Community Broadband Study

Prepared for The Township of Edison New Jersey

October 7th, 2022
# Table of Contents

Executive Summary .................................................................................................................................................. 4  
Background .......................................................................................................................................................... 4  
Mission Statement ............................................................................................................................................. 5  
Current Broadband Market Interest Survey ........................................................................................................ 5  
Local Market Survey Assumptions & Conclusions ............................................................................................... 5  
Market Technology Overview ................................................................................................................................... 17  
  DSL .................................................................................................................................................................... 18  
  Coaxial (Cable) .................................................................................................................................................. 19  
  Fixed Wireless ................................................................................................................................................... 20  
  Satellite .............................................................................................................................................................. 20  
  Fiber-to-the-home (FTTH) .............................................................................................................................. 21  
Technical Feasibility .............................................................................................................................................. 23  
  Utility Poles & Make Ready .............................................................................................................................. 23  
  Underground Construction ............................................................................................................................. 24  
  Construction Benchmarking ........................................................................................................................... 25  
  Inventory of Existing Infrastructure .................................................................................................................. 25  
High-Level Engineering ....................................................................................................................................... 27  
  Network Architecture ....................................................................................................................................... 27  
  Network Specifications ..................................................................................................................................... 29  
  Sample Area Overview .................................................................................................................................... 31  
Financial Feasibility ............................................................................................................................................. 31  
  Potential Sources of Capital ............................................................................................................................. 31  
  Estimated Capital Expenditures Schedule ....................................................................................................... 33  
    Engineering- Survey & Design .......................................................................................................................... 33  
    Right-of-Way Make Ready ............................................................................................................................ 33  
    Hub Equipment & Electronics ........................................................................................................................ 33  
    Customer Premise Equipment & Electronics .................................................................................................. 33  
    Material ......................................................................................................................................................... 33  
    Market Labor .................................................................................................................................................. 33  
    Professional Services-Project & Construction Management ........................................................................ 33  
Estimated Operational Expenditures & Revenue .................................................................................................. 34  
  Management .................................................................................................................................................... 34
<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Third Party Services</td>
<td>34</td>
</tr>
<tr>
<td>Equipment &amp; Tools</td>
<td>35</td>
</tr>
<tr>
<td>Maintenance Personnel</td>
<td>35</td>
</tr>
<tr>
<td>Customer Service &amp; Ticketing</td>
<td>35</td>
</tr>
<tr>
<td>Churn rate &amp; Customer Installations</td>
<td>35</td>
</tr>
<tr>
<td>Inventory &amp; Warehousing</td>
<td>35</td>
</tr>
<tr>
<td>Emergency Restoration &amp; Response</td>
<td>35</td>
</tr>
</tbody>
</table>

**Appendix A-100% Capital Deployment Sample Proforma** ........................................... 37

**Appendix B-Sample Maps & Schematics** ................................................................ 38

  - Field Split & Distribution methodology ......................................................... 38
  - Residential Node Area Distribution .................................................................. 38

**Appendix D-Glossary of Terms** ............................................................................ 39
Executive Summary

Background-

The township of Edison, NJ is home to more than 100,000 residents within its 32 square-mile border. Home to Thomas Alva Edison's laboratory responsible for perfecting the incandescent light bulb in 1879 the township has a long-standing history of benchmarking technological innovation. Physical location, population density, premiere educational institutions, and an abundance of locally sourced skilled labor make the Township of Edison ideal for both residential and commercial development. However, barriers to growth and community development are currently limited by minimal private sector investment attempting to recoup previous capital investment in failing technology and infrastructure in lieu of replacement.

Given the status of this failing infrastructure the current administration sought to evaluate the possibility of advancing their communities access to leading technology by ensuring the equitable access to modern broadband infrastructure and services for all Edison residents, public schools, public services, and businesses for which it serves.

Following the onset of Covid-19 current network infrastructure deficiencies were highlighted nationwide resulting in inconsistent service, speed, and reliability. Although the term “working remote” and “virtual classroom” became mainstream during this time, long before this epidemic American households have trended to increasing their affection for modern electronics along with the services and convenience with which they provide to our lifestyle.

Exponential growth and advancement in electronics manufacturing accompanied with rising global demand for these consumer level devices created a revolving inventory surplus of generational electronics and more equitable access to devices for American households. Unfortunately, the performance of these devices, both independently, and collectively, are dependent upon the amount of network bandwidth available to download/upload data with which it is connected.

The Township of Edison proactively sought out this study to determine the financial feasibility of public investment into capital communications infrastructure within its community. Although the primary focus of this study will be to provide the feasibility assessment of cost and revenue estimates for both capital and operational expenses required to deploy a FTTH network, a multitude of ancillary community benefits and additional revenue generating opportunities exist through readily available fiber infrastructure. The benefits of municipally/community owned infrastructure cannot be understated considering the current and future social demand for integrated intelligence and equipment for all public services.
Project Mission Statement

Community Broadband Initiative

Matrix Design Group has been commissioned to conduct this market study to further examine feasible options for technology deployment best suited to the community’s goals today and future generations. The basis of this research was to adequately assess and collect public interests for a community-based infrastructure intended to support equitable access to broadband connections for residents, businesses, and municipal government. Identifying modern communications infrastructure types, costs, and compatibility with equipment for all potential community benefit projects adding valued engineering to mitigate potential risks associated with network construction and operations. Sample sizes for this study consist of 7 unique Node models whereas areas of localized neighborhood conditions residing within the Township of Edison were reviewed and analyzed for technical feasibility and assessment of the required network architecture, construction methods, available right-of-way inventory and service distribution connections.

Community Interest & Opinion Survey

The Township of Edison conducted a sample survey of residents for both quantitative and qualitative analysis purposes intended to assess the Townships’ resident’s local market use, satisfaction, interest, pricing, priority, reliability, and customer loyalty for their current broadband service provider. During a 35-day period between June 18, 2022, and July 23, 2022, the Township of Edison conducted an online broadband survey with which a total of 3099 submissions from community respondents were received.

With the onset of Covid-19 forcing employees to work from home along with social distancing practices and costly retrofitting of commercial spaces for Federal/State/Local compliance forced both employees and employers to make swift adjustments and accommodations to the workforce in order to balance conflicts between professional and personal responsibilities during life lived within a pandemic. Responsibilities and schedules developed during this time for everyday life have shifted conventional operational approaches for most employers wishing to retain and/or attract white-collar positions.
In support of this growing trend, the Township of Edison had 64% of respondents list “Working from Home” as their primary use. Table A below shows additional support for the Townships’ local need for appropriate bandwidth in scale with the surrounding area illustrating a significantly larger margin (+16.5%) of educated labor force locally when compared to the surrounding areas.

**Table A (Census Sample)**

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Population Characteristics</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Veterans, 2016-2020</td>
<td>363</td>
<td>552P</td>
<td>8,043</td>
<td>107,028</td>
<td>55,708</td>
</tr>
<tr>
<td>Foreign born persons, percent, 2016-2020</td>
<td>28.2%</td>
<td>43.0%</td>
<td>21.6%</td>
<td>46.0%</td>
<td>31.2%</td>
</tr>
<tr>
<td>Housing</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Housing units, July 1, 2021 (Y2021)</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Owner-occupied housing unit rent, 2016-2020</td>
<td>72.4%</td>
<td>20.5%</td>
<td>63.2%</td>
<td>10.1%</td>
<td>10.1%</td>
</tr>
<tr>
<td>Median value of owner-occupied housing units, 2016-2020</td>
<td>$310,450</td>
<td>$371,500</td>
<td>$352,200</td>
<td>$362,800</td>
<td>$207,200</td>
</tr>
<tr>
<td>Median selected monthly owner costs with a mortgage, 2016-2020</td>
<td>$2,614</td>
<td>$2,410</td>
<td>$2,380</td>
<td>$2,657</td>
<td>$1,849</td>
</tr>
<tr>
<td>Median selected monthly owner costs without a mortgage, 2016-2020</td>
<td>$1,145</td>
<td>$1,010</td>
<td>$945</td>
<td>$1,150</td>
<td>$941</td>
</tr>
<tr>
<td>Median gross rent, 2016-2020</td>
<td>$1,020</td>
<td>$1,245</td>
<td>$1,837</td>
<td>$1,657</td>
<td>$1,624</td>
</tr>
<tr>
<td>Building permits, 2021</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Families &amp; Living Arrangements</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Households, 2016-2020</td>
<td>4,215</td>
<td>16,827</td>
<td>8,108</td>
<td>34,010</td>
<td>15,919</td>
</tr>
<tr>
<td>Persons per household, 2016-2020</td>
<td>2.45</td>
<td>3.06</td>
<td>2.87</td>
<td>2.40</td>
<td>2.40</td>
</tr>
<tr>
<td>Living in same house 1 year ago, percent of persons age 1 year, 2016-2020</td>
<td>87.8%</td>
<td>91.0%</td>
<td>90.5%</td>
<td>89.1%</td>
<td>86.1%</td>
</tr>
<tr>
<td>Language other than English spoken at home, percent of persons age 5 years, 2016-2020</td>
<td>44.5%</td>
<td>80.2%</td>
<td>28.6%</td>
<td>57.2%</td>
<td>53.2%</td>
</tr>
<tr>
<td>Computer and Internet Use</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Households with a computer, percent, 2016-2020</td>
<td>90.0%</td>
<td>90.5%</td>
<td>92.0%</td>
<td>94.9%</td>
<td>90.2%</td>
</tr>
<tr>
<td>Households with broadband internet subscription, percent, 2016-2020</td>
<td>88.5%</td>
<td>89.1%</td>
<td>90.5%</td>
<td>82.3%</td>
<td>77.3%</td>
</tr>
<tr>
<td>Education</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>High school graduate or higher, percent of persons age 25 years+, 2016-2020</td>
<td>89.0%</td>
<td>71.5%</td>
<td>82.7%</td>
<td>82.0%</td>
<td>54.9%</td>
</tr>
<tr>
<td>Bachelor’s degree or higher, percent of persons age 25 years+, 2016-2020</td>
<td>35.4%</td>
<td>15.3%</td>
<td>38.9%</td>
<td>55.4%</td>
<td>23.0%</td>
</tr>
</tbody>
</table>
Community Interest Survey - Performance

**Chart B: Broadband Performance**

Respondents’ indications of unfavorable views regarding current broadband performance indicate quality as the largest variable influencing their opinion of current broadband services. The neutral position in the following instances shall serve as median value of a Gaussian distribution and having the largest range between the unfavorable and favorable respondents indicating this trend as the most important factor in the respondents’ opinion of current broadband quality as determined by the largest skew in data landing between unfavorable (54%) and favorable (12%) positions within the qualitative survey questions.

**Chart C: Broadband Performance Trend**

Responses distributed in Chart C show “performance” having the largest slope or severity of trend linearly when compared with other variables in this study. Although reliability is the next qualitative data point collected within the “Quality” category it is important to note that reliability and performance are not mutually exclusive of each other and should be weighted together as such for combined influence in current residents’ perception of service.
Community Interest Survey-Reliability

Chart D: Broadband Reliability

In addition to performance opinions, survey participants were asked to rate their current internet service reliability. Following in line with the previous opinions on current performance, the data collected indicates a trend toward unfavorable opinions about their connection’s reliability. Although, Chart D shows the distribution of opinions much closer to a normal distribution than that of performance. Indicators by the slope trend toward the same unfavorable opinion of current service.
Community Interest Survey-Connection Speeds

Chart F: Broadband Speed

The current service offerings located within the Township of Edison are varied and highly localized based upon the current local providers network footprint with regards to symmetrical vs. non-symmetrical speed offerings. Notable for reduced upload speed being the main distinction between availability based on the technology being deployed within that area over Cable TV or other Copper based infrastructure. Currently the Federal Communications Commission defines “broadband” as available download/upload of 25/3 Mbps; however, industry insiders expect the regulating authority to change its definition to at least 100/25 Mbps but realistically provisioning for 100/100 Mbps as the new minimum standard in services from most providers.

Throughout the Township of Edison broadband service by this definition is widely available and according to the respondents of this survey is the least influential qualitative data point influencing opinions. Conflicting commentary received from those respondents who agree they receive the necessary speed but only at certain intervals during the day indicate respondents viewed “temporary or peak time” speed issues as either reliability or performance related not a function of data speed. However, even with a smaller divide between unfavorable and favorable opinions, current market perception landed those unfavorable 8.33% above those with favorable views.
**Community Interest Survey-Customer Loyalty**

*Chart H: Willingness to Switch Providers*

The question of customer loyalty in this survey was used to assess the likelihood of residents’ willingness to switch service to a different provider. Results of this opinion poll question show that 82.22% of current residents support switching providers. When creating a consumer demand profile and considerations for individual motivations for change, this variable will serve as a basis with which the take rate assumptions are developed for financial feasibility review. Please note that all other variables influencing respondents’ decision to switch must remain equal in the assumption to move service from the incumbent provider such as monthly service pricing, installation charges, equipment charges, etc. that may adversely affect the baseline established from this survey question.

The range of values between Agree and Strongly Agree provide additional support for baseline metrics used in financial feasibility modeling for this study. Those of the “Strongly Agree” opinion shall be the conservative baseline of 66%, while a more liberal baseline shall include those respondents whom
“Agree” bringing the total estimated take rate up to 82.22%. Risk management and assessments completed outside the parameters of this study should account for the same range of values used to budget “contingency” in variable Operational Expenses accompanied with those same correlations to associated Capital Expenses required to “pass” those locations. Further market analysis and data collection efforts would be well suited to narrow this margin and reduce overall project risk outlined in subsequent sections of this report.
Community Interest Survey-Elected Services

Current market share for residential services of respondents indicates an overwhelmingly monopolized market share of broadband services according to the study. For the basis of this studies’ benchmarking, the current pricing for internet services from the primary provider were used to extrapolate average costs for additional services households often combined with broadband locally.

Survey participants were asked what speed they currently subscribed to with their current ISP. Initially presented as an optional field within the survey parameters between June 8th, 2022, and June 14th, 2022. All 1350 participants during this time elected to leave this category blank; therefore, the field requirement was changed to better understand the current distribution of service speeds throughout the community. The survey format was amended to make this field mandatory for submission and subsequently obtained 1749 submissions within this data set. Initial indications show the 300 Mbps data package offering as the most popular choice coming in at 38% of responses. However, it would be prudent to acknowledge that although the 100 Mbps package only ascertained 21% of responses it is possible this category is much larger. “Unknown” speeds consisted of 21% of responses indicating that the participant was unaware to what service speed with which they were subscribing. Upon further review of the “Unknown” responses it was found that of the total 365 submissions within this category, 238 subscribe to Cable TV services compiling of 65% of this group. A possible explanation as to why Cable TV service has such a large market share within this group would categorize these respondents as “light” broadband users and would most likely fall within the 100 Mbps data package. Adding this category to the 100 Mbps group brings the collective total to 42% and beats the 300 Mbps category by a narrow margin.

The distribution percentage of service speed from this survey when compared with non-introductory deals or promotions of service pricing from Optimum as the primary area provider would be used in the development of the financial feasibility analysis model determining the study benchmark for
maximum monthly ARPU for any ISP looking to compete within this local broadband market. Additional considerations should be weighted by any new provider considering entry into this market as many incumbent providers plan and respond to competition in order to retain and further anchor their market share. Typical examples of such efforts include offering special pricing to existing customers, advertising promotional plans to new customers, or even deliberately slowing down the make-ready efforts in construction if they are the existing pole/conduit owners to discourage competition.

Broken down into subcategories of “Service Types” or common “packaged” services with which the local community chooses to elect was as follows:

- Single Service (Internet Only)
- Double Play Service (Internet & 1 Optional)
- Triple Play Service (Internet & 2 Optional)
- Unlimited Service (All Service Options)

Accompanied with the primary “Service Type” category additional data points were collected regarding the equipment lease options and managed services exercised for each of the three categories indicated as “+”.

Making up roughly 32% of all respondents “Double Play” & “Double Play +” service categories show a large skew in data points favoring Internet & Streaming Services as the preferred packaging method of the area. Trends found within the data set indicate a hard market shift away from Cable TV and into alternative “Streaming” entertainment services. These “Cord Cutting” customers are assumed to be seeking a more personalized experience and/or exercise cost control options with their monthly budgets by selecting only the services they wish to subscribe to for directly sourced entertainment & media.
Disproportionately distributed data regarding “Triple Play” type service levels are inconsistent with the study parameters of this particular area in which the incumbent provides the same internet service over Cable TV infrastructure and is included as the third and final major service category available for respondents. It should be noted that despite the service subscription to Cable TV the infrastructure at these locations provide significantly lower internet upload speeds than that of areas with which the fiber infrastructure is available. This duplication of services could be contributing to an increased perception of quality with Cable TV when compared with streaming services due to insufficient data transport. To support this trend, those whom subscribed to triple play services with equipment within the Internet-Cable TV-Streaming category was twice that of either Cable TV or Streaming chosen as alternatives to each other.
Survey Assumptions & Conclusions

Finding #1: Network Infrastructure

The only current communications infrastructure capable of accommodating the needs of all current and future broadband network architectures and service all municipal interests in the service of a community is a properly surveyed, engineered, and scaled FTTx infrastructure.

To maximize the community benefits the Township of Edison would need to own and operate the broadband network or partner with a provider with diverse capabilities and experience across multiple technology platforms used in public improvement, public safety, municipal government, as well as FTTH applications.

FTTx network assets should be constructed using a strategic approach to target the most efficient means of capital expenditure by the community by value engineering fiber program management. Further study is required to determine potential means of supplemental funding sources earmarked to public works, public safety, education, and other public improvement projects made available by local, state, and federal grant funding and properly allocated for inclusion with any Municipally sponsored broadband project.

FTTx infrastructure provides the best market position for long term infrastructure assets and generates opportunities for technological advancement. Current equipment available for both residential and business class services can provide up to 10 Gbps+ symmetrical service speed, and with readily available fiber assets for Municipal use, Commercial development, Fiber Leasing and ensure equitable access to broadband for future generations. Finding #2: Community Support

Public Opinions: The results of this survey indicate that existing users of broadband within the Township of Edison have overall unfavorable opinions of the existing state of broadband available.

Reasoning: Quality of service was rated by respondents in the form of performance and reliability factors and was the leading factor influencing the opinions of respondents.

Integrating a readily available fiber inventory will provide communication assets for the community along with supporting commercial development and/or revitalization projects for generations to come. Consolidation of assets could also create budgetary efficiencies through deployment of commonly shared assets across department budgets.

Support: Respondents are overwhelmingly favorable to the idea of switching broadband providers at over 82% total. Take rate assumptions used for financial feasibility analysis use data mirroring the 66% of those respondents whom “Strongly Agree” to switch when all other decision influencing variables such as installation costs, service pricing, speed, and available services are held equal between broadband service providers options.
Finding #3: Necessity & Means

High speed broadband is a critical base to any thriving, diverse economy in our current economic climate. Surely this demand will exponentially increase moving forward as more personal and commercial business is conducted online. Mostly found within urban areas, high speed broadband service is essential to attract, retain, and produce economic growth within the community. Suburban and rural broadband service access for residential class customers has gained the attention and funding resources are being made available from local, state, and federal programs targeted for these essential services provided for home businesses, those who work from home, and educational opportunities equally to the Township of Edison.

This unprecedented demand has created a heavy emphasis for opportunities related to virtual learning and the educational system reliance to the benefits provided by broadband. Connecting students with teachers, providing adult learning, unbridled access to educational resources for continuing education and workforce development. Fiber optic infrastructure will positively affect the community as a collective and ensure future generations a pathway to these vast opportunities.

Broadband is also critical to healthcare, connecting patients with medical providers for telehealth appointments and information, and for remote treatment sessions. Remote access requirements of both healthcare and education institution alike rely on the ability to video conference in high definition, with consistent streaming quality, and low latency. Telehealth services require a higher quality of broadband connections currently available to residents to allow providers the ability to read facial expressions and empathize, creating a communication environment that leads to better quality patient care.

Importantly, the benefits of fiber optic cable and its material properties maintaining “future proof” qualities, means it will remain relevant, competitive, and scalable as new technology emerges in our everyday lives and as our society advances as a community. A future proof fiber network will serve the township’s bandwidth needs today and for future generations alike.

Community advancement by integration into communication assets and resources further support a municipal/community solution. Supporting public safety, public works, workforce development and community revitalization projects should further bond the subscribers to service as they are able to witness where how their monthly service fees support providing a better quality of life as a whole.
Market Technology Overview

Broadband Speed Guide

According to the FCC Household Broadband Guide the minimum download and upload service speeds needed based on user device quantity and activity can be found in the table below; however, speed is a dependent variable based upon the available bandwidth within the network as follows:

Imagine that bandwidth in a communications network represents the “highway” where you can travel faster in your vehicle over longer distances. Your “supercar” is sitting in the garage, and you would like to take it on the highway as it is intended. The “supercar” is the user’s device in this analogy, designed to be the fastest device available but medium is no more useful than the 1980’s chevy cavalier crawling along side you in traffic.

The communications infrastructure currently in use can be compared with driving your “supercar” on a highway built 30 years ago, lined with potholes, and designed to handle a 1/3 of the population we have today. Evidence of this limitation can be found within the Township’s survey responses with a significant number of comments referring to such occasions of devices slowing down in certain time windows when peak traffic exists. Despite having the fastest car on the highway, you are inevitably at the mercy of the traffic and conditions found on that road.

Current providers of broadband trend “patch” infrastructure in areas where market share has limited competition to maximize the return on their current infrastructure investments that are outdated when compared to currently available technology having limited bandwidth capabilities, limiting the “highway” to only a few lanes of traffic in this analogy. Conversely, a 100% fiber optic network matched with the proper equipment and operator can provide the flexibility to add exponentially more lanes of travel to the highway and raise the speed limit at the same time.

A few models and descriptions of broadband types according to the FCC are defined in the user definitions table found below. Please keep in mind there are many more hybrid models of communications networks found throughout our public infrastructure today; however, limiting factors of both the elemental properties of the infrastructure via copper or otherwise conductive means are considered “active” and experience less reliability, more maintenance and repair than that of a “passive” network such as PON, GPON, XGS-PON, etc.

Service providers having previously leveraged capital assets for outdated technologies and attempting to maximize their return-on-investment (ROI), often only patch the potholes in their highway to forgo overhaul of facilities and reduce capital investment in new technology. Incumbent providers highly leveraged in existing copper-based facilities will forever pose a prohibitive factor in attracting competition for their communities. Investment of new facilities with a competing provider cannot collect the necessary market share for typical FTTx providers. This barrier to market entry can adversely affect the general publics’ best interests in obtaining equitable and affordable access to current technologies. However, by adding the ancillary benefits of community ownership to fund growth and essential social services within the same network the total benefits are of community inclusion are incalculable.
Digital Subscriber Line (DSL):

DSL is a wireline transmission technology that transmits data faster over traditional copper telephone lines already installed to homes and businesses. DSL-based broadband provides transmission speeds ranging from several hundred Kbps to millions of bits per second (Mbps). The availability and speed of your DSL service may depend on the distance from your home or business to the closest telephone company facility.

(Maes, Peeters, Guenach, & Storry, 2008)

The following are types of DSL transmission technologies:

<table>
<thead>
<tr>
<th>Light Use</th>
<th>Moderate Use</th>
<th>High Use</th>
</tr>
</thead>
<tbody>
<tr>
<td>(Basic functions: email, browsing, basic video, VoIP, internet radio)</td>
<td>(Basic functions plus one high-demand application: streaming HD video, multiparty video conferencing, online gaming, telecommuting)</td>
<td>(Basic functions plus more than one high-demand application running at the same time)</td>
</tr>
<tr>
<td>1 user on 1 device</td>
<td>Basic</td>
<td>Basic</td>
</tr>
<tr>
<td>2 users or devices at a time</td>
<td>Basic</td>
<td>Medium</td>
</tr>
<tr>
<td>3 users or devices at a time</td>
<td>Medium</td>
<td>Medium</td>
</tr>
<tr>
<td>4 users or devices at a time</td>
<td>Medium</td>
<td>Advanced</td>
</tr>
</tbody>
</table>

Basic Service = 3 to 8 Mbps*

Medium Service = 12 to 25 Mbps

Advanced Service = More than 25 Mbps
• **Asymmetrical Digital Subscriber Line (ADSL)** – Used primarily by residential customers, targeted for Internet browsers. Larger percentage of data usage use at the time of this technology required much smaller data transfer prior modern streaming-based media sources and operating system applications. Users typically could download smaller files effectively; however, uploading files takes substantially longer in duration. ADSL allows faster downstream data transmission over the same line used to provide voice service, without disrupting regular telephone calls on that line.

• **Symmetrical Digital Subscriber Line (SDSL)** – Used typically by businesses for services such as video conferencing, which need significant bandwidth both upstream and downstream. Residential use of this technology was primarily prohibitive due to the cost of the upgraded equipment, non-traditional (large copper gauge & bundle) materials, and specialized installation labor costs for ISPs to set up this type of service.

Faster forms of DSL typically available to businesses include:

- High data rate Digital Subscriber Line (HDSL); and
- Very High data rate Digital Subscriber Line (VDSL)

**Coaxial Infrastructure & Technology**

**Radio Frequency Channel Networks:**

Equipment based technology advancement such as copper network bridge interface systems are inherently limited to the material properties of copper-based infrastructure with which the signal is being transported. Subscriber Equipment is responsible for the demodulation of electrical signals within a limited number of shared frequencies from the ISP. “Active” telecommunication infrastructures require a series of powered subsystems and equipment to regenerate the signal over frequent intervals due to the supporting infrastructures signal loss properties. Furthermore, the strength of the user’s equipment’s (upstream) power and interface play an important role in the advancement of this infrastructure; however, the material limitations rendered such technology obsolete as a stand-alone solution with the introduction of commercially available fiber optic cable.

Versions of Cable modem service enabled operators to provide broadband using the same coaxial cables that deliver pictures and sound to your TV set. Most cable modems are external devices that have two connections: one to the cable wall outlet, the other to a modem. They provide transmission speeds of 1.5 Mbps or more. Subscribers can access their cable modem service by simply turning on their computers, without dialing-up an ISP. You can still watch cable TV while using it as most protocols separate the signals on separate channels. Transmission speeds vary depending on the type of cable modem, cable network, and traffic load.

**Wireless**

• Wireless broadband connects a home or business to the Internet using a radio link between the
customer's location and the service provider's facility. Wireless broadband can be mobile or fixed.

- Wireless technologies using longer-range directional equipment provide broadband service in remote or sparsely populated areas where DSL or cable modem service would be costly to provide. Speeds are generally comparable to DSL and cable modem. An external antenna is usually required.

- Wireless broadband Internet access services offered over fixed networks allow consumers to access the Internet from a fixed point while stationary and often require a direct line-of-sight between the wireless transmitter and receiver. These services have been offered using both licensed spectrum and unlicensed devices. For example, thousands of small Wireless Internet Services Providers (WISPs) provide such wireless broadband at speeds of around one Mbps using unlicensed devices, often in rural areas not served by cable or wireline broadband networks.

- Wireless Local Area Networks (WLANs) provide wireless broadband access over shorter distances and are often used to extend the reach of a "last-mile" wireline or fixed wireless broadband connection within a home, building, or campus environment. Wi-Fi networks use unlicensed devices and can be designed for private access within a home or business or be used for public Internet access at "hot spots" such as restaurants, coffee shops, hotels, airports, convention centers, and city parks.

- Mobile wireless broadband services are also becoming available from mobile telephone service providers and others. These services are generally appropriate for highly mobile customers and require a special PC card with a built-in antenna that plugs into a user's laptop computer. Generally, they provide lower speeds, in the range of several hundred Kbps.

**Satellite**

Just as satellites orbiting the earth provide necessary links for telephone and television service, they can also provide links for broadband. Satellite broadband is another form of wireless broadband and is also useful for serving remote or sparsely populated areas. However, like copper-based technologies the user equipment is one the limiting growth factor along with the subscriber's geographic location relative to the satellite's orbital pattern and any adverse atmospheric conditions.

Downstream and upstream speeds for satellite broadband depend on several factors, including the provider and service package, the consumer's line of sight to the orbiting satellite, and the weather. Typically, a consumer can expect to receive (download) at a speed of about 500 Kbps and send (upload) at a speed of about 80 Kbps. These speeds may be slower than DSL and cable modem, but they are about 10 times faster than the download speed with dial-up Internet access. Service can be disrupted in extreme weather conditions.

**Broadband over Powerline (BPL)**

BPL is the delivery of broadband over the existing low- and medium-voltage electric power distribution network. BPL speeds are comparable to DSL and cable modem speeds. BPL can be provided to homes using existing electrical connections and outlets. BPL is an emerging technology
that is available in very limited areas. It has significant potential because power lines are installed virtually everywhere, alleviating the need to build new broadband facilities for every customer. However, at the time of this study there is no current equipment capable of providing the symmetrical speeds and bandwidth necessary to compete with either coax-based systems or fiber-based systems.

Fiber-to-the-Home (FTTH)

- Fiber optic technology converts electrical signals carrying data to light and sends the light through transparent glass fibers about the diameter of a human hair. Fiber transmits data at speeds far exceeding current DSL or cable modem speeds, typically by hundreds of Mbps with some providers offering 1Gbps symmetrical service capacity.

- The actual speed you experience will vary depending on a variety of factors, such as how close to your computer the service provider brings the fiber and how the service provider configures the service, including the amount of bandwidth utilized. The same fiber providing your broadband services can also simultaneously deliver voice (VoIP) and video services, including video-on-demand / over the top.

- Variations of the technology run the fiber all the way to the customer's home or business, to the curb outside, or to a location somewhere between the provider's facilities and the customer.

- FTTH networks can be configured and operated in several different ways. All configurations pose their own inherent challenges in defining which party is responsible for the operational oversight, installation costs, maintenance, and repair. Some of the high-level examples include:
  - Single Service Provider- a single service provider in a closed network environment would assume all the associated costs to build and operate the network.
  - OSP Physical handoff- As an open access dark fiber configuration where, competing providers can lease fiber and place their own optical/electronics to complete the service. In the physical handoff model the costs for construction of the Hub/Distribution facility, physical distribution network(s), as well as the maintenance and repair costs of physical network would be the responsibility of the dark fiber owner. The service provider would be responsible for the optical/electronics in the Hub/Distribution facility and end user electronics.
  - Electronic handoff- As an open access dark fiber configuration where the network owner provides the optical/electronics for competing service providers to patch their backhaul service to the optical/electronics and then leases the dark fiber distribution network to competing providers. In the service handoff model the competing providers are responsible for signal backhaul presence and customer equipment. IT management, equipment compatibility and operational cost considerations require clearly defined contractual agreements in this model and are well suited for larger scale FTTH projects where the initial total number of services can support the providers’ upfront Capital investment. Additionally, identification and estimation of costs are inherently difficult to calculate increasing the risk assessment of the model.
  - Software handoff- As a Software Defined Network, where competing providers interconnect with the electronics at the physical network handoff. Users select their provider in a virtual manner; however, end user electronics as well as provider equipment must be compatible. All associated construction, operation, and maintenance costs would be the responsibility of the physical plant owner.
Technical Feasibility

Accounting for the project mission in developing a community wide broadband solution having the capabilities to facilitate the delivery of communications through several technology platforms. The infrastructure would require fiber optic cable as the medium for all signal transport to equipment demarcation points. Estimations of the infrastructure scale given Edison Township’s physical area would require roughly (a) 400 Miles of fiber optic cabling, (b) two diverse backhaul circuits, and (c) two Central Office locations. Backhaul network transport should be appropriately sized to handle the entire network with each circuit so should a failure occur downtime and latency would be minimized for the network subscribers.

Consideration for the Township of Edison to self-perform the construction of a fiber network at the scale, production, and technical quality compared with contracting outside labor could be considered technically feasible but not practical or financially feasible. Fiber optic cable installation, splicing, testing, and IT related networking resources should be sourced from local market contractors capable of providing the production rates, specialized equipment, and skilled personnel required to capture and maintain the required market share from eager and willing residents searching for alternative broadband. Following the large-scale construction of the network the operations staff would assume the responsibilities for fiber records, maintenance, repair, churn, and new installations at a much smaller scale and is technically feasible by this studies determination.

<table>
<thead>
<tr>
<th>Category</th>
<th>Quantity</th>
<th>Assumptions &amp; Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Road Miles</td>
<td>314</td>
<td>No private roads were included as part of this study.</td>
</tr>
<tr>
<td>Fiber Miles</td>
<td>408.2</td>
<td>Approximately 30% additional fiber required for slack, splice and sagging along with non linear transitions</td>
</tr>
<tr>
<td>Population</td>
<td>107588</td>
<td>Sixth most populous municipality in New Jersey according to Wikipedia</td>
</tr>
<tr>
<td>Potential Subscribers</td>
<td>47061</td>
<td>Rounded Total number of Households, Additional Consideration for financial analysis of Commercial use required.</td>
</tr>
<tr>
<td>Aerial Facilities (Miles)</td>
<td>279.46</td>
<td>Majority of infrastructure miles throughout the Township.</td>
</tr>
<tr>
<td>UG Facilities (Miles)</td>
<td>34.54</td>
<td>Sample Area Distribution Shows highly localized areas of developments with UG facilities</td>
</tr>
</tbody>
</table>

Utility Poles & Make Ready

This study is based on constructing a fiber to the x network (FTTx), and as such, the only vertical infrastructure in need of consideration is the existing utility poles. Aerial construction remains the most cost-effective method to deliver communications infrastructure and should be the preferred method of construction.

The average cost to perform make-ready (the process of creating pole attachment space and clearance) on utility poles in the Tri-State area average range between $792-$1056 per pole. This equates to approximately $31,680 per mile assuming 30-40 poles per mile. Pole replacements can be expected to cost roughly $3,000 on average and will be required where the existing poles do not provide the adequate structural integrity and/or clearance (height) required for the pole to remain compliant with the NESC (National Electrical Safety Code), OSHA 1910.268 & 1910.269 Standards, and any other local compliance orders.
The general condition of utility poles in the Township would be rated as “fair” in terms of overall condition; however, the overall pole height and clearance between conductors and required road height clearance as defined within the NESC would most likely call for pole replacements along the areas of “minor” roadways within or leading to smaller neighborhoods. Alternatively, most pole class/heights observed were found suitable for clearance following most “major” roadways.

It should be noted that conventional methods of using conductive steel messenger for support of the fiber optic cable infrastructure was used in determining the general conditions and corresponding estimated cost values of this study. However, alternative material selection and installation specialization exist to deliver fiber optic cable when a limited clearance to conductors is present. This material known as All Dielectric Self Support (ADSS) fiber cable may be beneficial to use in these areas to reduce third-party make ready costs required for clearance.

**Underground Construction**

Sample analytics show the network footprint consisting of 89% Aerial and 11% Underground facilities. Recommended methods and procedures for installation of conduit facilities can be substantially varied due to a variety of conditions; however, for estimation purposes conventional trenching (typical) shown below was used for “worst case” budgeting purposes for a more conservative approach while providing additional contingency should “best case” conditions be available. Modern methods have been developed for less costly, invasive, and safer procedures such as micro-trenching, vibratory plow, chain trenching, and vacuum excavation; however, as most roadways found throughout Edison are asphalt covered this study assumes micro-trenching and vacuum excavation as the only significant savings solutions for this area where conditions are favorable for their deployment.

Additionally, it would be prudent for The Township to document and audit a collective list of shared assets held by other municipal departments such as DPW, Building Inspector, traffic control, public safety, etc. to obtain potential existing “city-shadow” conduit pathways from previous projects or potential to share existing conduit routes and handoffs that may reduce the cost of capital infrastructure within the Township.

The conventional trenching typical sample cross section below illustrates the larger footprint of disturbance to the existing right-of-way. Although previous communications technologies required larger diameter conduit to house communications cables, modern improvements in materials used in fiber optics and manufacturing processes can now provide the market with substantially larger fiber strand counts in micro-ribbon configurations requiring a much smaller conduit.

Value engineering from deploying this method of construction can be maximized by including communications conduit in the design of public improvement projects throughout municipal
departments. Additionally, lease agreements for other conduit occupancies & access agreements with both communications carriers and electric service providers alike should remain priority to reduce overall capital costs. Additionally, electric service partnerships for smart metering/charging, SCADA systems and other monitoring systems can utilize the fiber infrastructure of the municipality.

Alternative methods of underground conduit installation (shown right) illustrate the impact of having less disturbance of the existing surface area by minimizing the cross section to less than 6” in most equipment available to the market today. Additionally, this method is faster to install per foot and in most cases requires less traffic control costs. Of the existing methods to install conduit in finished road surfaces micro trenching is the preferred deployment by most Tier 1 providers throughout the Northeast.

Highly specialized equipment is required to perform micro trenching and in consideration of total capital expenditures for equipment required for this project it is assumed this work would be performed by outside telecommunications contractors specializing in this method. With market conditions calling for broadband throughout the country these resources are most likely being utilized at their capacity and should be planned well in advance.

**Construction Benchmarking**

<table>
<thead>
<tr>
<th>Category</th>
<th>Rate</th>
<th>Additional Assumptions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aerial Line Construction</td>
<td>2500’ Day x # of 3 Man Crews</td>
<td>Communications space strand &amp; lash</td>
</tr>
<tr>
<td>Backbone Splicing &lt;144 Count</td>
<td>.5 per Day</td>
<td>Ribbon, Inc. Testing Time</td>
</tr>
<tr>
<td>Backbone Splicing &gt;144 to 288 Count</td>
<td>.33 per Day</td>
<td>Ribbon, Inc. Testing Time</td>
</tr>
<tr>
<td>Service Terminal Splicing &lt;12 Count</td>
<td>4 per Day</td>
<td>Pigtailed Factory Preterminated Ports &amp; Express Cut 1 Buffer, Inc. Testing Time</td>
</tr>
<tr>
<td>UG Conventional Trenching</td>
<td>75-125’ Day/Crew</td>
<td>Variable based on localized conditions</td>
</tr>
<tr>
<td>Micro Trenching</td>
<td>300-500’ Day/Crew</td>
<td>Variable based on localized conditions</td>
</tr>
<tr>
<td>Single Structure Drop Installation</td>
<td>8/Day/Crew x # Crews</td>
<td>OSP to Customer Demarcation point - Exterior Traffic Control Maximized for Construction to (1) Service Terminal/Day</td>
</tr>
<tr>
<td>Single Structure CPE Installation</td>
<td>4/Day</td>
<td>Per Individual Installer</td>
</tr>
<tr>
<td>Multi Tenanted Unit</td>
<td>3 Man Crew x 1 Day</td>
<td>Assume 12 Units/Structure with common utility points on Average</td>
</tr>
<tr>
<td>Multi Tenanted Unit CPE Installation</td>
<td>4/Day</td>
<td>Per Individual Installer</td>
</tr>
</tbody>
</table>

**Inventories of Existing Infrastructure**

Edison residents and businesses have limited access to internet providers and only have two options offering a broadband connection. The ISP’s (Internet Service Providers) within Edison are Optimum (Altice) and Verizon. This information can be found through multiple sites and found on the ISP’s respective main web page. As such, Matrix audited the availability of all fiber optic cable, coaxial cable and DSL broadband connection offerings.
**Optimum (Altice)**

The main provider to Edison residents and businesses is Optimum (Altice) and is the only ISP offering high speed internet to most of Edison and the surrounding areas. High Speed internet is any internet connection delivering equal to or greater than 100mbps/25mbps (Download/Upload speed). They offer service through a standard coaxial cable network with a max speed of 940mbps download and 35mbps upload. Optimum has a few coaxial cable packages for most of the Edison residents and businesses, while maintaining the minimal upload speeds through their asymmetrical internet speed packages. Optimum does offer fiber optic cable connections but is limited to a small percentage of the Edison area.

Optimum additionally provides cable modem services with Wi-Fi equipment with all their fiber optic cable and coaxial cable packages.

**Verizon**

For Verizon we have identified areas where their service is available through a DSL cable network. Verizon provides ISP service to portions of Edison. For residences, Verizon can provide a maximum 15Mbps (Download Speed) service in some areas based upon their geographic location to the Central Office. Business service is available, and pricing can be found on their website.

According to the Broadband Search site, Verizon Fios Fiber Optic Network is only available for less than 7.5% of the area. Additionally, Verizon provides cable modem services with Wi-Fi equipment with all their fiber optic cable and coaxial cable packages.
**High-Level Engineering**

**Network Architecture**

The design of the physical fiber transmissions & distribution plant determines the network's future scalability and restricts how the plant is operated & maintained. The architecture is also the main determinant of the total cost of the deployment.

Active Ethernet (AE) technology is a point-to-point application whereas each subscriber has dedicated Transmitter and bandwidth through the deployment of individually dedicated lasers at the Optical Line Terminal (OLT) and pre-assigned homerun fiber to the Optical Network Terminal (ONT). When comparing AE to current GPON technology service providers can expect an estimated increase of $1,200 per subscriber in network equipment and lasers, increased capital material expenditure due to fiber sizing (1 fiber=1 subscriber) and increased labor costs associated with the total number of fibers joined for splicing at around $30.00 per fiber. While not a cost-effective means of deployment network wide AE connections can still be utilized for heavy commercial users or for leasing dark fiber “last mile” connections between data center Point of Presence.

Due to the difference in network architecture, more efficient use of materials and equipment along with the cost of construction services, **10-Gigabit Symmetrical Passive Optical Network** (XGS-PON) is the recommended platform of broadband deployment in this study. Current XGS-PON technology can sustain 10 Gbps download & upload service utilizing an increased form factor through up to 1x128 optical splitters. This allows maximum flexibility and minimum expense in selecting materials and design topology throughout the network.

The Network Overview below shows on a high-level network architecture for sample XGS-PON FTTx network. The drawing illustrates the primary devices and components required to operate and support a scalable network. Due to the inherent design of a GPON architecture, should dedicated links be required for business or government connections, dedicated backbone reserve fiber not allocated to residential subscribers can provide dedicated circuits should the need arise to accommodate individual Active Ethernet (AE) connections over 10 Gbps.

<table>
<thead>
<tr>
<th>PON System Specification Summary</th>
<th>GPON</th>
<th>XGS-PON</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Standard</strong></td>
<td>ITU-T G.983</td>
<td>ITU-T G.984</td>
</tr>
<tr>
<td><strong>Downstream Bitrate</strong></td>
<td>155, 622 Mibs, 1.2 Gibs</td>
<td>155, 622 Mibs, 1.2, 2.5 Gibs</td>
</tr>
<tr>
<td><strong>Upstream Bitrate</strong></td>
<td>155, 622 Mibs</td>
<td>155, 622 Mibs, 1.2, 2.5 Gibs</td>
</tr>
<tr>
<td><strong>Downstream Wavelength</strong></td>
<td>1490, 1550</td>
<td>1490</td>
</tr>
<tr>
<td><strong>Upstream Wavelength</strong></td>
<td>1310</td>
<td>1310</td>
</tr>
<tr>
<td><strong>Protocol</strong></td>
<td>ATM</td>
<td>Ethernet over ATM/IP or TDM</td>
</tr>
<tr>
<td><strong>Video</strong></td>
<td>RF at 1550 or IP at 1490</td>
<td>RF at 1550 or IP at 1490</td>
</tr>
<tr>
<td><strong>Max PON Splits</strong></td>
<td>32</td>
<td>64</td>
</tr>
<tr>
<td><strong>Transmitter Power</strong></td>
<td>OLT -9 to -4 dBm, OLT -4 to +2 dBm</td>
<td>OLT -9 to -4 dBm, OLT -4 to +2 dBm</td>
</tr>
<tr>
<td><strong>Power Budget</strong></td>
<td>-13dB (min) to 29dB (max) w/32 split</td>
<td>-13dB (min) to 29dB (max) w/32 split</td>
</tr>
<tr>
<td><strong>Coverage</strong></td>
<td>20 km</td>
<td>10, 20, 40, 60 km (versions)</td>
</tr>
</tbody>
</table>

* There are several versions of each type that vary so these are typical ranges.
Components of the network design:

- **Internet / Back-Haul** – Connection from the Hub site to a core site or central office
- **Core Network / Managed Services** – Router, firewall, and network management servers
- **Head End** – OLT equipment, provisions for fault detection, traffic re-routing, traffic flow, flexibility for service class changes, physical & logical layers
- **Premise drops**

Passive Optical Network Architecture Benefits:

- **Efficiency** – Cost effective servicing many subscribers from a single fiber. Passive components don’t require external power in the field unlike a hybrid fiber coaxial system. With a lower fiber count density. Additionally, in the event of physical damage restoration is typically completed quicker than a more fiber dense active Ethernet model.
• **Manageability** – simplified provisioning and management of subscribers and services

• **Flexibility** – Providing varying levels and classes of service to different customer locations. Variable speed tiers, phone options, and dedicated links may be offered.

**Network Specifications-**
Hub Design-Central Office

**Interior – Specifications**

Minimum dimensions required are 36’ Long x 18’ Wide x 9’ High. Wall and ceiling to use R11 insulation as required by local authority having jurisdiction, with white FRP on ½” wood substrate trim and cove base throughout. Floor standard 12” VCT. (3) 4’ florescent light fixtures with on/off switch by entry. Twenty double duplex 110V 20a electrical outlets, two on each long wall. (20) 120V 30A L5-30 outlets for battery backup unit(s) in corresponding rack configuration.

**Exterior – Specifications**

Insulated entry door, frame and drip cap, lever handle, lock with changeable core, weather stripping, pick plate and aluminum threshold, and entry illumination necessary for entry door with photocell and motion detector.

**Electrical – Specifications**

Dedicated (3) 500 Amp 120/240V electrical services, manual disconnect, automatic generator transferswitch, Backup generator mounted outdoors stationary, propane or dual fueled, tank sized to run the Hub for a minimum of 72 hours uninterrupted before refueling. Maintenance contract recommended for fueling, maintenance & emergency service to generator unit.
Conduits/Points of Entry – Specifications

From nearest riser pole to Hub (2) 4” SCH40 PVC conduits for telecom use (F1 fiber feed(s) & middle mile drop), all telecom conduits should extend to a minimum of 10’ up the riser pole to prevent vandalism.

Environmental – Specifications

(2) 25,000 BTU HVAC unit, separate electrical circuits and individual programmable controls, status contact outputs- on/off/failure/trouble, auxiliary exhaust fan, and emergency interior lighting fixture with flood lamps, fire extinguisher suitable for electronic equipment room.

Network – Specifications

Internet access backhaul, bandwidth = (2) 100GigE x2, Access Sub Bandwidth = 2000 Mbps and ramp up with customer activation. Access Bandwidth to scale as needed proportionally to unmetered network usage.

Customer Premise Design

Customer Premises with existing aerial or underground pathways capable of accommodating a new fiber drop cable for the purposes of directly interfacing the customer premise into the fiber distribution system shall be considered a standard installation. For the purposes of the construction costs calculations the average drop length is assumed to be less than 300’. Within each premise at the time of final installation an Optical Network Terminal (ONT) should be provided with a fiber interface for direct connection into the fiber distribution network. ONT should also have RJ45 (Ethernet) & RJ11 (POTS) interface for optional router or POTS phone.

Assumptions of potential take rates assume installation costs for subscribers would be rolled into the capital expense to build the network. Community buy-in to a municipal communications network is necessary along with migration of existing customers from the incumbent service provider to be considered feasible to achieve the minimum take rate for the project success.
Financial Feasibility

Potential Sources of Capital

While different local area markets offer emerging trends for increased broadband and infrastructure, the township of Edison may potentially be eligible for several capital funding options. Additional study will be required to analyze and refine the specific criteria for each individual opportunity as the availability of programs contained within the current and future broadband market vary greatly.

Integration of municipal programs into a community wide network can open additional capital assets, funding opportunities and valued engineering born from public safety, public works, and/or municipal government objectives collectively. For instance, upgrading the public schools remote physical access control systems, surveillance and intelligent analytics software can be planned and integrated into the municipal communications network. Other internal departmental budgets also have the potential to reduce capital costs by offsetting the net present value of their internal project budgets for inclusion while leveraging increased efficiency gained from modern technology and equipment.
Open Access & Joint Partnerships

Open access fiber network models are varied by both geography and the communities in which they have been piloted throughout the Midwest. In this model the potential host community would invest in the network infrastructure and hand off service within the Central Office with a fiber patch to the competing ISP firms interested in providing service and allocate a point of presence within the Central Office. In most instances competing service providers would be responsible for installation of fiber leaving the public right of way along with the end user equipment. Leasing rates and options to the service providers can be difficult to calculate but should account for funding the associated maintenance and repair costs to maintain continuity of infrastructure connections and fiber records along the right of way.

Public-Private Partnerships can offer several benefits to both market sectors where each participant is responsible for completing the tasks in which they thrive. Public sponsored projects are conducted with the overall goal to provide critical infrastructure to the community in which it represents; however, most often these projects are not executed in the most efficient manner due to increased regulatory process and procedure requiring government oversight and compliance. Privately sponsored projects are mostly designed to deliver the most efficient time to completion and fastest return on investment through efficiency refinement and industry specialized construction management and technical efficacy.

Both partnership models can help provide the necessary Capital funds along with the specialized industry skills and experience to best execute highly technical public interest projects; however, it requires a clearly defined responsibilities outlined within contractual agreements to both mitigate risk and define benefits for all parties independently through a shared ownership/use platform.
Estimated Capital Expenditures

Capital Expenditure Schedule Outline

1. **Network Design and Engineering**
   1.1. Network Pathway Survey
      1.1.1. Pole Data Collection
      1.1.2. UG Conduit Data Collection
         1.1.2.1. Lease & Occupancy of Existing Infrastructure-Inventory
         1.1.2.2. Locate & Proof: GPR (Ground Penetrating Radar), Conduit Survey, Rod & Rope, Etc.
      1.1.3. Environmental Impact Studies
   1.2. Network Pathway Design
      1.2.1. Pole Licensing Application Processing
      1.2.2. UG Pathway Area Design-
   1.3. Network Outside Plant Make-Ready
      1.3.1. Pole Replacement
      1.3.2. Existing Attachment Moves
      1.3.3. New UG Conduit: Survey Design & Professional Engineering (PE)
   1.4. Head End Distribution Facility Design (HUB) (CO)
      1.4.1. Land Purchase, Lease Agreement, & Location Preparation
      1.4.2. Facility Layout Design & Technical Specifications
   1.5. Outside Plant Design
      1.5.1. Fiber sizing & allocations
      1.5.2. Architecture and Loss Modeling
      1.5.3. Material Selection & Procurement
      1.5.4. Construction Plan Development
      1.5.5. Permitting
   1.6. Bid Document Generation & Hosting Services
      1.6.1. Bid Analysis
      1.6.2. Construction Award

2. **Central Office Construction**
   2.1. Architecture Design
   2.2. Material Procurement
   2.3. Electronics Procurement
   2.4. Special Equipment Procurement

3. **Subscriber Electronics**
   3.1. ONT (Optical Network Terminal)
   3.2. UPS Battery Back Up
   3.3. TAP (Network Interface Enclosure) - Exterior Structure Handoff

4. **Distribution Materials**
   4.1. ROW Fiber
   4.2. ROW Steel Strand Support & Hardware
   4.3. Distribution Splice Cases & Hardware
   4.4. FAP (Fiber Access Point) Splice Cases & Hardware
   4.5. Drop Fiber

5. **Construction & Project Management**
   5.1. Construction Plans
5.2. Contract Compliance
5.3. Material Staging & Receiving Logistics
5.4. Equipment Staging & Oversight
5.5. Technical Compliance
5.6. Subscriber Installations & Scheduling
5.7. Electronics Management and Configurations
5.8. Final Documentation Acceptance and Testing Services

### Estimated Operational Expenditures

The network operator will be responsible for Hub equipment, back-haul internet connectivity, customer activation, marketing, sales, customer service, billing, collections, equipment, maintenance, and overall plant and records management. Following the table below key responsibilities and staffing requirements estimated for network operations are outlined; however, both inefficiencies and efficiencies gained from service provider experience and/or intelligent automation between systems and processes can greatly affect the expense structure of operations.

#### 1. Operations Management
   1.1. Network Operations Center (NOC)
   1.2. Customer Service
   1.3. Technical Support
   1.4. Outside Plant (OSP) Network Management
      1.4.1. Fiber Records
      1.4.2. Inventory Management

#### 2. Outside Plant (OSP) Network Maintenance & Repair
   2.1. Installation Labor-Technician(s)
      2.1.1. Misc. Tools & Trade Equipment
   2.2. Technical Analysis Equipment
      2.2.1. Fusion Splicers
2.2.2. OTDR/Power Meters

2.3. Hoisting Equipment
   2.3.1. Bucket Trucks (Aerial Lifts)
   2.3.2. Splice Labs (Mobile Lab)
   2.3.3. Excavation Equipment
   2.3.4. Specialty Equipment

2.4. Operations Scheduling
   2.4.1. Churn
   2.4.2. New Installations
   2.4.3. Emergency Response & Restoration

3. **Provision VoIP phone system offerings-recommendation:**

   3.1. Anonymous call rejections
   3.2. Call blocking
   3.3. Call forwarding
      3.3.1. Always
      3.3.2. Busy line
      3.3.3. Don't answer
      3.3.4. Not reachable
      3.3.5. Selective
   3.4. Call logs
   3.5. Call return
   3.6. Call waiting
   3.7. Caller ID
   3.8. Caller ID delivery blocking
   3.9. Do not disturb
   3.10. Follow-me/Find-me
   3.11. Speed dial
   3.12. 2 way calling
   3.13. Voicemail
   3.14. Voicemail to Email

4. **Electronics Management**

   4.1. Network Hardware & Software Maintenance
   4.2. Network Engineering Platform Workflow Management
   4.3. End User Electronics Integration
   4.4. Ticketing & Billing System Integrations
   4.5. Troubleshooting

5. **Estimated Operational Staffing Requirements:**

   5.1. Officers (3)
      5.1.1. General Manager (1)
      5.1.2. Chief Technology Officer (1)
      5.1.3. Chief Operating Officer (1)
   5.2. Outside Plant (11)
5.2.1. Technical Manager (2)
5.2.2. Technical Foreman (3)
5.2.3. Technicians (6)
5.3. Customer Service (8)
   5.3.1. Tier 1 Support Representatives (5)
   5.3.2. Tier 2 Support (3)
5.4. Warehousing & Logistics (2)
   5.4.1. Material & Inventory Operator (2)

Network Operations Responsibilities & Revenue Summary

1. Abide by regulatory agency compliance
   1.1. Coordinate Scheduling
2. Configure network equipment
3. Integrate protections for subscriber traffic
4. Customer support recommendation:
   4.1. 24/7 Telephone
   4.2. 24/7 Email
   4.3. 24/7 Ticketing
   4.4. 24/7 Network monitoring
5. Configure Customer VoIP phone service
6. Facilitate and execute phone number portage
7. Monitor and maintain sufficient capacity to handle the network bandwidth utilization
8. Provide, maintain, activate customer premise equipment
9. Operational Policy & Procedures
10. Marketing & Sales campaigns
11. Service interruption notifications
12. Service calls
   12.1. Scheduling
   12.2. Coordination
   12.3. Troubleshooting solution and repairs
13. Billing & collections
   13.1. Monthly billing
14. Payment processing
   14.1. ACH
   14.2. Credit Card
   14.3. Check
15. Provide customer billing portal
16. Provide options paper mailed monthly bill
17. Network monitoring
   o 24/7
   17.1. Repairs or restoration from damages
18. Backup configuration maintenance
19. New customer sign-up
20. Website hosting & regular maintenance
21. Network insurance
22. Finance
   22.1. Accounting
23. Optional Service Offerings
   23.1. Wi-Fi Router
   23.2. Wi-Fi Extender
   23.3. Static IP address
   23.4. Business VoIP phone
### Summary P&L & Balance Sheet

| Scenario | 2 Year | 3 Year | 4 Year | 5 Year | 6 Year | 7 Year | 8 Year | 9 Year | 10 Year | 11 Year | 12 Year | 13 Year | 14 Year | 15 Year | 16 Year | 17 Year | 18 Year | 19 Year | 20 Year |
|----------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|
| Mileage  | 144.14 | 144.14 | 144.14 | 144.14 | 144.14 | 144.14 | 144.14 | 144.14 | 144.14 | 144.14 | 144.14 | 144.14 | 144.14 | 144.14 | 144.14 | 144.14 | 144.14 | 144.14 |
| Churn    | 3%     | 3%     | 3%     | 3%     | 3%     | 3%     | 3%     | 3%     | 3%     | 3%     | 3%     | 3%     | 3%     | 3%     | 3%     | 3%     | 3%     | 3%     | 3%     |
| Capex    | 113,899,405.39 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Grant    | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Operational Variable | 4,125,000 | 4,125,000 | 4,125,000 | 4,125,000 | 4,125,000 | 4,125,000 | 4,125,000 | 4,125,000 | 4,125,000 | 4,125,000 | 4,125,000 | 4,125,000 | 4,125,000 | 4,125,000 | 4,125,000 | 4,125,000 | 4,125,000 | 4,125,000 |

### Expenses

- Network Build-Up: Fixed
- Staffin: 3,060,918
- 3.50% Staffin: 103,122,925

### Revenues

- Landline Revenue: 7,776,480
- Service Revenue: 25,775,212

### Capital

- 221,876,625.39

### Other Addend

<table>
<thead>
<tr>
<th>Year</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
<th>11</th>
<th>12</th>
<th>13</th>
<th>14</th>
<th>15</th>
<th>16</th>
<th>17</th>
<th>18</th>
<th>19</th>
<th>20</th>
</tr>
</thead>
<tbody>
<tr>
<td>Miles</td>
<td>144.14</td>
<td>144.14</td>
<td>144.14</td>
<td>144.14</td>
<td>144.14</td>
<td>144.14</td>
<td>144.14</td>
<td>144.14</td>
<td>144.14</td>
<td>144.14</td>
<td>144.14</td>
<td>144.14</td>
<td>144.14</td>
<td>144.14</td>
<td>144.14</td>
<td>144.14</td>
<td>144.14</td>
<td>144.14</td>
<td>144.14</td>
<td></td>
</tr>
<tr>
<td>Churn</td>
<td>3%</td>
<td>3%</td>
<td>3%</td>
<td>3%</td>
<td>3%</td>
<td>3%</td>
<td>3%</td>
<td>3%</td>
<td>3%</td>
<td>3%</td>
<td>3%</td>
<td>3%</td>
<td>3%</td>
<td>3%</td>
<td>3%</td>
<td>3%</td>
<td>3%</td>
<td>3%</td>
<td>3%</td>
<td>3%</td>
</tr>
<tr>
<td>Capex</td>
<td>113,899,405.39</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Grant</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Operational Variable</td>
<td>4,125,000</td>
<td>4,125,000</td>
<td>4,125,000</td>
<td>4,125,000</td>
<td>4,125,000</td>
<td>4,125,000</td>
<td>4,125,000</td>
<td>4,125,000</td>
<td>4,125,000</td>
<td>4,125,000</td>
<td>4,125,000</td>
<td>4,125,000</td>
<td>4,125,000</td>
<td>4,125,000</td>
<td>4,125,000</td>
<td>4,125,000</td>
<td>4,125,000</td>
<td>4,125,000</td>
<td>4,125,000</td>
<td></td>
</tr>
</tbody>
</table>
Appendix-B Sample Maps & Schematics

Field Split & Distribution methodology
GPON adds digital IPTV to simplify the ONT

GPON ONT provides outputs for all services to subscriber

1.1. Residential Node Scale: (Illustration Purposes)
   1.1.1. Transport Fiber to Field Splitter increases availability of core fiber network
   1.1.2. (9) Backbone Fibers=288 Distribution Fibers w/ 1x32 Splitter Cabinet- (Other Options Available)
Appendix-C Glossary of Terms

Commonly used terminology within the telecommunications industry:

**Adapter**: A mechanical media termination device designed to align and join fiber optic connectors often referred to as coupling, bulkhead, or interconnect sleeve.

**Angled Polish Connector**: (APC) Connectors which have their end-face mating surface polished at an 8-degree angle to the fiber axis. Minimizes reflections; required in RF video applications.

**Architecture**: Describes how network elements logically relate to each other.

**Armor**: Additional protective element beneath outer jacket to provide protection against severe outdoor environments. Usually made of plastic-coated steel, it may be corrugated for flexibility.

**ARPU**: Average Revenue Per User

**Attenuation**: The decrease in a signal's magnitude of power during transmission between points. A term used for expressing the total loss of an optical system, normally measured in decibels (dB) at a specific wavelength.

**Attenuation Coefficient**: The rate of optical power loss with respect to distance along the fiber, usually measured in decibels per kilometer (dB/km) at a specific wavelength. The lower the number, the better the fiber's attenuation. Multimode wavelengths are 850 and 1300 nanometers (nm); single-mode wavelengths are 1310 and 1550 nm. Note: When specifying the attenuation, it is important to note whether the value is average or nominal.

**Brownfield**: Existing neighborhoods and/or MDUs already served by at least one provider.

**Buffer Tube**: Extruded cylindrical tube covering optical fiber(s) used for protection and isolation

**Business**: Refers to large (corporate), medium, and small (small business/ small office/home office) business users. Businesses may occupy a multitenanted unit (MTU), such as an office block/ tower, or a single-tenanted unit (STU), such as a stand-alone office building or warehouse.

**Cable Assembly**: Optical fiber cable that has connectors installed on one or both ends. General use of these cable assemblies includes the interconnection of optical fiber cable systems and optoelectronic equipment. If connectors are attached to only one end of a cable, it is known as a pigtail. If connectors are attached to both ends, it is known as a jumper or patch cord.

**Central Office (CO)**: The telephone company's central location containing active (powered) equipment, from which services are provided. May contain telephone switching equipment and/or optical line terminals and RF video for GPON systems.

**Cladding**: The material surrounding the core of an optical waveguide. The cladding must have a lower index of refraction to keep the light reflecting through the core.

**Conduit**: Pipe or tubing through which cables can be pulled or housed.

**Connector Panel**: A patch panel designed for use with fiber optic hardware; it contains either 6, 8, or 12 connector adapters pre-installed for use with field-installable or preconnectorized termination methods.

**Core**: The central region of an optical fiber through which light propagates from the transmitter.
**Decibel (dB):** Unit for measuring the relative strength of light signals. Normally expressed in dB, it is equal to one-tenth the common logarithm of the ratio of the two levels $dB = 10 \log \frac{P_{out}}{P_{in}}$. Expressed in dBm when a power level is compared to a milliwatt. Note: $1 \text{ mW (electrical)} = 0 \text{ dBm (optical)}$, $dBm = 10 \log \text{ mW}$.

**Digital:** A data format that uses differing physical levels to transmit information corresponding to zeros and ones. A discrete or discontinuous signal.

**EPON:** Ethernet Passive Optical Network

**Fiber:** An optical waveguide consisting of a core and cladding that can carry information in the form of light signals.

**Fiber Bend Radius:** Radius a fiber can bend before it risks breakage or an increase in attenuation. Fiber Optics Light transmission through optical fibers for communication or signaling.

**Fiber to the x (FTTx):** Refers to a host of acronyms based on taking fiber to the home (FTTH), node (FTTN), curb (FTTC), etc.

**Future-Ready:** Design decision process in which elements that may not be required today, but which are very likely to be needed in the future, are either built into the design up front or are planned as simple upgrades.

**GbE:** Gigabit Ethernet

**Gigabit Passive Optical Network (GPON):** based on higher gigabit speeds. These systems may use an RF overlay for video, but because of their increased bandwidth per subscriber, are also being used for IPTV deployment, in which all services (voice, video, and data) are placed on the GPON, and the RF video overlay is not required.

**Gbps:** Gigabits per second; 1 billion bits transmitted per second.

**Greenfield:** New construction of MDUs and neighborhoods. In this case, no service provider and no broadband network communications exists. Fiber cable system can be planned and placed efficiently while walls, ceilings, basements, and attics are openly accessible to create pathways.

**Headend (HE):** Cable television term analogous to the telephone company’s central office.

**ISP:** Internet Service Provider

**Mbps:** Megabits per second
Bibliography


