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Deploying a Broadband Network – From Start to Finish (and Beyond)

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1 Executive Overview

Building a broadband network is a time-consuming, capital-intensive endeavor, which requires a considerable amount of planning and analysis to be successful. To be successful, a broadband network must be able to meet the customer's demands both today and into the future. Much of the investment in a broadband network is used to install elements that have economic lives of 30 years or longer, a term for which it can be difficult – if not impossible – to accurately predict customer demands over the life of the network. Long-term capital investments such as this can therefore be very risky ventures for the broadband provider and their investors.

The risk is significantly greater still in rural areas where the cost to construct to any given customer is much higher than urban areas. The lower population densities in the rural areas require the provider to make much larger investments in infrastructure and incur more expense associated with environmental permitting processes. The low customer density and large geographies of rural areas also result in higher operational costs as well.

There are a variety of network architectures being used today to deliver broadband, but nearly all providers understand that fiber provides the best broadband capabilities both immediately and over the longer term. Wireline networks are most commonly based on copper cables, such as coaxial or twisted pair, which struggle to keep up with the rapidly increasing broadband demands. As these copper networks reach the end of their useful lives, it is common for the copper cables to be replaced with fiber.

Like wireline copper networks, many wireless networks also struggle to deliver adequate broadband speeds because of limited spectrum availability, environmental effects, or over-loading. To minimize these broadband bottlenecks, wireless and wireline providers alike are replacing large portions of their networks with fiber.

It is costly to deploy a broadband network even in ideal conditions. However, there are many local factors and customer demographics that can dramatically increase the costs. Customer density is one of the largest contributors to network costs. There is often no business case to serve customers who live outside areas with customer densities less than what is typical for a town customer. In rural areas that surround larger metropolitan areas, the broadband provider may be able to justify serving the rural customers by cost averaging the lower cost town customers with the higher cost rural customers. However, in some rural areas, the towns themselves are too small to have enough lower cost customers to make the rural areas economical to serve. In these instances, even where capital to build is on hand or otherwise in theory available, the provider must rely on mechanisms such as Universal Service Funding to make a business case to serve the rural customers.

Deploying a broadband network is a very capital-intensive undertaking, regardless if it is in a greenfield environment or when replacing an existing network. The extensive planning, long construction timeframes, and the coordination of approvals and permits from various regulatory, government and private entities add to the complexity and cost. The intent of this document is to give a brief overview of the process often needed to deploy a broadband network. This document is not intended to be exhaustive, since there are often local or regional rules and regulations that impact deployment costs and increase timeframes. This document will overview the processes common to nearly all deployments, focusing on the initial deployment but also covering some aspects of the operational expense and complexity introduced once the network is built.

2 Network Deployment Steps

For this document, the network deployment discussion has been divided into five primary phases. These are, 1) Business Planning, 2) Financing, 3) Design and Engineering, 4) Construction, and 5) Operations. As shown in Figure 2-1, each of these stages require complex, time-consuming, and costly efforts to be performed before the deployment can proceed to the subsequent phase or services ultimately delivered. Many of these tasks require a provider to obtain outside resources to properly and fully complete the requirements. Each of these phases are described in the following sections.

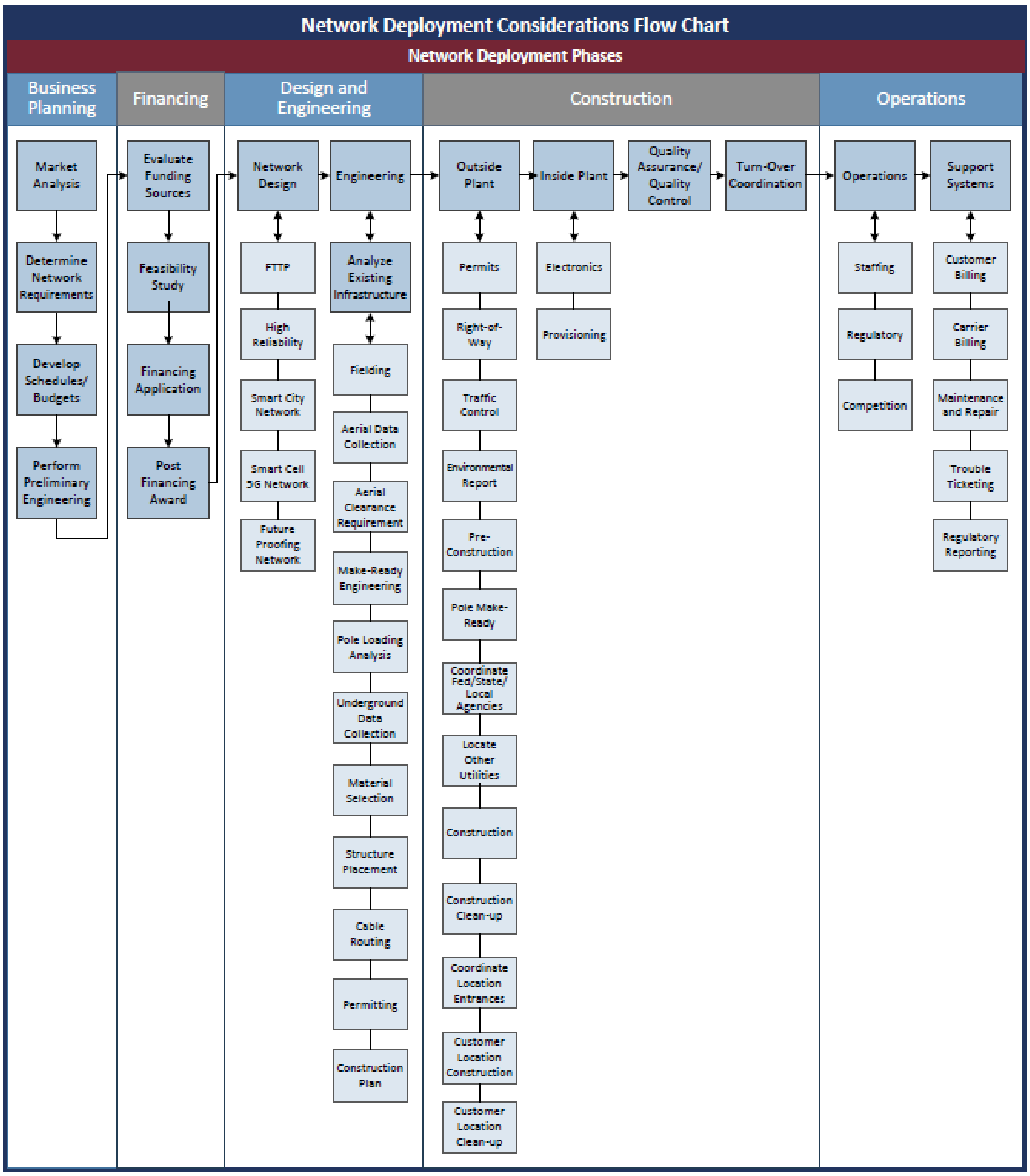


Figure 2-1: Network Deployment Phases

3 Business Planning

The initial step of a network deployment is the business planning phase. The business planning determines the area to be built, the services to be offered, the deployment schedule, and the overall project budget. The business planning requires a significant amount of effort and research and often requires outside resources to perform surveys, market studies, and high-level technical studies for compiling estimated budgets and schedules.

Once a business plan has been developed, it is typically reviewed by the provider's senior management, board of directors, business partners, and/or investors to decide whether to proceed with the project or not. A viable business plan is often a balance between the cost to deploy the broadband network along with anticipated upgrade costs and the expected revenues from customers and other sources that will provide at least some reasonable return and/or the ability to repay any debt.

3.1 Market Analysis

When offering new services to existing customers or building a network outside of a service provider's existing footprint, it is important to study the demographics and needs of the potential customers. To determine market demand and penetration rates, the provider must analyze the current wireline and wireless competition in the market. A detailed market analysis often includes a survey process to gather information from the potential customers to determine many key factors, such as:

- Capabilities and product pricing of current service providers
- Customer satisfaction with current service providers
- Customer demand
- Estimates of take rates
- Pricing sensitivity

This process is time consuming and typically utilizes outside sources to make phone calls and conduct focus groups.

The market analysis may also include coordinating with the local governments to determine interest in Smart City-type applications and identify potential anchor institutions. This could include service to local institutions (schools, libraries, public safety and other government buildings), as well as sensors (street lights and traffic signals).

3.2 Competition Analysis

Another item to consider when deploying a broadband network is determining the competitive environment in the areas being overbuilt. This step is often missed or only partially completed. In reviewing the market, a competitive analysis should be completed to determine how the service take rates may be impacted. In completing a competitive analysis, the main items to be considered consist of the following:

- Identify the Incumbent Service Provider(s) – The incumbent could be a price cap carrier, a wireless carrier, and/or a cable provider. Research of the market should be completed to determine which carriers are currently providing service today.
- Determine Presence of Competitive Providers – In addition to incumbent providers, determine if there are any competitive providers which may include both wireline/cable providers as well as wireless carriers.
- Strength of Name Recognition – Having a strong name and/or brand recognition and being known for high quality service would carry over in to a new market. Customers' perception of the services provided will have a significant impact on whether a new broadband provider will have a solid take rate and customer following.
- Current Services and Rates – A review of what services are currently being offered to the market as well as the current rates being charged will be the precursor of the services and rates to be offered when deploying a new broadband network.

In addition, an assessment must be made regarding the incumbent's ability and willingness to react to an additional competitor. Since building a competing network takes months or years of effort, the incumbent has the opportunity to upgrade its network if able and willing to do so, which could have impacts on the business plan.

3.3 Determine Network Required to Deliver Services

Following the market analysis, the second element of business planning is to determine the network topologies that would support the services the customers desire. This is necessary for compiling high-level project cost estimates and schedules. The correct network may be a combination of more than one network technology to meet the needs of all types of users including residential, business, and anchor institutions.

Much planning goes into the network topology planning and requires engineering resources to perform preliminary designs and options, cost estimates and technical reports regarding the pros and cons of various options. The following are types of modern wireline networks that are often considered, although the processes and procedures outlined in this paper are not limited to such networks; most are equally applicable to other terrestrial networks, particularly when one considers again that even "wireless" networks are in most cases dependent upon increasing densification of cells and wired backhaul to handle current and future data needs. To use a colloquial phrase: Wireless needs wires.

Fiber to the Premises (FTTP) Network

Most broadband networks today, regardless if they are wireless or wireline, rely heavily on fiber optic cable. Most modern wireline networks are constructed entirely of fiber because it is the least expensive medium to deploy and operate measured over the life of the network assets and has the largest bandwidth capabilities as an initial matter and as a matter of scalability in the future. These wireline networks are generically referred to as Fiber-to-the-Premises (FTTP) networks. FTTP networks can be architected as either a shared or dedicated design depending on the service needs of subscribers.

The shared network architecture utilizes passive optical network (PON) topology. Optical splitters are utilized in the network to share the broadband capacity between groups of subscribers (typically up to 32 subscribers). It is generally targeted to residential subscribers and small businesses that require up to 1 Gbps services, and has a cost advantage over a dedicated system because not every fiber has to "home run" back to an active equipment location, which results in fewer fibers and fewer fiber splices.

Some FTTP architectures rely on a dedicated fiber to each customer and often utilize Active Ethernet (AE) technology. This design implements a point-to-point architecture with dedicated fiber to serve residential and business customers. This means that each subscriber is served by a fiber strand that is dedicated from their premises back to the site where the distribution electronics are located. AE technology provides for speeds of 1 Gbps or more both upstream and downstream for each user. It is generally targeted to businesses and "power user" residential subscribers that require 1 Gbps or higher services, with 10 Gbps services planned for some areas.

Dedicated Circuit Services

While FTTP services are typically utilized for providing Internet service, some end users may request services to enable private transport connections between the sites. For example, this could be a large business with multiple sites. Carrier Ethernet technologies such as Ethernet Private Line (EPL) can be utilized to enable these private circuits between customer locations.

Custom Services

The network can also be designed to support a variety of Smart City services depending on the needs of the city. This could include supporting Smart City applications such as street light sensors, traffic sensors, cameras and connecting various city institutions. Depending on specific needs of the applications, the network could support dedicated dark fiber, private dedicated circuits, or broadband connections such as 1 Gbps or 10 Gbps, and be ready for 100 Gbps when demand requires.

Likewise, the network can also be designed to support Small Cell services depending on the needs of service providers. This could include dark fiber or broadband connections (such as 1 Gbps or 10 Gbps) to the Small Cell locations.

3.4 Develop Preliminary Schedules and Budgets

A final step of the business planning phase is to determine preliminary project schedules and budgets. The project schedules may include a phased plan for how the network will be constructed over several years. The project phases could be determined by specific geographic areas based on ease of construction, customer density, or political or government factors, or based on expected penetration rates. Alternatively, the project phases could be determined by the prioritization of services that are being provided, such as residential and business.

Once the project phases are determined, budgetary estimates can be compiled for each of the phases of the projects. This would include outside plant, electronics, operations and maintenance budgets. Additionally, operations and maintenance budgets are compiled. This includes staff salary and benefits requirements for the provider's various departments. It also includes areas such as vehicles, test equipment, billing systems, trouble ticket systems, and mapping systems.

4 Financing

4.1 Evaluation of Funding Sources

Depending on the geographic location, the status of competition, and the types of services to be offered, there are several state and federal financing options in addition to private lending institutions that are typically evaluated as potential funding sources.

Several states have developed broadband grant programs to provide funds for broadband deployments in areas that are currently unserved or underserved. Minnesota and New York are a couple of examples of states that have recently offered broadband grant awards.

Additionally, federal grant and low interest loan programs are available through the USDA's Rural Utilities Service (RUS). These include the Telecommunications Infrastructure, Farm Bill Broadband, and Community Connect programs.

These programs are often targeted to providing broadband to customers that meet specific criteria such as rurality of the serving area, currently available broadband speeds, number of competitors, and proposed service offerings that affect the eligibility of the specific proposed project. Therefore, considerable effort is required to understand the requirements of each program and to identify potential projects that satisfy the requirements.

In some areas, the cost to serve the customer is simply too great. The end user revenues needed to deploy and then support the network over time are beyond what the end user is willing or able to pay. In these instances, a business case cannot be made with a low interest loan (or even a federal, state, or local grant or the provider's own cash on hand), and the provider must therefore rely upon outside sources of funding such as what is available through the Universal Service Funds (USF) to make the business case.

4.2 Feasibility Study and Financing Application

Any external funding source will require some form of feasibility study to be provided. Depending on the program, it is likely that portions of the application may need to be developed and certified by a provider's professional engineering firm and financial consultant.

These studies incorporate the budgets, market penetration, rates and service offering information from the business planning phase to develop a multi-year financial forecast. A financial forecast includes the capital costs and depreciation, balance sheet, operating revenues and expenses and cash flows for each future year. Sample feasibility study information is included in Appendix A. Some key financial statements in the feasibility study include:

- Projected balance sheet
- Projected income statement
- Projected cash flow
- Projected ROR on investment
- Projected breakeven
- Projected financing ratios (DSCR, Debt-to-Equity, TIER)

In addition to the feasibility study, there is a large amount of additional information that most financing applications require. This may include:

- Company history
- Management experience
- Service plans and pricing
- Marketing plan
- Competition analysis
- Network maps
- Existing and proposed network descriptions
- Demonstration of community support
- Financial references

4.3 Post Financing Award

Once a provider has been awarded financing, there is typically a large amount of reporting requirements and procedures that must be followed, including:

- Construction progress reports
- Periodic financial reports
- Requests for reimbursement
- Audit support

The financing entity may also have specific procedures that the provider must adhere to regarding how construction contracts are awarded. This may include utilizing the entity's contract forms and obtaining approvals prior to the award of contracts.

5 Design and Engineering

Assuming the business plan and financial studies look positive, the design and engineering of the network commences. This is a time- and labor-intensive phase in which detailed designs and engineering plans are developed. A detailed engineering plan requires extensive on-site surveys and research to develop construction maps. Licensed professional engineers are often engaged to ensure that the plans meet local, state, and national codes in addition to industry standards, as well as protect the public safety.

5.1 Design

The overall design is based on delivering the services that were determined to be required in the business plan in the most cost-effective manner. Each of the service offerings require that specific network design needs be met.

Rural network designs are almost always more expensive on a per-subscriber basis than urban designs. It is not uncommon for the cost to serve a rural customer to be 4 or more times the cost to serve a town customer. The lower subscriber density of rural networks results in fewer subscribers over which to spread the network costs across. Additionally, rural network designs are unable to obtain the efficiencies of scale that can be achieved with urban networks. For example, a centralized electronics building in an urban network typically serves thousands of subscribers. This allows an urban provider to spread the building, back-up power, and other infrastructure elements across many subscribers. Rural networks typically must distribute their electronics across remote cabinets or huts that serve small numbers of subscribers. This is unavoidable and results in less efficiency in a rural network design.

Early in the design phase, aggregation sites must be identified. These are the primary locations of the electronics which directly serve the locations within the serving area, and all the local connections within the serving area must have a connection path back to an aggregation site. The aggregation site may serve as a co-location site for multiple entities that are utilizing the network to place their service electronics. The aggregation site may be a cabinet or a small building, or it may be located inside an existing building somewhere within the network footprint. Aggregation sites are typically placed in secure locations with 24/7 access and backup power capabilities. Some local codes may require that the aggregation sites be entirely underground or disguised as another type of building such as a house.

Next, the backbone fiber network that connects the various aggregation sites is designed. The backbone fiber network is typically deployed in ring architectures to provide network redundancy. To provide additional resiliency, backbone fiber typically enters the aggregation locations in two separate entrances and separation of the ring segments is maintained throughout the network. This allows for aggregation sites to remain connected in the event of a fiber cut, and for customers paying for ring protected services to maintain service during most network outage events.

Once the aggregation site and backbone fiber designs have been completed, the distribution networks, as described in the following sections, can be designed. The selection of the distribution architecture or combination of architectures affects the size of fiber cables and the amount and type of electronics that are required. Figure 5-1 depicts the various distribution network elements that are addressed in the design phase.

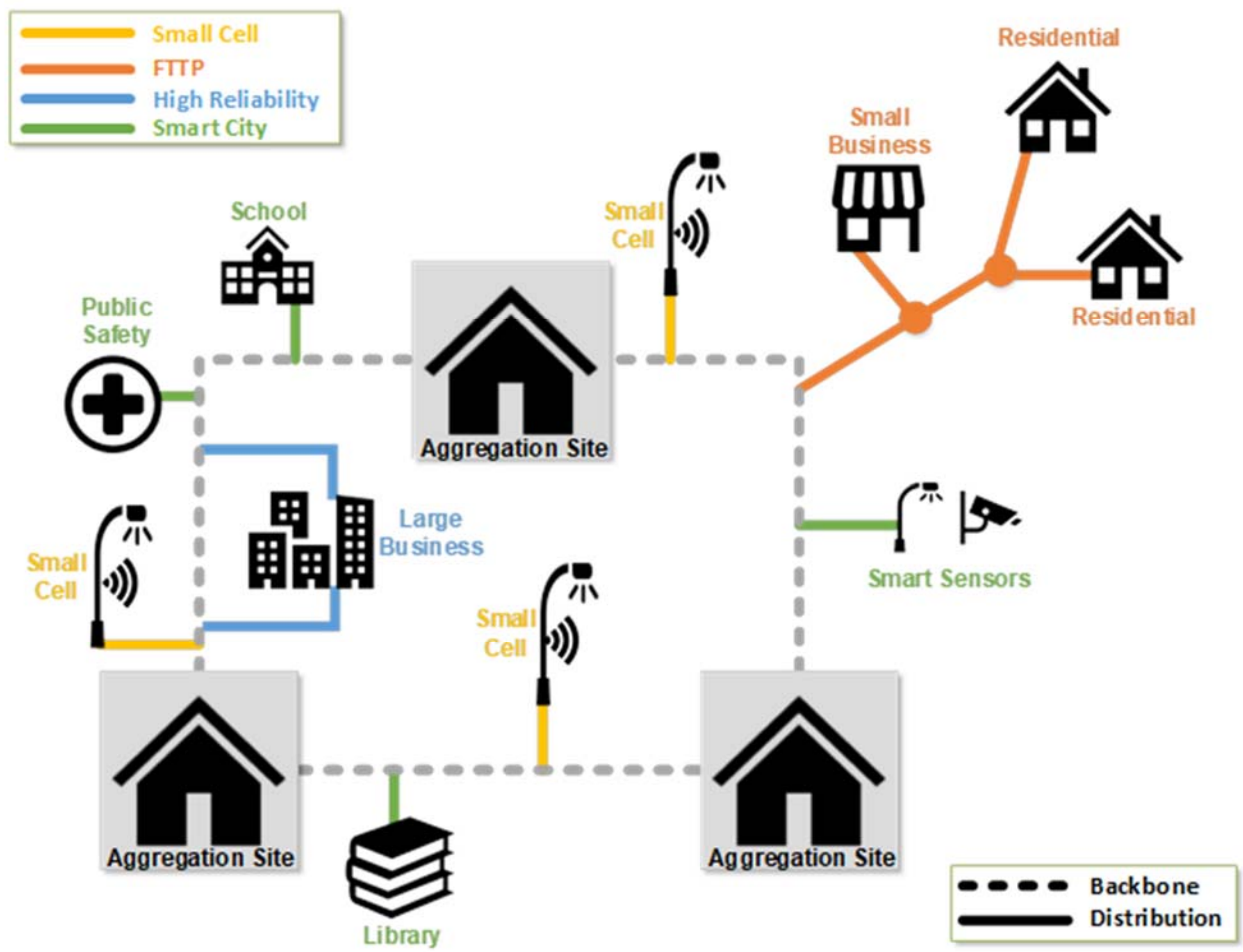


Figure 5-1: Distribution Network Design Elements

5.1.1 FTTP

As described in Section 2.2, an FTTP network can deliver services over a shared PON architecture or a dedicated AE architecture. In a PON architecture, optical splitters may be centrally located at the aggregation site or they may be distributed in the field. If they are distributed in the field, less fiber is required all the way back to the aggregation site. However, centrally locating the splitters allows for more efficient use of the splitters and the associated electronics ports. It also provides for an easier transition to an AE architecture in the future.

In an AE architecture, dedicated fiber connects from the subscriber back to the aggregation site. This requires more fiber in the distribution network than a distributed PON architecture and more electronics are required since each customer has a dedicated electronics port. However, it provides the most broadband capability to the subscriber.

5.1.2 High Reliability

Some medium and large businesses (or other entities that provide critical services) require higher service reliability than may be required for residential and smaller business applications. In these cases, a fiber ring topology can be utilized to connect the businesses and provide redundancy that can survive a fiber cut or network outage on a portion of the ring.

5.1.3 Smart City Network

Smart City architectures could include items such as cameras at intersections, connections to traffic signal boxes, light sensors, and SCADA systems. It may also include fiber to city institutions such as schools, municipal buildings and libraries. The fiber design develops terminal locations for sensor connections and may include ring architectures for applications that require high levels of redundancy.

5.1.4 Small Cell 5G Network

A fiber deployment design may include working with carriers to design appropriate endpoints, route diversity and redundancy for Small Cell 5G deployments. This is typically designed based on coordination with the wireless carrier’s backhaul and fronthaul requirements.

5.1.5 Future Proofing the Network

It is also important to build capacity and flexibility into the network design to accommodate future growth and technologies. The growth capacity can be built into the fiber network by increasing spare fiber availability at various network locations. Growth capacity can also be included in the aggregation sites to allow for more equipment racks. In addition to spare fiber and space availability, future growth and technology support can sometimes be accommodated by replacing the electronics that are attached to the fiber network. This capacity planning helps minimize future capital expenditures in the event of customer growth.

5.2 Engineering

Once the network design has been completed, detailed engineering is performed. This engineering results in construction plans that dictate construction materials, facility placement and network routing. Additionally, permit packages are completed and submitted during the engineering phase.

In preparation of the field engineering and permitting, the first step is to determine all agency jurisdictions that are impacted by the project. This includes municipal, state, federal, railroad, water, and environmental agencies that have jurisdiction in the project area. Once this list has been established, the next step is to meet with each agency to obtain their specific requirements.

5.2.1 Fielding

Fielding involves detailed onsite data collection, material selection, structure placement, and cable routing. The fielding staff develop construction plans that ensure the network design parameters, pole owner, and jurisdictional agency requirements are being met. The following describe the primary fielding tasks in more detail. Many providers utilize outside engineering firm resources to perform the fielding. Examples of fielding design maps are included in Appendix B.

<u>Aerial Fielding</u>

Data collection of existing and proposed aerial facilities is required on all poles that the new infrastructure will be framed on. This includes mainline, drop, and guy poles. The fielding staff gather both telecommunications and power infrastructure information.

Regional, state, and national regulating bodies have established minimum clearance requirements that all aerial installations must uphold. These entities include the National Electric Safety Code (NESC) and the National Electric Code (NEC). The fielding staff review the existing aerial infrastructure to determine if new cables can be added to the poles while meeting clearance and loading requirements.

In many instances additional communications plant cannot be added to a pole without creating a clearance violation. This violation may be a ground clearance issue or an overcrowding of different attachments. To resolve these violations, engineers perform make-ready engineering. This involves determining the work that needs to be performed on the pole to allow for the new attachment while not creating any violations. This commonly involves relocating existing attachments to a different height to create additional room on the pole. If no existing cables can be moved to create room on a pole, while maintaining all code requirements, the engineer often proposes a pole changeout to a taller pole or proposes an alternate construction method, such as underground construction.

Using the data collected in the field for each pole, an engineer also performs pole loading analysis (PLA) to ensure that the pole will not be overloaded. PLA is performed to meet federal, state, local, and pole owner requirements. In some instances, pole owners have higher standards than national, state, or local codes. If a pole does not meet the loading requirements, the engineer develops alternative solutions. This may be in the form of a pole change out or an alternate construction method. A sample PLA report for a single pole is included in Appendix B.

Underground Fielding

For underground data collection, the fielding staff determine the optimal running line of the underground fiber cable. To do this, the fielding staff must first research the existing utilities and right-of-way information in the project area. This research process includes meeting with local officials and residents to obtain maps and preliminary information and can take weeks or months depending upon the size of the area being constructed.

In determining existing utilities locations, cable and utility locates are also conducted. Any entity who has infrastructure near the proposed facilities will mark the exact location of their utility. The fielding staff will note the existing utilities from a reference point, such as the centerline of the road, along with the proposed fiber. Additionally, the fielding staff meets with local officials and residents to discuss items such as storm sewer information, soil conditions, and areas that may contain high amount of rock in the soil.

Material Selection

As part of the engineering process, an approved material list is created. During the fielding, this material list is utilized to select the actual products to be utilized for each facility placement. In the selection of materials, the engineer must review local codes, environmental requirements, manufacturer requirements and unique requirements of each placement location. For example, a structure that is being placed in a high-traffic area will have different requirements than a structure placed in a low traffic area. The engineer must also evaluate the upfront costs and long-term maintenance expenses associated with various materials choices.

There are numerous choices within each of the material types that must be decided upon. Each of these choices have cost and maintenance trade-offs and sometimes reliability or regulatory tradeoffs. This includes materials such as:

- Field cabinets
- Optical splitters
- Aerial cable
- Underground cable
- Conduit
- Aerial strand and materials
- Splice closures
- Manholes, handholes and vaults
- Grounding

Structure Placement

Structure placement is determined to minimize construction and operations/maintenance costs while meeting the design, engineering and agency jurisdiction requirements. This includes structures such as cabinet, handholes, vaults, and manholes. Some areas considered in the structure placement include:

- Permitting requirements – The permitting agency may have specific requirements that detail the acceptable placement of the structures.
- Location access – The placement must be evaluated to ensure that it can be easily accessed in the future for maintenance. For example, typically areas that require significant traffic control to access the structure are avoided.
- Interference with sidewalks or driveways
- Americans with Disabilities Act (ADA) compliance work – Placing a structure within an ADA area may result in significant cost to restore the area to ADA compliance.
- Grade of the terrain – Areas of steep grade of terrain are typically avoided as significant effort may be required in order to meeting permit and manufacturer requirements for the installation of the structure.

Cable Routing

The fielding staff plan the cable routing for the network. The fielding staff design the most efficient routes while adhering to the design and engineering specifications. Some considerations during the routing include:

- Minimum separations with other utilities, as specified in NESC and local codes, must be maintained along the route
- Locating splices where they can be easily accessed
- Avoiding easements that may be time consuming or expensive to obtain
- Avoiding locations that may have extensive permit requirements

The cable routing selection is critical, since a significant amount of the network investment is the labor associated with the placement of this cable. If this cable must be relocated for some reason before the end of the cable's economic life, the feasibility of the business plan can change dramatically.

5.2.2 Permitting

The permitting process is usually conducted in parallel to the fielding process. For a typical rural project there are usually many more agencies that require permits than an urban deployment. An urban deployment may only require coordination with a single municipality, while a rural deployment may require coordination with federal, state, county, and tribal agencies. Rural deployments may also require substantial amounts of private right-of-way coordination in some states depending on the rural roadway right-of-way laws. The permitting process often takes at least 30-60 days and involves the following entities:

- **Department of Transportation (DOT)** - DOT agencies often have specific permit drawing requirements. These include showing existing utilities, detailing the placement of cable relative to center line or right-of-way line, and inclusion of stationing and mile post information for all equipment placed in the right-of-way. The agencies may also require traffic control plans and storm water prevention plans. Often, they also request drive throughs with the field personnel to review proposed cable placement.
- **State/School** - Some states own land for purposes of recreation or wildlife conservation. To cross state-owned lands, a survey completed by a licensed surveyor may be required. In environmental sensitive areas, additional surveys may be required to ensure endangered species will not be affected. Completing these types of surveys requires significant time of three to six months to complete the necessary paperwork.
- **County Roads** - Counties may have specific construction requirements that need to be determined in the permitting process. This may include items such as: all roads and approaches must be bored, boring extra depth under culverts, cables may need to be placed on the edge of the road or in the actual road bed.
- **Municipal Permits** – Municipal entities may require such items as showing existing utilities, meetings with the city council to review the project, traffic control plans, and storm water prevention plans. These all require significant time and resources to engineer, compile drawings, and meet with the local officials.
- **Railroad** - Railroads often require engineered drawings to be submitted with the permits. The fees for crossing railroads can often be high cost and may take as long as 6 months for permits to be approved by the railroad.

Relevant particularly to rural construction and operations, the Federal government owns 28% of the land in the United States. When constructing in rural areas, it is therefore not uncommon to have to cross Federal land. When constructing on Federal lands, there are a variety of agencies that also require permits, which can be a time-consuming and costly process. These agencies could include one or more of the following:

- Bureau of Reclamation
- Bureau of Land Management

- US Forest Service/Grasslands
- US Park Service
- US Fish & Wildlife Waterfowl Areas
- Army Corp of Engineers
- Department of Natural Resources

These Federal entities often require additional information before permits will be granted. They may require cultural resource surveys and/or biological surveys (botany, mammalian, reptilian, insect). They may also require that construction only occur during specific times of the year to reduce impact to specific plant or wildlife species. They may require cable placement at deeper than normal depths, especially crossing larger water bodies. These items add significant time to reach an approved permit. Most Federal lands require a minimum of 6 months and often longer to receive an approved permit.

In many areas of the country, the provider may be constructing on tribal areas which may include the following coordination:

- Obtaining a tribal business license
- Complying with a Tribal Employment Rights Ordinance (TERO)
- Performing cultural surveys (could be in addition to other environmental surveys)
- Bureau of Indian Affairs (BIA) road and land permit approvals
- Tribal council permit/easement approvals for construction on tribal-owned tracts
- Allotted land easements (may require surveys, payment and signatures of 50% of interest holders)

To complete all the necessary paperwork and signatures for easements may require 6 months. Completion of the permit packages is often prioritized based on the processing lead-times indicated by the permitting agencies. Each required permit package is assembled according the specific permitting agency standards.

Once submitted, there is ongoing coordination that occurs with the permitting agency. This includes obtaining periodic updates from the permitting agency to verify that the permit is being processed and to answer questions.

5.2.3 Construction Plans

Once the design and engineering has been completed, the construction plans are developed. The construction plans include the proposed construction maps, guide drawings, and construction standards. The construction plans are typically combined with contract requirement documents and then utilized in a competitive bid process to select a construction contractor for the project.

The competitive bid process typically requires pre-bid meetings with the potential contractors to answer questions and ensure that the bidders have full understanding of the project. Once the bids are received, they are tabulated and reviewed to ensure the accuracy of the bids and to select the successful contractor.

6 Construction

6.1 Outside Plant

The construction of the outside plant network is very time-intensive and requires many resources. Again, rural networks are more expensive to construct on a per-subscriber basis than urban networks. Factors that make the costs more expensive include higher contractor deployment costs to these remote areas, long subscriber drops, and low density of subscribers in the service area. There is also typically a shorter construction season for rural networks since the buried construction techniques utilized in rural areas are impacted more by the freezing of the soil. Urban construction typically utilizes existing conduit and boring techniques that are not as impacted by freezing soil.

Outside plant construction requires large amounts of construction equipment, construction materials, contractor staff, and service provider representatives. Much effort is taken to ensure that the network is properly constructed. Improper construction can result in safety issues, expensive rework costs, and long-term maintenance issues.

6.1.1 Pre-Construction

Prior to actual construction, there are many logistical and communication items that need to be coordinated between the provider, the engineer, and the outside plant contractor.

Once awarded the contract, an initial step of the contractor is to place the order for the materials required by the construction plans. To receive, store, and distribute these materials, the contractor will need to procure a warehouse. Additionally, the contractor will need to obtain an equipment staging area for storing equipment when not in use and for performing equipment maintenance.

The contractor may also be required to conduct crew training prior to construction. This could include training certification by local government agencies for street cuts and restoration as well as safety training. It may also include training by specific material manufacturers regarding acceptable construction techniques.

The contractor and the provider also finalize the sequencing of the construction areas to be built. This may be prioritized by customer demand, status of construction permits, type of construction, or other factors. Based on the agreed upon sequencing, the contractor provides the provider a projection of the number of crews and construction schedule for each of the build areas.

Finally, prior to construction, the provider and contractor establish communication and escalation protocols. This typically includes contact lists and discussion regarding the types of issues that various staff should be notified of when they occur. These communication protocols may also include third-party provider representatives that will assist the provider through the construction process, such as quality control.

6.1.2 Construction

The contractor’s construction is dictated by the construction and permit packages for the work. This includes ensuring that all material is installed per the provider’s requirements, material manufacturer instructions, and local, state and national codes. The construction also includes performing more than just the placement of the fiber cable and materials, encompassing tasks such as tree trimming, aerial pole make-ready, locating of utilities, and restoration of the impacted area after construction. Each of these items requires teams of workers to perform the necessary work.

Once construction has commenced, there is much ongoing coordination between the contractor and the provider's representatives. It is important for the provider to be aware of daily contractor crew locations and activities. This is necessary for notifying residents and business of upcoming construction in the area, performing quality control inspections and providing updates to local government officials. For aerial construction, is also necessary for keeping poles owners aware of make-ready and cable placement schedule and construction status.

During the construction, there are many safety processes that are implemented. Traffic control plans are implemented to provide for safe construction along roadways. Additionally, protocols are implemented that dictate zones around the construction where only specific personnel with the appropriate safety equipment can be located. Other safety procedures include digging holes to visually observe utilities that are being crossed by the new constructions.

Inspection of the contractor's work is performed by the provider's representatives throughout the construction process. This process is described in more detail in section 6.3. Additionally, the provider's representatives answer questions regarding construction plans, make decisions regarding field changes, and ensure that construction is being performed according to the plans and specifications.

Daily production is typically reported by the contractor and verified by the provider's representatives. The production information is utilized to assess construction status, such as whether construction timeline goals are being met and the accuracy of contractor payment requests. When goals are not being met, the production reports are useful in determining potential resolutions, such as additional crew personnel, additional crew training, or more efficient construction techniques.

The provider also keeps the permit agencies and pole owners informed of construction status to ensure timely inspection of the construction and to close-out permits and applications as soon as possible.

Once the construction in an area has been completed, the construction corridor must be restored to its previous condition. This includes removing any waste materials and filling and repairing holes in roads, sidewalks and driveways. It may also include restoring residents' lawns and seeding areas with grass.

After the fiber has been constructed, the fiber cables are spliced together to provide connectivity throughout the network. This requires careful planning to ensure that the fibers are spliced efficiently throughout the network and to maximize the use of the fiber. It also requires documentation and labeling to allow for future maintenance and troubleshooting of the network. After the fibers are spliced, they are tested to ensure that the fiber splices meet minimum requirements and to verify that the correct fibers have been spliced together. Example splice diagrams and test results are included in Appendix C.

6.2 Inside Plant

6.2.1 Electronics

Once the fiber network has been constructed, the operations and management of the system begins. At the aggregation sites, several electronics systems must be installed and provisioned. This includes the core data network, transport electronics, distribution electronics, voice service electronics, and potentially video electronics. The service provider typically conducts a competitive bid process for these systems and evaluates the proposals to determine which solutions best fit their network.

6.2.2 Provisioning

Once the electronics systems have been installed and tested, they must be configured to interoperate, and the appropriate circuits and services must be provisioned. As part of this installation process, the management systems for each of the electronics systems is installed. The service provider's technicians also undergo training in the operations and troubleshooting of each of the systems.

6.3 Quality Assurance / Quality Control

To speed time to market, save costs, and maximize construction quality many providers develop Quality Assurance (QA) and Quality Control (QC) procedures for the outside and inside plant construction. QA is the act of observing and providing feedback to correct potential issues during construction but prior to project final acceptance. The purpose of QA is to identify potential problems and allow them to be corrected early in the construction process. This may include issues such as:

- Training deficiencies
- Poor crew performance
- Incorrect understanding of requirements
- Inconsistency between subcontractors
- Use of outdated specifications
- Installation of incorrect material

QC is the final inspection of the construction product. An effective QA process should result in very few issues being identified during the QC inspections.

Both QA/QC are most often performed by strategically sampling the construction. Critical construction elements and items that are very difficult to correct are sampled at higher rates than less critical items. Additionally, the sampling is typically adjusted depending on the contractor crew performance.

Third-party firms are typically utilized by the provider to perform the QA/QC. The third-party firm tasks may include inspection of work to confirm conformance with the specifications, development of deficiency punch lists, analyzing trends, performing contractor training, and verifying correction of issues.

6.4 Turn-over Coordination

Once the construction has been completed, the contractor provides a turn-over package to the provider. This package typically includes fiber test results, tabulation of all constructed units, and contract close-out paperwork.

It is common for the provider to utilize the third-party QA/QC firm to review this information and to also perform the as-built redlines of the construction maps. This includes compiling a geo accurate inventory of the constructed system and building databases and maps of the information required to maintain and locate the facilities. This results in every fiber strand being accounted for and traceable in the network.

6.5 Customer Location Construction

Once the fiber routes have been constructed and the electronics systems have been installed and provisioned, the customer turn-up can begin. This involves constructing a drop to the customer, installing customer premises equipment, provisioning the customer's service, testing the service, and educating the customer.

The installation requires coordination and scheduling with the customers. Providers may have several staff that are dedicated to maintaining installation schedules and coordinating the installation crews.

During the installation, installation crews perform grounding/bonding work and must adhere to NEC and local safety standards and codes. The installation crew must also interface or perform rework of the customer's inside wiring.

7 Operations and Management

7.1 Operations

Once the network has been constructed, the job is hardly done; from one perspective, the job of delivering broadband is just starting as of that point. There are several items that need to be considered and completed to ensure a successful operation of the network. The operations and maintenance of a rural network is more expensive on a per-subscriber basis than an urban network. Low subscriber density results in maintenance staff having to cover large service territories. Additionally, rural networks are more susceptible to environmental factors such as floods, grass fires, and ice storms that may take down miles of pole lines.

7.1.1 Staffing

A significant part of the operations and management planning is ensuring adequate staffing is allocated. Staffing levels need to be established based on the size of the service market and services offered. Positions include technicians experienced in maintaining the outside plant facilities, the central office, distribution electronics, and data network elements.

Staff should be qualified with the experience in operating and maintaining the network. In addition to subscriber turn-ups, the service provider must troubleshoot network issues and perform network maintenance and repair.

In addition to operating the network, positions will be required in customer service as well as marketing and sales to sell the services and in accounting for billing and financial accountability.

7.1.2 Regulatory Considerations

State and federal regulatory requirements are another area that is often overlooked during the planning stages of building a broadband network. Deploying a network capable of delivering voice, broadband and even video services comes with a long list of regulatory considerations that could have a strain on the operations from labor demand to the financials. The level of complexity in regulatory components varies depending on the services that are offered.

A few of the regulatory considerations to be addressed may consist of the following:

- Obtaining Regulatory Authority and/or Eligible Telecommunications Carrier (ETC) status
- Interconnection Agreements
- Obtaining Numbering Resources and Local Number Portability
- E911 Plans
- Tariff Development and Filings – Both State and Interstate Tariffs
- Obtaining FCC Registration Number and Completing FCC Regulatory Filings (*e.g.*, Forms 477, 499, and 502; any ETC reporting duties)
- CPNI Compliance
- Red Flag Compliance
- CALEA Compliance

- Video – Programming and Retransmission Negotiations

In addition to the upfront startup regulatory considerations, there are regular regulatory filings that are required. These filings vary in recurrence with some being quarterly, semi-annually and annually.

7.2 Support Systems

There are several support systems that a typical service provider deploys to aid in the operations and management of the network. Each of these systems adds costs and requires staff and training to utilize.

A mapping system is needed to maintain the maps of the placed facilities. These systems contain information such as cable route, cable size, fiber splicing information and structure placement types and locations. These mapping systems typically also incorporate GPS location information regarding the facilities.

System providers also deploy trouble ticket systems. These systems are utilized to log subscriber troubles, assign them to staff for troubleshooting, and for escalating the issues. Trouble ticket systems can also be utilized to categorize the types of issues that are occurring and aid in identifying issue trends.

Providers also utilize complex billing and provisioning systems. These systems track customer information, financial information, service information, and various report functions. These systems may also be tied to flow through provisioning capabilities that allow a provider's customer representative to enable subscriber services through the network.

Appendices

Appendix A – Business Plan Examples

ABC COMPANY - FTTP FEASIBILITY STUDY
PROJECTED BALANCE SHEETS FOR YEARS 1 - 5

	Year 1	Year 2	Year 3	Year 4	Year 5
ASSETS					
CURRENT ASSETS					
CASH	$ 23,233	$ 69,016	$ 218,670	$ 398,844	$ 765,244
DEFERRED TAX ASSET	50,655	121,572	152,147	134,662	61,511
TOTAL CURRENT ASSETS	$ 73,888	$ 190,588	$ 370,817	$ 533,506	$ 826,755
PROPERTY, PLANT & EQUIPMENT					
PROPERTY, PLANT & EQUIPMENT	3,946,128	4,505,338	4,785,031	5,064,549	5,341,627
LESS: ACCUMULATED DEPRECIATION	47,218	251,580	491,161	754,218	1,040,565
NET PROPERTY, PLANT & EQUIP.	$ 3,898,910	$ 4,253,758	$ 4,293,870	$ 4,310,331	$ 4,301,062
TOTAL ASSETS	$ 3,972,798	$ 4,444,346	$ 4,664,687	$ 4,843,837	$ 5,127,817
LIABILITIES & EQUITY					
CURRENT LIABILITIES					
TOTAL CURRENT LIABLITIES	$ -	$ -	$ -	$ -	$ -
EQUITY					
PAID IN CAPITAL	$ 4,071,128	$ 4,680,338	$ 4,960,031	$ 5,105,240	$ 5,247,221
RETAINED EARNINGS	(98,330)	(235,992)	(295,344)	(261,403)	(119,404)
TOTAL EQUITY	$ 3,972,798	$ 4,444,346	$ 4,664,687	$ 4,843,837	$ 5,127,817
TOTAL LIABILITIES AND EQUITY	$ 3,972,798	$ 4,444,346	$ 4,664,687	$ 4,843,837	$ 5,127,817

ABC COMPANY - FTTP FEASIBILITY STUDY
PROJECTED INCOME STATEMENT FOR YEARS 1 - 5

	Year 1	Year 2	Year 3	Year 4	Year 5
OPERATING REVENUE					
VoIP SERVICES REVENUE	$ 45,000	$ 135,000	$ 202,500	$ 247,500	$ 292,500
VIDEO SERVICES REVENUE	90,804	354,889	419,297	512,511	621,995
BROADBAND DATA REVENUE	79,425	238,275	357,413	436,838	516,263
LESS: UNCOLLECTIBLE REVENUE (1%)	(2,152)	(7,282)	(9,792)	(11,968)	(14,308)
TOTAL OPERATING REVENUE	$ 213,077	$ 720,882	$ 969,418	$ 1,184,881	$ 1,416,450
OPERATING EXPENSE					
PLANT SPECIFIC OPERATIONS EXPENSE	$ 68,609	$ 120,524	$ 123,712	$ 129,955	$ 136,282
PLANT NON-SPECIFIC OPERATIONS EXPENSE	20,100	55,236	82,273	100,311	118,350
DEPRECIATION & AMORTIZATION EXPENSE	47,218	204,362	239,581	263,057	286,347
CUSTOMER OPERATIONS EXPENSE	107,044	215,673	217,708	165,844	96,003
CORPORATE OPERATIONS EXPENSE	50,950	50,074	52,455	54,278	56,135
VIDEO PROGRAMMING AND BROADBAND EXPENSE	65,478	274,581	331,498	405,199	490,477
GENERAL TAX [1]	2,663	9,011	12,118	14,811	17,706
TOTAL OPERATING EXPENSES	$ 362,062	$ 929,461	$ 1,059,344	$ 1,133,454	$ 1,201,300
NET OPERATING INCOME (LOSS)	$ (148,985)	$ (208,579)	$ (89,927)	$ 51,426	$ 215,150
PROVISION FOR INCOME TAXES [2]	$ (50,655)	$ (70,917)	$ (30,575)	$ 17,485	$ 73,151
NET INCOME (LOSS)	$ (98,330)	$ (137,662)	$ (59,352)	$ 33,941	$ 141,999
EBIDTA	***$ (101,767)***	***$ (4,217)***	***$ 149,654***	***$ 314,483***	***$ 501,497***

[1] The General Tax Expense has been calculated at 2.5% on half of the annual gross revenues.
[2] The Federal Income Tax Expense has been calculated at a rate of 34%. The tax benefit of tax losses in the initial years has been taken into consideration in subsequent years.

ABC COMPANY - FTTP FEASIBILITY STUDY
PROJECTED CASH FLOW STATEMENT FOR YEARS 1 - 5

	Year 1	Year 2	Year 3	Year 4	Year 5
CASH FLOW FROM OPERATING ACTIVITIES:					
NET INCOME (LOSS)	(98,330)	(137,662)	(59,352)	33,941	141,999
DEPRECIATION & AMORTIZATION EXPENSE	47,218	204,362	239,581	263,057	286,347
(INCREASE) DECREASE IN DEFERRED TAX ASSET	(50,655)	(70,917)	(30,575)	17,485	73,151
NET CASH PROVIDED (USED) BY OPER. ACT.	(101,767)	(4,217)	149,654	314,483	501,497
CASH FLOW FROM INVESTMENT ACTIVITIES:					
PROPERTY, PLANT AND EQUIPMENT ADDITIONS	(3,946,128)	(559,210)	(279,693)	(279,518)	(277,078)
NET CASH USED BY INVESTING ACTIVITIES	(3,946,128)	(559,210)	(279,693)	(279,518)	(277,078)
CASH FLOW FROM FINANCING ACTIVITIES:					
EQUITY INVESTMENT	4,071,128	609,210	279,693	145,209	141,981
NET CASH PROVIDED (USED) BY FIN. ACT.	4,071,128	609,210	279,693	145,209	141,981
NET INCREASE (DECREASE) IN CASH	$ 23,233	$ 45,783	$ 149,654	$ 180,174	$ 366,400
CASH, BEGINNING OF PERIOD	$0	$ 23,233	$ 69,016	$ 218,670	$ 398,844
CASH, END OF PERIOD	$ 23,233	$ 69,016	$ 218,670	$ 398,844	$ 765,244

ABC COMPANY - FTTP FEASIBILITY STUDY
PROJECTED PROPERTY, PLANT AND EQUIPMENT INVESTMENT

Projected Subscribers	Year 1	Year 2	Year 3	Year 4	Year 5
VoIP	188	375	469	563	656
Broadband Data	250	500	625	750	875
Video	200	400	500	600	700

Projected Electronics & Switching Equipment Investment	Year 1	Year 2	Year 3	Year 4	Year 5
Standard STB Count	229	229	115	114	115
DVR STB Count	98	98	49	49	49
Fiber-to-the-Premises (FTTP)					
Electronics	287,515	287,515	143,758	143,758	143,758
VIDEO					
Customer Premise Equipment - STB Standard	37,785	37,785	18,975	18,810	16,500
Customer Premise Equipment - STB DVR	24,500	24,500	12,250	12,250	12,250
Middleware - Incremental Cost (Licenses)	12,000	12,000	6,000	6,000	6,000
Encryption - Incremental Cost	3,270	3,270	1,640	1,630	1,500
Total Projected Electronics and Video [1]	**$ 365,070**	**$ 365,070**	**$ 182,623**	**$ 182,448**	**$ 180,008**

Projected Outside Plant Investment	Year 1	Year 2	Year 3	Year 4	Year 5
Mainline					
Town Fiber	3,156,907				
Fiber Drop to Premise	$194,140	$194,140	$97,070	$97,070	$97,070
Total Projected Outside Plant [1]	**$ 3,351,047**	**$ 194,140**	**$ 97,070**	**$ 97,070**	**$ 97,070**

Central Office Investment	Year 1	Year 2	Year 3	Year 4	Year 5
Hut	$ 230,011	$ -	$ -	$ -	
Total Central Office and Hut Investment [1]	**$ 230,011**	**$ -**	**$ -**	**$ -**	**$ -**

Total Projected Property, Plant & Equipment Investment	**$ 3,946,128**	**$ 559,210**	**$ 279,693**	**$ 279,518**	**$ 277,078**
Cumulative Investment Totals	$ 3,946,128	$ 4,505,338	$ 4,785,031	$ 5,064,549	$ 5,341,627
Total Projected Subscribers	250	500	625	750	875
Investment per Subscriber	$ 15,785	$ 9,011	$ 7,656	$ 6,753	$ 6,105

[1] Overheads to cover engineering, taxes and delivery have been included. - Year 1 is the construction year for the outside plant fiber and electronics.

ABC COMPANY - FTTP FEASIBILITY STUDY
PROJECTED PENETRATION RATES & REVENUES

Exchange	Total Locations[1]	Line Growth %	Year 1	Year 2	Year 3	Year 4	Year 5
Unserved USA	2,500	0.0%	2,500	2,500	2,500	2,500	2,500
Totals	2,500	0	2,500	2,500	2,500	2,500	2,500
Penetration Rate							
VoIP Access Lines			7.5%	15.0%	18.8%	22.5%	26.3%
Projected Subscribers							
VoIP Access Lines			188	375	469	563	656
Total VoIP Lines			188	375	469	563	656

VoIP Revenues	Year 1	Year 2	Year 3	Year 4	Year 5
Monthly Local Rate - Includes LD	$ 40.00	$ 40.00	$ 40.00	$ 40.00	$ 40.00
Local Service Revenue	45,000	135,000	202,500	247,500	292,500
Total VoIP Revenue[2]	$ 45,000	$ 135,000	$ 202,500	$ 247,500	$ 292,500

Video Subscribers at Year End	Subscriber Growth %	Year 1	Year 2	Year 3	Year 4	Year 5
Total Potential Video Subscribers [1*]	0.0%	2,500	2,500	2,500	2,500	2,500
Penetration Rate		8.0%	16.0%	20.0%	24.0%	28.0%
Video Subscribers		200	400	500	600	700
Basic Package Percentage		18%	18%	18%	18%	18%
Basic Package Subscribers		36	73	91	109	127
Expanded Package Percentage		50%	50%	50%	50%	50%
Expanded Package Subscribers		100	199	249	299	348
Digital Package Percentage		32%	32%	32%	32%	32%
Digital Package Subscribers		64	128	160	192	224
Premium Channels Package Percentage		18%	18%	18%	18%	18%
Premium Channels Package Subscribers		36	72	89	107	125
Additional Set Top Box Percentage		64%	64%	64%	64%	64%
Additional Set Top Box Subscribers		127	254	318	381	445
DVR Percentage		49%	49%	49%	49%	49%
DVR Subscribers		98	196	245	294	343
Whole Home DVR Percentage		17%	17%	17%	17%	17%
Whole Home DVR Subscribers		34	68	85	102	119

Video Rates					
Growth in Rates		0%	3%	0%	3%
Basic Package	$ 31.95	$ 31.95	$ 32.91	$ 32.91	$ 33.90
Expanded Package	$ 68.95	$ 68.95	$ 71.02	$ 71.02	$ 73.15
Digital Package	$ 82.95	$ 82.95	$ 85.44	$ 85.44	$ 88.00
Premium Channels	$ 12.95	$ 12.95	$ 13.34	$ 13.34	$ 13.74
Projected Video Revenues					
Basic Package	6,901	27,988	32,383	39,492	48,002
Expanded Package	41,370	164,653	190,902	233,514	283,968
Digital Package	31,853	127,411	147,640	180,449	219,648
Premium Channels	2,797	11,189	12,886	15,688	19,126
Total Video Revenues[2]	$ 82,921	$ 331,241	$ 383,811	$ 469,143	$ 570,744
CPE Lease Rates					
Additional Set Top Box	$ 4.95	$ 4.95	$ 4.95	$ 4.95	$ 4.95
DVR	$ 5.95	$ 5.95	$ 5.95	$ 5.95	$ 5.95
Whole Home DVR	$ 3.00	$ 3.00	$ 3.00	$ 3.00	$ 3.00
Projected CPE Revenues					
Additional Set Top Box	3,772	11,316	16,988	20,760	24,532
DVR	3,499	10,496	15,744	19,242	22,741
Whole Home DVR	612	1,836	2,754	3,366	3,978
Total CPE Lease Revenues[4]	$ 7,883	$ 23,648	$ 35,486	$ 43,368	$ 51,251

[1] Per information provided by VPS engineering Cap Ex estimates

[1*] No marketing survey completed. Penetration estimate based on previous feasibilities in the area by VPS

[2] Annual Revenues are based on avg Projected Subscribers at the beginning and end of the year multiplied by Projected Rates

ABC COMPANY - FTTP FEASIBILITY STUDY
PROJECTED PENETRATION RATES & REVENUES

Broadband Data Subscribers at Year End	Year 1	Year 2	Year 3	Year 4	Year 5
Broadband penetration rate [1]	10.0%	20.0%	25.0%	30.0%	35.0%
Broadband Data Subscribers	250	500	625	750	875
Total	250	500	625	750	875
Broadband Data Subscribers-4M / 1M - Penetration	45%	45%	45%	45%	45%
Broadband Data Subscribers-4M / 1M - Subscribers	113	225	281	338	394
Broadband Data Subscribers-10M / 2.5M - Penetration	23%	23%	23%	23%	23%
Broadband Data Subscribers-10M / 2.5M - Subscribers	56	113	141	169	197
Broadband Data Subscribers-25M / 6.25M - Penetration	23%	23%	23%	23%	23%
Broadband Data Subscribers-25M / 6.25M - Subscribers	56	113	141	169	197
Broadband Data Subscribers-50M / 12.5M - Penetration	5%	5%	5%	5%	5%
Broadband Data Subscribers-50M / 12.5M - Subscribers	13	25	31	38	44
Broadband Data Subscribers-100M / 25M - Penetration	5%	5%	5%	5%	5%
Broadband Data Subscribers-100M / 25M - Subscribers	13	25	31	38	44
Broadband Data Rates					
Broadband Data Subscribers-4M / 1M	$ 39.95	$ 39.95	$ 39.95	$ 39.95	$ 39.95
Broadband Data Subscribers-10M / 2.5M	$ 49.95	$ 49.95	$ 49.95	$ 49.95	$ 49.95
Broadband Data Subscribers-25M / 6.25M	$ 59.95	$ 59.95	$ 59.95	$ 59.95	$ 59.95
Broadband Data Subscribers-50M / 12.5M	$ 79.95	$ 79.95	$ 79.95	$ 79.95	$ 79.95
Broadband Data Subscribers-100M / 25M	$ 124.95	$ 124.95	$ 124.95	$ 124.95	$ 124.95
Projected Broadband Data Revenues					
Broadband Data Subscribers-4M / 1M	26,966	80,899	121,348	148,314	175,281
Broadband Data Subscribers-10M / 2.5M	16,858	50,574	75,862	92,720	109,578
Broadband Data Subscribers-25M / 6.25M	20,233	60,699	91,049	111,282	131,515
Broadband Data Subscribers-50M / 12.5M	5,996	17,989	26,983	32,979	38,976
Broadband Data Subscribers-100M / 25M	9,371	28,114	42,171	51,542	60,913
Total Broadband Data Revenues [2]	**$ 79,425**	**$ 238,275**	**$ 357,413**	**$ 436,838**	**$ 516,263**

[1] No marketing survey completed. Penetration estimate based on previous feasibilities in the area by VPS

[2] Annual Revenues are based on an average of Projected Subscribers at the beginning and end of the year multiplied by Projected Rates

ABC COMPANY - FTTP FEASIBILITY STUDY
TOTAL PROJECTED OPERATING EXPENSES

	Year 1	Year 2	Year 3	Year 4	Year 5
Annual Expense Growth Factor	3%	3%	3%	3%	3%
Projected VoIP subscribers	188	375	469	563	656
Projected video subscribers	200	400	500	600	700
Projected data subscribers	250	500	625	750	875
Network Expenses					
Vehicle					
Number of Vehicles-Maintenance	1	1	1	1	1
Monthly Operating Cost (Service Vehicle)	$ 600	$ 618	$ 637	$ 656	$ 676
Total Vehicle Expense	$ 7,200	$ 7,416	$ 7,644	$ 7,872	$ 8,112
Contracted Services					
Contracted Inside Wiring ($150 per installation) [1]	-	-	-	-	-
Digital Headend Encoding Cost ($2.50 /Sub/Mo)	3,000	9,000	13,500	16,500	19,500
EPG Annual Fee ($500 min plus $0.50/sub)	550	650	725	775	825
Annual Support Fee - License ($3.50/sub)	350	1,050	1,575	1,925	2,275
Annual Encryption Fee ($1.50/STB)	285	1,140	1,425	1,710	1,995
Personnel Related Network Expenses	33,614	69,243	71,320	73,459	75,664
Electronics & Equip. Investment warranty & support	6,000	6,180	6,365	6,556	6,753
Miscellaneous Plant Materials & Supplies ($50 per sub)	9,375	9,375	4,688	4,688	4,687
Total Contracted Services	$ 53,174	$ 96,638	$ 99,598	$ 105,613	$ 111,700
VoIP Services					
VoIP Costs ($16.00/Sub - includes LD costs)	19,500	54,000	81,000	99,000	117,000
Total VoIP Services	$ 19,500	$ 54,000	$ 81,000	$ 99,000	$ 117,000
Facility Leases					
Pole Lease Rate-In town(per attachments per yr)	$10.00	$10.00	$10.00	$10.00	$10.00
In town Attachments [2]	1,647	1,647	1,647	1,647	1,647
Lease - Pole Attachment(In town) Expense	8,235	16,470	16,470	16,470	16,470
Total Facility Leases	$ 8,235	$ 16,470	$ 16,470	$ 16,470	$ 16,470
Miscellaneous					
Electricity / Utilities	600	$ 1,236	$ 1,273	$ 1,311	$ 1,350
Total Network Expenses	**$ 88,709**	**$ 175,760**	**$ 205,985**	**$ 230,266**	**$ 254,632**
Video Programming and Internet Expense					
Basic Expense %	57%	57%	57%	57%	57%
Expanded Package Expense %	70%	70%	70%	70%	70%
Digital Package Expense %	75%	75%	75%	75%	75%
Premium Expense %	78%	78%	78%	78%	78%
HD Expense %	78%	78%	78%	78%	78%
Incremental cost per Data Sub per Month - 4/1	$ 4.53	$ 4.53	$ 4.53	$ 4.53	$ 4.53
Incremental cost per Data Sub per Month - 10/2.5	$ 7.59	$ 7.59	$ 7.59	$ 7.59	$ 7.59
Incremental cost per Data Sub per Month - 25/6.25	$ 10.65	$ 10.65	$ 10.65	$ 10.65	$ 10.65
Incremental cost per Data Sub per Month - 50/12.5	$ 18.30	$ 18.30	$ 18.30	$ 18.30	$ 18.30
Incremental cost per Data Sub per Month - 100/25	$ 32.56	$ 32.56	$ 32.56	$ 32.56	$ 32.56
Basic Package Programming Cost [3]	3,934	15,953	18,458	22,510	27,361
Expanded Package Programming Cost [3]	28,959	115,257	133,631	163,460	198,778
Digital Package Programming Cost [3]	23,890	95,558	110,730	135,337	164,736
Premium Programming Cost [3]	2,182	8,727	10,051	12,237	14,918
HD Programming Cost [3]	-	-	-	-	-
Total Video Programming Expense	$ 58,964	$ 235,496	$ 272,871	$ 333,544	$ 405,793
Projected Incremental High Speed Internet Expenses [4]	6,514	39,085	58,627	71,655	84,684
Total Video Programming and Internet Expense	**$ 65,478**	**$ 274,581**	**$ 331,498**	**$ 405,199**	**$ 490,477**
Customer Operations Expense					
Personnel Related Customer Operations Expenses	12,448	25,642	26,411	27,203	28,019
Marketing [5]	93,750	187,500	187,500	125,000	62,500
Billing & Collection Costs [6]	846	2,531	3,797	4,641	5,484
Total Customer Operations Expenses	**$ 107,044**	**$ 215,673**	**$ 217,708**	**$ 165,844**	**$ 96,003**

[1] Inside Wiring installations assumes existing employees will complete and the labor costs are assumed to cover the cost.

[2] Assumes 30 attachments per fiber mile.

[3] Assumes basic channel line ups and applied average programming costs for the packages based on a % of revenue for the expenses

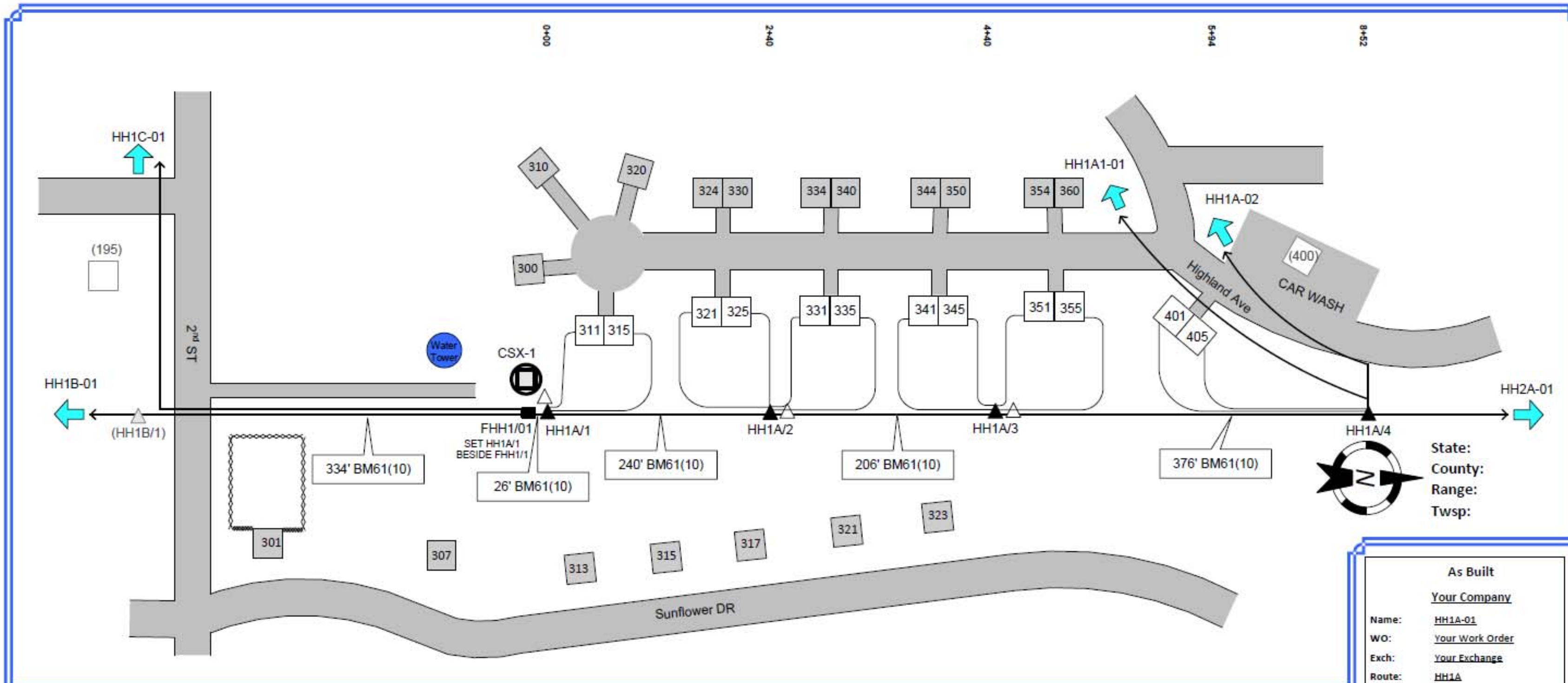
[4] Estimated cost per subscriber is based on the following costs: $4.53 for the 5/1.5; $10.65 for the 25/5; and $18.30 for the 50/5 offering - includes costs for bandwidth, call center tech support and additional maintenance. Subscribers added during year are assumed added in middle of year.

[5] Marketing costs are calculated at an annual rate of $10 per year per potential location in Year 1. In the remaining years, marketing costs are calculated at an annual rate of $5 per year per potential location.

[6] Billing & Collection costs are assumed to be $0.75 per subscriber.

Appendix B – Design and Engineering Examples

Field Design Maps Examples



From	To	PType	Units	Feet	BM		HB	HO		NID	Remarks
(HH1B/1)	FHH1/01	BHF(48x72x36)	BFO 576RI	412	2(5/8)(8)	1	FO(576)	12	48		TYCO 450D
	FHH1/01		BFO 576RI	334	61(10)	334					LEAVE 100 COILS IN FHH1/1
	FHH1/01		BFO 576RI	334							
	FHH1/01		BFO 576RI	334							
	FHH1/01		BFO 576RI	334							
	FHH1/01		BFO 576RI	334							
	FHH1/01		BFO 144RI	334							
	FHH1/01		BFO 48RI	412							
	FHH1/01		BFOV(2x1.25)	334							

As Built

Your Company

Name: HH1A-01
WO: Your Work Order
Exch: Your Exchange
Route: HH1A
ROW: Public

Staked By: ______ Date: ______
Revised By: ______ Date: ______
Plowed By: ______ Date: ______
Tabbed By: ______ Date: ______

VantagePoint

Drawing Not to Scale

Sheet	1	of	3

Field Design Maps Examples - Continued

From	To	PType	Units	Feet	BM		HB	HO		NID	Remarks
	FHH1/01		BFOV(9x2)	334							
	CSX-1	E(CSX-216)									
FHH1/01	HH1A/1	TV-106	BFO 576RI	26	2(5/8)(8)	1	FO(48)	1	2		TYCO 450B
	HH1A/1		BFO 576RI	26	61(10)	26					
	HH1A/1		BFO 576RI	26							
	HH1A/1		BFO 576RI	26							
	HH1A/1		BFO 576RI	26							
	HH1A/1		BFO 144RI	44							
	HH1A/1		BFO 96RI	44							
	HH1A/1		BFO 48RI	104							
	HH1A/1		BFO 48RI	44							
	HH1A/1		BFOV(4x1.25)	26							
	HH1A/1		BFOV(8x2)	26							
HH1A/1	HH1A/1		BFOV(2x1.25)	8							
HH1A/1	311		SEBF 4	124	83	1		1	1	3	
HH1A/1	315		SEBF 4	236	83	1		1	1	3E	
HH1A/1	HH1A/2	TV-106	BFO 576RI	240	2(5/8)(8)	1	FO(48)	1	4		TYCO 450B
	HH1A/2		BFO 576RI	240	61(10)	240					LEAVE 36' COIL IN HH1B/2
	HH1A/2		BFO 576RI	240							
	HH1A/2		BFO 576RI	240							
	HH1A/2		BFO 576RI	240							
	HH1A/2		BFO 144RI	240							
	HH1A/2		BFO 96RI	240							
	HH1A/2		BFO 48RI	276							
	HH1A/2		BFO 48RI	240							
	HH1A/2		BFOV(4x1.25)	240							
	HH1A/2		BFOV(8x2)	240							
HH1A/2	HH1A/2		BFOV(2x1.25)	8							
HH1A/2	321		SEBF 4	212	83	1		1	1	3	
HH1A/2	325		SEBF 4	108	83	1		1	1	3	
HH1A/2	331		SEBF 4	88	83	1		1	1	3	
HH1A/2	335		SEBF 4	168	83	1		1	1	3	
HH1A/2	HH1A/3	TV-106	BFO 576RI	206	2(5/8)(8)	1	FO(48)	1	4		TYCO 450B
	HH1A/3		BFO 576RI	206	61(10)	206					LEAVE 36' COIL IN HH1B/3
	HH1A/3		BFO 576RI	206							
	HH1A/3		BFO 576RI	206							
	HH1A/3		BFO 576RI	206							
	HH1A/3		BFO 144RI	206							
	HH1A/3		BFO 96RI	206							
	HH1A/3		BFO 48RI	242							
	HH1A/3		BFO 48RI	206							
	HH1A/3		BFOV(4x1.25)	206							
	HH1A/3		BFOV(8x2)	206							
HH1A/3	HH1A/3		BFOV(2x1.25)	8							
HH1A/3	341		SEBF 4	180	83	1		1	1	3	

As Built

Your Company

Name: HH1A-01
WO: Your Work Order
Exch: Your Exchange
Route: HH1A
ROW: Public

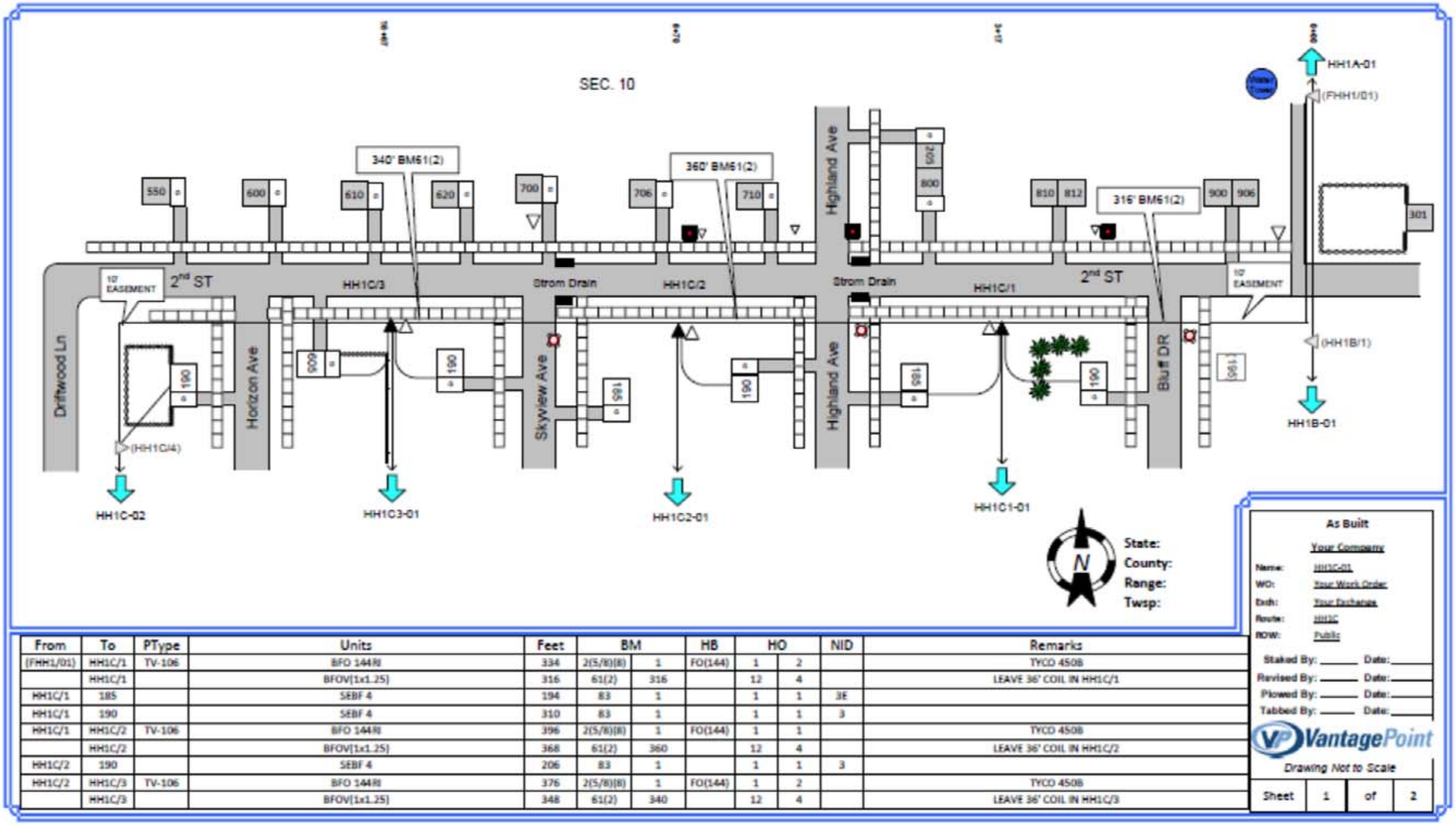
Staked By: ______ Date: ______
Revised By: ______ Date: ______
Plowed By: ______ Date: ______
Tabbed By: ______ Date: ______

VantagePoint

Drawing Not to Scale

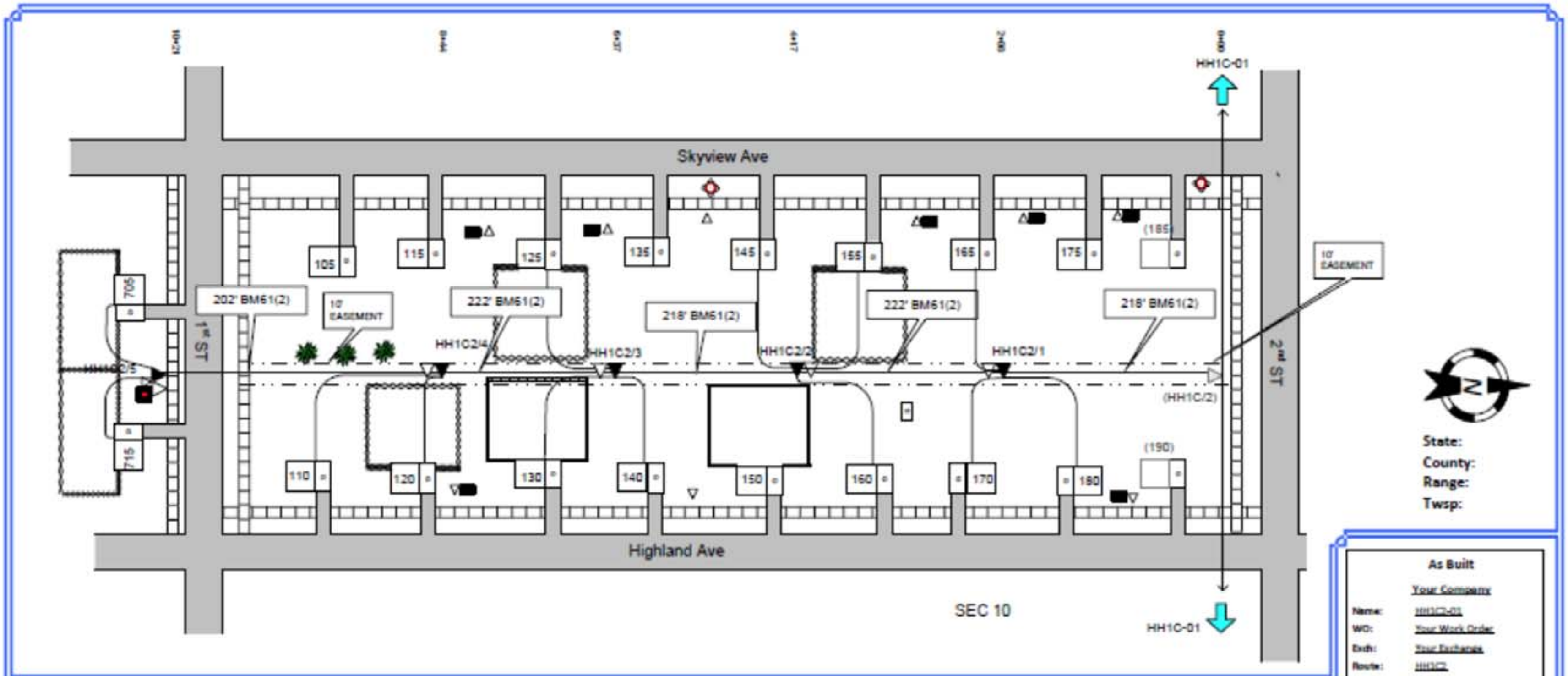
Sheet	1A	of	3

Field Design Maps Examples - Continued



From	To	PType	Units	Feet	BM		HB	HO		NID	Remarks
(FHH1/01)	HH1C/1	TV-106	BFO 144RI	334	2(5/8)(8)	1	FO(144)	1	2		TYCO 450B
	HH1C/1		BFOV(1x1.25)	316	61(2)	316		12	4		LEAVE 36' COIL IN HH1C/1
HH1C/1	185		SEBF 4	194	83	1		1	1	3E	
HH1C/1	190		SEBF 4	310	83	1		1	1	3	
HH1C/1	HH1C/2	TV-106	BFO 144RI	396	2(5/8)(8)	1	FO(144)	1	1		TYCO 450B
	HH1C/2		BFOV(1x1.25)	368	61(2)	360		12	4		LEAVE 36' COIL IN HH1C/2
HH1C/2	190		SEBF 4	206	83	1		1	1	3	
HH1C/2	HH1C/3	TV-106	BFO 144RI	376	2(5/8)(8)	1	FO(144)	1	2		TYCO 450B
	HH1C/3		BFOV(1x1.25)	348	61(2)	340		12	4		LEAVE 36' COIL IN HH1C/3

Field Design Maps Examples - Continued



From	To	PType	Units	Feet	BM		HB	HO		NID	Remarks
(HH1C/2)	HH1C2/1	TV-106	BFO 48RI	254	2(5/8)(8)	1	FO(48)	1	3		TYCO 450B
	HH1C2/1		BFOV(1x1.25)	218	61(2)	218					LEAVE 36' COIL IN HH1C2/1
HH1C2/1	170		SEBF 4	214	83	1		1	1	3	
HH1C2/1	165		SEBF 4	240	83	1		1	1	3	
HH1C2/1	180		SEBF 4	212	83	1		1	1	3	
HH1C2/1	HH1C2/2	TV-106	BFO 48RI	258	2(5/8)(8)	1	FO(48)	1	3		TYCO 450B
	HH1C2/2		BFOV(1x1.25)	222	61(2)	222					LEAVE 36' IN HH1C2/2
HH1C2/2	155		SEBF 4	148	83	1		1	1	3	
HH1C2/2	145		SEBF 4	128	83	1		1	1	3	

As Built

Your Company

Name: HH1C2-01
WO: Your Work Order
Exch: Your Exchange
Route: HH1C2
ROW: Public

Staked By: ______ Date: ______
Revised By: ______ Date: ______
Plowed By: ______ Date: ______
Tabbed By: ______ Date: ______

VantagePoint

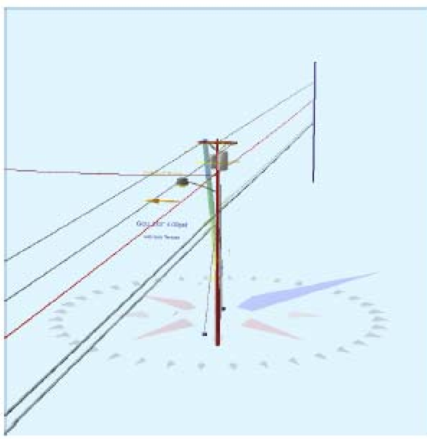
Drawing Not to Scale

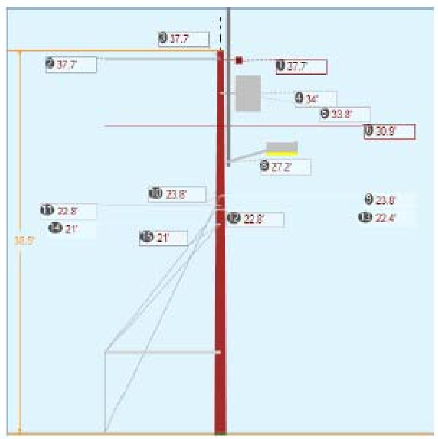
Sheet	1	of	1

Pole Loading Analysis Example (for a single pole)

Pole ID:Pole_99_pplx.pplx | **O-Calc® Pro *Standard Report*** | Thursday, December 28, 2017 5:11 PM

Pole Num:	**99**	Pole Length / Class:	**45 / 3**	Code:	**NESC**	Structure Type:	**Guyed Tangent**
Map Number	**B1101C**	Species:	**DOUGLAS FIR**	NESC Rule:	**Rule 250B**	Status	**Guy Wires Adequate**
Aux Data 2	**Unset**	Setting Depth (ft):	**6.50**	Construction Grade:	**B**	Pole Strength Factor:	**0.65**
Aux Data 3	**Unset**	G/L Circumference (in):	**37.31**	Loading District:	**Medium**	Transverse Wind LF:	**2.50**
Aux Data 4	**Unset**	G/L Fiber Stress (psi):	**8,000**	Ice Thickness (in):	**0.25**	Wire Tension LF:	**1.65**
Aux Data 5	**Unset**	Allowable Stress (psi):	**5,200**	Wind Speed (mph):	**39.53**	Vertical LF:	**1.50**
Aux Data 6	**Unset**	Fiber Stress Ht. Reduc:	**No**	Wind Pressure (psf):	**4.00**		
Latitude:	**0.000000 Deg**	Longitude:			**0.000000 Deg**	Elevation:	**0 Feet**





Pole Capacity Utilization (%)		**Height (ft)**	**Wind Angle (deg)**
Maximum	86.6	0.0	233.4
Groundline	86.6	0.0	233.4
Vertical	7.0	24.1	146.0

Pole Moments (ft-lb)		**Load Angle (deg)**	**Wind Angle (deg)**
Max Cap Util	**60,228**	211.9	233.4
Groundline	**60,228**	211.9	233.4
GL Allowable	**71,284**		

Pole Loading Analysis Example (for a single pole) - Continued

Pole ID:Pole_99_pplx.pplx — **O-Calc® Pro *Standard Report*** — Thursday, December 28, 2017 5:11 PM

Guy System Component Summary				Load From Worst Wind Angle on Pole	
Description	**Lead Length (ft)**	**Lead Angle (deg)**	**Height (ft)**	**Nominal Capacity (%)**	**Wind Angle (deg)**
Single - 10" - Soil Class 4	6.0	326.0		24.2	233.4
10M (Sidewalk)			21.0	34.0	233.4
Sidewalk Strut	6.0	326.0	8.0	77.9	233.4
EHS 1/4 (Sidewalk)			22.8	29.6	233.4
Single - 10" - Soil Class 4	14.0	146.0		0.0	233.4
10M (Down)			23.8	0.0	233.4
Single - 10" - Soil Class 4	188.0	326.0		17.4	233.4
HS 7/16 (Span/Head)			37.7	26.6	233.4
			System Capacity Summary:	**Adequate**	

Groundline Load Summary - Reporting Angle Mode: Load - Reporting Angle: 211.9°

	Shear Load* (lbs)	Applied Load (%)	Bending Moment (ft-lb)	Applied Moment (%)	Pole Capacity (%)	Bending Stress (+/- psi)	Vertical Load (lbs)	Vertical Stress (psi)	Total Stress (psi)	Pole Capacity (%)
Powers	1,816	48.5	59,794	99.3	83.9	4,808	230	2	4,810	92.5
Comms	2,227	59.5	41,494	68.9	58.2	3,337	897	8	3,345	64.3
GuyBraces	-804	-21.5	-51,859	-86.1	-72.8	-4,170	6,734	61	-4,109	-79.0
PowerEquipments	114	3.0	2,978	4.9	4.2	239	1,928	17	257	4.9
Pole	287	7.7	5,028	8.4	7.1	404	1,774	16	420	8.1
Crossarms	5	0.1	171	0.3	0.2	14	159	1	15	0.3
Streetlights	44	1.2	1,561	2.6	2.2	126	114	1	127	2.4
Risers	47	1.3	805	1.3	1.1	65	43	0	65	1.3
Insulators	7	0.2	256	0.4	0.4	21	44	0	21	0.4
Pole Load	3,742	100.0	60,228	100.0	84.5	4,843	11,923	108	4,950	95.2
Pole Reserve Capacity			11,056		15.5	357			250	4.8

Detailed Load Components:

Power		Height (ft)	Horiz. Offset (in)	Cable Diameter (in)	Sag at Max Temp (ft)	Cable Weight (lbs/ft)	Lead/Span Length (ft)	Span Angle (deg)	Wire Length (ft)	Tension (lbs)	Tension Moment* (ft-lb)	Offset Moment* (ft-lb)	Wind Moment* (ft-lb)	Moment at GL* (ft-lb)
Secondary	TRIPLEX 2 AWG	30.92	7.11	0.8060	2.04	0.248	188.0	326.0	188.0	1,710	-35,686	44	2,883	-32,760
Secondary	TRIPLEX 2 AWG	30.92	7.11	0.8060	0.45	0.248	50.0	236.0	50.0	143	6,656	12	16	6,684

Pole Loading Analysis Example (for a single pole) - Continued

Pole ID:Pole_99_pplx.pplx **O-Calc® Pro *Standard Report*** Thursday, December 28, 2017 5:11 PM

Secondary	TRIPLEX 2 AWG	30.92	7.11	0.8060	1.54	0.248	149.0	146.0	149.0	1,710	35,686	35	2,285	38,006
Neutral	#4 COPPER 7 STRAND	37.67	43.95	0.2316	0.54	0.129	149.0	146.0	149.0	1,000	25,428	-6	1,560	26,981
Neutral	#4 COPPER 7 STRAND	37.67	43.95	0.2316	0.54	0.129	149.0	146.0	149.0	1,000	25,428	10	1,560	26,997
										Totals:	57,512	94	8,303	65,909

Comm		Height (ft)	Horiz. Offset (in)	Cable Diameter (in)	Sag at Max Temp (ft)	Cable Weight (lbs/ft)	Lead/Span Length (ft)	Span Angle (deg)	Wire Length (ft)	Tension (lbs)	Tension Moment* (ft-lb)	Offset Moment* (ft-lb)	Wind Moment* (ft-lb)	Moment at GL* (ft-lb)
Overlashed Bundle	1/4" EHS	22.42	7.11	0.2500	1.24	0.121	149.0	146.0	149.0	1,142	17,282	48	3,244	20,574
CATV	CATV .75	22.13	7.11	1.0700	1.66		149.0	146.0	149.0			95	2,576	2,671
Overlashed Bundle	1/4" EHS	22.42	7.11	0.2500	1.95	0.121	188.0	326.0	188.0	1,351	-20,442	61	4,093	-16,288
CATV	CATV .75	22.13	7.11	1.0700	2.27		188.0	326.0	188.0			120	3,250	3,371
Overlashed Bundle	10M	21.00	4.70	0.3060	0.72	0.165	149.0	146.0	149.0	3,030	42,946	15	3,035	45,996
Telco	TELE 1.0	20.71	4.70	1.0000	0.52		149.0	146.0	149.0			19	2,407	2,426
Fiber	ADSS Fiber	22.83	4.59	0.4640	0.93	0.071	149.0	146.0	149.0	544	8,385	5	1,246	9,635
Overlashed Bundle	10M	23.83	4.53	0.3060	0.16	0.165	188.0	326.0	188.0	1,496	-24,075	-8	1,435	-22,648
										Totals:	24,096	357	21,284	45,738

PowerEquipment		Height (ft)	Horiz. Offset (in)	Offset Angle (deg)	Rotate Angle (deg)	Unit Weight (lbs)	Unit Height (in)	Unit Depth (in)	Unit Diameter (in)	Unit Length (in)	Offset Moment* (ft-lb)	Wind Moment* (ft-lb)	Moment at GL* (ft-lb)
Transformer	75KVA	34.03	22.93	100.0	100.0	1015.00	44.00	52.00	--	26.00	--	2,515	1,433
Transformer	15KVA	33.85	18.94	175.0	175.0	270.00	34.00	52.00	--	18.00	--	1,338	1,850
										Totals:	-571	3,854	3,282

Crossarm		Height (ft)	Horiz. Offset (in)	Offset Angle (deg)	Rotate Angle (deg)	Unit Weight (lbs)	Unit Height (in)	Unit Depth (in)	Unit Length (in)	Offset Moment* (ft-lb)	Wind Moment* (ft-lb)	Moment at GL* (ft-lb)
Normal	CROSSARM 3-1/2 X 4-1/2 X 8	37.67	5.46	146.0	146.0	53.00	4.50	3.50	96.00	0	188	188
									Totals:	0	188	188

Streetlight		Height (ft)	Horiz. Offset (in)	Offset Angle (deg)	Rotate Angle (deg)	Unit Weight (lbs)	Unit Height (in)	Unit Depth (in)	Unit Diameter (in)	Unit Length (in)	Offset Moment* (ft-lb)	Wind Moment* (ft-lb)	Moment at GL* (ft-lb)
General	Street Light	27.25	4.33	236.0	236.0	76.00	24.00	31.81	3.00	72.00	533	1,187	1,720
										Totals:	533	1,187	1,720

Riser		Height (ft)	Horiz. Offset (in)	Offset Angle (deg)	Rotate Angle (deg)	Unit Weight (lbs)	Unit Height (in)	Unit Depth (in)	Unit Diameter (in)	Unit Length (in)	Offset Moment* (ft-lb)	Wind Moment* (ft-lb)	Moment at GL* (ft-lb)
Riser 90.0°	Riser	28.92	6.09	90.0	90.0	28.92	347.00	3.50	3.50	347.00	-15	903	888
										Totals:	-15	903	888

Pole Loading Analysis Example (for a single pole) - Continued

Pole ID:Pole_99_pplx.pplx **O-Calc® Pro *Standard Report*** Thursday, December 28, 2017 5:11 PM

Insulator		Height (ft)	Horiz. Offset (in)	Offset Angle (deg)	Rotate Angle (deg)	Unit Weight (lbs)	Unit Diameter (in)	Unit Length (in)	Offset Moment* (ft-lb)	Wind Moment* (ft-lb)	Moment at GL* (ft-lb)
Bolt	Three Bolt CATV	22.42	0.00	236.0	146.0	5.00	3.00	0.00	4	0	4
Deadend	Three Bolt Telco	21.00	0.00	146.0	146.0	5.00	3.00	0.00	1	0	1
Deadend	F/O	22.83	0.00	146.0	146.0	5.00	3.00	0.00	1	0	1
Deadend	Three Bolt MCI	23.83	0.00	326.0	326.0	5.00	3.00	0.00	-1	0	-1
Spool	Spool 4"	30.92	0.00	236.0	146.0	3.00	4.00	4.12	2	33	35
Deadend	Deadend 12.75"	37.67	-40.00	63.8	0.0	3.00	3.80	12.75	-11	118	107
Deadend	Deadend 12.75"	37.67	40.00	228.2	0.0	3.00	3.80	12.75	16	118	134
								Totals:	13	269	282

Guy Wire and Brace		Attach Height (ft)	End Height (ft)	Lead/Span Length (ft)	Wire Diameter (in)	Percent Solid (%)	Lead Angle (deg)	Incline Angle (deg)	Wire Weight (lbs/ft)	Rest Length (ft)	Stretch Length (in)
10M	Sidewalk	21.00	0.00	6.00	0.306	75.00	326.0	64.9	0.165	22.16	0.62
EHS 1/4	Sidewalk	22.83	0.00	6.00	0.25	75.00	326.0	67.6	0.121	23.86	0.58
10M	Down	23.83	0.00	14.00	0.306	75.00	146.0	59.4	0.165	27.45	0.00
HS 7/16	Span/Head	37.67	37.67	188.00	0.438	75.00	326.0	0.0	0.399	187.69	3.02

Guy Wire and Brace (Loads and Reactions)		Elastic Modulus (psi)	Rated Tensile Strength (lbs)	Guy Strength Factor	Allowable Tension (lbs)	Initial Tension (lbs)	Loaded Tension*[2] (lbs)	Maximum Tension[2] (lbs)	Applied Tension[3] (lbs)	Vertical Load (lbs)	Shear Load In Guy Dir (lbs)	Shear Load At Report Angle (lbs)	Moment at GL[3] (ft-lb)
10M	Sidewalk	2.30e+7	10,000	0.90	9,000	700	5,600	3,394	3,062	2,772	1,302	-532	-3,924
EHS 1/4	Sidewalk	2.30e+7	6,650	0.90	5,985	700	3,263	1,978	1,771	1,638	675	-276	-2,435
10M	Down	2.30e+7	10,000	0.90	9,000	700	0	0	0	0	0	0	216
HS 7/16	Span/Head	2.30e+7	14,500	0.90	13,050	700	6,178	3,745	3,472	0	3,472	-1,421	-51,020
									Totals:	4,410	5,449	-2,229	-57,162

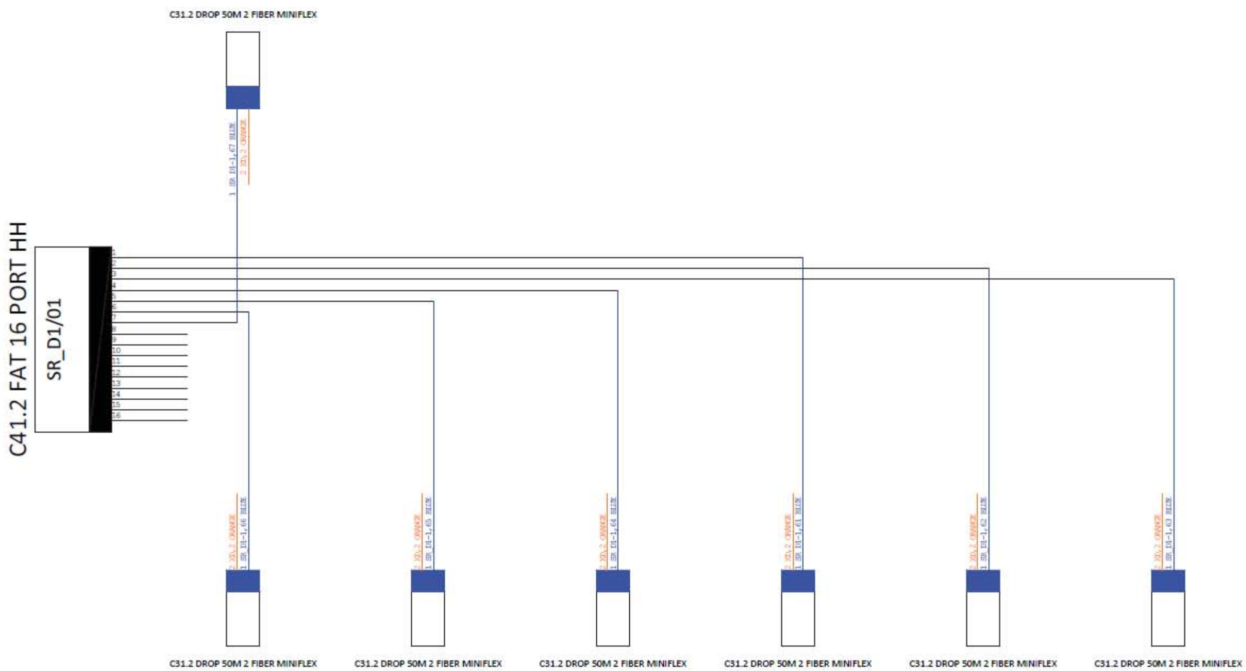
Anchor/Rod Load Summary	Rod Length AGL (in)	Lead Length (ft)	Lead Angle (deg)	Strength of Assembly (lbs)	Anchor/Rod Strength Factor	Allowable Load (lbs)	Max Load[2] (lbs)	Load at Pole MCU[3] (lbs)	Max Required Capacity[2] (%)
Single - 10" - Soil Class 4	0.00	6.00	326.0	20,000	1.00	20,000	5,370	4,832	26.8
Single - 10" - Soil Class 4	0.00	14.00	146.0	20,000	1.00	20,000	0	0	0.0
Single - 10" - Soil Class 4	0.00	188.00	326.0	20,000	1.00	20,000	3,745	3,472	18.7

Pole Buckling

Buckling Constant	Buckling Column Height* (ft)	Buckling Section Height (% Buckling Col. Hgt.)	Buckling Section Diameter (in)	Minimum Buckling Diameter at GL (in)	Diameter at Tip (in)	Diameter at GL (in)	Modulus of Elasticity (psi)	Pole Density (pcf)	Ice Density (pcf)	Pole Tip Height (ft)	Buckling Load Capacity at Height (lbs)	Buckling Load Applied at Height (lbs)	Buckling Load Factor of Safety
0.71	24.15	33.61	10.92	17.12	7.32	11.88	1.60e+6	60.00	57.00	38.50	170,437	**1703.22**	**14.29**

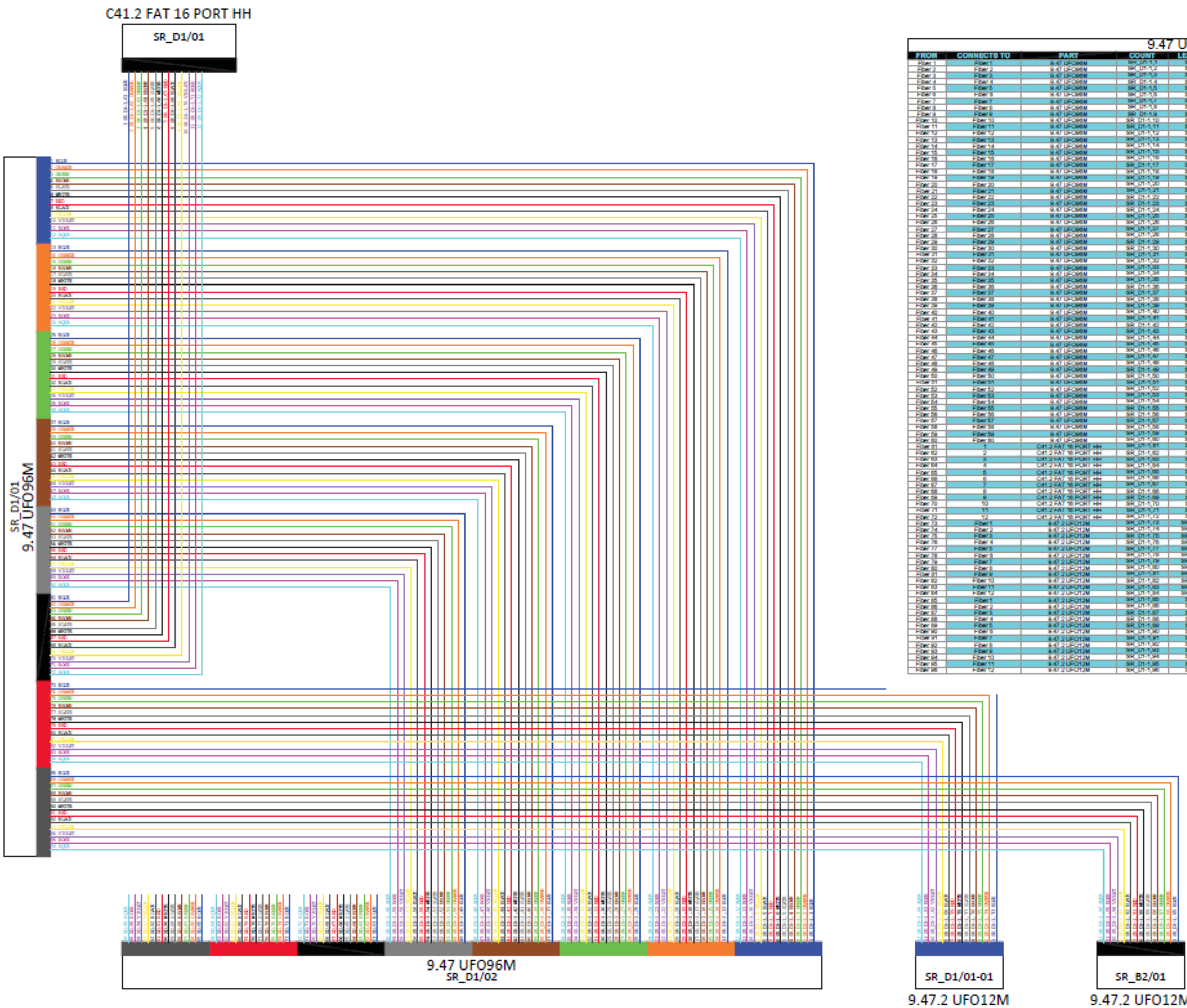
Appendix C - Construction Examples

Fiber Splicing Plans



C41.2 FAT 16 PORT HH - SR_D1/01										
FROM	CONNECTS TO	PART	COUNT	LEAD/POLE	CUSTOMER	NAME	OWNER	SERVICE CATEGORY	USE	WEIGHT
1	Fiber 1	C31.2 DROP 50M 2 FIBER MINIFLEX	SR_D1-1,61						SR_D1/01 Part: C41.2 FAT 16 PORT HH	
2	Fiber 1	C31.2 DROP 50M 2 FIBER MINIFLEX	SR_D1-1,62						SR_D1/01 Part: C41.2 FAT 16 PORT HH	
3	Fiber 1	C31.2 DROP 50M 2 FIBER MINIFLEX	SR_D1-1,63						SR_D1/01 Part: C41.2 FAT 16 PORT HH	
4	Fiber 1	C31.2 DROP 50M 2 FIBER MINIFLEX	SR_D1-1,64						SR_D1/01 Part: C41.2 FAT 16 PORT HH	
5	Fiber 1	C31.2 DROP 50M 2 FIBER MINIFLEX	SR_D1-1,65						SR_D1/01 Part: C41.2 FAT 16 PORT HH	
6	Fiber 1	C31.2 DROP 50M 2 FIBER MINIFLEX	SR_D1-1,66						SR_D1/01 Part: C41.2 FAT 16 PORT HH	
7	Fiber 1	C31.2 DROP 50M 2 FIBER MINIFLEX	SR_D1-1,67						SR_D1/01 Part: C41.2 FAT 16 PORT HH	
8			XD,8							
9			XD,9							
10			XD,10							
11			XD,11							
12			XD,12							
13			XD,13							
14			XD,14							
15			XD,15							
16			XD,16							

Fiber Splicing Plans- Continued



9.47 UFO96M - SR_D1/01

FROM	CONNECTS TO	PART	COUNT	LEAD/POLE	CUSTOMER	NAME	OWNER	SERVICE CATEGORY	USE	WEIGHT
Fiber 1	Fiber 1	9.47 UFO96M	SR_D1-1,1	SR_D1/02						
Fiber 2	Fiber 2	9.47 UFO96M	SR_D1-1,2	SR_D1/02						
Fiber 3	Fiber 3	9.47 UFO96M	SR_D1-1,3	SR_D1/02						
Fiber 4	Fiber 4	9.47 UFO96M	SR_D1-1,4	SR_D1/02						
Fiber 5	Fiber 5	9.47 UFO96M	SR_D1-1,5	SR_D1/02						
Fiber 6	Fiber 6	9.47 UFO96M	SR_D1-1,6	SR_D1/02						
Fiber 7	Fiber 7	9.47 UFO96M	SR_D1-1,7	SR_D1/02						
Fiber 8	Fiber 8	9.47 UFO96M	SR_D1-1,8	SR_D1/02						
Fiber 9	Fiber 9	9.47 UFO96M	SR_D1-1,9	SR_D1/02						
Fiber 10	Fiber 10	9.47 UFO96M	SR_D1-1,10	SR_D1/02						
Fiber 11	Fiber 11	9.47 UFO96M	SR_D1-1,11	SR_D1/02						
Fiber 12	Fiber 12	9.47 UFO96M	SR_D1-1,12	SR_D1/02						
Fiber 13	Fiber 13	9.47 UFO96M	SR_D1-1,13	SR_D1/02						
Fiber 14	Fiber 14	9.47 UFO96M	SR_D1-1,14	SR_D1/02						
Fiber 15	Fiber 15	9.47 UFO96M	SR_D1-1,15	SR_D1/02						
Fiber 16	Fiber 16	9.47 UFO96M	SR_D1-1,16	SR_D1/02						
Fiber 17	Fiber 17	9.47 UFO96M	SR_D1-1,17	SR_D1/02						
Fiber 18	Fiber 18	9.47 UFO96M	SR_D1-1,18	SR_D1/02						
Fiber 19	Fiber 19	9.47 UFO96M	SR_D1-1,19	SR_D1/02						
Fiber 20	Fiber 20	9.47 UFO96M	SR_D1-1,20	SR_D1/02						
Fiber 21	Fiber 21	9.47 UFO96M	SR_D1-1,21	SR_D1/02						
Fiber 22	Fiber 22	9.47 UFO96M	SR_D1-1,22	SR_D1/02						
Fiber 23	Fiber 23	9.47 UFO96M	SR_D1-1,23	SR_D1/02						
Fiber 24	Fiber 24	9.47 UFO96M	SR_D1-1,24	SR_D1/02						
Fiber 25	Fiber 25	9.47 UFO96M	SR_D1-1,25	SR_D1/02						
Fiber 26	Fiber 26	9.47 UFO96M	SR_D1-1,26	SR_D1/02						
Fiber 27	Fiber 27	9.47 UFO96M	SR_D1-1,27	SR_D1/02						
Fiber 28	Fiber 28	9.47 UFO96M	SR_D1-1,28	SR_D1/02						
Fiber 29	Fiber 29	9.47 UFO96M	SR_D1-1,29	SR_D1/02						
Fiber 30	Fiber 30	9.47 UFO96M	SR_D1-1,30	SR_D1/02						
Fiber 31	Fiber 31	9.47 UFO96M	SR_D1-1,31	SR_D1/02						
Fiber 32	Fiber 32	9.47 UFO96M	SR_D1-1,32	SR_D1/02						
Fiber 33	Fiber 33	9.47 UFO96M	SR_D1-1,33	SR_D1/02						
Fiber 34	Fiber 34	9.47 UFO96M	SR_D1-1,34	SR_D1/02						
Fiber 35	Fiber 35	9.47 UFO96M	SR_D1-1,35	SR_D1/02						
Fiber 36	Fiber 36	9.47 UFO96M	SR_D1-1,36	SR_D1/02						
Fiber 37	Fiber 37	9.47 UFO96M	SR_D1-1,37	SR_D1/02						
Fiber 38	Fiber 38	9.47 UFO96M	SR_D1-1,38	SR_D1/02						
Fiber 39	Fiber 39	9.47 UFO96M	SR_D1-1,39	SR_D1/02						
Fiber 40	Fiber 40	9.47 UFO96M	SR_D1-1,40	SR_D1/02						
Fiber 41	Fiber 41	9.47 UFO96M	SR_D1-1,41	SR_D1/02						
Fiber 42	Fiber 42	9.47 UFO96M	SR_D1-1,42	SR_D1/02						
Fiber 43	Fiber 43	9.47 UFO96M	SR_D1-1,43	SR_D1/02						
Fiber 44	Fiber 44	9.47 UFO96M	SR_D1-1,44	SR_D1/02						
Fiber 45	Fiber 45	9.47 UFO96M	SR_D1-1,45	SR_D1/02						
Fiber 46	Fiber 46	9.47 UFO96M	SR_D1-1,46	SR_D1/02						
Fiber 47	Fiber 47	9.47 UFO96M	SR_D1-1,47	SR_D1/02						
Fiber 48	Fiber 48	9.47 UFO96M	SR_D1-1,48	SR_D1/02						
Fiber 49	Fiber 49	9.47 UFO96M	SR_D1-1,49	SR_D1/02						
Fiber 50	Fiber 50	9.47 UFO96M	SR_D1-1,50	SR_D1/02						
Fiber 51	Fiber 51	9.47 UFO96M	SR_D1-1,51	SR_D1/02						
Fiber 52	Fiber 52	9.47 UFO96M	SR_D1-1,52	SR_D1/02						
Fiber 53	Fiber 53	9.47 UFO96M	SR_D1-1,53	SR_D1/02						
Fiber 54	Fiber 54	9.47 UFO96M	SR_D1-1,54	SR_D1/02						
Fiber 55	Fiber 55	9.47 UFO96M	SR_D1-1,55	SR_D1/02						
Fiber 56	Fiber 56	9.47 UFO96M	SR_D1-1,56	SR_D1/02						
Fiber 57	Fiber 57	9.47 UFO96M	SR_D1-1,57	SR_D1/02						
Fiber 58	Fiber 58	9.47 UFO96M	SR_D1-1,58	SR_D1/02						
Fiber 59	Fiber 59	9.47 UFO96M	SR_D1-1,59	SR_D1/02						
Fiber 60	Fiber 60	9.47 UFO96M	SR_D1-1,60	SR_D1/02						
Fiber 61	1	C41.2 FAT 16 PORT HH	SR_D1-1,61	SR_D1/01						
Fiber 62	2	C41.2 FAT 16 PORT HH	SR_D1-1,62	SR_D1/01						
Fiber 63	3	C41.2 FAT 16 PORT HH	SR_D1-1,63	SR_D1/01						
Fiber 64	4	C41.2 FAT 16 PORT HH	SR_D1-1,64	SR_D1/01						
Fiber 65	5	C41.2 FAT 16 PORT HH	SR_D1-1,65	SR_D1/01						
Fiber 66	6	C41.2 FAT 16 PORT HH	SR_D1-1,66	SR_D1/01						
Fiber 67	7	C41.2 FAT 16 PORT HH	SR_D1-1,67	SR_D1/01						
Fiber 68	8	C41.2 FAT 16 PORT HH	SR_D1-1,68	SR_D1/01						
Fiber 69	9	C41.2 FAT 16 PORT HH	SR_D1-1,69	SR_D1/01						
Fiber 70	10	C41.2 FAT 16 PORT HH	SR_D1-1,70	SR_D1/01						
Fiber 71	11	C41.2 FAT 16 PORT HH	SR_D1-1,71	SR_D1/01						
Fiber 72	12	C41.2 FAT 16 PORT HH	SR_D1-1,72	SR_D1/01						
Fiber 73	Fiber 1	9.47.2 UFO12M	SR_D1-1,73	SR_D1/01-01						
Fiber 74	Fiber 2	9.47.2 UFO12M	SR_D1-1,74	SR_D1/01-01						
Fiber 75	Fiber 3	9.47.2 UFO12M	SR_D1-1,75	SR_D1/01-01						
Fiber 76	Fiber 4	9.47.2 UFO12M	SR_D1-1,76	SR_D1/01-01						
Fiber 77	Fiber 5	9.47.2 UFO12M	SR_D1-1,77	SR_D1/01-01						
Fiber 78	Fiber 6	9.47.2 UFO12M	SR_D1-1,78	SR_D1/01-01						
Fiber 79	Fiber 7	9.47.2 UFO12M	SR_D1-1,79	SR_D1/01-01						
Fiber 80	Fiber 8	9.47.2 UFO12M	SR_D1-1,80	SR_D1/01-01						
Fiber 81	Fiber 9	9.47.2 UFO12M	SR_D1-1,81	SR_D1/01-01						
Fiber 82	Fiber 10	9.47.2 UFO12M	SR_D1-1,82	SR_D1/01-01						
Fiber 83	Fiber 11	9.47.2 UFO12M	SR_D1-1,83	SR_D1/01-01						
Fiber 84	Fiber 12	9.47.2 UFO12M	SR_D1-1,84	SR_D1/01-01						
Fiber 85	Fiber 1	9.47.2 UFO12M	SR_D1-1,85	SR_B2/01						
Fiber 86	Fiber 2	9.47.2 UFO12M	SR_D1-1,86	SR_B2/01						
Fiber 87	Fiber 3	9.47.2 UFO12M	SR_D1-1,87	SR_B2/01						
Fiber 88	Fiber 4	9.47.2 UFO12M	SR_D1-1,88	SR_B2/01						
Fiber 89	Fiber 5	9.47.2 UFO12M	SR_D1-1,89	SR_B2/01						
Fiber 90	Fiber 6	9.47.2 UFO12M	SR_D1-1,90	SR_B2/01						
Fiber 91	Fiber 7	9.47.2 UFO12M	SR_D1-1,91	SR_B2/01						
Fiber 92	Fiber 8	9.47.2 UFO12M	SR_D1-1,92	SR_B2/01						
Fiber 93	Fiber 9	9.47.2 UFO12M	SR_D1-1,93	SR_B2/01						
Fiber 94	Fiber 10	9.47.2 UFO12M	SR_D1-1,94	SR_B2/01						
Fiber 95	Fiber 11	9.47.2 UFO12M	SR_D1-1,95	SR_B2/01						
Fiber 96	Fiber 12	9.47.2 UFO12M	SR_D1-1,96	SR_B2/01						

Fiber Testing Results Example

FTTP Acceptance Test Results Form (To Be Completed By OSP Contractor)

Serving Area__________ Client__________ Date______________

				1310 nm			1550 nm					
Fiber #	OTDR Distance in feet	ber of fu splices	umber onnecto	Maximum lowable lo	Power Meter Actual Loss	DR Estima Span Loss	Maximum Allowable loss	Power Meter Actual Loss	OTDR Estimated Span Loss	End Point	Subscriber Address	Notes
1	11601	4	1	2.71		1.123	2.36		0.649			
2	11601	4	1	2.71		1.123	2.36		0.649			
3	11601	4	1	2.71		1.123	2.36		0.649			
4	11601	4	1	2.71		1.123	2.36		0.649			
5	11878	6	2	3.65	2.84	1.218	3.29	1.93	0.802	A3/8	12987 CEDAR HILLS DR	
6	11325	6	2	3.58		1.486	3.24		0.963			
7	11601	4	1	2.71		1.315	2.36		0.793			
8	11604	4	1	2.71		1.488	2.36		1.06			
9	11601	4	1	2.71		1.356	2.36		0.834			
10	11438	6	2	3.59	2.77	1.286	3.25	2.1	0.758	A3/7	13063 CEDAR HILLS DR	
11	11530	6	2	3.61	2.01	1.038	3.25	1.47	0.577	A3/7	13032 CEDAR HILLS DR	
12	11624	6	2	3.62	1.86	1.198	3.26	1.46	0.752	A3/7	13064 CEDAR HILLS DR	
13	11329	4	1	2.68		1.292	2.34		0.914			
14	11609	4	1	2.72		1.299	2.36		0.841			
15	11606	4	1	2.71		1.304	2.36		0.875			
16	11367	6	2	3.59	2.11	1.037	3.24	1.71	0.767	A3/6	13136 CEDAR HILLS DR	
17	11482	6	2	3.60	2.46	1.154	3.25	2	0.792	A3/6	13121 CEDAR HILLS DR	
18	11172	6	2	3.56	1.79	1.506	3.22	1.39	0.973	A3/6	13128 CEDAR HILLS DR	
19	11193	4	1	2.66		1.352	2.32		0.977			
20	11420	6	2	3.59	2.97	2.312	3.24	2.45	2.061	A3B/2	13087 CEDAR HILLS DR	
21	11193	4	1	2.66		1.287	2.32		0.98			
22	11193	4	1	2.66		1.245	2.32		0.924			
23	11155	6	2	3.56	2.45	1.033	3.22	1.98	0.751	A3B/1	1311 CEDAR HILLS DR	
24	11132	6	2	3.56	3.32	1.645	3.22	2.94	1.437	A3B/1	13159 CEDAR HILLS DR	
25	11082	4	1	2.65		1.261	2.31		0.827			
26	11082	4	1	2.65		1.261	2.31		0.827			
27	11082	4	1	2.65		1.261	2.31		0.827			
28	11082	4	1	2.65		1.261	2.31		0.827			
29	11082	4	1	2.65		1.261	2.31		0.827			
30	11082	4	1	2.65		1.261	2.31		0.827			
31	11082	4	1	2.65		1.261	2.31		0.827			
32	11082	4	1	2.65		1.261	2.31		0.827			
33	11082	4	1	2.65		1.261	2.31		0.827			
34	11082	4	1	2.65		1.261	2.31		0.827			
35	11082	4	1	2.65		1.261	2.31		0.827			
36	11082	4	1	2.65		1.261	2.31		0.827			
37	11082	4	1	2.65		1.261	2.31		0.827			
38	11082	4	1	2.65		1.261	2.31		0.827			
39	11082	4	1	2.65		1.261	2.31		0.827			
40	11082	4	1	2.65		1.261	2.31		0.827			
41	11377	6	2	3.59	1.8	1.265	3.24	1.74	1.027	A3/5-1	11707 CEDAR HILLS DR	
42	11082	4	1	2.65		1.346	2.31		0.869			
43	11082	4	1	2.65		1.338	2.31		0.865			

Fiber Testing Results Example - Continued

FTTP Acceptance Test Results Form (To Be Completed By OSP Contractor)

Serving Area__________ Client_________ Date____________

				1310 nm			1550 nm					
Fiber #	OTDR Distance in feet	ber of fu splices	umber onnecto	Maximum owable lo	Power Meter Actual Loss	DR Estima Span Loss	Maximum Allowable loss	Power Meter Actual Loss	OTDR Estimated Span Loss	End Point	Subscriber Address	Notes
44	11084	4	1	2.65		1.316	2.31		0.867			
45	11082	4	1	2.65		1.296	2.31		0.834			
46	11109	6	2	3.55	2.23	1.446	3.22	1.84	0.979	A3/5-2	11762 32ND RD	
47	10982	6	2	3.54	2.36	1.087	3.20	1.9	0.729	A3/5-2	13142 CEDAR HILLS DR	
48	11023	6	2	3.54	2.58	1.066	3.21	2.17	0.882	A3/5-2	13186 CEDAR HILLS DR	
49	11606	4	1	2.71		1.329	2.36		0.83			
50	11606	4	1	2.71		1.315	2.36		0.914			
51	11606	4	1	2.71		1.329	2.36		0.918			
52	10521	6	2	3.48	2	0.948	3.16	1.63	0.461	A3/5	11768 32ND RD	
53	9591	4	1	2.47		1.276	2.18		0.69			
54	9593	4	1	2.47		1.127	2.18		0.624			
55	9807	6	2	3.40	2.12	1.04	3.10	1.63	0.531	A3/4-1	11961 32ND RD	
56	9761	6	2	3.39	2.82	0.928	3.09	2.28	0.473	A3/4-1	11963 32ND RD	
57	11606	4	1	2.71		1.308	2.36		0.662			
58	11606	4	1	2.71		1.283	2.36		0.758			
59	9964	6	2	3.41	2.71	1.141	3.11	2.24	0.615	A3/4	11794 32ND RD	
60	9668	6	2	3.38	2.27	0.97	3.08	1.85	0.635	A3/4	11952 32ND RD	
61	11604	4	1	2.71		1.215	2.36		0.827			
62	9051	6	2	3.30	2.02	1.17	3.03	1.65	0.745	A3/3	12042 32ND RD	
63	11604	4	1	2.71		1.426	2.36		1.162			
64	9042	6	2	3.30	2.06	0.789	3.03	1.66	0.495	A3/2	13140 IRISH RIDGE RD	
65	8538	6	2	3.24		0.954	2.98		0.621			
66	8540	5	1	2.54		0.899	2.28		0.52			
67	8540	7	2	3.44	2.16	0.833	3.18	1.69	0.41	A3A/1	12043 32ND RD	
68	8538	7	2	3.44	2.72	0.819	3.18	2.35	0.449	A3A/1	12039 32ND RD	
69	11604	4	1	2.71		1.367	2.36		1.102			
70	11601	4	1	2.71		1.377	2.36		1.233			
71	11604	4	1	2.71		1.381	2.36		1.177			
72	8532	5	2	3.04	2.38	0.895	2.78	1.85	0.511	A3/1	12123 32ND RD	
73	8684	5	1	2.56		1.038	2.29		0.626			
74	8684	5	1	2.56		0.937	2.29		0.595			
75	8684	5	1	2.56		1.091	2.29		0.594			
76	8684	5	1	2.56		0.807	2.29		0.399			
77	8684	5	1	2.56		0.99	2.29		0.65			
78	8684	5	1	2.56		0.961	2.29		0.474			
79	9130	7	2	3.51	2.25	0.896	3.23	1.78	0.44	A/12	13151 IRISH RIDGE RD	
80	8831	7	2	3.48	2.26	0.751	3.21	1.83	0.373	A/12	13179 IRISH RIDGE RD	
81	8684	4	1	2.36		1.09	2.09		0.654			
82	8682	4	1	2.36		0.947	2.09		0.598			
83	8682	4	1	2.36		0.982	2.09		0.651			
84	8912	6	2	3.29	1.71	0.801	3.01	1.36	0.392	A/11	13158 IRISH RIDGE RD	
85	8381	4	1	2.32		1.031	2.07		0.601			
86	8381	4	1	2.32		0.994	2.07		0.619			

About the Authors

Larry Thompson is a licensed Professional Engineer and CEO of Vantage Point Solutions. Larry has a Physics degree from William Jewell College and Bachelor and Master degrees in Electrical Engineering from the University of Kansas. Larry has helped hundreds of telecommunication companies be successful in this rapidly changing technical and regulatory environment. He has designed many wireless and wireline networks as he has assisted his clients in their transition from legacy TDM networks to broadband IP networks.

Brian Enga is a licensed Professional Engineer and part of the Senior Engineering team at Vantage Point Solutions. Brian has Bachelor of Science degrees in Electrical Engineering and Engineering Physics from South Dakota State University. He has been working in the telecommunications industry for nearly 20 years. Brian has engineered a variety of broadband networks and has been a pioneer in deploying IP video networks.