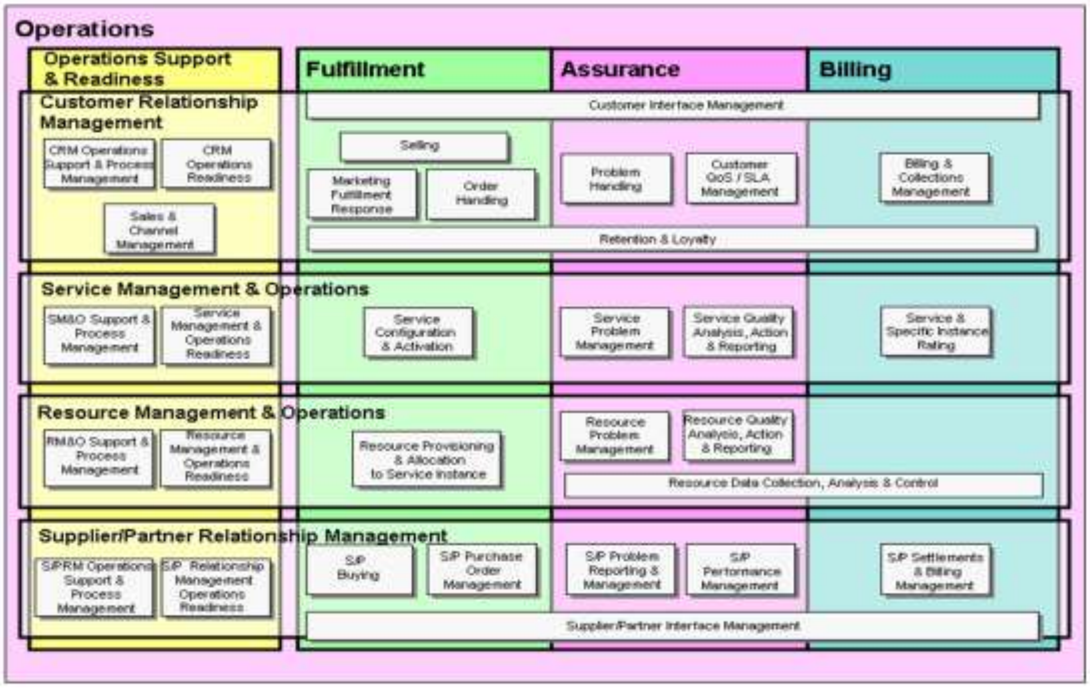


Figure 5-1. eTOM Operations Framework

The parties relevant to CBN operations are the Customers, the SPs, and CBN Operations. Given the eTOM Framework, the following activities are related to each of the parties as follows:

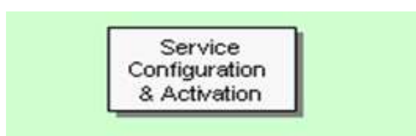
Table 5-2. Operations Activities

CATEGORY	ACTIVITY	PARTY
Fulfillment	Customer	SP (end-Customer), CBN (SP, in support of end-Customer)
	Service Management	SP & CBN (in tandem)
	Resource Management	SP & CBN (separately)
Assurance	Customer	SP
	Service Management	SP & CBN (in tandem)
	Resource Management	SP & CBN (separately)
Billing	Customer	SP
	Service / Aggregate	CBN (to SP)

5.4.1 Service Fulfillment – Customer

Figure 5-2. Service Fulfillment

CBN operations allow Customers to activate/change/delete services. SPs are responsible for front-line sales and order management. CBN provides a Self-service Portal, where Customers can view all available services from all SPs, as well as community information and services. To provide efficient service fulfillment, it is useful to have system integration between the Self-service Portal and the SP's Customer Relationship Management (CRM) and/or Order Management system. In doing so, services chosen by an end-user could have the ability of quickly being activated with the SP's and CBN's network. The decision to support integration between the Portal and SP is done by the SP, and the cost is incurred by the SP. For further analysis, see Section 5.6.



5.4.1.1 Service Fulfillment – Service Management

Figure 5-3. Service Fulfillment

In regards to CBN Service Management, all services available within CBN must be defined, and the definitions reference various CBN resources to create an instance of a service. For example, an SP service definition consists of:

- VLAN / VLAN range (depending whether VLAN-per-customer or VLAN-per-service model is being used)
- Bandwidth (CIR (Committed Information Rate) / EIR (Excess Information Rate), upstream / downstream)
- QoS (Quality of Service) settings

This service is created as a template, and during service activation, the various resources are allocated and configured with the service, namely:

- Service instantiation, based on service template
- CPE (Customer Premises Equipment) port
- VLAN assigned (in the case of VLAN-per-customer)
- CIR bandwidth assigned (to prevent oversubscription of CIR within network)

All service parameters and use of associated resources are agreed upon between the SP and CBN as part of SLAs.

Defined services are available to CBN Order Management system for activation. CBN Order Management staff activates services upon receipt of an activation notification from an SP.

For automated activation of services, integration must exist between CBN and SP systems. For more information, see Section 5.6.

CBN provides transport service only from an SP to a premises location. CBN is not responsible for information between an SP and their Customer. The SP manages the Customer relationship and CBN enables the service to be active at the Customer's location.

5.4.1.2 Service Fulfillment – Resources

Figure 5-4. Service Fulfillment

In this context, CBN manages the resources available in delivering a service. These resources are necessary to provide Ethernet transport:

- Access switch port
- CPE device
- CPE port
- Service router virtual interface
- VLAN (per-service or per-customer, depending upon service definition)
- VPLS instance (per-service)

- CBN network bandwidth
- Oversubscription is used to support EIR
- CIR implies no oversubscription for the aggregate instances of CIR-based services

During deployment, a pool of network equipment resources is procured and deployed, namely:

- CPE devices – one for each premises, plus pool of spares for replacement purposes (due to failure and theft)
- Access switches – one port allocated per premises, in support of point-to-point architecture. Since 100% initial build-out, need for small amount of extra ports, to support new/refurbished construction)
- Services routers – to support deployed equipment at 100% initial deployment, with additional capacity as take rates/bandwidth consumption increases in future

Furthermore, resources are defined and consumed during the definition and instantiation of network services. The resources are logical; a pool of these resources is allocated when a service is defined between the SP and CBN, and consumed when a service is activated:

- CPE port – allocated at deployment, consumed when service is activated
- VPLS instances – allocated/consumed at service definition
- VLAN – allocated at service definition, consumed at service definition, in the case of VLAN-per-service, otherwise consumed at service activation, in the case of VLAN-per-Customer
- CIR bandwidth – allocated at service definition, consumed at service activation
- EIR bandwidth – target oversubscription rate defined, take rates defined, initial EIR bandwidth deployed with network; EIR consumption monitored, additional bandwidth added as target oversubscription rates are realized

CBN will build out the access and core/metro networks at 100% during initial deployment. The core network equipment support capacity based on the take-rate assumption, associated bandwidth levels of services, and oversubscription rate. With increased take-rates and/or bandwidth utilization, resources may be added to the network, including:

- Core router interfaces between CBN core routers
- Uplink interfaces between access switches and core routers
- Interconnect interfaces between CBN core routers and SP routers. NOTE – it is the SPs' responsibility to initiate and pay for this. Customer satisfaction of an SP is likely tied to performance of the SP's services, which is partly determined by oversubscription rate and related capacity

5.4.1.3 Service Assurance – Customer

Figure 5-5. Service Assurance

CBN's SLA is provided to SPs. End-Customers service level agreements are provided directly from their SPs. A tiered structure is implemented to support issues with the SP network and CBN network, and the ability for SPs and CBN to interact on issues.

Table 5-3. Problem Handling Tiers

Tier	SP	CBN
1	Help Desk – direct Customer support, performs low-complexity troubleshooting (any network outages reported, CPE port down)	Not applicable (no direct Customer support)
2	Medium-complexity issue, if problem is identified with CBN network, initiates CBN problem ticket	Medium-complexity issue, as identified by SP and/or CBN NOC
3	Advanced-complexity issue	Advanced-complexity issue

The NOC includes a service desk for taking calls from SPs, and a ticketing system to track issues. To provide SPs with automated support, CBN provides an SP Portal or system to view/monitor aspects of CBN network as specified in the SLA, including the ability to determine whether a Customer's CPE is connected to the network, and whether the CPE's port connected to the Customer's device has Link Up or Down.

5.4.1.4 Service Assurance – Service & Resource

Figure 5-6. Service Assurance

Active Service Assurance is provided by CBN. CBN monitors and provides fault management within the network and responds to those events as they occur. Additionally, CBN responds to Customer requests from an SP and responds in accordance with defined SLAs. Premium services may be provided for additional charges and are documented in the SLA.

5.4.1.5 Billing – Customer

Figure 5-7. Billing

End-user Customer billing is performed by the SPs. They keep service activation records associated with Customers, and perform all billing and collections from Customers. CBN does not implement aggregated billing, where multiple SPs group their billing. For instance, an IPTV provider might partner with an Internet provider to send a single bill, but this function is performed entirely by the SPs

5.4.1.6 Billing Mediation – Service & Resource

Figure 5-8. Billing Mediation

CBN sends billing invoices to each SP on a monthly basis. CBN collects all EDRs for service activations/deactivations for each SP. CBN then calculates service ratings and the final billing amounts. CBN must also handle credits, in the case of service outages. For more information, see Section 5.3.10, SP Billing.

5.4.2 Service Fulfillment

An Order Management system contains the information to allow a Customer to place an order for service. Service Fulfillment is the process of taking a Customer order, processing the associated workflow, provisioning the service, and managing the resources associated with the service. The Order Management system will display pertinent services by SPs.

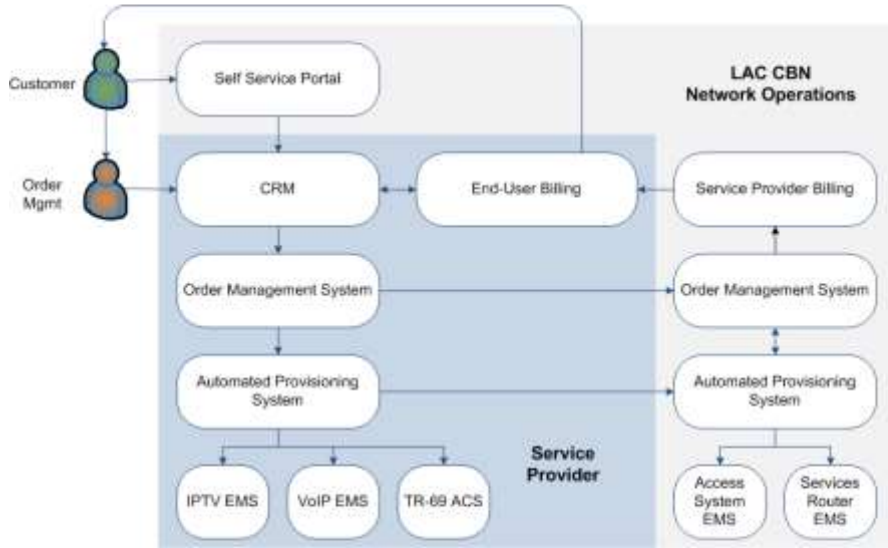


Figure 5-9. Service Fulfillment

Figure 5-9 describes various systems related to Service Fulfillment, for both the SPs and CBN Network Operations. This diagram assumes the relevant ways to interact, which is determined by:

- Integration between Portal and SP CRM/Order Management System – determined whether automation is implemented
- Integration between SP Automated Provisioning System and CBN Automated Provisioning System – determines whether automation is implemented

For more information on this integration, see Section 5.6.

Most services should be defined and have attributes that will be supported in an automated and/or non-automated fashion. In the case of larger-scale enterprise Customers that require a custom solution, it is assumed that Service Fulfillment will follow a high-touch, manual process.

5.4.2.1 Order Entry, Validation and Processing

These processes deal with providing the ability of a Customer and/or SP to enter an order for service. Two paths for order initiation include:

- Self-Selection Portal – Customer directly enters order into Portal; order can either be handled through automation (if fully integrated) or through manual interaction by SP
- SP Sales – Customer contacts SP directly to place order – through SP inside or outside sales

An order entry is entered into the SPs CRM/Order Management system, and validated against current business rules to ensure whether fulfillment is possible. The validation includes:

- Address serviceability – while CBN plans for 100% initial build-out, serviceability will be available incrementally, as construction will incrementally add coverage areas

- Service availability – services may follow a lifecycle
- Resource availability – CIR-based services might require reserved bandwidth, and those resources must be available in the network

Automation between the SP and CBN should support validation; otherwise, CBN can provide a Portal for the SP to confirm validation manually, or SP can directly contact CBN Order Management for validation. CBN can provide an Order Management system to SPs that is pre-integrated with CBN Order Management system. This is appropriate for smaller/startup SPs, in order to lower the barrier-of-entry. Larger/existing SPs will likely have their own Order Management (and related CRM systems); in this circumstance, integration will be required. For more information about integration and automation, see 3.5 Integration Summary.

5.4.2.2 Order Fulfillment

This section provides two example workflows between the SP and CBN Network Operations, demonstrating an order fulfillment. The Automated Provisioning System will process the request and provision the service to the CPE. CBN is unable to guarantee when service will be turned up from the SP.

Television Fulfillment – Fully Automated

The first example considers TV service fulfillment in a fully automated scenario. Figure 5-10 illustrates this process.

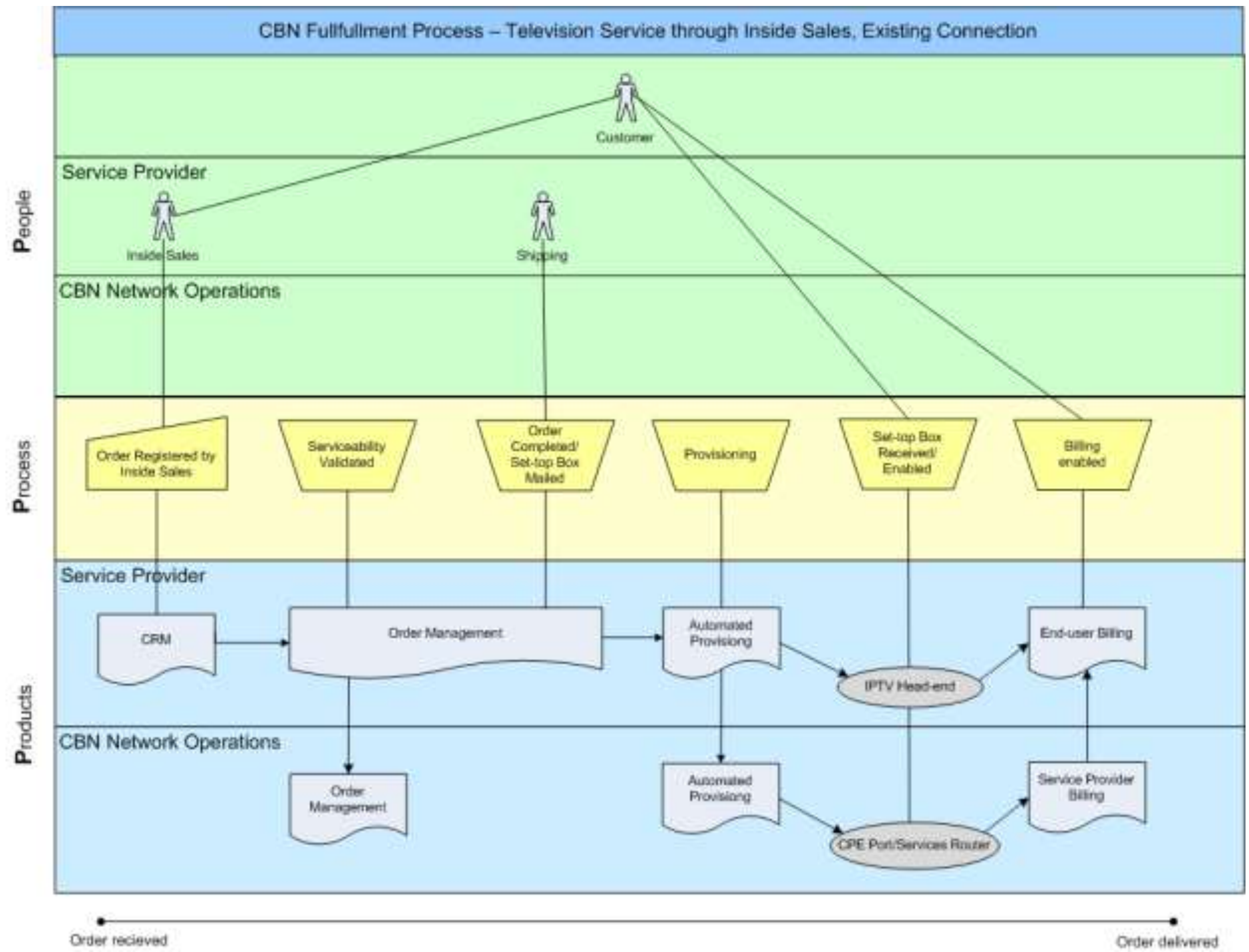


Figure 5-10. TV Service Fulfillment

Because CBN will be fully built-out to all premises in LAC, the Service Fulfillment process is simplified, as SPs and Network Operations do not have to coordinate last-mile installation to the Customer. This scenario assumes that the premises already has some existing in-home wiring, so the end Customer is able to connect and power-up an IPTV set-top box.

The following steps are taken:

1. Customer calls SP of choice. The SP inside sales representative takes the order in the CRM system
2. While the order is being taken, the CRM system contacts the SP Order Management system, which in turn consults with CBN Order Management system to check for serviceability information
3. If the SP Order Management system is not fully automated, the sales rep would manually consult with CBN Portal
4. If service is not available, CBN could provide an estimated service date, and a workflow/notification could be established. This may require direct interaction with CBN Network Operations Order Management staff

5. When order is completed, the SP Order Management system notifies the SP shipping department to mail a set-top box to the Customer
6. The service fulfillment request is passed to the SP automated provisioning system, which then contacts the EMSs for the local IPTV head-end to provision the service
7. The service fulfillment request is also passed to CBN automated provisioning system, which configures the Customer premises Ethernet switch, DSF switches, and POP equipment through their respective EMSs
8. In scenarios with less automation, SP staff might directly provision the service. In addition, they might contact CBN Network Operations staff to provision the service in CBN
9. The Customer receives the set-top box in the mail, and connects it to a television and the Customer premises Ethernet switch, powers it on, and registers. Activation is detected by both the IPTV head-end and CBN equipment
10. Service is activated in both CBN SP billing system and SP Customer billing system
11. In scenarios with less automation, Network Operations staff may need to enable billing

Note that in the fully-automated scenario, no direct interaction is required by Network Operations staff. While this is the optimal scenario, some direct interaction between SP and Network Operations staff may be necessary.

Internet Fulfillment – Fully Automated through Portal

The second example considers Internet service fulfillment when the Customer selects an Internet service from the Portal. Figure 5-11 illustrates this scenario.

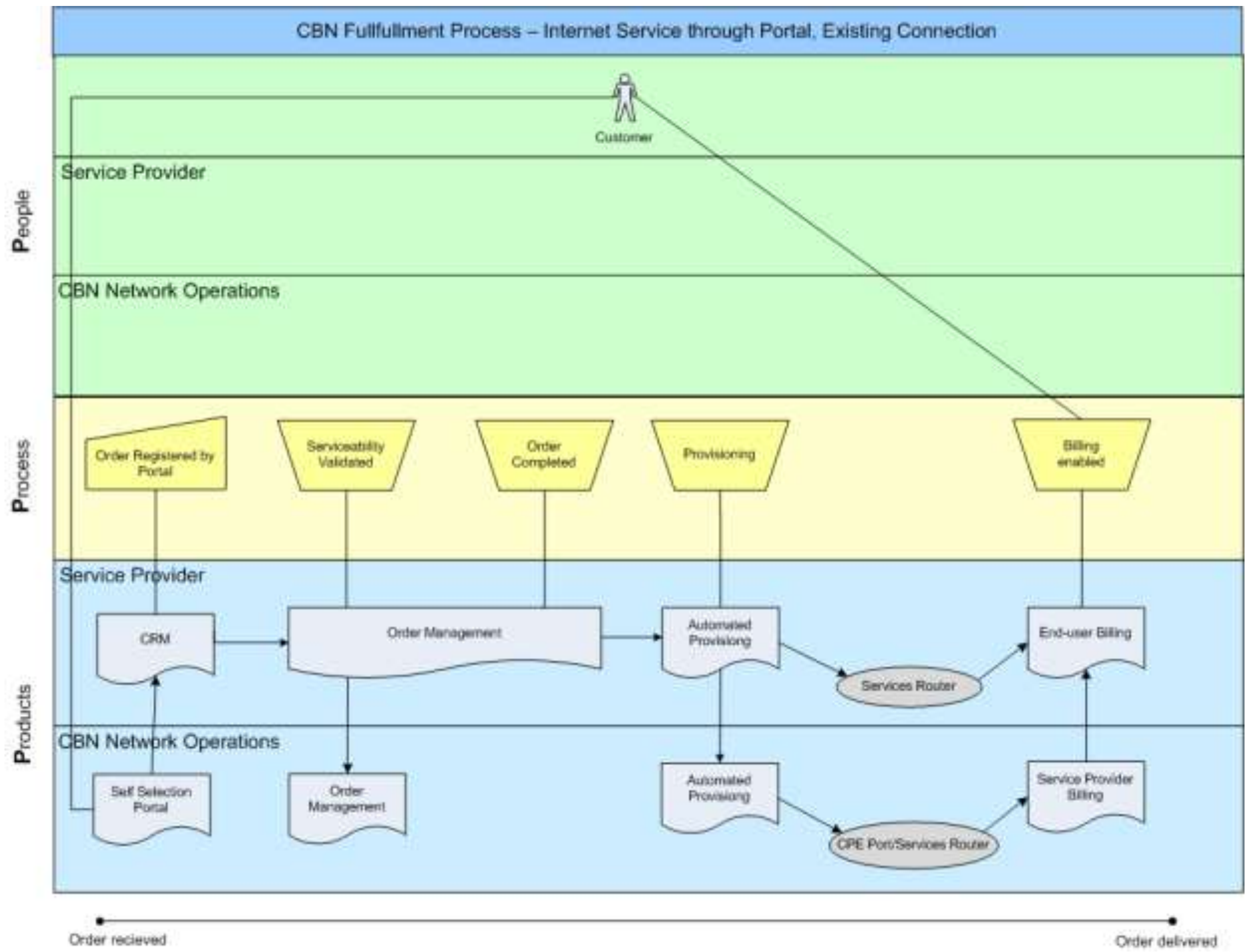


Figure 5-11. Internet Service Fulfillment

This scenario assumes that the Customer does not need to cancel a previous Internet service prior to subscribing to a new one. The following steps are taken:

1. The Customer connects a computer to CBN and is directed to CBN Portal. The Customer navigates to the Internet service offerings and selects an Internet service from a list of competing SPs. The Portal then contacts the SP's CRM system to take the order information
2. While the order is being taken, the CRM system contacts the SP Order Management system, which in turn consults with CBN Order Management system to check for serviceability information
3. If not fully automated, the Customer will not be able to instantly access the Internet service
4. The order is complete when all steps are taken to enter Customer information, billing information, potentially credit check, etc.
5. The service fulfillment request is passed to the SP automated provisioning system, which then contacts the EMS for the SPs wholesale Internet provider to configure the services router and other systems, as necessary

6. The service fulfillment request is also passed to CBN automated provisioning system, which configures the Customer premises Ethernet switch, DSF switches, and POP equipment through their respective EMSs
7. Service is activated in both CBN SP billing system and SP Customer billing system
8. In scenarios with less automation, Network Operations staff may need to enable billing

5.4.2.3 Reporting

Reporting will provided by the systems supporting CBN. These reports are provided by CBN to the SPs (with data relevant only to the specific SP), and to the network owner (network owner-specific reports are listed below):

- Orders received – Report indicating received orders which were entered and accepted in the Order Management system (Order Management system)
- Orders cancelled – Report indicating cancelled orders which were entered and accepted in the Order Management system (Order Management system)
- Orders completed – Report indicating completed orders which were entered and accepted in the Order Management system (Order Management system)
- Provisioning/Activation – Report indicating provisioning/activation needed for delivering services for orders in process (Automated Provisioning system)
- Ticketing Reports – auto-escalation alerts on incidents which are approaching their Expected Time To Resolution (ETTR) and have not yet been resolved. (Ticketing system)
- Outage reports (Network Monitoring and Ticketing system)
- Overdue Orders – Report for SPs for orders which have been accepted but not yet completed because of missing information from the SP (order management system)

As previously discussed, CBN will also provide billing invoices to the SPs. LAC, as the network owner, will also receive reports from the CBN NOC.

5.4.3 Service Assurance

The service assurance function includes incident management, problem management, change management and release management. The following sections describe each of these processes.

5.4.3.1 Incident Management

Incident management, as defined by Information Technology Infrastructure Library, is the process of handling an individual issue which causes an interruption or a reduction of the quality of the service. The objective is to restore normal operations as quickly as possible with the least possible impact on either the business or the user, at a cost-effective price.

The NOC personnel coordinate incidents which occur during the ordering, provisioning/activation, installation and maintenance of the network. Using the trouble-ticketing system NOC personnel use the NMS and trouble-ticketing system to track, manage and escalate incidents, and route them to the appropriate teams resolve incidents in accordance with SLA established timeframes. NOC personnel rank incidents by severity and priority.

5.4.3.2 Incident Management Lifecycle

The following flowchart describes the lifecycle of an incident, as reported either by a SP, or by internal assurance procedures.

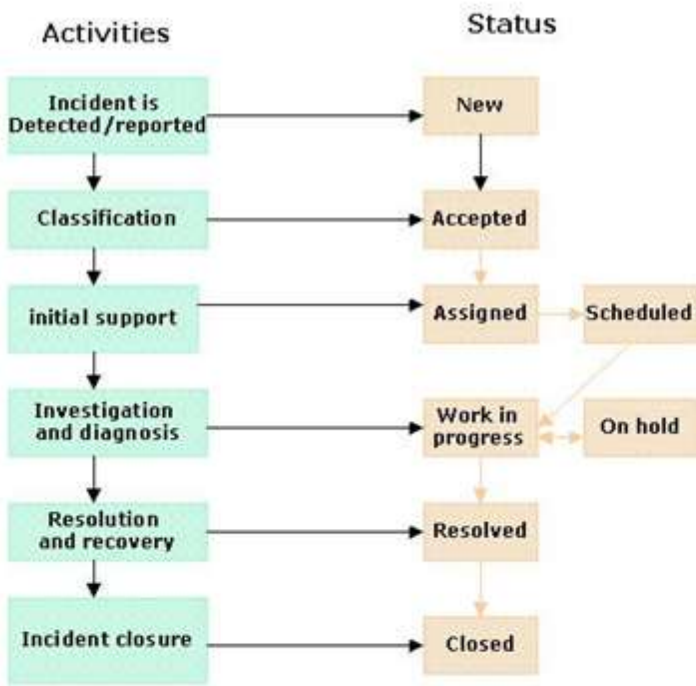


Figure 5-12. Incident Management Process

The following activities and related status are included in the lifecycle:

- Incident is reported or rejected – this could occur by an SP contacting the Network Operator and/or detection through network monitoring. A new incident is created in the ticketing system.
- Classification – the problem is classified by CBN service desk, depending on the type of incident.
- Initial support – by analyzing the incident SLA, classification, severity, and details, the incident is assigned. Response is scheduled in accordance with incident assignment.
- Investigation and diagnosis – the issue is investigated and diagnosed
- Resolution and recovery – the problem is fixed, through action by appropriate CBN personnel.
- Report generation – incident report is generated. The Customer receives a report and if an outage occurred within the established SLA, a report is generated for reconciliation with billing.
- Incident closure – once the problem has been resolved, the incident is then Closed.

5.4.3.3 Incident Management Matrix

Table 5-4 is an example matrix that maps an incident's urgency and impact to its severity. This matrix will be determined as a global CBN policy and within the parameters of a service-level agreement between CBN and the various SPs.

Table 5-4. Incident Matrix

		Incident Impact				
		Non-impacting (i.e. service request, billing inquiry)	**Low Impact** (1 – 50 Customers)	**Moderate Impact** (50 – 1000 Customers)	**High Impact** (1000+ Customers)	**Extreme Impact** (system-wide)
Incident Urgency	**Non-urgent**	**6 Very Low**	**5 Low**	**5 Low**	**4 Medium**	**4 Medium**
	Low Urgency	**5 Low**	**5 Low**	**5 Low**	**4 Medium**	**4 Medium**
	Moderate Urgency	**4 Medium**	**4 Medium**	**3 High**	**3 High**	**3 High**
	High Urgency	**4 Medium**	**3 High**	**2 Critical**	**1 Severe**	**1 Severe**
	Extreme Urgency	**3 High**	**2 Critical**	**2 Critical**	**1 Severe**	**1 Severe**

The following matrix provides an example of the response requirements, based on the priority of an incident. As with the Priority and Urgency Matrix, these figures are defined with a service level agreement between the Network Operator and the SPs.

Table 5-5. Incident Response Times

		Timing of Actions				
		Initial Response Time	**Status Interval**	**Escalation Interval**	**Resource Commitment**	**ETTR**
Incident Priority	**1. Severe**	15 minutes	Continuous	2 hours	24 hours/day	4 hours
	2. Critical	15 minutes	Continuous	6 hours	24 hours/day	12 hours
	3. High	1 hour	4 hours	12 hours	24 hours/day if needed	24 hours
	4. Medium	4 hours	1 business day	1.5 business days	Normal business hours	3 business days
	5. Low	1 business day	Upon request	1 week	Normal business hours	2 weeks
	6. Very Low	As required	N/A	30 days	Normal business hours	Up to 30 days

5.4.3.4 Problem Management

Problem Management deals with resolving the underlying cause of one or more Incidents. The focus of Problem Management is to resolve the root cause of errors and to find permanent solutions. Although every effort is made to resolve the problem as quickly as possible this process is focused on the resolution of the problem rather than the speed of the resolution.

At some point, CBN will experience unplanned or unscheduled outages, whether dealing with outside plant or network devices. In order to provide a quick restoration of services it is important to establish a predetermined path of escalation, define a notification process for affected Customers, and develop effective and efficient means of communication between teams.

CBN NOC coordinates problem management meetings with the network owner and SPs and facilitates root cause analysis (RCA). The NOC manages action item lists from these meetings to resolve problems on the network in a controlled change management process.

5.4.3.5 Change Management and Release Management

The objective of Change Management is to ensure, through proper processes and procedures, changes on the network are performed with minimal impact to the network and services. All proposed changes to the network are documented with a change management request form to declare the schedule, implementation steps, testing procedures, and a contingency roll-back plan. Proposed changes are then reviewed by the Change Management Board for approval before any action is taken.

5.4.3.5.1 Change Management Request Form

The change management request form is used by CBN NOC/OSP/Portal to request a change on the network. This request is used for all non-emergency changes including but not limited to outside plant maintenance, network maintenance, devices, service application changes, new product integration.

Information in this document provides CBN detailed information about the planned work such as: Location(s), duration of the change (maintenance window), systems, services or Customers affected by the change, responsible person/team conducting the change along with contact information, a detailed Method of Procedure (MOP) which detailing out step by step procedures for the duration of the work and a rollback plan. This document is required to be completed in full and approved before any changes on the network is authorized.

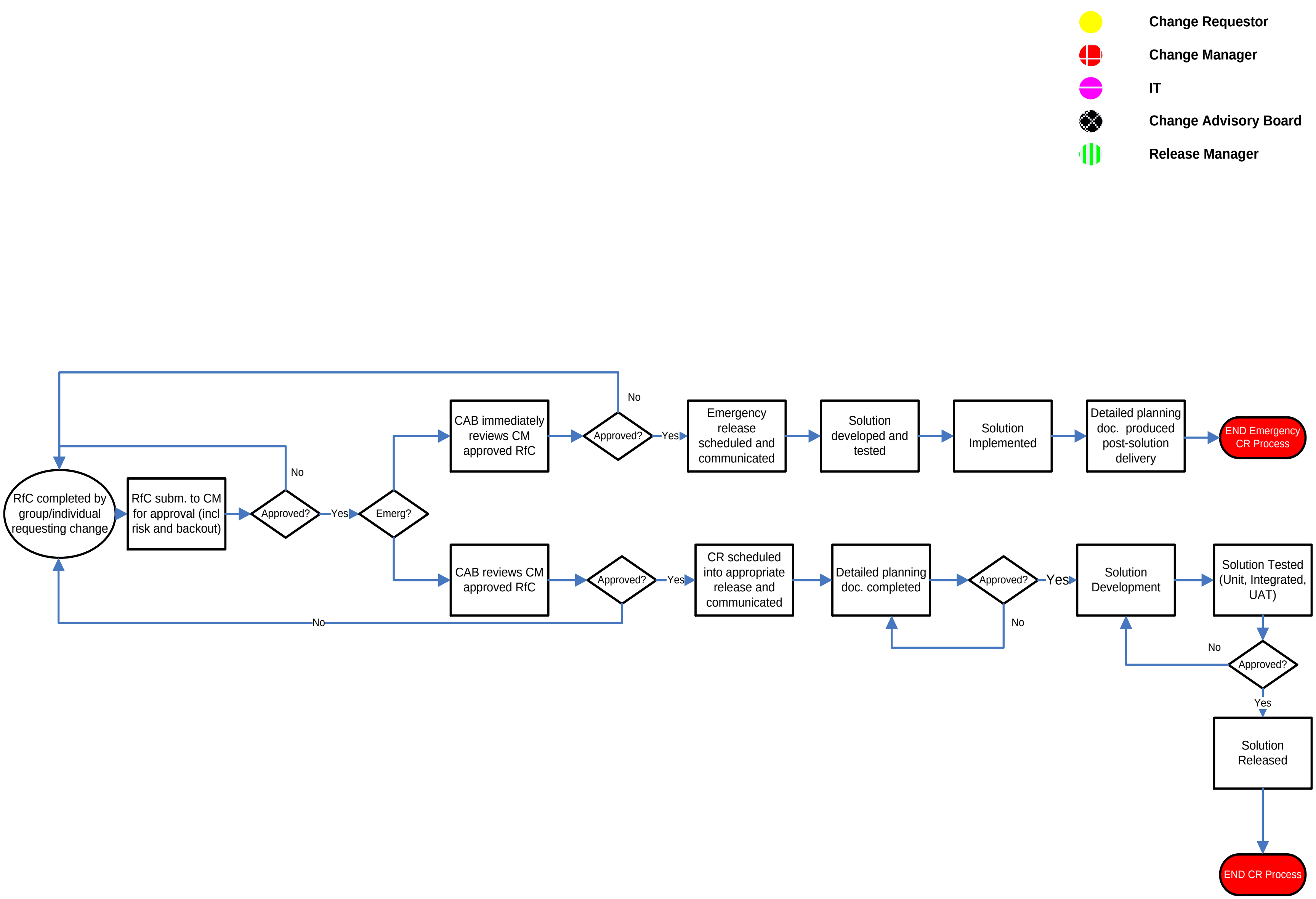


Figure 5-13. Change Management Process

5.4.3.6 Release Management

The role of release management is to ensure communication to appropriate parties the plan to rollout a change and manage expectations of changes with Customers. The network owner or designee is the central communication point for all release notifications including planned and unplanned change management notifications to Customer(s).

5.4.4 Geographic Information System (GIS)

A Geographic Information System (GIS) database a visual representation of OSP network infrastructure and its components. It includes spatial features like construction running lines, cables, conduit, parcel boundaries, service areas, addresses, splice locations, poles, etc., and non-spatial items like splicing information, construction information (build date, type of construction, etc.) and makes them available in one database. The GIS system is used to create maps, to model and support OSP activities, and the information behind the order management system.

5.4.4.1 Infrastructure changes

Changes to infrastructure must be documented and delivered in the form of a standard construction inspection form. This will include a “redline” drawing and notes to explain what changes were made and the location of the changes. These items would include but are not limited to: cable changes or relocation, conduit changes or relocation, and hand hole size and or placement changes.

5.4.4.2 Changes made to infrastructure (As-built changes)

Field changes made during construction or work that is performed after initial construction that results in an infrastructure change or relocation/move need to be documented in order to keep the data up-to-date. Having accurate and current data GIS system makes network troubleshooting, adding new connections, expanding the network, leasing infrastructure, and other network functions much easier and more efficient.

5.4.4.3 Splicing Changes

Splicing changes will need to be documented on splicing “cut sheets” or schematic drawing of the splice case. This information will be used to update data in the GIS and will be kept as a hard copy record of fiber splicing in a specific splice case.

5.4.4.4 GPS

Mapping grade GPS equipment is used to adjust OSP network features so they are represented accurately (sub 1 meter) in the database and on maps. Location information is used and is very valuable to installation crews, repair and maintenance crews, and locating companies. New GPS shots are taken for infrastructure changes as needed.

5.5 Staffing Models

CBN operations can be conducted wholly by Los Alamos County, referred to as “in-house” operations, or the NOC, OSP, Portal or any combination thereof may be outsourced. The technical and capital cost impacts for the outsourced NOC operations model is described in the following section.

5.5.1 Outsourced NOC Operations

It is desirable to consider an Outsourced NOC model, given the cost involved with an In-House NOC, and also the size of CBN. Based on the need for a 24/7/365 NOC and the minimal staffing levels required, economies of scale are better realized with an outsourced NOC that services an aggregate customer base larger than CBN. There are a number of assumptions for staffing of an Outsourced NOC:

- All NOC functions are outsourced to a third party, including:
    - Order Management & Service Provisioning
    - Operations & Network Element Systems Software Maintenance
    - SP Technical Support
- There are no assumptions as to whether the outsourced NOC provider implements automated / non-automated provisioning.
- CBN Network Engineering staff responsible for deployment and ongoing support of CBN.
- Network Engineers are assumed to work 1st shift, but also work off-hours as required, for maintenance, troubleshooting, and handling outages. At least one Network Engineer is on-call at all times.
- CBN Systems include Portal and EMS, as reflected in the CBN systems staffing.
- Software / Systems Engineers are assumed to work 1st work off-hours as required, for maintenance, troubleshooting, and handling outages.
- Costs related to the Outsourced NOC include a fixed, annual fee and a per-customer fee.
- Portal and EMS costs are separate from the Outsourced NOC provider costs.

5.5.1.1 SP Considerations

In addition to CBN costs for In-house vs. Outsourced NOC options, there are also SP considerations that impact costs involved with providing services on CBN. In particular, the costs are:

1. Integration with Self Selection Portal
2. Integration with CBN Order Management and Automated Provisioning Systems.

There are no requirements as to the level of automation for each SP. It is a business decision solely within each SP to determine the level of integration with CBN, and also the level of automation within the SPs' own network. These decisions will balance the SPs ability to provide services (potentially instantaneous) and do so with a high or low level of customer touch. Regardless of the internal decisions made by the SP, it is desirable for CBN to lower the barriers-to-entry with CBN, for the following reasons:

- Increased competition

- Lower end-customer costs
- Increased levels of service
- Increased end-customer satisfaction
- Resulting in higher take-rates, and increased financial viability of CBN
- Economic development by opening door to smaller, local SPs
- Innovation by allowing new service ideas to be deployed on CBN

5.5.1.1.1 Self Selection Portal

The Self Selection Portal works best in an environment where a service can be selected, the SP is notified of the service activation request, and the service is instantaneously activated in both the SP / CBN networks, and respective systems. In order to do so, the SP must support automation within its network operation, as well as support integration with the Self Selection Portal.

The Portal will support the following two modes of integration with the SP:

1. Email notification –SP Order Management personnel manually provisions the service upon receipt of an Email notification from the portal. Instantaneous provisioning is not supported. Adds staffing cost to SP
2. SP Order Management integration – the Portal makes a call to the API of the SP Order Management / CRM system

Given the second option, there is cost involved with the integration between the Portal and the SP systems. The Portal defines a common notification API that would need to be supported by the SP Order Management System. Following prevailing costs, the typical adapter cost in regards to automated provisioning is in the $50,000-75,000 range. This cost is incurred by the SP, and outside the scope of CBN consideration.

The $50,000-75,000 integration cost may be a barrier-to-entry for smaller SPs. The email notification option may be their other option, but will likely put them at a disadvantage to other (larger) SPs with fully automated provisioning, and incurs additional staffing costs, as customers might find that instantaneous provisioning is desirable.

5.5.1.1.2 Provisioning of CBN Services

When a service is activated or deactivated with the SP (whether through the Self Selection portal or manually entered by SP Order Management personnel), it is desirable for both the SP and CBN to support service provisioning automation. This allows instantaneous activation or deactivation of services and is critical for keeping CBN staffing costs controlled, especially as CBN adds customers.

As previously discussed in this report, integration between SP and CBN Order Management and/or Automated Provisioning Systems is highly desirable to minimize operational expenses and streamline operational workflows in an open access environment. CBN will provide common API for SPs to utilize. SPs may deploy disparate Order Management / Provisioning systems, and custom integration may be required.

5.5.1.1.3 Out-of-the-box Integration

Given the strong desire to have full integration between the Portal and SP, as well as SP to CBN Order Management and Automated Provisioning, CBN can provide an out-of-the-box integration for the SP, in order to eliminate the need for custom integration. The ideal solution would be to provide an Order Management system to the SP that bridges the Portal to the CBN Order Management system.

In this scenario, all service activations and deactivations flow from Portal, to SP Order Management, to CBN Order Management in a seamless, pre-integrated, out-of-the-box fashion. The SP will likely still need to integrate between the SP Order Management system and its own Automated Provisioning System for provisioning network equipment with the SP network, but this reduced the number and scope of integration points. Furthermore, the SP can benefit further if it deploys an Automated Provisioning System similar to CBNs that might be pre-integrated with the Order Management system.

5.5.1.1.4 SP Integration Option Summary

There are several options in the way SPs may integrate with CBN, resulting in different costs and levels of automation, in regards to Order Management from SP to CBN. These options are summarized as follows:

- Email Notification – SP sends email with service activation/deactivation, CBN processes email in an automated fashion. No additional cost to SP. No ability to support instantaneous provisioning
- Common API – SP integrates Order Management System to utilize CBN Common API in supporting service activation/deactivation. No additional cost to SP. Ability to support instantaneous provisioning
- Out-of-the-box solution – CBN provides pre-integrated Order Management system to SP. Cost recovery options being considered. Ability to support instantaneous provisioning
- Customer adapter – Common API inadequate capabilities/mapping to SP. Requires custom development/adapter. Costs incurred by SP. Ability to support instantaneous provisioning

The first two options are the general options provided to SPs, at no additional cost. The out-of-the-box solution is highly desirable, and cost recovery scenarios to be evaluated. Customer adapter is funded by SP.

5.5.2 Network Operations Personnel

As outlined in the eTOM framework section, there are various functions that must be performed in supporting CBN Network Operations. This section discusses some of the personnel requirements and functions in performing the network operations. It assumes a certain level of automation within CBN and also automation integration with the SPs. For instance, it assumes that basic services can be automatically activated in CBN through systems alone (without the need for CBN human interaction with Order Management).

The functions described here include all those required for CBN Operations. All of the functions may be outsourced – for instance Order Management and Technical Support, both NOC functions, could be accomplished through the use of an outsourced NOC.

Given the size of CBN, the job functions can be accomplished with the same job description/position. A summary table describes the actual job positions required for CBN Operations.

5.5.2.1 Order Management

With the Order Management function, service activations are processed from SPs. Note that this function could be part of an outsourced NOC:

- Processes Order requests from SPs
- Enters in Network Operator database, validates order, passes to Operations staff for configuration
- Forwards advanced service activations to the Network Engineer, for instance, enterprise VPN

Full automation would limit needed headcount.

- Skills – phone, basic computer
- Education – High School

5.5.2.2 SP Technical Support

With the SP Technical Support function, CBN Operations provides technical support to SPs. Note that this function could be part of an outsourced NOC:

- Tier II level support provided from Network Operator to SP
- Assumes appropriate level of network VLAN visibility to SP for initial troubleshooting by SP
- Performs basic network troubleshooting
- Escalates to Tier III (network engineer)
- Skills – network/services troubleshooting
- Education – high school, basic certification (Cisco CCNA)

5.5.2.3 Operations & Maintenance

The Operations & Maintenance function monitors the network for faults and service issues, as well as performs maintenance and upgrades, as necessary. A portion of this function may be outsourced due to maintenance requirements performed in-house:

- Performs service activation and continuous network monitoring, utilizing service assurance tools
- Performs network upgrades
- Responds to service outages or degradations by taking corrective actions
- Escalates issues to Network Engineer, as necessary
- Possibly same personnel an SP Technical Support
- Skills – network/services troubleshooting
- Education – high school, basic certification (Cisco CCNA)

5.5.2.4 Network Deployment & Configuration

The Network Deployment & Configuration function performs the initial deployment of network equipment, turning up and initially configuring the equipment, as well as ongoing support of the deployment.

- Senior and mid-level network engineer
- Deploys and configures core/access network elements
- Defines and deploys new services, based on definitions from Wholesale Product Management
- Performs Tier III troubleshooting and network repair
- Skills – network design and deployment, network operations
- Education – college level (engineering/computer), vendor experience and/or higher level certification (Cisco CCNP/CCIE)

5.5.2.5 System /Integration Development

Regarding System Development, this function is responsible for software integration efforts with CBNs systems and with SP systems. It is assumed that systems, in general, have a level of integration (otherwise, a larger professional services project is required as part of systems procurement). This function focuses on customized integration and smaller scale integration efforts.

- Performs software integration, as part of automation
- Focuses on CBN system integration and SP/CBN system integration
- Skills – software engineering/integration
- Education – college level (computer science/software engineering)

5.5.2.6 Portal Administration/Deployment

Regarding Portal Deployment, this function is responsible for deploying and administering the Community Portal and Self Selection Portal

- Customizes and deploys Portals
- Makes changes, as necessary, in support of Community-related content and new services
- Skills – software engineering, web development
- Education – college level (computer science/software engineering)

5.5.2.7 System Administration/Deployment

Regarding System Administration, this function is responsible for deploying and maintaining the systems

- Deploys and maintains OSS/BSS systems
- Applies upgrades, debugs issues with systems
- Works with systems vendors to ensure properly functioning systems

- Headcounts and skill levels are heavily determined by OSS/BSS selections and their capabilities/requirements
- Skills – system administration
- Education – high school, system admin certifications (Microsoft Certified Systems Administrator (MCSA), Red Hat Certified System Administrator (RHCSA))

5.5.2.8 Database Administration/Deployment

Regarding Database Administration, this function is responsible for deploying and maintaining the databases related to the OSS/BSS systems

- Deploys and maintains OSS/BSS database systems
- Skills – database administration
- Education – high school, database admin certifications (MCDBA, OCA)

5.5.2.9 Abuse

Regarding the Abuse function, Abuse may be identified through Network Monitoring tools (such as bandwidth utilization), Customers (such as Denial of Service attacks), and/or law enforcement (such as illegal activities). A network engineer and/or systems administrator will then take action on the Abuse, but changing network configuration to minimize abuse and/or collecting logs/data as necessary.

- Utilizes service assurance tools to identify network abuse:
  - Bandwidth
  - Address cloning
- Viruses
- Denial of Service attacks
- Takes actions to isolate abusive users
- Responds to law enforcement requests for data
- Performed by Network Engineer and/or System Administrator

5.5.2.10 New Service Definition/Deployment

Regarding Wholesale Product Management, services are defined and modified, in collaboration with SPs:

- Performs product/service template configuration, does testing in the lab
- Pushes service template availability to Operations
- Performed by Project Manager, in collaboration with Network Engineer

5.5.2.11 Accounts Receivable

Accounts Receivable bills and receives payments from SPs:

- Creates billing to SP on a monthly basis
- Processes payments from SPs

- Deals with necessary credits for outages or other penalties according to SLAs
- Skills – accounting, billing
- Education – college (accounting)

5.5.2.12 Summary of Network Operations Personnel

Table 5-6 lists the NOC personnel positions for the in-house model, listing the responsibilities for each position.

Table 5-6. CBN Operations Personnel Positions, In-house Model

Position	Responsibilities	Notes
NOC Manager	Management of NOC/networking staff	All NOC/networking staff report
Senior NOC Engineer	Operations & Maintenance Order Management SP Technical Support	Can act as shift manager, 3 shifts a day
NOC Engineer	Operations & Maintenance Order Management SP Technical Support	3 shifts a day
Principal Network Engineer	Network Deployment & Configuration SP Technical Support New Service Definition/Deployment Abuse	Day shift, after hours/on-call as necessary
Senior Network Engineer	Network Deployment & Configuration SP Technical Support New Service Definition/Deployment	Works under direction of Principal; Day shift, after hours/on-call as necessary
Systems Manager	Management of Software/Systems staff	All Software/Systems staff report
Senior Software Engineer	System Integration/Development Portal Administration/Deployment	Customizes Portal, performs integration between CBN systems and also SP/CBN systems
Senior System Administrator	Systems Administration/Deployment Abuse	Deploys OSS/BSS and EMS systems
Database Administrator	Database Administration/Deployment	Deploys/supports databases related to

Figure 5-14 shows the personnel organizational chart for the in-house model.

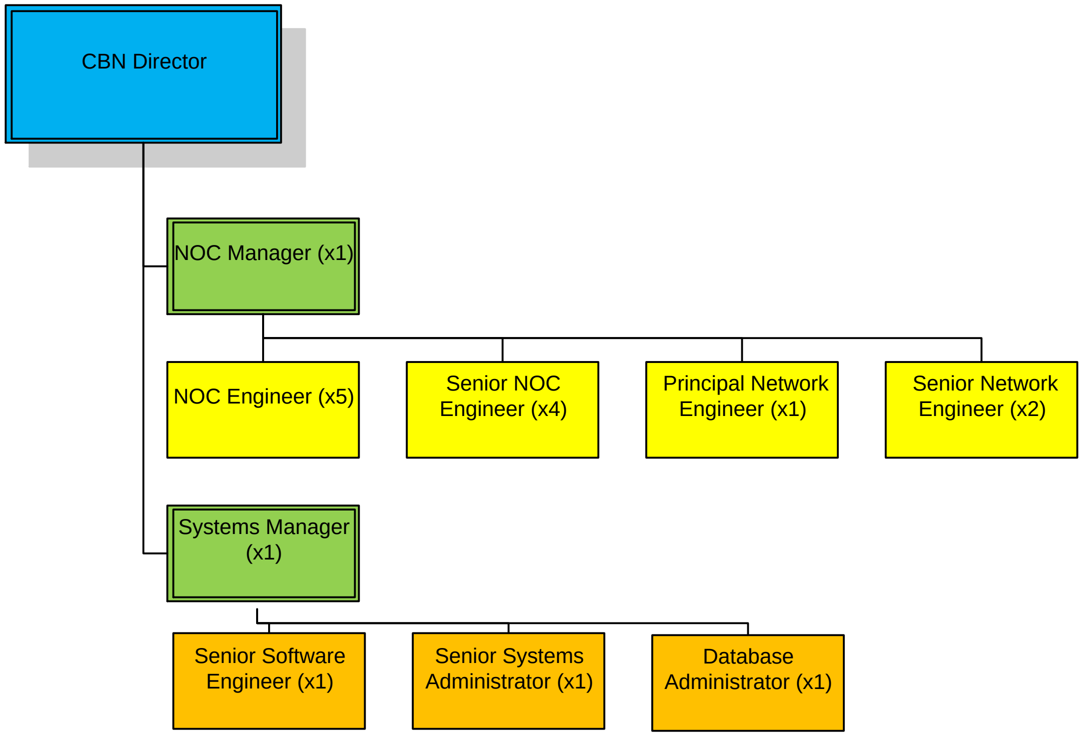


Figure 5-14. In-House NOC Organizational Chart

Table 5-7 lists the NOC personnel positions for the outsourced model, listing the responsibilities for each position.

Table 5-7. CBN Operations Personnel Positions, Outsourced Model

Position	Responsibilities	Notes
Principal Network Engineer	Network Deployment & Configuration SP Technical Support New Service Definition/Deployment Abuse	Day shift, after hours/on-call as necessary
Senior Network Engineer	Network Deployment & Configuration SP Technical Support New Service Definition/Deployment	Works under direction of Principal; Day shift, after hours/on-call as necessary
Systems Manager	Management of Software/Systems staff	All Software/Systems staff report
Senior Software Engineer	System Integration/Development Portal Administration/Deployment	Customizes Portal, performs integration between CBN systems and also SP/CBN systems
Senior System Administrator	Systems Administration/Deployment Abuse	Deploys OSS/BSS and EMS systems
Database Administrator	Database Administration/Deployment	Deploys/supports databases related to

Figure 5-15 shows the personnel organizational chart for the outsourced model.

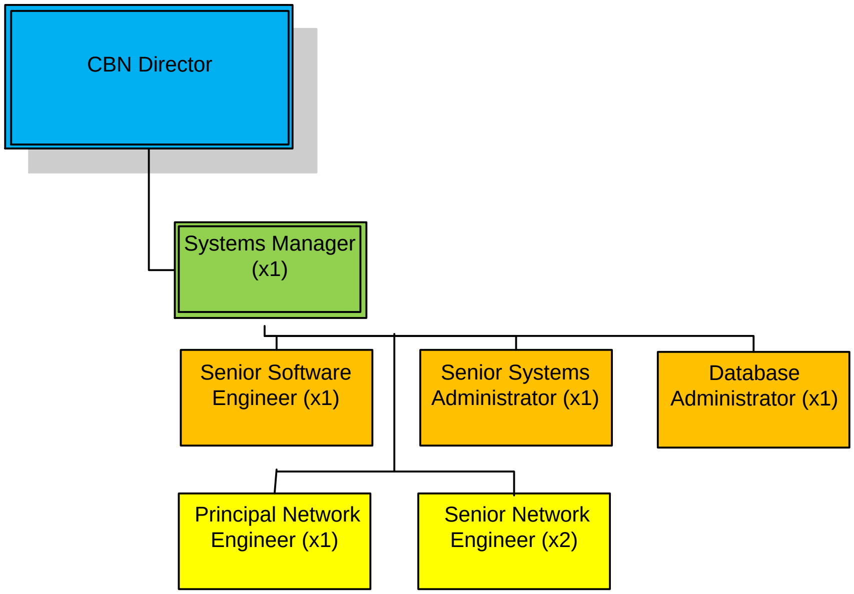


Figure 5-15. Outsourced NOC Organizational Chart

5.6 Integration Summary

There are various integration points in CBN systems – with CBN and between CBN and the SPs. This section summarizes the integration points, a summarization of attributes for the interface, and the decision points around integration. Table 5-8 identifies the integration points, describes what each integration point involves, and provides options for accomplishing the integration function.

Table 5-8. Integration Points

Integration Point	Description	Options
Portal / SP Order Management System	To automate service requests from the Self Selection Portal, integration must be performed so that the SP Order Management system will handle requests from the Portal.	An adaptor is created between the Portal and SP Order Management System to support automated service activations from Portal. No automation, Portal notifies SP through email, SP enters order manually.
SP Order Management / CBN Order Management System	To automate service validation and activation, the SP Order Management System must interact with CBN Order Management System.	An adaptor is created between the Order Management Systems to support automated service validations and activations. CBN provides a Portal so that SP Order Management personnel can validate/activate orders on CBN network. SP personnel contacts CBN personnel through phone/email for service validation/activation SP utilized a CBN-provided (and pre-integrated) Order Management system
SP Automated Provisioning System / CBN Automated Provisioning System	To automate service configuration, the SP Automated Provisioning System must interact with CBN Automated Provisioning System	An adaptor is created between the Automated Provisioning Systems to support automated service configuration. CBN provisioning acts as a consequence of CBN Order Management system entry
CBN Automated Provisioning System / Network Equipment/EMSs	To automate service configuration within CBN, CBN Automated Provisioning System must interact with the network equipment/EMSs within CBN network	An adaptor is created between CBN Automated Provisioning System and each type of network equipment/EMS (EMS for access/CPE equipment and direct to network equipment for core routers) Some or all network configuration is performed manually

For each of the possible adaptors mentioned in the table, it is recommended to have them supplied by the system vendor(s), either through an out-of-the-box solution or professional services.

5.6.1 Portal / SP Order Management Integration

The follow data attributes are relevant to Portal / SP Order Management Integration

- Customer Name
- Customer Billing Address
- Customer Service Address
- Contact Information (email, phone number)

- Billing Information
- Service Selection / Attributes

5.6.2 SP & CBN Order Management Systems

- Customer Location
- Service Selection / Attributes
- Notification of Serviceability

5.6.3 SP & CBN Automated Provisioning Systems

- Customer Location
- Service Selection / Attributes

5.6.4 CBN Automated Provisioning System / Network Equipment/EMSs

Dependent upon equipment vendor selection:

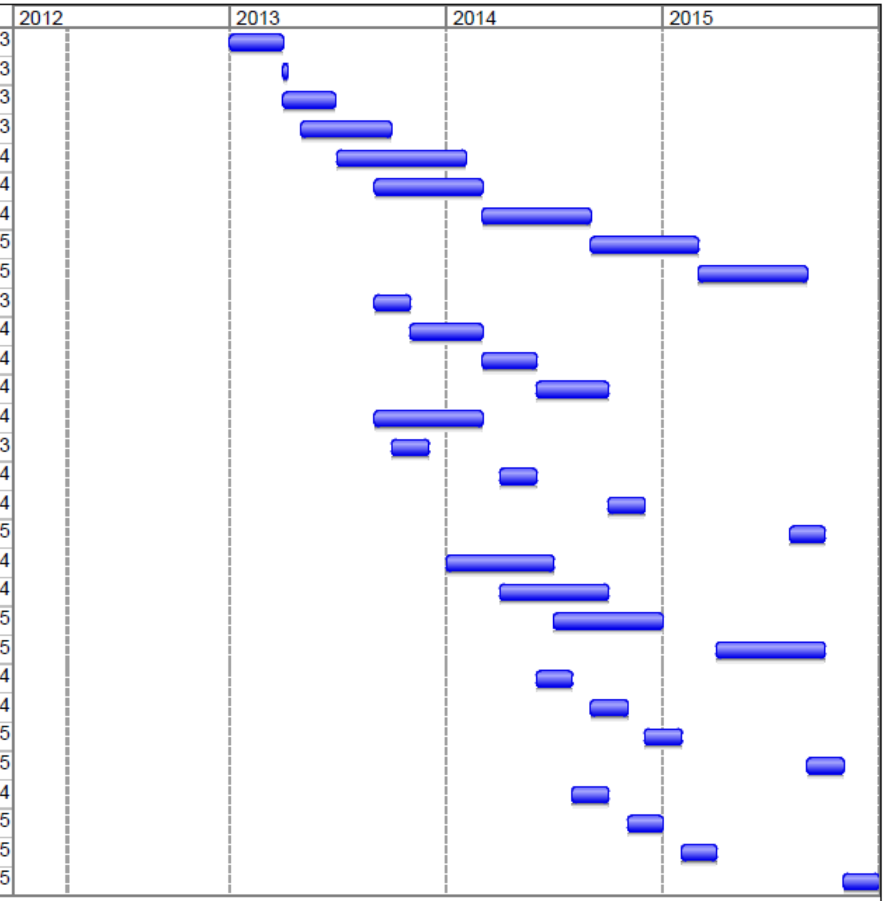
- Core router
- Port/interface number
- VLAN/VPLS mapping
- CIR/EIR rate
- QoS profile
- DSF switch
- CPE device

Section 6. Preliminary Implementation Schedule

The schedule reflects a two-year build-out timeframe, involving parallel activities. A final schedule will be determined by the awarded contractor(s). Zones represent geographical areas; these areas must be further defined by the contractor's proposal. The scheduled tasks are defined as follows:

- Make Ready Construction – primarily aerial infrastructure - inspection, replacement, modifications as needed.
- Underground Construction – boring, trenching and installation of buried conduit and fiber
- Aerial Construction – aerial fiber installation
- Equipment Deployment – NOC, POP equipment delivery and installation
- Install Premises –Customer Premises Equipment installation
- Test – Network connectivity and end to end testing activities
- System Deployment – Configure and prepare CBN and Service Provider systems for service activation

ID		Task Name	Duration	Start	Finish
1		RFP Process for Contractor	65 days	Tue 1/1/13	Mon 4/1/13
2		Contract Negotiations	6 days	Mon 4/1/13	Mon 4/8/13
3		Permit Process	65 days	Mon 4/1/13	Fri 6/28/13
4		Make Ready Construction	109 days	Wed 5/1/13	Mon 9/30/13
5		NOC, POP Construction	156 days	Mon 7/1/13	Mon 2/3/14
6		Underground Construction Zone 1	131 days	Mon 9/2/13	Mon 3/3/14
7		Underground Construction Zone 2	131 days	Mon 3/3/14	Mon 9/1/14
8		Underground Construction Zone 3	131 days	Mon 9/1/14	Mon 3/2/15
9		Underground Construction Zone 4	132 days	Mon 3/2/15	Tue 9/1/15
10		Aerial Construction Zone 1	45 days	Mon 9/2/13	Fri 11/1/13
11		Aerial Construction Zone 2	87 days	Fri 11/1/13	Mon 3/3/14
12		Aerial Construction Zone 3	66 days	Mon 3/3/14	Mon 6/2/14
13		Aerial Construction Zone 4	88 days	Mon 6/2/14	Wed 10/1/14
14		Equipment Deployment - NOC, POP	131 days	Mon 9/2/13	Mon 3/3/14
15		Equipment Deployment Zone 1	45 days	Tue 10/1/13	Mon 12/2/13
16		Equipment Deployment Zone 2	45 days	Tue 4/1/14	Mon 6/2/14
17		Equipment Deployment Zone 3	44 days	Wed 10/1/14	Mon 12/1/14
18		Equipment Deployment Zone 4	44 days	Mon 8/3/15	Thu 10/1/15
19		Install Premises Zone 1	130 days	Wed 1/1/14	Tue 7/1/14
20		Install Premises Zone 2	132 days	Tue 4/1/14	Wed 10/1/14
21		Install Premises Zone 3	133 days	Tue 7/1/14	Thu 1/1/15
22		Install Premises Zone 4	132 days	Wed 4/1/15	Thu 10/1/15
23		Test Zone 1	45 days	Mon 6/2/14	Fri 8/1/14
24		Test Zone 2	46 days	Mon 9/1/14	Mon 11/3/14
25		Test Zone 3	46 days	Mon 12/1/14	Mon 2/2/15
26		Test Zone 4	45 days	Tue 9/1/15	Mon 11/2/15
27		System Deployment Zone 1	44 days	Fri 8/1/14	Wed 10/1/14
28		System Deployment Zone 2	44 days	Mon 11/3/14	Thu 1/1/15
29		System Deployment Zone 3	43 days	Mon 2/2/15	Wed 4/1/15
30		System Deployment Zone 4	44 days	Mon 11/2/15	Thu 12/31/15



CBN Preliminary Schedule
Friday 3/30/12

Task	Milestone	External Tasks
Split	Summary	External Milestone
Progress	Project Summary	Deadline

Page 1

Figure 6-1. Preliminary Implementation Schedule

Appendix A. Abbreviations and Acronyms

Acronym	Definition
AE	Active Ethernet
ANSI	American National Standards Institute
BICSI	Building Industry Consulting Service International
BSS	Business Support System
CBN	Community Broadband Network
CFR	Code of Federal Regulations
CoS	Class of Service
CPE	Customer Premises Equipment
DPU	Department of Public Utilities
DSF	Distribution Switch Facility
EIA	Electronic Industries Alliance
eTOM	enhanced Telecom Operations Map
ETTR	Expected Time To Resolution
ERPS	Ethernet Ring Protection Switching
FTTP	Fiber To The Premises
Gbps	Gigabits per second
GIS	Geospatial Information System
GPON	Gigabit-capable Passive Optical Network
HVAC	Heating, Ventilation, and Air Conditioning
HD	High Definition
IEEE	Institute of Electrical and Electronics Engineers
IPTV	Internet Protocol Television
LAC	Los Alamos County
LAC-ITD	Los Alamos County Information Technology Division
LAG	Link Aggregation Group
Mbps	Megabits per second
MCSA	Microsoft Certified Systems Administrator

Acronym	Definition
MDU	Multiple Dwelling Unit
MSTP	Multiple Spanning Tree Protocol
NEPA	National Environmental Policy Act
NESC	National Electric Safety Code
NetOp	Network Operator
NFPA	National Fire Protection Association
NG-PON	Next Generation Passive Optical Networking
NOC	Network Operations Center
OSP	Outside Plant
MPLS	Multiprotocol Label Switching
OSS	Operations Support System
PON	Passive Optical Networking
POP	Point of Presence
RSTP	Rapid Spanning Tree Protocol
RHCSA	Red Hat Certified System Administrator
RUS	Rural Utilities Service
SDR	Service Description Record
STP	Spanning Tree Protocol
SWMU	Solid Waste Management Unit
TAC	Technical Assistance Center
TCP	Transmission Control Protocol
TIA	Telecommunications Industry Association
UDP	User Datagram Protocol
VLAN	Virtual Local Area Network
VoIP	Voice over Internet Protocol
VPLS	Virtual Private LAN Service
VPN	Virtual Private Network
WDM	Wavelength Division Multiplexing

Appendix B. CBN Requirements

This appendix contains CBN functional requirements, including the following:

- Residential and commercial service requirements
- Priority of services
- Public safety integration
- Customer interface and service provisioning
- Reliability requirements
- Network requirements

Council Requirements - April 19, 2011

1. Develop a plan to provide open and advanced broadband communications access to all Los Alamos citizens and institutions.
2. This purpose will be accomplished through building a fiber to the premises (FTTP) network.
3. The general concept of the fiber backbone as defined in the previous Network Expansion study project will be accepted and used and that work will not be re-performed.
4. New conceptual design work will start with the previous study and build outward from there.
5. The target speed will be a minimum of 1 gigabits per second
6. The County will not generally be an overall content provider or a SP. Private business services and content will be provided by private businesses (e.g. phone, cable, internet, gaming, etc.). Some County services may be provided through the new network infrastructure.
7. Coordination with any potential radio project will occur.

Network Architecture Requirements

1. CBN shall;
   a. be an open network that supports voice, video and data service delivery from multiple SPs
   b. be designed according to industry standards
   c. support equipment interoperability from multiple vendors
   d. provide symmetrical bandwidth of 1 Gbps
   e. be scalable
   f. be secure
   g. be an Active Ethernet network

Premises Classification

1. A premises shall be classified as either;
    a. Residential single family
    b. Residential multiple dwelling unit
    c. Commercial
    d. Exempt
    e. Los Alamos County

Network Component Requirements

1. CBN shall be a fiber based network from the head-end to the premises
2. CBN shall have a dedicated Point-Of-Presence that will provide access to the Internet
3. CBN shall have a Network Operations Center for operating and maintaining the network
4. A Distribution Switch Facility shall be a remote optical facility that will direct traffic to each user
5. A Drop Closure shall be a passive facility used to connect up to 12 homes
6. Customer Premises Equipment shall be installed at each premises

Point of Presence Requirements

1. The POP shall provide data routing and switching for Customer Internet access
2. The POP facility shall have East and West diverse fiber routing for a redundant fiber optic network topology.
3. The POP facility backup power systems shall consist of UPS and diesel power generator capable of supplying not less than 48 hours of full-load power.

The Network Operations Center Requirements

1. The NOC shall provide the following functions;
    a. Technical support
    b. Customer service
    c. Field support
    d. System management, monitoring, and diagnostics
    e. Account management and billing
    f. Engineering
    g. Facilities management
    h. Physical security

i. Network security

j. Incident/outage management

Fiber Cable Requirements

1. Drop Fiber: 2 fibers
2. Lateral Fiber: 144-288 fibers
3. Core Fiber: 432 fibers
4. CBN shall provide spare fiber capacity for future growth

Distribution Switch Facility Requirements

1. The DSF shall be an Active Ethernet facility
2. The DSF shall support a maximum of 1000 customers
3. Each DSF shall have access to the following power systems;
   a. LAC utility power
   b. Uninterruptible Power Supply that can provide 4 hours of battery backup

Outside plant standards shall include;

1. RUS 7 CFR 1751 - Telecommunication System Planning and Design Criteria, and Procedures
2. 1751F-635 -Construction of Aerial Plant
3. 1751F-641 - Construction of Buried Plant
4. 1751F-642 - Construction Route Planning of Buried Plant
5. 1751F-644 - Underground Plant Construction
6. 1751F-815 - Electrical Protection of Outside Plant
7. RUS 7 CFR 1755 - Telecommunications Standards and Specifications for Materials, Equipment and Construction
8. NESC - National Electrical Safety Code, IEEE
9. NEC - National Electric Code, NFPA
10. OSHA - Occupational Safety and Health Administration (OSHA) Regulations 1910, Occupational Safety and Health Standards, and OSHA Regulations 1926, Safety and Health Regulations for Construction.
11. ANSI/TIA/EIA 526 - Standard Test Procedures for Fiber Optic Systems
12. ANSI/TIA/EIA 568 - Commercial Building Telecommunications Cabling Standard
13. ANSI/TIA/EIA 569 - Commercial Building Standard for Telecommunication Pathways and Spaces

14. ANSI/TIA/EIA 606 - Administration Standard for Commercial Telecommunications Infrastructure
15. ANSI/TIA/EIA 607 - Commercial Building Grounding and Bonding Requirements for Telecommunications
16. ANSI/TIA/EIA 758 - Customer-Owned Outside Plant Telecommunications Cabling Standard
17. ANSI/BICSI 002-2011 - Data Center Design and Implementation Best Practices
18. BICSI OSP - BICSI Customer-Owned Outside Plant Design Manual
19. BICSI ITS - BICSI Informational Transport Systems Installation Manual
20. BICSI TDMM - BICSI Telecommunications Distribution Methods Manual
21. LAC-ITD - Los Alamos County Information Technology Division, Standards and Specifications For Building and Campus Distribution Systems
22. LAC-ITD - Los Alamos County Information Technology Division, Guidelines for Access to Fiber Vaults, Splice and Pull Boxes

Ethernet Operations, Administration and Maintenance standards shall include;

1. IEEE 802.3ah
2. IEEE 802.1ag
3. IEEE Y.1731

Appendix C. Equipment Vendor Research

To provide a feasible design and dependable budgetary cost estimates, detailed research with equipment vendors was conducted. On-site or telephone discussions for each equipment type were completed. This research identified the latest product offerings in the following categories:

Table C-1. Vendor Research Summary

Equipment Type	Vendors
Distribution Equipment	Allied Telysis, Zhone, Calix, Cisco, Ericsson
CPE Equipment	Allied Telysis, Zhone, Calix, Cisco, Ericsson
Fiber Duct Cable	Clearfield, Miniflex
Fiber Cable	OSF Optics, Corning, Prysmian
Fiber Distribution Products	TE Connectivity (ADC), Clearfield, Zhone
Core Equipment	Cisco, Fujitsu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Appendix D. System Architecture Evaluation

There are two primary architectures that deliver last-mile fiber networks: PON and AE. Although both methods deliver fiber to the premises, they differ with their fiber distribution networks, bandwidth, scalability and cost.

The PON Approach

Customers in a PON system have a dedicated fiber from their premises to a distribution point where a passive optical splitter is located. The passive optical splitter can aggregate up to 64 customers onto a single fiber back to the POP or central office.

Customers in an AE system have a dedicated fiber from their premises to a distribution point where Ethernet aggregation switches are located. At that point a dedicated fiber may be assigned to a customer back to the POP or the optical signal from multiple customers can be placed onto a dedicated fiber via wave division multiple access equipment.

Some advantages of the PON approach are:

- GPON selected as the standard by Verizon, AT&T, Bell South in January 2003
- 1:16, 1:32, 1:64 optical splitters -multiple customers can share the same fiber
- Lower fiber plant costs
- NG-PON2 can achieve 1.2Gbps split 32 ways
- Laboratory OFDMA PON test trials - 100Gbps

Some disadvantages of the PON approach are:

- Bandwidth is shared among multiple customers
- Challenge supporting open network architecture
- Evolving industry standards
- Star topology – Splitter can be a single-point-of-failure
- Passive splitter is unable to transmit precise location for problem management events. Technicians need to be deployed in the field.

Some advantages of the AE approach are:

- Supports an open network architecture
- Mature industry standards
    - IEEE 802.3
    - Equipment interoperability from multiple vendors
    - Decreasing equipment costs
    - Easy to train and acquire labor for maintenance
    - Easy to configure and support
- Symmetrical bandwidth

- Dedicated bandwidth
- Optimized for triple play
- Modular building block – build as you grow
- Scalability
- Security
- Greater distance for optical equipment
- Enables differentiated service for different Customers
- Topology is flexible and can be built with ring redundancy
- Ethernet equipment enables the NOC to monitor service delivery in real-time and to pin-point location for problem management events
- Some disadvantages of the AE approach are:
- Increased fiber cable infrastructure
- Maintenance costs of Active Ethernet environment (equipment, power)

Recommendation

After assessing the advantages and disadvantages of PON and AE, and placing this analysis within the context of County Council's directive of providing a dedicated 1 Gbps data rate to each user, AE is the preferred architecture for CBN, as currently available PON systems do not support 1 Gbps symmetrical data rates.

Appendix E. Detailed Budgetary Cost Estimate

Section 2 provided the capital expense budgetary cost estimates for each of the CBN system components. This section collects together all of the separate cost estimate tables.

NOC					
	Item	**Qty**	**Unit Price**	**Extended Price**	**Adjusted Price**
Materials	Office space	1,317	185.00	$243,645	$251,685
Materials	Toilets/mechanical space	803	215.00	$172,645	$178,342
Materials	Generator	1	64,000.00	$64,000	$66,112
Materials	UPS - TVSS	1	23,000.00	$23,000	$23,759
Materials	Storm water storage	1	24,000.00	$24,000	$24,792
Labor	A&E Fees	1	80,000.00	$80,000	$88,683
Labor	LEED Expenses	1	90,000.00	$90,000	$99,768
Materials	Electrical service and transformer	1	45,000.00	$45,000	$46,485
Materials	Physical security	1	5,000.00	$5,000	$5,165
Labor	Physical security installation	1	5,000.00	$5,000	$5,542
Labor	Paving for parking, landscaping, grading, excavation and fencing	1	160,000.00	$160,000	$177,366
Labor	Geo-technical services	1	4,500.00	$4,500	$4,988
Materials	Furnishings for 8 staffers	8	4,000.00	$32,000	$33,056
Materials	BSS and OSS software and servers	1	350,000.00	$350,000	$361,550
Materials	Maintenance Van	2	40,000.00	$80,000	$82,640
		Sub-total		**$1,378,790**	**$1,449,935**

South POP					
	Item	**Qty**	**Unit Price**	**Extended Price**	**Adjusted Price**
Materials	Building	3,000	400.00	$1,200,000	$1,239,600
Materials	Generator, fuel tank, ATS (included in building price)	2	0.00	$0	$0
Materials	HVAC system (included in building price)	1	0.00	$0	$0
Labor	Power hookup	1	10,000.00	$10,000	$11,085
Materials	UPS for CBN equipment	10	1,300.00	$13,000	$13,429
Materials	Fiber entrance vault	2	1,500.00	$3,000	$3,099
Labor	Install fiber entrance vault	2	2,000.00	$4,000	$4,434
Materials	Fiber entrance cabinet	2	5,000.00	$10,000	$10,330
Labor	Splicing labor for tails at FEC, loose tube	1	10,800.00	$10,800	$11,972
Labor	Install Fiber Entrance Cabinet and conduit to fiber entrance vault	2	600.00	$1,200	$1,330
Materials	Cross-connect rack	2	22,000.00	$44,000	$45,452
Labor	Labor for cross-connect installation	2	5,000.00	$10,000	$11,085
Materials	Fiber trays	1	5,000.00	$5,000	$5,165
Labor	Fiber tray installation	1	1,000.00	$1,000	$1,108
Materials	Ladder trays	1	5,000.00	$5,000	$5,165
Labor	Ladder tray installation	1	1,000.00	$1,000	$1,108
Materials	Fire suppression	1	30,000.00	$30,000	$30,990
Labor	Fire suppression installation	1	10,000.00	$10,000	$11,085
Materials	Physical security	1	5,000.00	$5,000	$5,165
Labor	Physical security installation	1	5,000.00	$5,000	$5,542
Materials	Colocation tenant woven wire security cage	6	1,800.00	$10,800	$11,156
		Sub-total		**$1,378,800**	**$1,428,304**

North POP					
	Item	Qty	Unit Price	Extended Price	Adjusted Price
Materials	Concrete prefabricated building	1	180,000.00	$180,000	$185,940
Materials	Generator, fuel tank, ATS (included in building price)	1	0.00	$0	$0
Materials	HVAC system (included in building price)	1	0.00	$0	$0
Labor	Power hookup	1	5,000.00	$5,000	$5,542
Materials	UPS for CBN equipment	10	1,300.00	$13,000	$13,429
Materials	Fiber entrance vault	2	1,500.00	$3,000	$3,099
Labor	Install fiber entrance vault	2	2,000.00	$4,000	$4,434
Materials	Fiber entrance cabinet	2	3,000.00	$6,000	$6,198
Labor	Splicing labor for tails at FEC	1	10,800.00	$10,800	$11,972
Labor	Install Fiber Entrance Cabinet and conduit to fiber entrance vault	2	600.00	$1,200	$1,330
Materials	Cross-connect rack	1	22,000.00	$22,000	$22,726
Labor	Labor for cross-connect installation	1	5,000.00	$5,000	$5,542
Materials	Fiber trays	1	2,500.00	$2,500	$2,582
Labor	Fiber tray installation	1	500.00	$500	$554
Materials	Ladder trays	1	2,500.00	$2,500	$2,582
Labor	Ladder tray installation	1	500.00	$500	$554
Materials	Fire suppression	1	15,000.00	$15,000	$15,495
Labor	Fire suppression installation	1	5,000.00	$5,000	$5,542
Materials	Physical security	1	2,500.00	$2,500	$2,582
Labor	Physical security installation	1	2,500.00	$2,500	$2,771
		Sub-total		**$281,000**	**$292,879**

WR POP					
	Item	**Qty**	**Unit Price**	**Extended Price**	**Adjusted Price**
Materials	Concrete prefabricated building	1	180,000.00	$180,000	$185,940
Materials	Generator, fuel tank, ATS (included in building price)	1	0.00	$0	$0
Materials	HVAC system (included in building price)	1	0.00	$0	$0
Labor	Power hookup	1	5,000.00	$5,000	$5,542
Materials	UPS for CBN equipment	6	1,300.00	$7,800	$8,057
Materials	Fiber entrance vault	2	1,500.00	$3,000	$3,099
Labor	Install fiber entrance vault	2	2,000.00	$4,000	$4,434
Materials	Fiber entrance cabinet	2	3,000.00	$6,000	$6,198
Labor	Splicing labor for tails at FEC	1	10,800.00	$10,800	$11,972
Labor	Install Fiber Entrance Cabinet and conduit to fiber entrance vault	2	600.00	$1,200	$1,330
Materials	Cross-connect rack	1	22,000.00	$22,000	$22,726
Labor	Labor for cross-connect installation	1	5,000.00	$5,000	$5,542
Materials	Fiber trays	1	2,500.00	$2,500	$2,582
Labor	Fiber tray installation	1	500.00	$500	$554
Materials	Ladder trays	1	2,500.00	$2,500	$2,582
Labor	Ladder tray installation	1	500.00	$500	$554
Materials	Fire suppression	1	15,000.00	$15,000	$15,495
Labor	Fire suppression installation	1	5,000.00	$5,000	$5,542
Materials	Physical security	1	2,500.00	$2,500	$2,582
Labor	Physical security installation	1	2,500.00	$2,500	$2,771
		Sub-total		**$275,800**	**$287,507**

Stage 1 POP Network Electronics					
	Item	**Qty**	**Unit Price**	**Extended Price**	**Adjusted Price**
Materials	POP Network Electronics: Switches, Routers, cards, configuration, installation	1	4,544,679	$4,544,679	$4,694,653
Materials	WDM Equipment	1	540,000.00	$540,000	$557,820
	Sub-total			**$5,084,679**	**$5,252,473**

Stage 2 POP Network Electronics					
	Item	**Qty**	**Unit Price**	**Extended Price**	**Adjusted Price**
Materials	POP Network Electronics: Switches, Routers, cards, configuration, installation	1	2,080,786	$2,080,786	$2,149,451
Materials	WDM Equipment	1	680,000.00	$680,000	$702,440
	Sub-total			**$2,760,786**	**$2,851,892**

Stage 3 POP Network Electronics					
	Item	**Qty**	**Unit Price**	**Extended Price**	**Adjusted Price**
Materials	POP Network Electronics: Switches, Routers, cards, configuration, installation	1	5,374,535	$5,374,535	$5,551,894
Materials	WDM Equipment	1	2,380,000.00	$2,380,000	$2,458,540
	Sub-total			**$7,754,535**	**$8,010,435**

Townsite Core Fiber - Buried cable in existing duct with innerduct					
	Item	**Qty**	**Unit Price**	**Extended Price**	**Adjusted Price**
Materials	432 fibers	52,081	3.25	$169,262	$174,847
Labor	UG fiber pull, no splicing	52,081	1.00	$52,081	$57,733
Labor	Mass fusion ribbon splice	144	120.00	$17,280	$19,155
Materials	Vault 48x60x48	10	2,000.00	$20,000	$20,660
Labor	Install vault	10	12,000.00	$120,000	$133,024
Materials	Splice Closure	10	500.00	$5,000	$5,165
		Sub-total		**$383,623**	**$410,586**
Townsite Core Fiber - Buried cable, new 3 ea. 1.25" duct					
	Item	**Qty**	**Unit Price**	**Extended Price**	**Adjusted Price**
Materials	432 fibers	19,544	3.25	$63,518	$65,614
Materials	1.25" SDR 13.5 duct	58,632	0.45	$26,384	$27,255
Labor	UG fiber pull, no splicing	19,544	1.00	$19,544	$21,665
Labor	Mass fusion ribbon splice	144	120.00	$17,280	$19,155
Labor	Core HDD labor	17,767	21.00	$373,113	$413,609
Materials	Pull box 48x48x48	30	1,500.00	$45,000	$46,485
Labor	Install pull box	30	2,000.00	$60,000	$66,512
		Sub-total		**$604,839**	**$660,297**
WR Core Fiber - Buried cable, new 3 ea. 1.25" duct					
	Item	**Qty**	**Unit Price**	**Extended Price**	**Adjusted Price**
Materials	432 fibers	14,300	3.25	$46,475	$48,008
Materials	1.25" SDR 13.5 duct	42,900	0.45	$19,305	$19,942
Labor	UG fiber pull, no splicing	14,300	1.00	$14,300	$15,852
Labor	Mass fusion ribbon splice	144	120.00	$17,280	$19,156
Labor	Core HDD labor	13,000	21.00	$273,000	$302,630
Materials	Pull box 48x48x48	22	1,500.00	$33,000	$34,089
Labor	Install pull box	22	2,000.00	$44,000	$48,775
		Sub-total		**$430,080**	**$488,454**
Rock Contingency for Buried Installation					
	Item	**Qty**	**Unit Price**	**Extended Price**	**Adjusted Price**
Labor	Townsite Core (45% of new HDD)	7,995	30.00	$239,858	$265,891
Labor	Townsite Lateral (45% of new HDD)	66,217	30.00	$1,986,512	$2,202,123
Labor	White Rock Core (45% of new HDD)	5,850	30.00	$175,500	$194,548
Labor	White Rock Lateral (45% of new HDD)	38,712	30.00	$1,161,351	$1,287,401
		Sub-total		**$3,563,221**	**$3,949,966**
		Total		**$4,981,762**	**$5,509,303**

Core Aerial: Townsite excluding Rendija - Guaje - PCS POP					
	Item	**Qty**	**Unit Price**	**Extended Price**	**Adjusted Price**
Materials	ADSS 432 fiber cable	30,395	4.00	$121,581	$125,592
Labor	ADSS installation	30,395	2.50	$75,988	$84,235
Labor	Fiber splicing	741	25.00	$18,525	$20,535
Materials	Vault 48x48x48	10	1,500.00	$15,000	$15,495
Labor	Vault placement	10	2,000.00	$20,000	$22,170
Labor	Pole assessment	818	50.00	$40,900	$45,339
Materials	Pole replacement 25%, Materials	205	1,000.00	$204,500	$211,248
Labor	Pole replacement 25%, Labor	205	4,000.00	$818,000	$906,784
	Sub-total			**$1,314,494**	**$1,431,402**

Core Aerial: Rendija - Guaje					
	Item	**Qty**	**Unit Price**	**Extended Price**	**Adjusted Price**
Materials	ADSS 432 fiber cable	13,860	4.00	$55,440	$57,269
Labor	ADSS installation	13,860	3.00	$41,580	$46,093
Labor	Fiber splicing	208	25.00	$5,200	$5,764
Materials	Vault 48x48x48	1	1,500.00	$1,500	$1,549
Labor	Vault placement	1	2,000.00	$2,000	$2,217
Labor	Pole assessment	39	50.00	$1,950	$2,161
Materials	Pole replacement 25%, Materials	10	1,000.00	$9,750	$10,071
Labor	Pole replacement 25%, Labor	10	4,000.00	$39,000	$43,232
	Sub-total			**$156,420**	**$168,360**

Core Aerial: Guaje - PCS POP					
	Item	**Qty**	**Unit Price**	**Extended Price**	**Adjusted Price**
Materials	ADSS 432 fiber cable	14,033	4.00	$56,131	$57,983
Labor	ADSS installation	14,033	4.00	$56,131	$62,223
Labor	Fiber splicing	208	25.00	$5,200	$5,764
Materials	Vault 48x48x48	1	1,500.00	$1,500	$1,549
Labor	Vault placement	1	2,000.00	$2,000	$2,217
Labor	Pole assessment	80	50.00	$4,000	$4,434
Materials	Pole replacement 25%, Materials	20	2,500.00	$50,000	$51,650
Labor	Pole replacement 25%, Labor	20	7,500.00	$150,000	$166,280
	Sub-total			**$324,962**	**$352,102**

Core Aerial: White Rock					
	Item	**Qty**	**Unit Price**	**Extended Price**	**Adjusted Price**
Materials	ADSS 288 fiber cable	22,923	2.25	$51,577	$53,279
Labor	ADSS installation	21,298	2.50	$53,246	$59,024
Labor	Fiber splicing	72	25.00	$1,800	$1,995
Materials	Vault 48x48x48	2	1,500.00	$3,000	$3,099
Labor	Vault placement	2	2,000.00	$4,000	$4,434
Labor	White Rock Pole assessment	393	50.00	$19,650	$21,782
Materials	Pole replacement 25%, Materials	98	1,000.00	$98,250	$101,492
Labor	Pole replacement 25%, Labor	98	4,000.00	$393,000	$435,655
		Sub-total		**$624,523**	**$680,763**
		Total		**$2,420,398**	**$2,632,627**

Distribution Switch Facility Cabinet - 50RU					
	Item	**Qty**	**Unit Price**	**Extended Price**	**Adjusted Price**
Materials	50RU Cabinet	7	27,500.00	$192,500	$198,852
Materials	Rectifier	7	3,000.00	$21,000	$21,693
Materials	Fiber distribution and storage panels, fibers w/100' pigtails	35	4,600.00	$161,000	$166,313
Materials	Fiber jumper cables	4,500	30.00	$135,000	$139,455
Materials	Card to slot mapping and cabling	7	700.00	$4,900	$5,061
Materials	Battery string	7	2,000.00	$14,000	$14,462
Materials	Filler Panel	7	200.00	$1,400	$1,446
Labor	DSF Cabinet Installation: site prep, cabinet and components	7	3,000.00	$21,000	$23,279
Labor	DSF fiber splicing	4,950	25.00	$123,750	$137,181
Materials	Vault 48x48x48	7	1,500.00	$10,500	$10,846
Labor	Install vault	7	2,000.00	$14,000	$15,519
	Sub-total			**$699,050**	**$734,110**
Distribution Switch Facility Cabinet - 25RU					
	Item	**Qty**	**Unit Price**	**Extended Price**	**Adjusted Price**
Materials	25RU Cabinet	16	17,800.00	$284,800	$294,198
Materials	Rectifier	16	2,000.00	$32,000	$33,056
Materials	Fiber distribution and storage panel, fibers w/100' pigtails	39	4,600.00	$179,400	$185,320
Materials	Fiber jumper cables	4,510	30.00	$135,300	$139,764
Materials	Card to slot mapping and cabling	16	700.00	$11,200	$11,569
Materials	Battery string	16	1,000.00	$16,000	$16,528
Materials	Filler Panel	16	200.00	$3,200	$3,305
Labor	DSF Cabinet Installation: site prep, cabinet and components	16	2,000.00	$32,000	$35,473
Labor	DSF fiber splicing	4,961	25.00	$124,025	$137,486
Materials	Vault 48x48x48	16	1,500.00	$24,000	$24,792
Labor	Install vault	16	2,000.00	$32,000	$35,473
	Sub-total			**$873,925**	**$916,968**
	Total			**$1,572,975**	**$1,651,078**

Stage 1 Distribution Switch Facility Network Equipment					
	Item	**Qty**	**Unit Price**	**Extended Price**	**Adjusted Price**
Materials	Townsite Switch Chassis	173	895.00	$154,835	$159,944
Materials	Townsite Subscriber Card	334	5,395.00	$1,801,930	$1,861,393
Materials	Townsite Subscriber 1GE CSFP	3,273	225.00	$736,425	$760,727
Materials	Townsite Uplink 10GE XFP	84	1,700.00	$142,800	$147,512
Labor	Townsite Install DSF Network Equipment	17	1,000.00	$17,000	$18,845
Materials	White Rock Switch Chassis	64	895.00	$57,280	$59,170
Materials	White Rock Subscriber Card	125	5,395.00	$674,375	$696,629
Materials	White Rock Subscriber 1GE CSFP	1,226	225.00	$275,738	$284,836
Materials	White Rock Uplink 10GE XFP	28	1,700.00	$47,600	$49,170
Labor	White Rock Install DSF Network Equipment	6	1,000.00	$6,000	$6,651
		Sub-total		**$3,913,983**	**$4,044,881**

Stage 2 Additional Distribution Switch Facility Network Equipment					
	Item	**Qty**	**Unit Price**	**Extended Price**	**Adjusted Price**
Materials	Townsite Uplink 10GE XFP	132	1,700.00	$224,400	$231,805
Materials	White Rock Uplink 10GE XFP	52	1,700.00	$88,400	$91,317
		Sub-total		**$312,800**	**$323,122**

Stage 3 Additional Distribution Switch Facility Network Equipment					
	Item	**Qty**	**Unit Price**	**Extended Price**	**Adjusted Price**
Materials	Townsite Uplink 10GE XFP	452	1,700.00	$768,400	$793,757
Materials	White Rock Uplink 10GE XFP	170	1,700.00	$289,000	$298,537
		Sub-total		**$1,057,400**	**$1,092,294**

Buried Lateral					
	Item	**Qty**	**Unit Price**	**Extended Price**	**Adjusted Price**
Materials	Townsite 288 fibers	225,578	2.25	$507,551	$524,299
Materials	Townsite 2 each 1.25" SDR 13.5 duct	325,543	0.45	$146,494	$151,328
Labor	Townsite Lateral HDD labor	147,149	18.00	$2,648,682	$2,936,164
Labor	Townsite Prepare existing conduit, place innerduct & fiber	48,847	2.50	$122,118	$135,371
Materials	Townsite Innerduct for existing conduit, 3 each 1.25" SDR 13.5	161,195	0.45	$72,538	$74,931
Labor	Townsite Fiber splicing	10,850	25.00	$271,250	$300,690
Materials	Townsite Lateral Splice Vault 48x48x48	114	1,500.00	$171,000	$176,643
Labor	Townsite Vault placement	114	2,000.00	$228,000	$252,746
Labor	Townsite Fiber splicing	5,425	25.00	$135,625	$150,345
Materials	White Rock 288 fibers	101,421	2.25	$228,197	$235,727
Materials	White Rock 2 each 1.25" SDR 13.5 duct	202,842	0.45	$91,279	$94,291
Labor	White Rock Lateral HDD labor	86,026	18.00	$1,548,468	$1,716,535
Labor	White Rock Fiber splicing	3,744	25.00	$93,600	$103,759
Materials	White Rock Lateral Splice Vault 48x48x48	46	1,500.00	$69,000	$71,277
Labor	White Rock Vault placement	46	2,000.00	$92,000	$101,985
Labor	White Rock Fiber splicing	1,872	25.00	$46,800	$51,879
		Sub-total		**$6,472,602**	**$7,077,979**
Aerial Lateral					
	Item	**Qty**	**Unit Price**	**Extended Price**	**Adjusted Price**
Materials	Townsite ADSS 288 fiber cable	89,060	2.25	$200,386	$206,998
Labor	Townsite ADSS installation	89,060	2.50	$222,651	$246,817
Labor	Townsite Lateral Fiber splicing	1,121	25.00	$28,025	$31,066
Materials	White Rock ADSS 432 fiber cable	69,923	4.00	$279,690	$288,920
Labor	White Rock ADSS installation	69,923	2.50	$174,807	$193,779
Labor	White Rock Lateral Fiber splicing	579	25.00	$14,475	$16,046
		Sub-total		**$920,034**	**$983,628**
		Total		**$7,392,636**	**$8,061,608**

Buried Drop Closure					
	Item	**Qty**	**Unit Price**	**Extended Price**	**Adjusted Price**
Materials	Townsite Pedestal mount drop closure	760	220.00	$167,200	$172,717
Materials	Townsite Pedestal 8" for drop closure	760	600.00	$456,000	$471,048
Labor	Townsite Install pedestal	760	200.00	$152,000	$168,497
Materials	Townsite Fusion Spliced Field-terminated Connectors at the drop closure	10,850	41.00	$444,850	$459,530
Materials	White Rock Pedestal mount drop closure	311	220.00	$68,420	$70,677
Materials	White Rock Pedestal 8" for drop closure	311	600.00	$186,600	$192,757
Labor	White Rock Install pedestal	311	200.00	$62,200	$68,951
Materials	White Rock Fusion Spliced Field-terminated Connectors at the drop closure	3,744	41.00	$153,504	$158,569
	Sub-total			**$1,690,774**	**$1,762,750**
Aerial Drop Closure					
	Item	**Qty**	**Unit Price**	**Extended Price**	**Adjusted Price**
Materials	Townsite Pole mount aerial drop closure	129	220.00	$28,424	$29,361
Labor	Townsite Install aerial drop closure	129	200.00	$25,840	$28,644
Materials	Townsite Fusion Spliced Field-terminated Connectors	2,242	41.00	$91,922	$94,955
Materials	White Rock Pole mount aerial drop closure	75	220.00	$16,421	$16,962
Labor	White Rock Install aerial drop closure	75	200.00	$14,928	$16,548
Materials	White Rock Fusion Spliced Field-terminated Connectors	1,158	41.00	$47,478	$49,044
	Sub-total			**$225,013**	**$235,518**
	Total			**$1,915,787**	**$1,998,268**

Buried Drop					
	Item	**Qty**	**Unit Price**	**Extended Price**	**Adjusted Price**
Materials	Townsite Fiber, 2 strands, ducted, non-connectorized (spliced)	1,258,605	0.25	$314,651	$325,034
Materials	Townsite Buried drop microduct from hand hole to fiber termination box	503,442	0.35	$176,205	$182,019
Labor	Townsite Install duct and fiber from hand hole to fiber termination box	503,442	3.00	$1,510,326	$1,674,253
Materials	Townsite Hand hole	1,869	15.00	$28,035	$28,960
Labor	Townsite Install Hand hole	1,869	30.00	$56,070	$62,155
Materials	Townsite Buried drop duct from hand hole to drop closure	755,163	0.45	$339,823	$351,037
Labor	Townsite Install duct and fiber from hand hole to drop closure	755,163	3.00	$2,265,488	$2,511,380
Materials	White Rock Fiber, 2 strands, ducted, non-connectorized (spliced)	549,108	0.25	$137,277	$141,807
Materials	White Rock Buried drop microduct from hand hole to fiber termination box	219,643	0.35	$76,875	$79,411
Labor	White Rock Install duct and fiber from hand hole to fiber termination box	219,643	3.00	$658,929	$730,448
Materials	White Rock Hand hole	912	15.00	$13,680	$14,131
Labor	White Rock Install Hand hole	912	30.00	$27,360	$30,329
Materials	White Rock Buried drop duct from hand hole to drop closure	329,465	0.45	$148,259	$153,151
Labor	White Rock Install duct and fiber from hand hole to drop closure	329,465	3.00	$988,394	$1,095,672
	Sub-total			**$6,741,373**	**$7,379,794**
Aerial Drop					
	Item	**Qty**	**Unit Price**	**Extended Price**	**Adjusted Price**
Materials	Townsite Aerial drop cable self-supporting spliced	160,553	0.75	$120,415	$124,388
Labor	Townsite Install aerial drop fiber cable	160,553	2.25	$361,244	$400,452
Materials	Townsite Aerial Drop clamp	2,242	7.35	$16,479	$17,022
Materials	White Rock Aerial drop cable self-supporting spliced	108,089	0.75	$81,067	$83,742
Labor	White Rock Install aerial drop fiber cable	108,089	2.25	$243,201	$269,597
Materials	White Rock Aerial Drop clamp	2,242	7.35	$16,479	$17,022
	Sub-total			**$838,883**	**$912,225**
	Total			**$7,580,256**	**$8,292,019**

Customer Premises Electronics					
	Item	**Qty**	**Unit Price**	**Extended Price**	**Adjusted Price**
Materials	Indoor ONT with 3 FE 1 GE ports	8,997	300.00	$2,699,100	$2,788,170
Materials	ONT 1GE bidi SFP	8,997	60.00	$539,820	$557,634
	Sub-total			**$3,238,920**	**$3,345,804**
Customer Premises Materials and Labor					
	Item	**Qty**	**Unit Price**	**Extended Price**	**Adjusted Price**
Materials	Interior fiber pre-terminated cable	8,997	60.00	$539,820	$557,634
Labor	Interior Fiber installation	8,997	125.00	$1,124,625	$1,246,689
	Sub-total			**$1,664,445**	**$1,804,324**
Customer Premises Fiber Termination Box					
	Item	**Qty**	**Unit Price**	**Extended Price**	**Adjusted Price**
Materials	Townsite Buried drop fiber termination box	5,425	30.00	$162,750	$168,120
Labor	Townsite Install fiber termination box	5,425	10.00	$54,250	$60,138
Materials	Townsite Fusion Spliced Field-terminated Connectors at the fiber termination box	5,425	16.00	$86,800	$89,664
Labor	Townsite Fiber splicing at the fiber termination box	5,425	25.00	$135,625	$150,345
Materials	White Rock Buried drop fiber termination box	1,872	30.00	$56,160	$58,013
Labor	White Rock Install fiber termination box	1,872	10.00	$18,720	$20,751
Materials	White Rock Fusion Spliced Field-terminated Connectors at the fiber termination box	1,872	16.00	$29,952	$30,940
Labor	White Rock Fiber splicing at the fiber termination box	1,872	25.00	$46,800	$51,879
Materials	Townsite Aerial drop fiber termination box	1,121	30.00	$33,630	$34,739
Labor	Townsite Fusion Spliced Field-terminated Connectors at the fiber termination box	1,121	41.00	$45,961	$50,949
Materials	White Rock Aerial drop fiber termination box	579	30.00	$17,370	$17,943
Labor	White Rock Fusion Spliced Field-terminated Connectors at the fiber termination box	579	41.00	$23,739	$26,315
	Sub-total			**$711,757**	**$759,802**
	Total			**$5,615,122**	**$5,909,930**

Professional Services					
	Item	**Qty**	**Unit Price**	**Extended Price**	**Adjusted Price**
Labor	Project Management	1	1,843,200.00	$1,843,200	$2,043,257
	Sub-total			**$1,843,200**	**$2,043,257**

CBN TOTAL SYSTEM COST	
Item	**Adjusted Price**
NOC	$1,449,935
South POP	$1,428,303
North POP	$292,879
WR POP	$287,507
Stage 1 POP Network Electronics	$5,252,473
Stage 2 POP Network Electronics	$2,851,891
Stage 3 POP Network Electronics	$8,010,434
Buried Core Fiber	$5,490,147
Aerial Core Fiber	$2,632,626
Distribution Switch Facility Cabinets	$1,651,077
Stage 1 Distribution Switch Facility Network Equipment	$4,044,881
Stage 2 Additional Distribution Switch Facility Network Equipment	$323,122
Stage 3 Additional Distribution Switch Facility Network Equipment	$1,092,294
Buried Lateral	$7,077,979
Aerial Lateral	$983,628
Buried Drop Closure	$1,762,749
Aerial Drop Closure	$235,517
Buried Drop	$7,379,793
Aerial Drop	$912,225
Customer Premises Electronics	$3,345,804
Customer Premises Materials and Labor	$1,804,323
Customer Premises Fiber Termination Box	$759,802
CBN Components Sub-total	**$59,088,556**
Project Management	$2,043,257
TOTAL	**$61,131,813**

CBN OPTIONS	
Item	**Adjusted Price**
Build the small south POP instead of the large south POP	($949,484)
Eliminate the NOC facility by outsourcing NOC operations	($1,263,995)
Omit Stage 3 POP and DSF network equipment build	($9,102,728)
Omit Stage 2 POP and DSF network equipment build	($3,175,014)
TOTAL	**-$14,491,223**

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Appendix F. DSF Details

For every twenty 1 Gbps customer ports, a minimum of four spare 1 Gbps ports were added. The spare ports will not be connected to any fibers or populated with SFP optical modules. The spare ports are included to meet future needs and replace customer ports that may fail.

The number of 10 Gbps uplink ports for each DSF was calculated to deliver the Stage 1 service profile. Because the DSF uplink architecture splits uplink ports between two diverse fiber paths, the number of uplink ports must be even. When the calculated number of uplink ports was odd, one additional uplink port was added to result in an even number of uplink ports.

The minimum number of rack units needed for each DSF was calculated with the following equation:

$$Rack\ Units\ = \frac{Total\ 1\ Gbps\ Ports}{24\ Ports\ per\ Rack\ Unit} = \frac{Subscriber\ Ports + Spare\ Ports}{24\ Ports\ per\ Rack\ Unit}$$

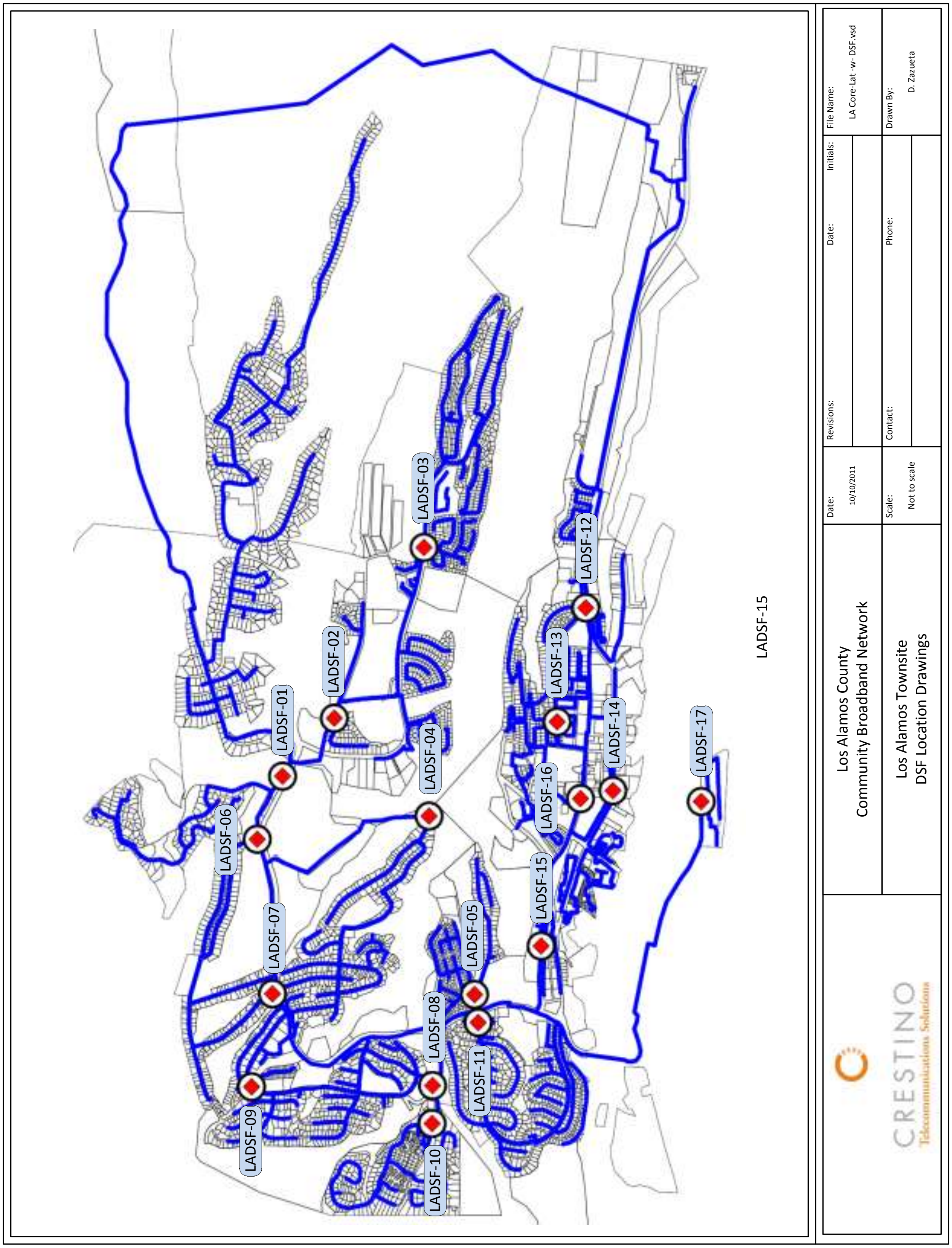
For DSFLA-01 this results in:

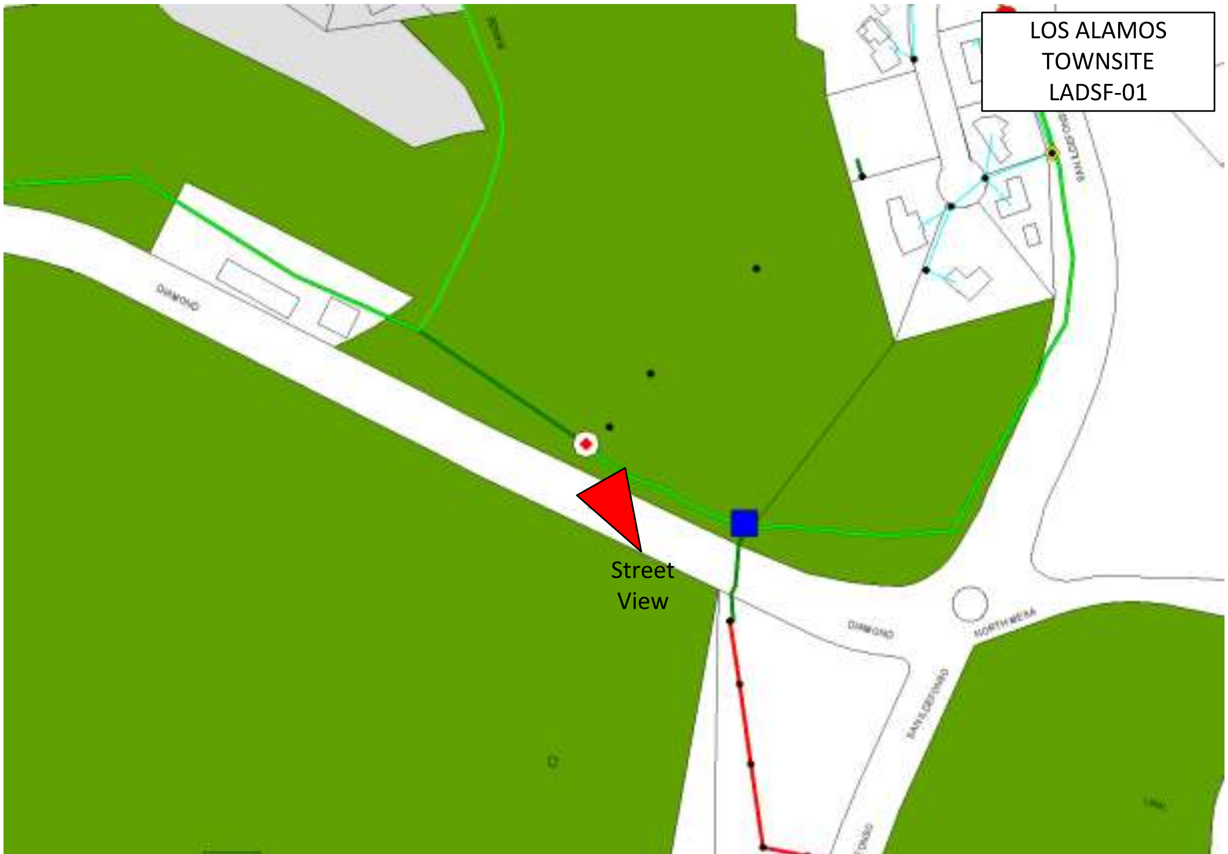
$$Rack\ Units = \frac{628\ + 140}{24} = 32$$

The ratio of *24 Ports per Rack Unit* was determined by halving the port density of a popular vendor's equipment. This ensures that the DSF's will be able to house equipment from other vendors with additional capacity for future added equipment.

Table F-1. DSF Attributes

DSF ID	1G CUSTOMER PORTS	1G SPARE PORTS	UPLINK PORTS	UPGRADE PORTS	MIN. RU CAPACITY
LADSF-01	628	140	8	24	32
LADSF-02	290	70	4	12	15
LADSF-03	731	157	8	24	37
LADSF-04	474	102	6	18	24
LADSF-05	282	78	4	12	15
LADSF-06	230	58	4	12	12
LADSF-07	253	59	4	12	13
LADSF-08	325	83	4	12	17
LADSF-09	241	71	4	12	13
LADSF-10	338	70	4	12	17
LADSF-11	538	110	6	18	27
LADSF-12	322	62	4	12	17
LADSF-13	483	117	6	18	25
LADSF-14	699	141	8	24	35
LADSF-15	275	61	4	12	14
LADSF-16	257	55	4	12	13
LADSF-17	171	45	2	6	9
WRDSF-01	332	76	4	12	17
WRDSF-02	583	137	6	18	30
WRDSF-03	816	168	10	30	41
WRDSF-04	396	84	4	12	20
WRDSF-05	133	35	2	6	7
WRDSF-06	197	43	2	6	10
TOTAL	8,994	2,022	112	336	460

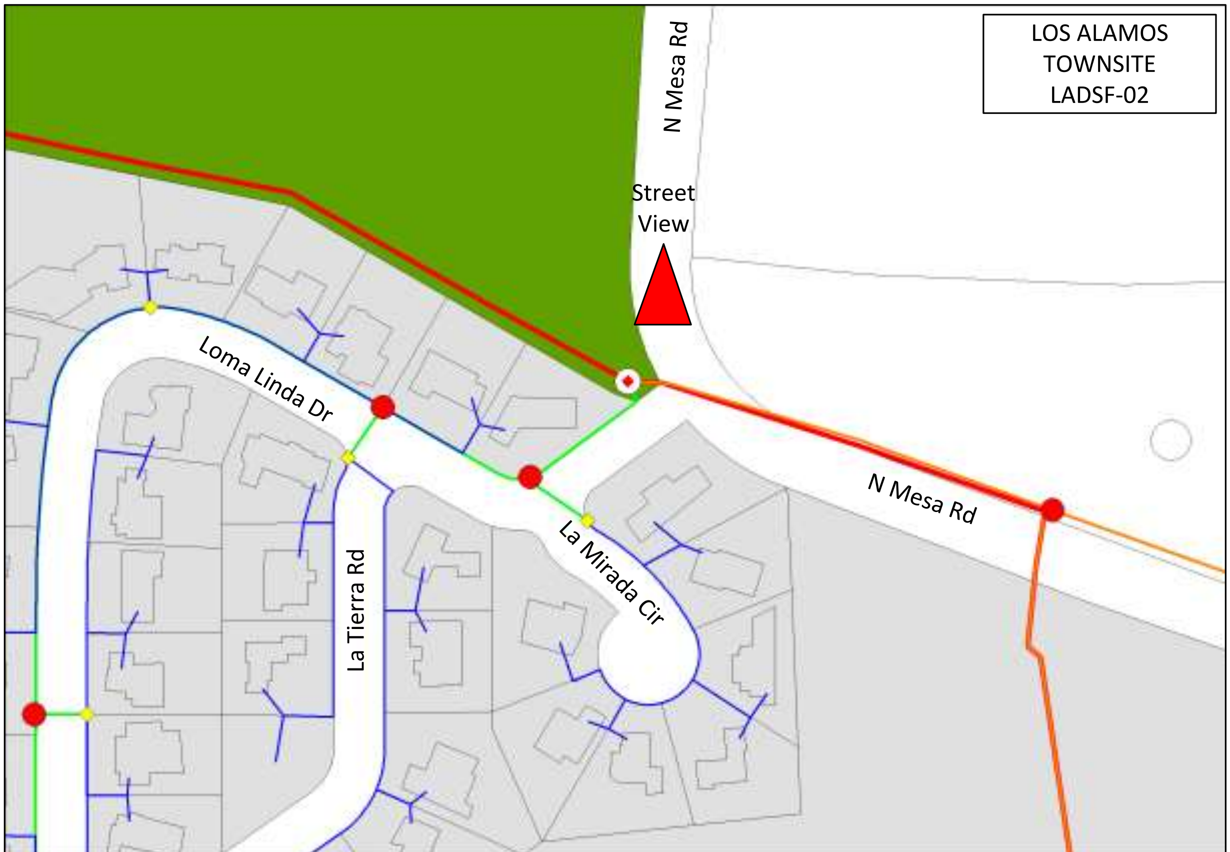

LADSF-01
LADSF-02
LADSF-03
LADSF-04
LADSF-05
LADSF-06
LADSF-07
LADSF-08
LADSF-09
LADSF-10
LADSF-11
LADSF-12
LADSF-13
LADSF-14
LADSF-15
LADSF-16
LADSF-17
LADSF-15
Los Alamos County
Community Broadband Network
Los Alamos Townsite
DSF Location Drawings
CRESTINO
Telecommunications Solutions
Date:
10/10/2011
Scale:
Not to scale
Revisions:
Contact:
Date:
Phone:
Initials:
File Name:
LA Core-Lat -w- DSF.vsd
Drawn By:
D. Zazueta



LEGEND

- DSF (Distribution Switch Facility)
- Drop Closure
- Lateral Splice
- Core Splice
- Core Fiber Aerial
- Core Fiber Underground
- Lateral Fiber Aerial
- Lateral Fiber Underground
- Drop Fiber Aerial
- Drop Fiber Underground

CRESTINO Telecommunications Solutions	Los Alamos County Community Broadband Network	Date: 10/10/2011	Revisions:	Date:	Initials:	File Name: LA Core-Lat -w-DSF.vsd
	Los Alamos Townsite LADSF-01 Location	Scale: Not to scale	Contact:	Phone:		Drawn By: D. Zazueta



LEGEND

- DSF (Distribution Switch Facility)
- Drop Closure
- Lateral Splice
- Core Splice
- Core Fiber Aerial
- Core Fiber Underground
- Lateral Fiber Aerial
- Lateral Fiber Underground
- Drop Fiber Aerial
- Drop Fiber Underground

CRESTINO Telecommunications Solutions	Los Alamos County Community Broadband Network	Date: 10/10/2011	Revisions:	Date:	Initials:	File Name: LA Core-Lat -w-DSF.vsd
	Los Alamos Townsite LADSF-02 Location	Scale: Not to scale	Contact:	Phone:		Drawn By: D. Zazueta

LEGEND

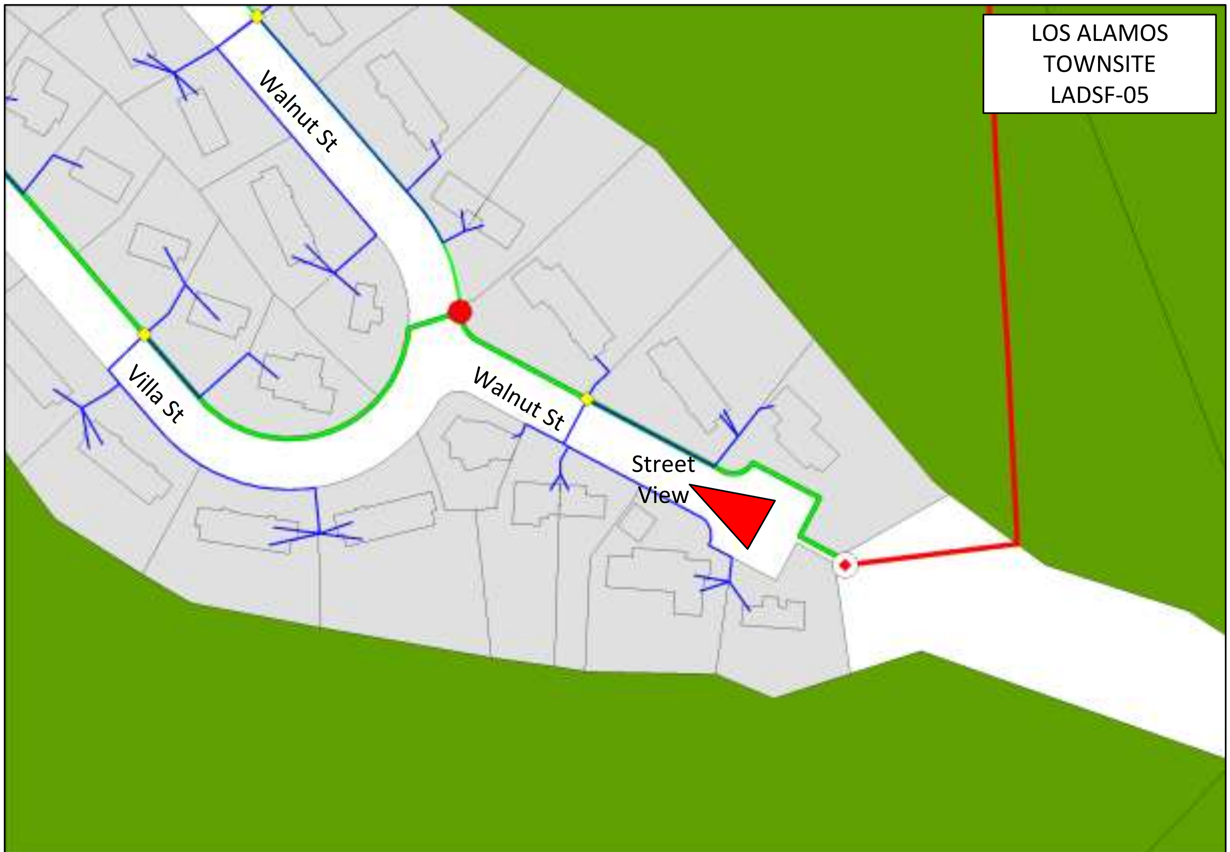
- DSF (Distribution Switch Facility)
- Drop Closure
- Lateral Splice
- Core Splice
- Core Fiber Aerial
- Core Fiber Underground
- Lateral Fiber Aerial
- Lateral Fiber Underground
- Drop Fiber Aerial
- Drop Fiber Underground

CRESTINO Telecommunications Solutions	Los Alamos County Community Broadband Network	Date: 10/10/2011	Revisions:	Date:	Initials:	File Name: LA Core-Lat -w-DSF.vsd
	Los Alamos Townsite LADSF-03 Location	Scale: Not to scale	Contact:	Phone:		Drawn By: D. Zazueta

LEGEND

- DSF (Distribution Switch Facility)
- Drop Closure
- Lateral Splice
- Core Splice
- Core Fiber Aerial
- Core Fiber Underground
- Lateral Fiber Aerial
- Lateral Fiber Underground
- Drop Fiber Aerial
- Drop Fiber Underground

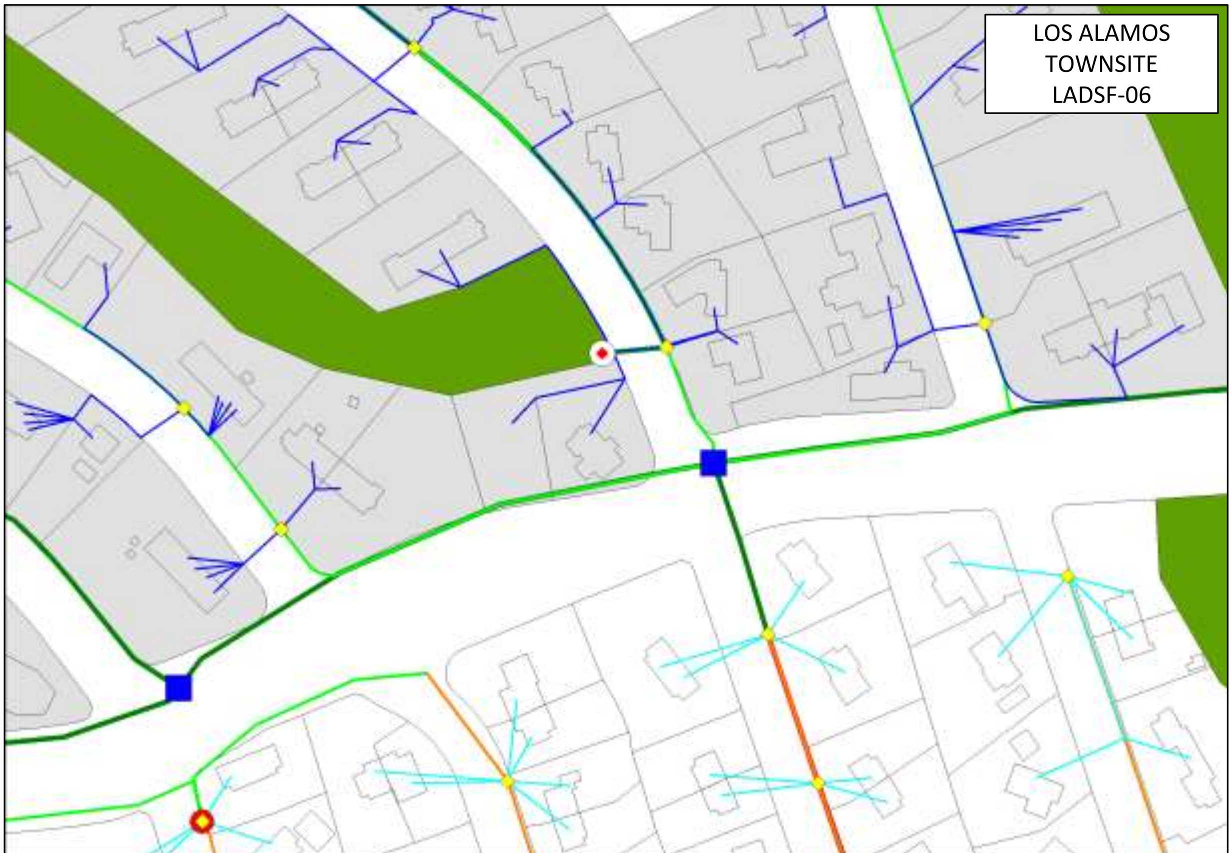
CRESTINO Telecommunications Solutions	Los Alamos County Community Broadband Network	Date: 10/10/2011	Revisions:	Date:	Initials:	File Name: LA Core-Lat -w-DSF.vsd
	Los Alamos Townsite LADSF-04 Location	Scale: Not to scale	Contact:	Phone:		Drawn By: D. Zazueta



LEGEND

- DSF (Distribution Switch Facility)
- Drop Closure
- Lateral Splice
- Core Splice
- Core Fiber Aerial
- Core Fiber Underground
- Lateral Fiber Aerial
- Lateral Fiber Underground
- Drop Fiber Aerial
- Drop Fiber Underground

CRESTINO Telecommunications Solutions	Los Alamos County Community Broadband Network	Date: 10/10/2011	Revisions:	Date:	Initials:	File Name: LA Core-Lat -w-DSF.vsd
	Los Alamos Townsite LADSF-05 Location	Scale: Not to scale	Contact:	Phone:		Drawn By: D. Zazueta



LEGEND

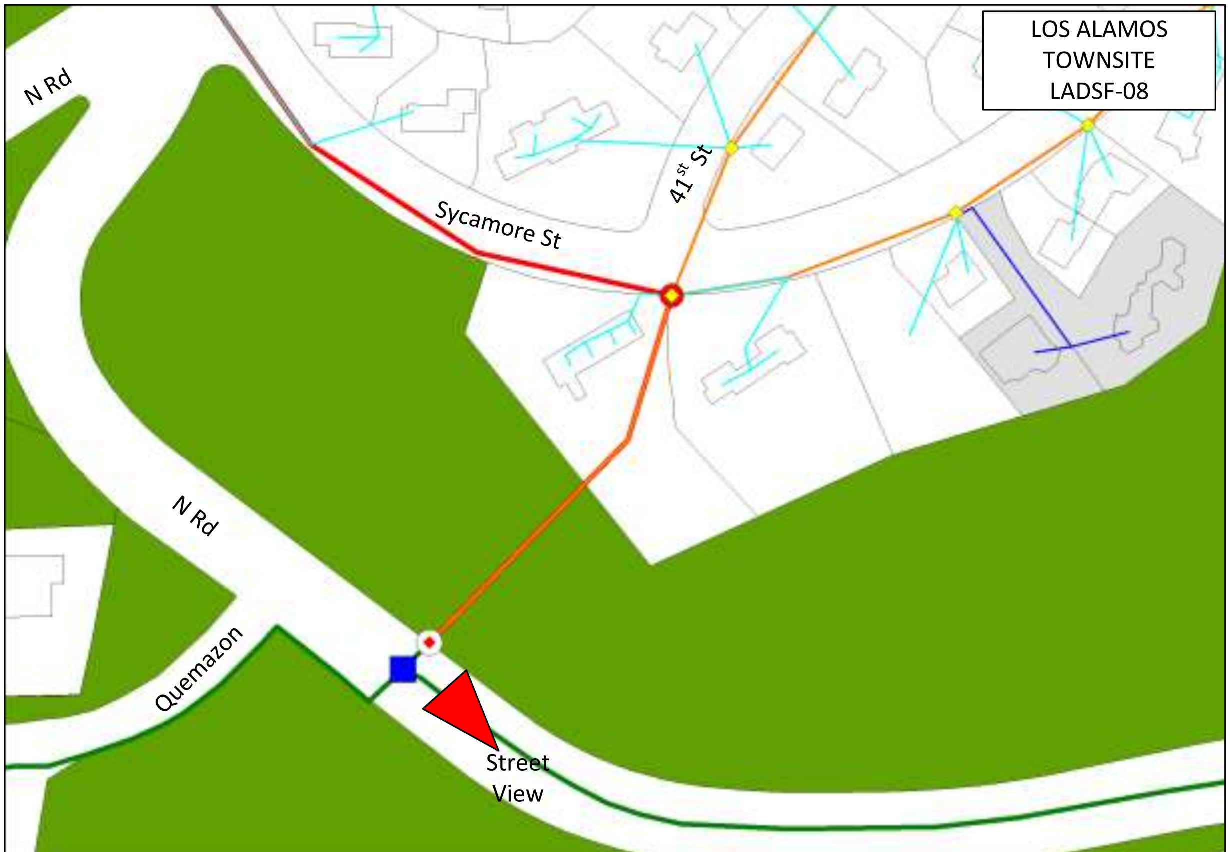
- DSF (Distribution Switch Facility)
- Drop Closure
- Lateral Splice
- Core Splice
- Core Fiber Aerial
- Core Fiber Underground
- Lateral Fiber Aerial
- Lateral Fiber Underground
- Drop Fiber Aerial
- Drop Fiber Underground

CRESTINO Telecommunications Solutions	Los Alamos County Community Broadband Network	Date: 10/10/2011	Revisions:	Date:	Initials:	File Name: LA Core-Lat -w-DSF.vsd
	Los Alamos Townsite LADSF-06 Location	Scale: Not to scale	Contact:	Phone:		Drawn By: D. Zazueta

LEGEND

- DSF (Distribution Switch Facility)
- Drop Closure
- Lateral Splice
- Core Splice
- Core Fiber Aerial
- Core Fiber Underground
- Lateral Fiber Aerial
- Lateral Fiber Underground
- Drop Fiber Aerial
- Drop Fiber Underground

CRESTINO Telecommunications Solutions	Los Alamos County Community Broadband Network	Date: 10/10/2011	Revisions:	Date:	Initials:	File Name: LA Core-Lat -w- DSF.vsd
	Los Alamos Townsite LADSF-07 Location	Scale: Not to scale	Contact:	Phone:		Drawn By: D. Zazueta



LEGEND

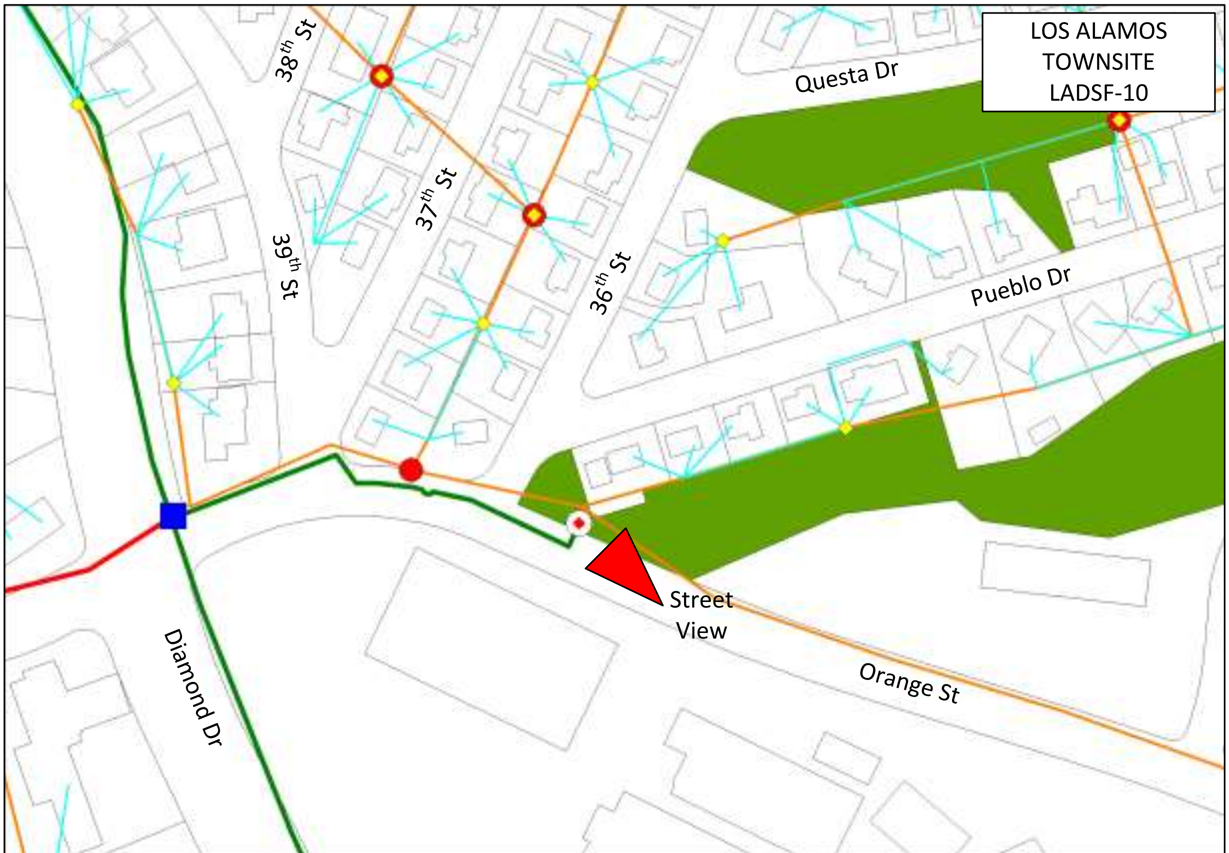
- DSF (Distribution Switch Facility)
- Drop Closure
- Lateral Splice
- Core Splice
- Core Fiber Aerial
- Core Fiber Underground
- Lateral Fiber Aerial
- Lateral Fiber Underground
- Drop Fiber Aerial
- Drop Fiber Underground

CRESTINO Telecommunications Solutions	Los Alamos County Community Broadband Network	Date: 10/10/2011	Revisions:	Date:	Initials:	File Name: LA Core-Lat -w-DSF.vsd
	Los Alamos Townsite LADSF-08 Location	Scale: Not to scale	Contact:	Phone:		Drawn By: D. Zazueta

LEGEND

- DSF (Distribution Switch Facility)
- Drop Closure
- Lateral Splice
- Core Splice
- Core Fiber Aerial
- Core Fiber Underground
- Lateral Fiber Aerial
- Lateral Fiber Underground
- Drop Fiber Aerial
- Drop Fiber Underground

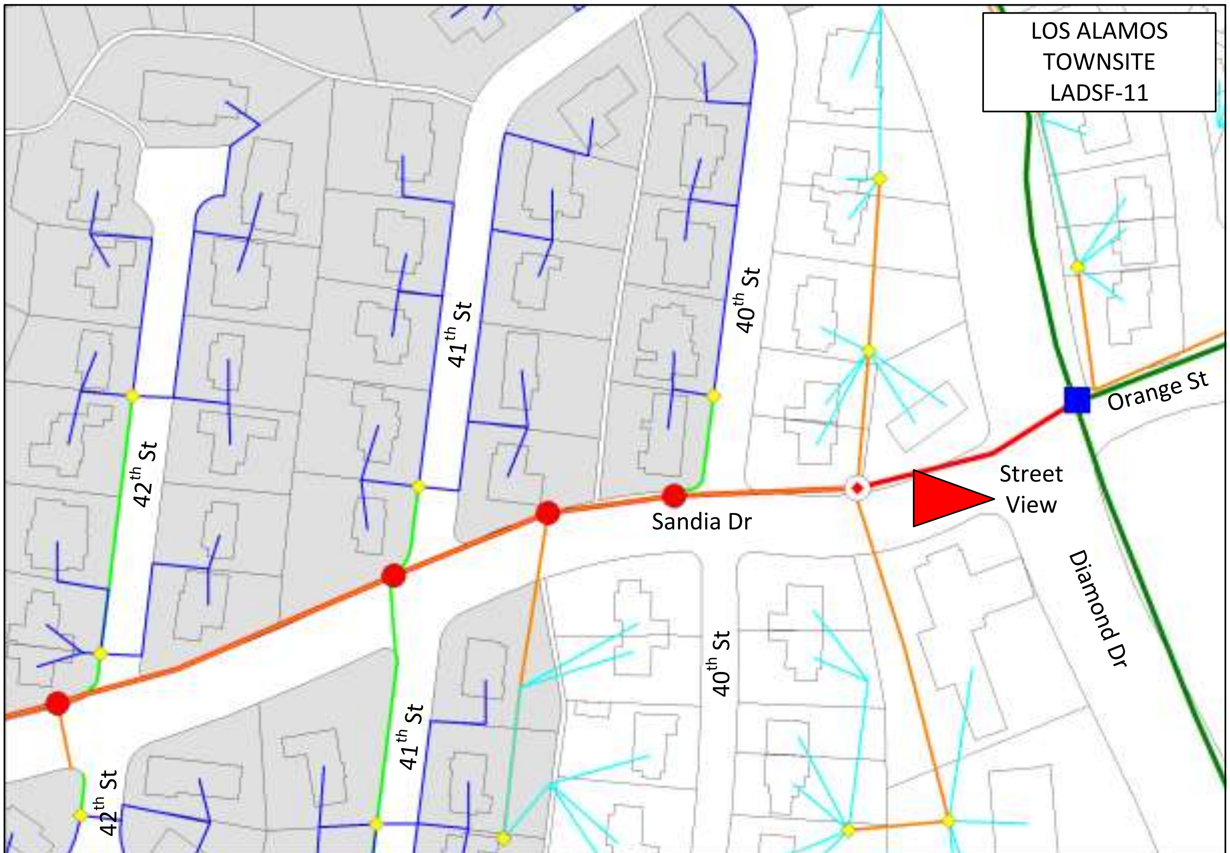
CRESTINO Telecommunications Solutions	Los Alamos County Community Broadband Network	Date: 10/10/2011	Revisions:	Date:	Initials:	File Name: LA Core-Lat -w-DSF.vsd
	Los Alamos Townsite LADSF-09 Location	Scale: Not to scale	Contact:	Phone:		Drawn By: D. Zazueta



LEGEND

- DSF (Distribution Switch Facility)
- Drop Closure
- Lateral Splice
- Core Splice
- Core Fiber Aerial
- Core Fiber Underground
- Lateral Fiber Aerial
- Lateral Fiber Underground
- Drop Fiber Aerial
- Drop Fiber Underground

CRESTINO Telecommunications Solutions	Los Alamos County Community Broadband Network	Date: 10/10/2011	Revisions:	Date:	Initials:	File Name: LA Core-Lat -w- DSF.vsd
	Los Alamos Townsite LADSF-10 Location	Scale: Not to scale	Contact:	Phone:		Drawn By: D. Zazueta



LEGEND

- DSF (Distribution Switch Facility)
- Drop Closure
- Lateral Splice
- Core Splice
- Core Fiber Aerial
- Core Fiber Underground
- Lateral Fiber Aerial
- Lateral Fiber Underground
- Drop Fiber Aerial
- Drop Fiber Underground

CRESTINO Telecommunications Solutions	Los Alamos County Community Broadband Network	Date: 10/10/2011	Revisions:	Date:	Initials:		File Name: LA Core-Lat -w-DSF.vsd
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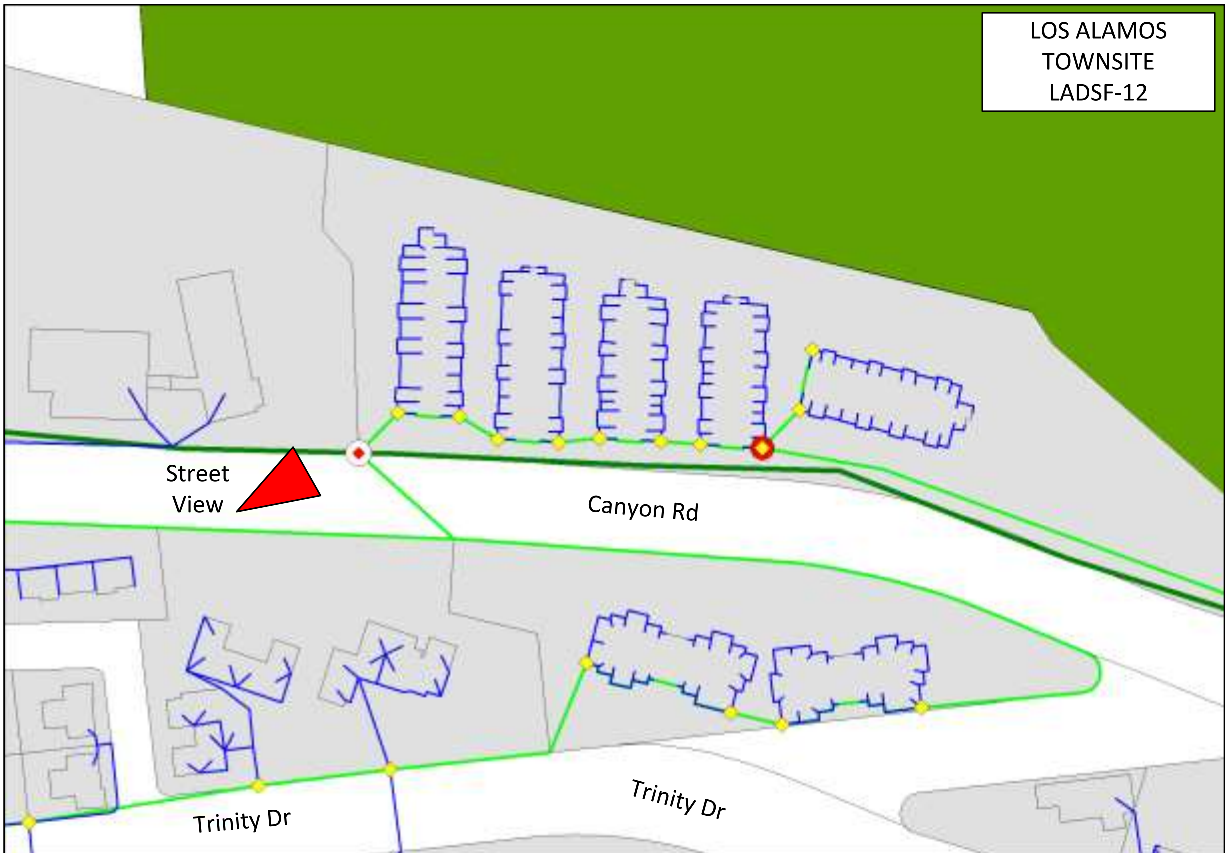
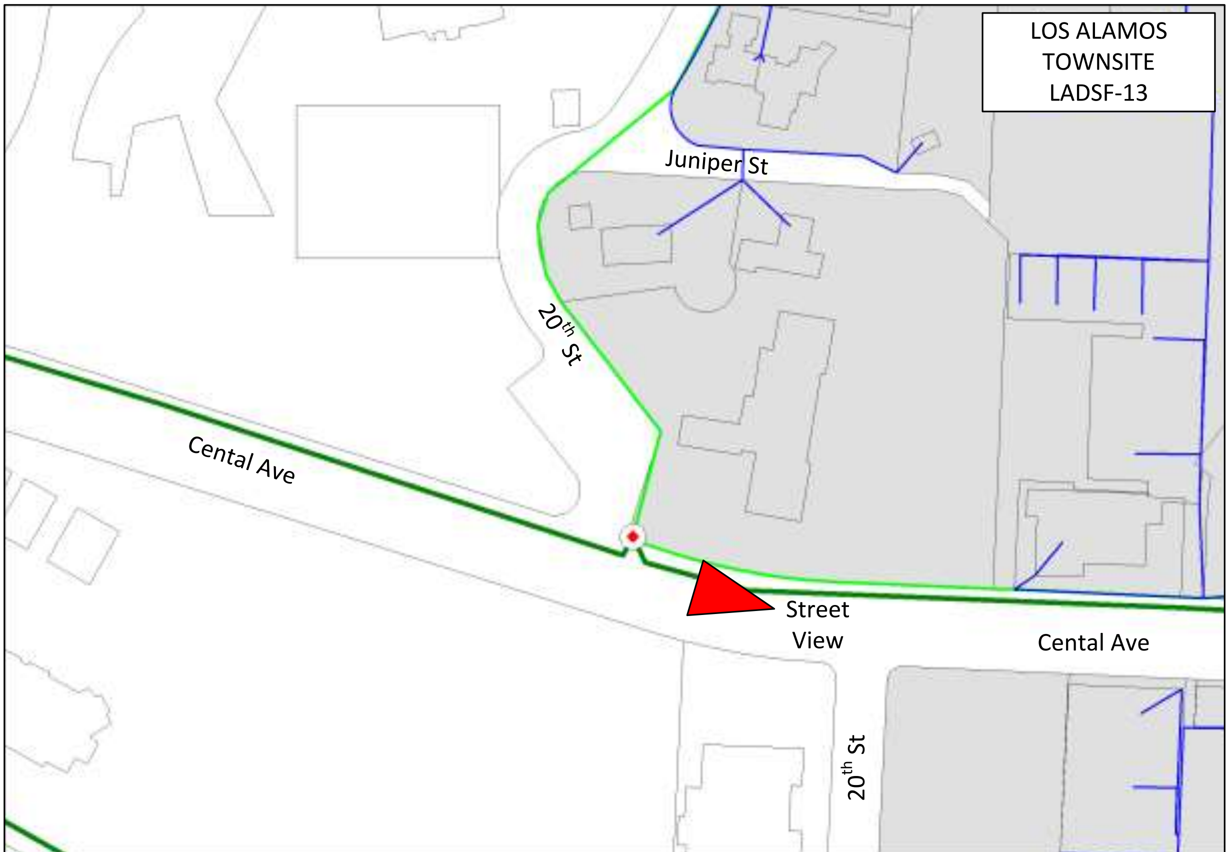


LEGEND

- DSF (Distribution Switch Facility)
- Drop Closure
- Lateral Splice
- Core Splice
- Core Fiber Aerial
- Core Fiber Underground
- Lateral Fiber Aerial
- Lateral Fiber Underground
- Drop Fiber Aerial
- Drop Fiber Underground

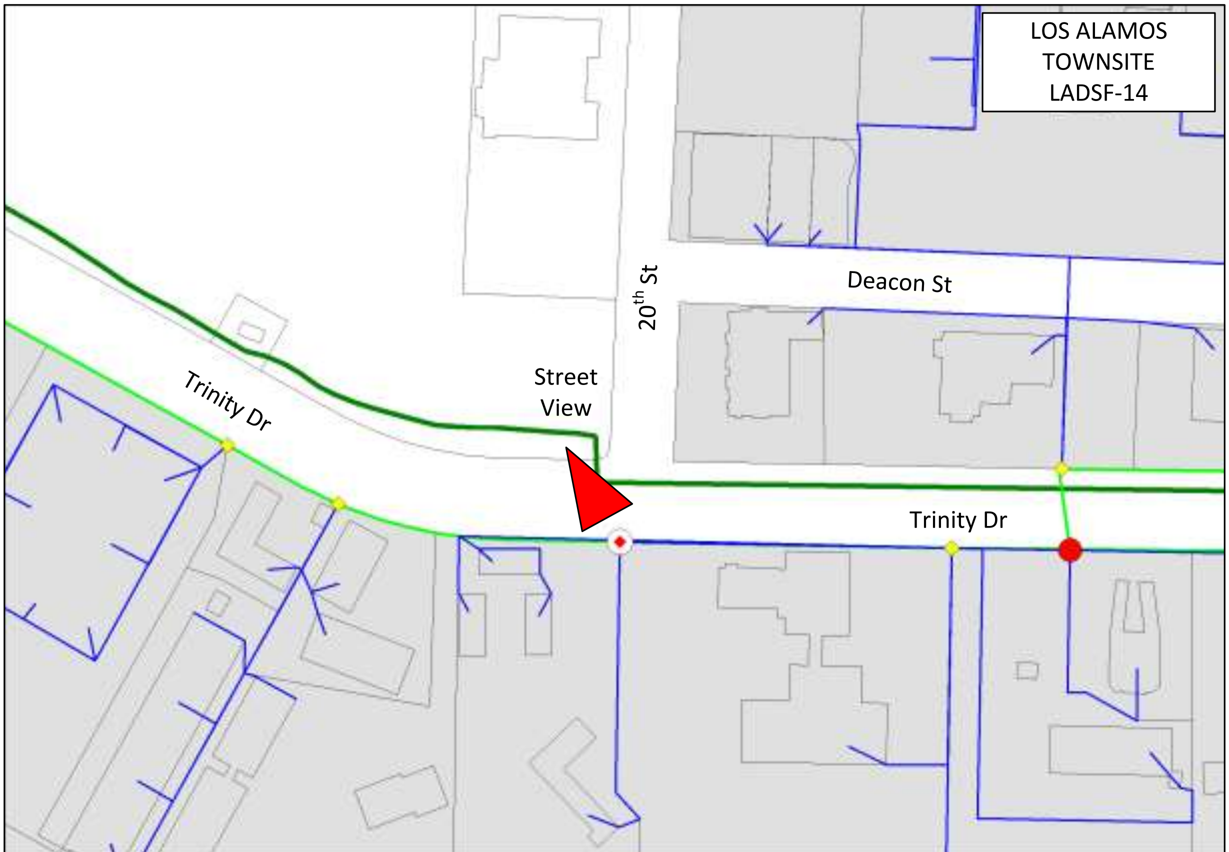
CRESTINO Telecommunications Solutions	Los Alamos County Community Broadband Network	Date: 10/10/2011	Revisions:	Date:	Initials:	File Name: LA Core-Lat -w-DSF.vsd
	Los Alamos Townsite LADSF-12 Location	Scale: Not to scale	Contact:	Phone:		Drawn By: D. Zazueta



LEGEND

- DSF (Distribution Switch Facility)
- Drop Closure
- Lateral Splice
- Core Splice
- Core Fiber Aerial
- Core Fiber Underground
- Lateral Fiber Aerial
- Lateral Fiber Underground
- Drop Fiber Aerial
- Drop Fiber Underground

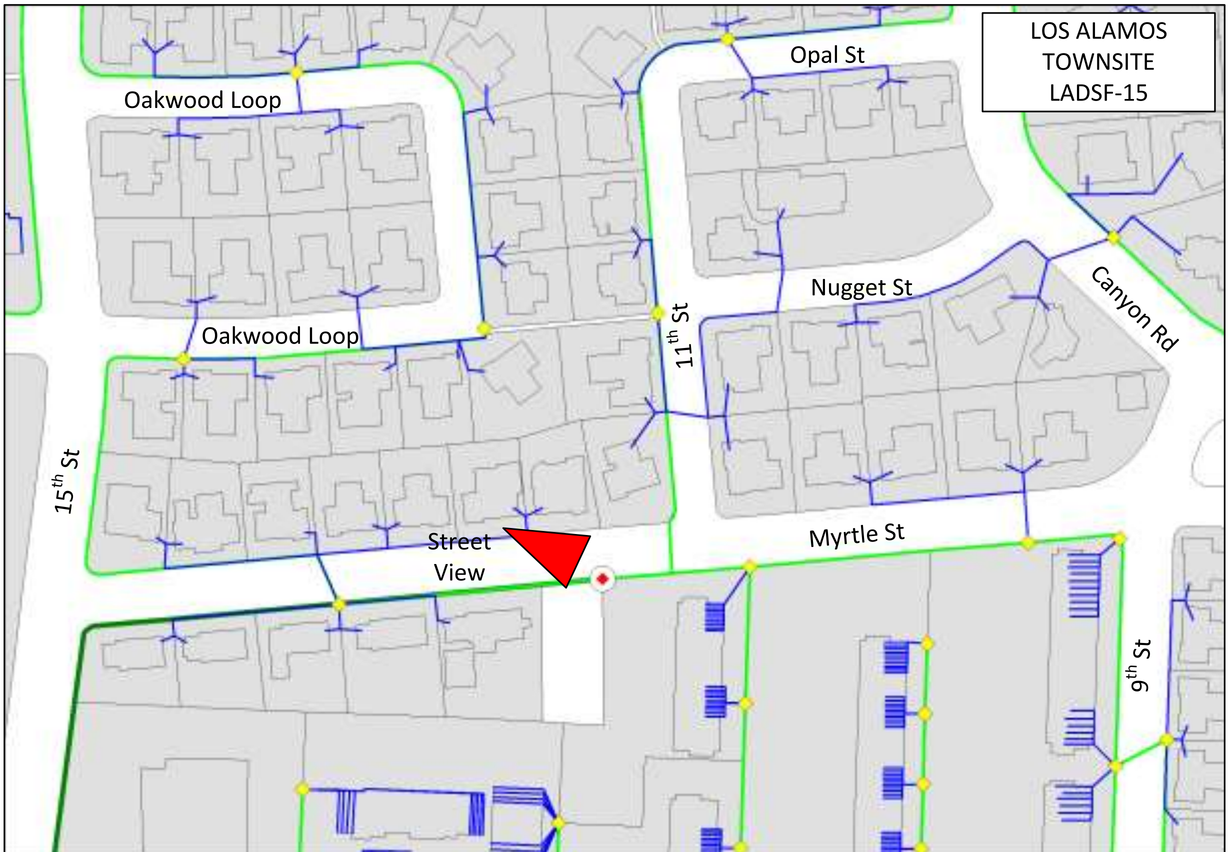
CRESTINO Telecommunications Solutions	Los Alamos County Community Broadband Network	Date: 10/10/2011	Revisions:	Date:	Initials:	File Name: LA Core-Lat -w-DSF.vsd
	Los Alamos Townsite LADSF-13 Location	Scale: Not to scale	Contact:	Phone:		Drawn By: D. Zazueta



LEGEND

- DSF (Distribution Switch Facility)
- Drop Closure
- Lateral Splice
- Core Splice
- Core Fiber Aerial
- Core Fiber Underground
- Lateral Fiber Aerial
- Lateral Fiber Underground
- Drop Fiber Aerial
- Drop Fiber Underground

CRESTINO Telecommunications Solutions	Los Alamos County Community Broadband Network	Date: 10/10/2011	Revisions:	Date: Initials:	File Name: LA Core-Lat -w-DSF.vsd
	Los Alamos Townsite LADSF-14 Location	Scale: Not to scale	Contact:	Phone:	Drawn By: D. Zazueta



LEGEND

- DSF (Distribution Switch Facility)
- Drop Closure
- Lateral Splice
- Core Splice
- Core Fiber Aerial
- Core Fiber Underground
- Lateral Fiber Aerial
- Lateral Fiber Underground
- Drop Fiber Aerial
- Drop Fiber Underground

CRESTINO Telecommunications Solutions	Los Alamos County Community Broadband Network	Date: 10/10/2011	Revisions:	Date:	Initials:	File Name: LA Core-Lat -w-DSF.vsd
	Los Alamos Townsite LADSF-15 Location	Scale: Not to scale	Contact:	Phone:		Drawn By: D. Zazueta

LOS ALAMOS TOWNSITE
LADSF-16

LEGEND

- DSF (Distribution Switch Facility)
- Drop Closure
- Lateral Splice
- Core Splice
- Core Fiber Aerial
- Core Fiber Underground
- Lateral Fiber Aerial
- Lateral Fiber Underground
- Drop Fiber Aerial
- Drop Fiber Underground

CRESTINO Telecommunications Solutions	Los Alamos County Community Broadband Network	Date: 10/10/2011	Revisions:	Date:	Initials:	File Name: LA Core-Lat -w-DSF.vsd
	Los Alamos Townsite LADSF-16 Location	Scale: Not to scale	Contact:	Phone:		Drawn By: D. Zazueta

LEGEND

- DSF (Distribution Switch Facility)
- Drop Closure
- Lateral Splice
- Core Splice
- Core Fiber Aerial
- Core Fiber Underground
- Lateral Fiber Aerial
- Lateral Fiber Underground
- Drop Fiber Aerial
- Drop Fiber Underground

CRESTINO Telecommunications Solutions	Los Alamos County Community Broadband Network	Date: 10/10/2011	Revisions:	Date:	Initials:	File Name: LA Core-Lat -w-DSF.vsd
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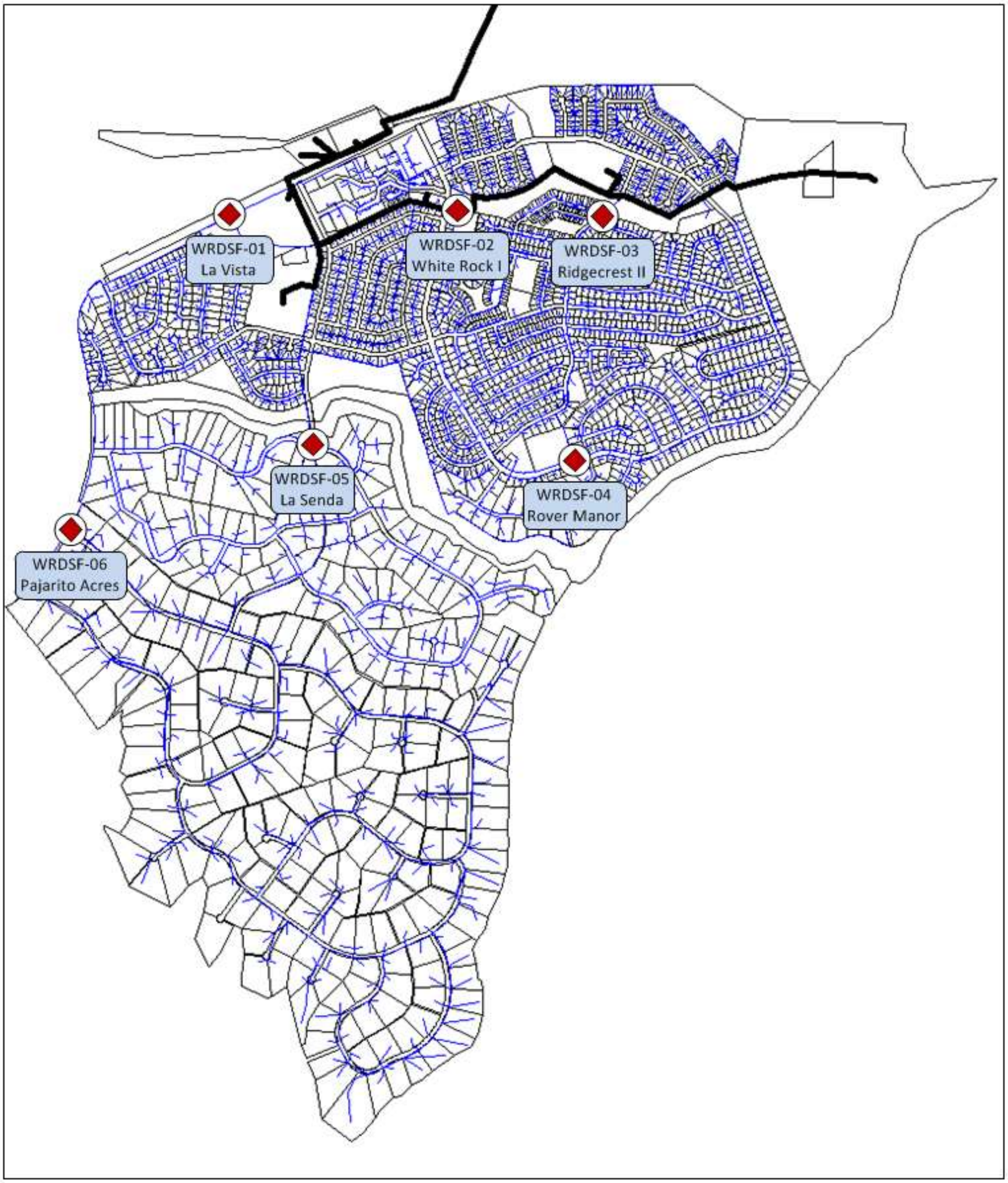
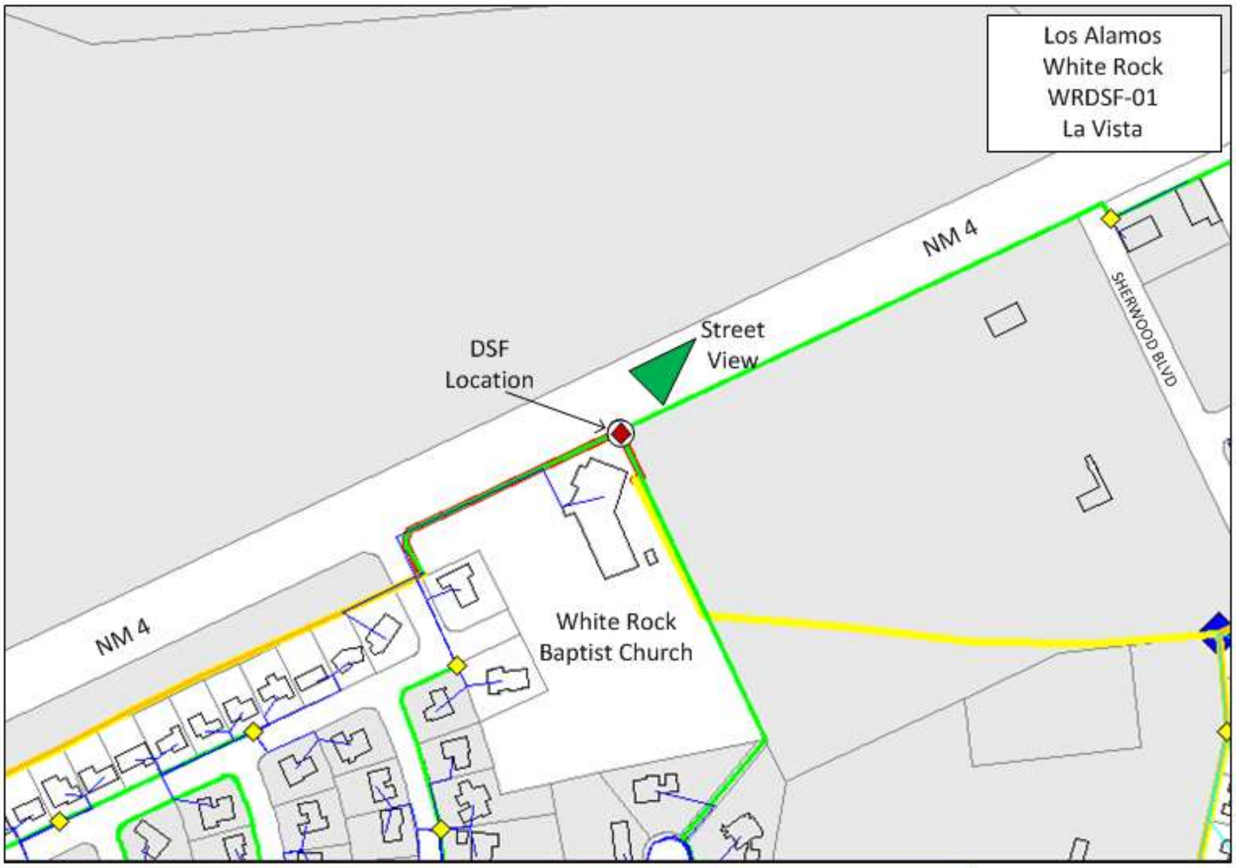


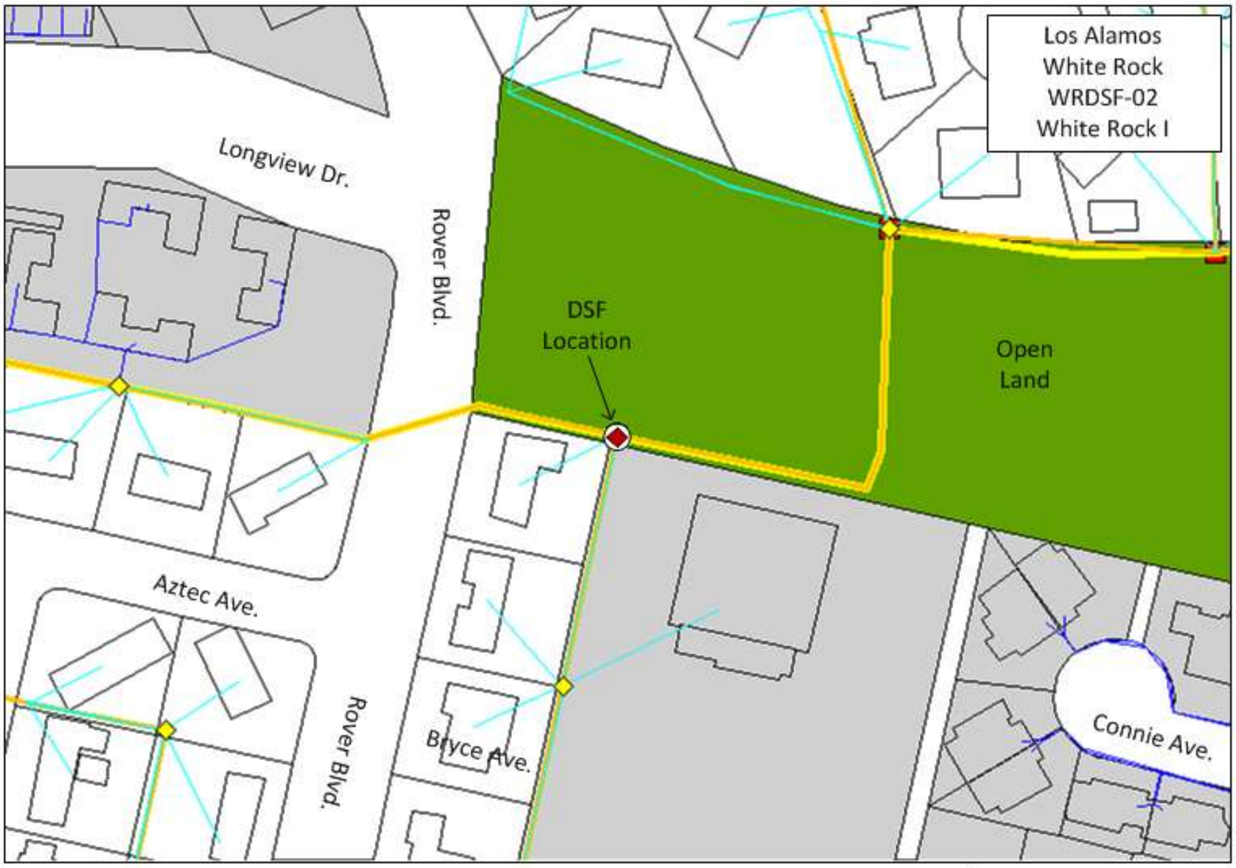
CRESTINO Telecommunications Solutions	Los Alamos County Community Broadband Network	Date: 9/23/2011	Revisions: Date: Initials:	File Name: WR Core-Lat -w-DSF.vsd
	White Rock DSF Location Drawings	Scale: Not to scale	Contact: Phone:	Drawn By: S.Delgado



LEGEND

- DSF (Distribution Switch Facility)
- Drop Closure
- Lateral Splice
- Core Splice
- Core Fiber Aerial
- Core Fiber Underground
- Lateral Fiber Aerial
- Lateral Fiber Underground
- Drop Fiber Aerial
- Drop Fiber Underground

CRESTINO Telecommunications Solutions	Los Alamos County Community Broadband Network	Date: 9/23/2011	Revisions:	Date:	Initials:	File Name: WR Core-Lat -w-DSF.vsd
	White Rock WRDSF-01 Location La Vista	Scale: Not to scale	Contact:	Phone:		Drawn By: S.Delgado



Picture Not Available

LEGEND

- DSF (Distribution Switch Facility)
- Drop Closure
- Lateral Splice
- Core Splice
- Core Fiber Aerial
- Core Fiber Underground
- Lateral Fiber Aerial
- Lateral Fiber Underground
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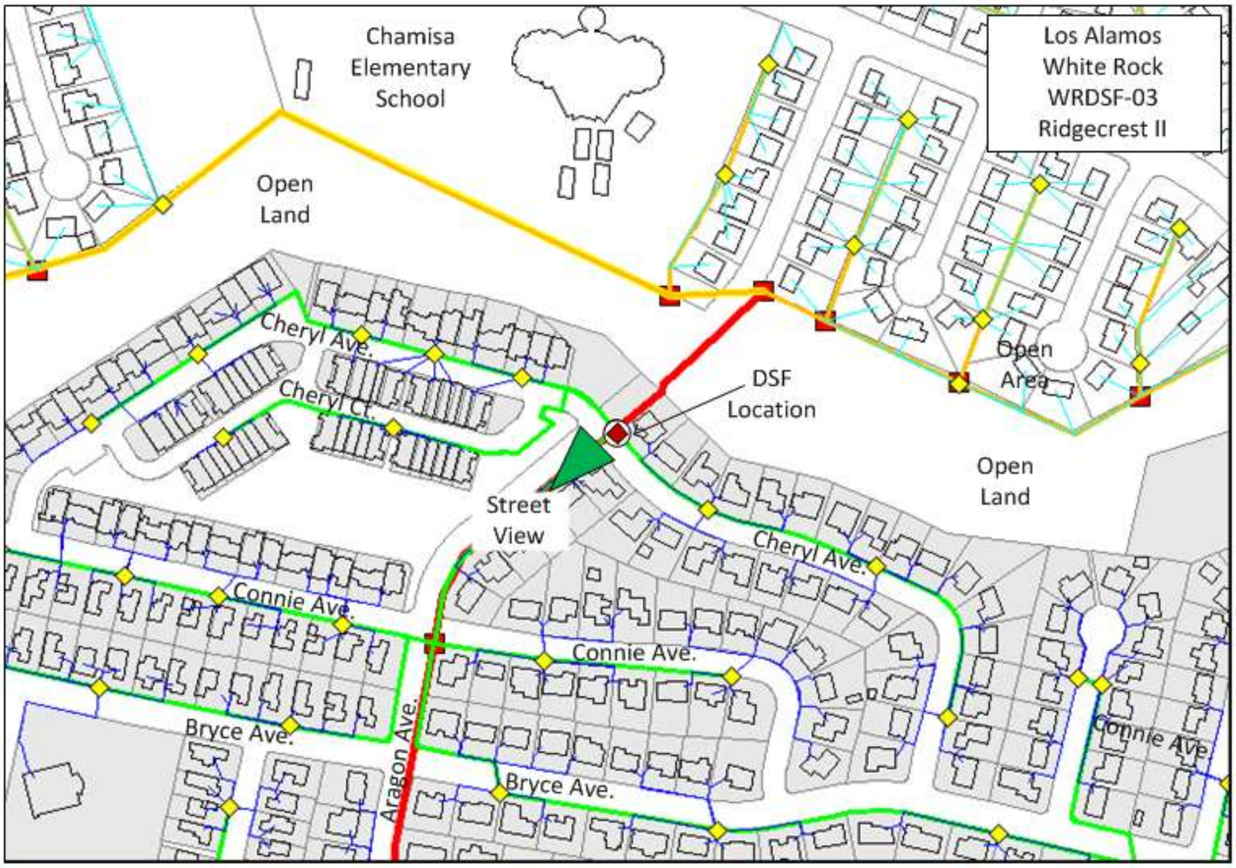
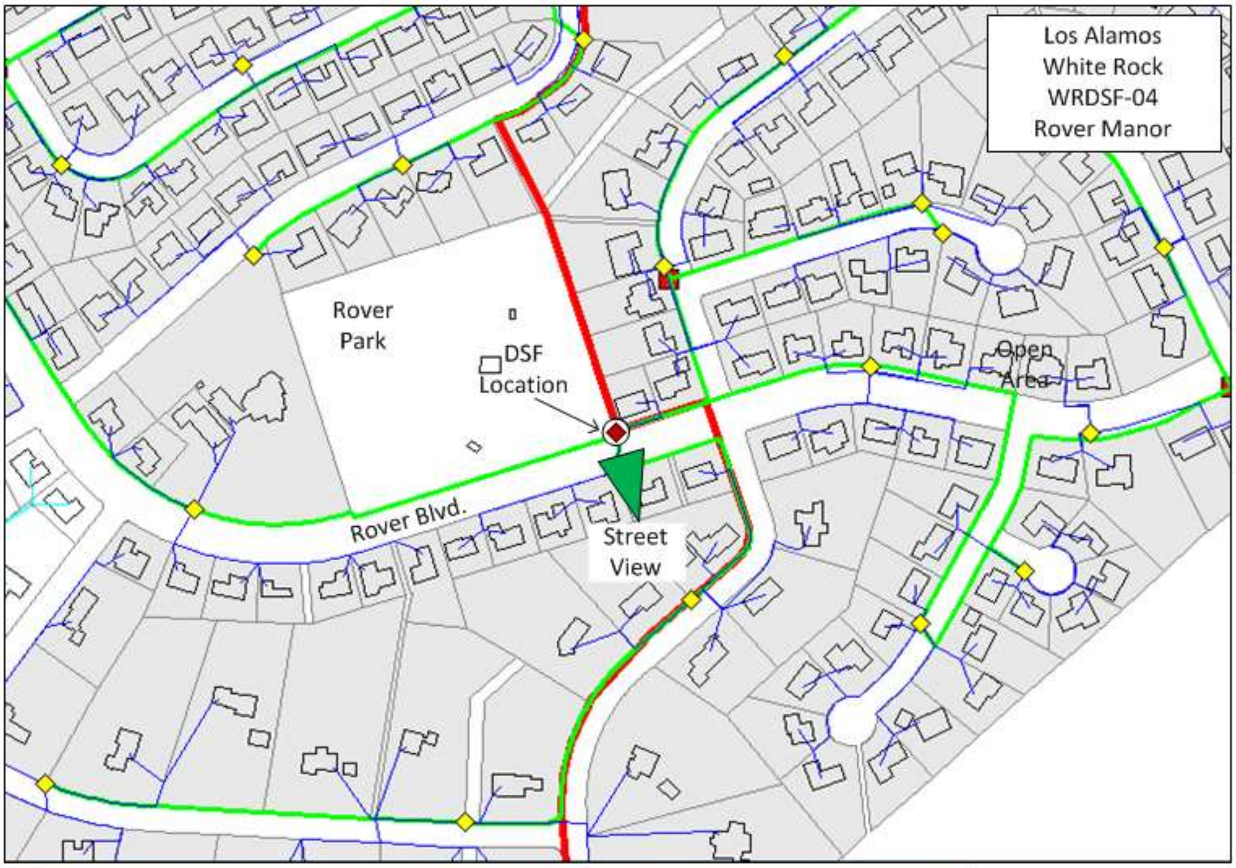
CRESTINO Telecommunications Solutions	Los Alamos County Community Broadband Network	Date: 9/23/2011	Revisions:	Date:	Initials:	File Name: WR Core-Lat -w-DSF.vsd
	White Rock WRDSF-02 Location White Rock I	Scale: Not to scale	Contact:	Phone:		Drawn By: S.Delgado



LEGEND

- DSF (Distribution Switch Facility)
- Drop Closure
- Lateral Splice
- Core Splice
- Core Fiber Aerial
- Core Fiber Underground
- Lateral Fiber Aerial
- Lateral Fiber Underground
- Drop Fiber Aerial
- Drop Fiber Underground

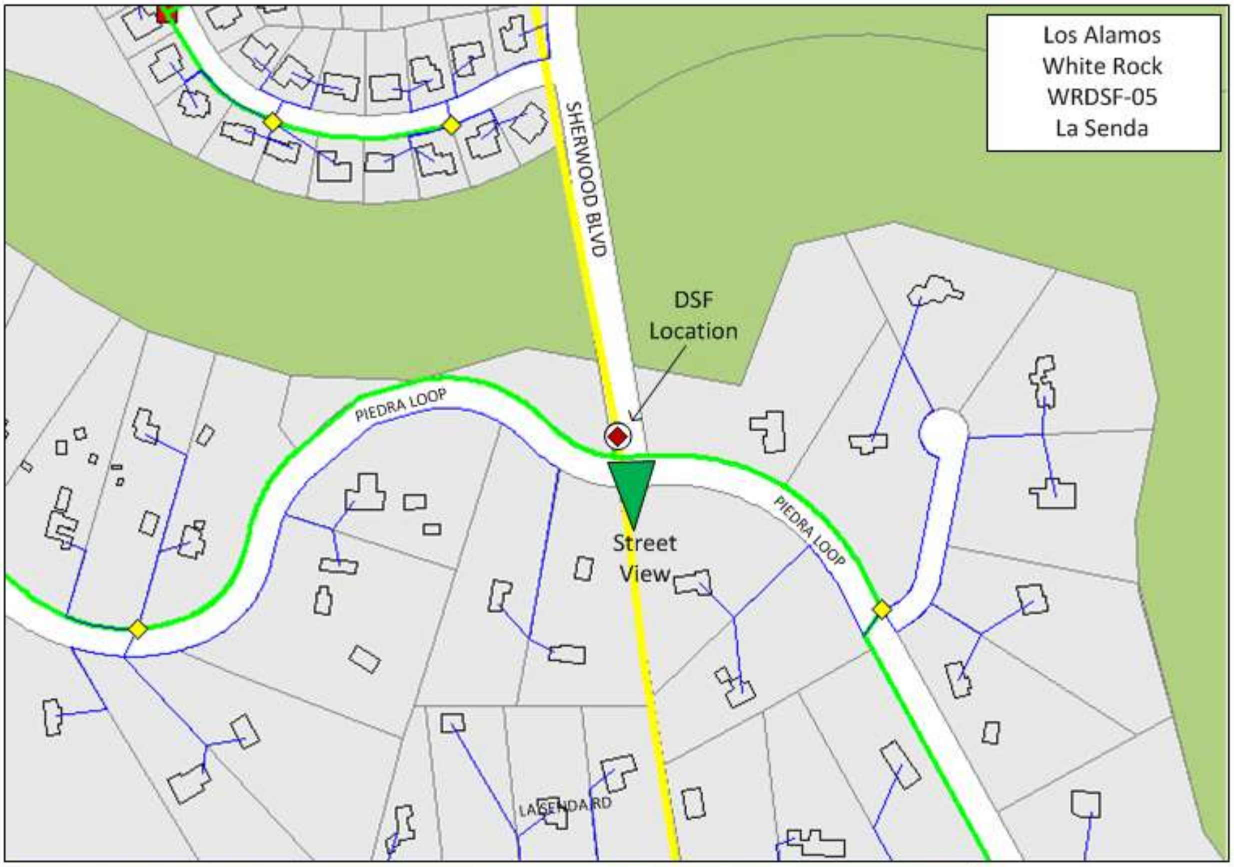
CRESTINO Telecommunications Solutions	Los Alamos County Community Broadband Network	Date: 9/23/2011	Revisions:	Date:	Initials:	File Name: WR Core-Lat -w-DSF.vsd
	White Rock WRDSF-03 Location Ridgecrest II	Scale: Not to scale	Contact:	Phone:		Drawn By: S.Delgado



LEGEND

- DSF (Distribution Switch Facility)
- Drop Closure
- Lateral Splice
- Core Splice
- Core Fiber Aerial
- Core Fiber Underground
- Lateral Fiber Aerial
- Lateral Fiber Underground
- Drop Fiber Aerial
- Drop Fiber Underground

CRESTINO Telecommunications Solutions	Los Alamos County Community Broadband Network	Date: 9/23/2011	Revisions:	Date:	Initials:	File Name: WR Core-Lat -w-DSF.vsd
	White Rock WRDSF-04 Location Rover Manor	Scale: Not to scale	Contact:	Phone:		Drawn By: S.Delgado



LEGEND

- DSF (Distribution Switch Facility)
- Drop Closure
- Lateral Splice
- Core Splice
- Core Fiber Aerial
- Core Fiber Underground
- Lateral Fiber Aerial
- Lateral Fiber Underground
- Drop Fiber Aerial
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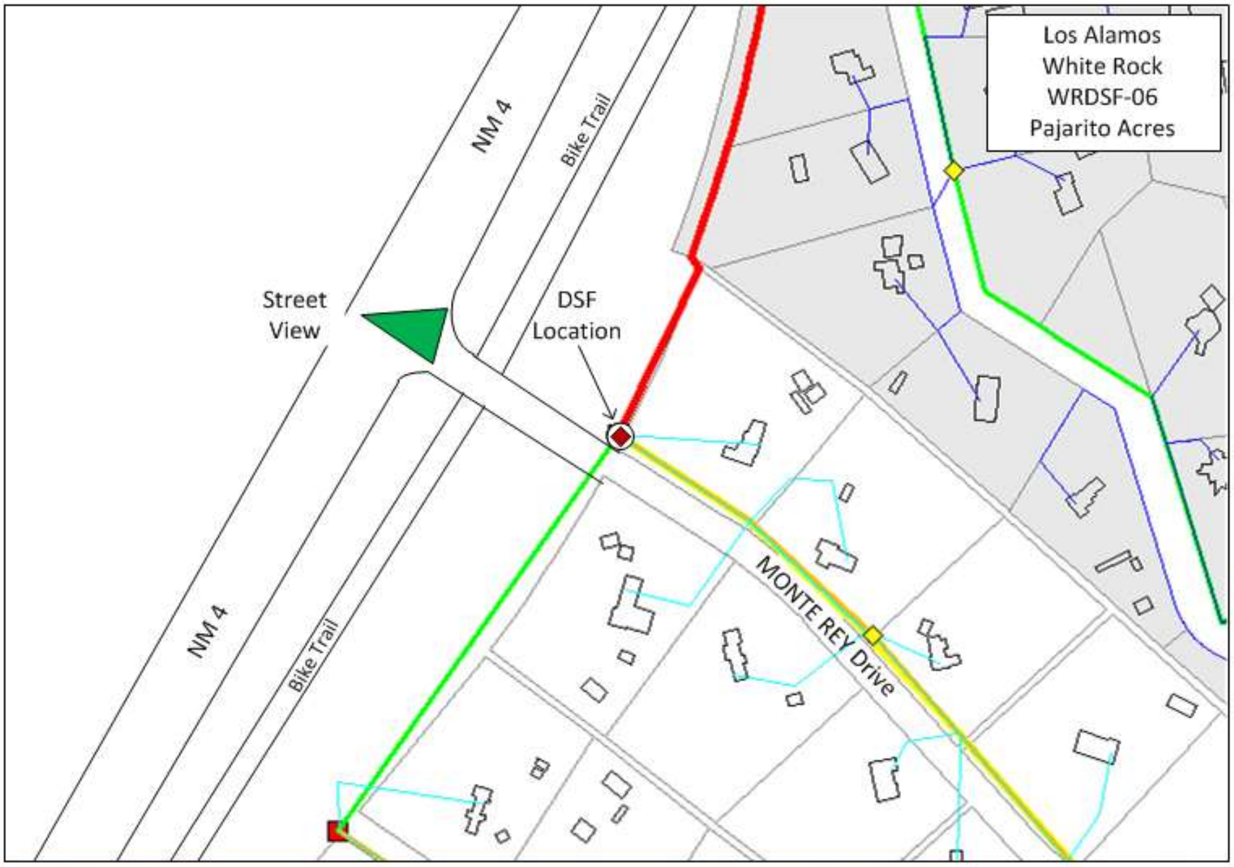
CRESTINO Telecommunications Solutions	Los Alamos County Community Broadband Network	Date: 9/23/2011	Revisions:	Date:	Initials:	File Name: WR Core-Lat -w-DSF.vsd
	White Rock WRDSF-05 Location La Senda	Scale: Not to scale	Contact:	Phone:		Drawn By: S.Delgado



LEGEND

- DSF (Distribution Switch Facility)
- Drop Closure
- Lateral Splice
- Core Splice
- Core Fiber Aerial
- Core Fiber Underground
- Lateral Fiber Aerial
- Lateral Fiber Underground
- Drop Fiber Aerial
- Drop Fiber Underground

CRESTINO Telecommunications Solutions	Los Alamos County Community Broadband Network	Date: 9/23/2011	Revisions:	Date:	Initials:	File Name: WR Core-Lat-w-DSF.vsd
	White Rock WRDSF-06 Location Pajarito Acres	Scale: Not to scale	Contact:	Phone:		Drawn By: S.Delgado