Infrastructure Improvements Feasibility Study

Frankfort Plant Board

Prepared by:
Engineering Associates, LLC
& Kersey Consulting Services, LLC

August 4, 2017

John Higginbotham
Assistant General Manager/Superintendent – Cable-Telecommunications
Frankfort Plant Board
PO Box 308
305 Hickory Drive
Frankfort, KY 40602

Dear Mr. Higginbotham:

RE: FPB Infrastructure Improvements Feasibility Study

Following a competitive procurement, the Frankfort Electric and Water Plant Board (FPB) engaged Engineering Associates, LLC (EA) in partnership with Kersey Consulting Services, LLC (KCS) to conduct a comprehensive cost and feasibility study for the potential implementation of infrastructure improvements in Frankfort, Kentucky. FPB has the opportunity to provide advanced infrastructure to better serve the citizens, businesses, and visitors of the Frankfort community. To this end, this Infrastructure Improvements Feasibility Study provides an assessment of FPB's current assets, current and future infrastructure needs, and proposes initiatives that FPB can take to ensure these needs are met, now and in the future.

EA and KCS have made a precise effort to apply our research, knowledge, and experience to provide FPB with a comprehensive document to use as a resource in taking their next steps in advancing their community. While the telecommunications industry is ever-evolving, we believe the information presented in this document to be the most current, applicable, and accurate information at this time. The primary goal of this document is to ensure that FPB is fully informed and best able to evaluate and prioritize options and alternatives for moving forward.

Respectfully Submitted,

Mr. Thomas Grigg, P.E., Engineering Associates LLC
Mr. Kim Kersey, Kersey Consulting Services LLC

Engineering Associates, LLC

Kersey CONSULTING SERVICES

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1. Overview

The Frankfort Plant Board ("FPB") has engaged Engineering Associates, LLC, represented by Mr. Thomas Grigg, P.E., and their associate partner Mr. Kim Kersey, Principal of Kersey Consulting Services, LLC, (together the "Consultants") to develop a cost and deployment study regarding the implementation of infrastructure improvements for broadband communications within the greater Frankfort, KY community served by the Cable/Telecom Division of FPB. The major objectives of the study include:

- An assessment of FPB's existing cable/telecom system and alternatives for improving the infrastructure to meet the current and future wholesale and retail demands by subscribers in the offering of voice, video, and data services.
- Capital and operating costs of alternative infrastructure design versus costs associated with improving the existing plant and design.
- A business case and deployment plan that allows FPB to provide services during a transition and/or maintain existing services long term while migrating services to a new infrastructure.
- Development of a strategy for phased deployment of improvements that could be accomplished through internal funding without additional outside financing.

Within the general scope of work to accomplish the objectives of the study, the Consultants met with FPB management and staff over the past few months to gain an understanding of FPB's current standing within the community as a service provider for voice, video, and data services, from both a market share and customer satisfaction perspective. FPB and the Consultants discussed FPB's vision for service improvements and the future trajectory for customer growth within its service categories, anticipating the changes that are occurring with on-line video program delivery, the transition of land-line telephone service to mobile telephones, and the accelerating increase in Internet bandwidth traffic year over year.

The Consultants worked closely with FPB's engineering staff to examine network maps of FPB's existing cable/telecom system to understand its general layout and design parameters. The Consultants and FPB staff made field visits to sample network locations to assess the general condition of the cables and line equipment and determine the availability of attachment space on FPB's and other providers' utility poles as well as estimate the amount of engineering and construction work necessary to create proper pole space for new attachments. FPB staff also identified unserved areas where FPB would like to expand its system over time.

Technology platform alternatives, including Fiber-to-the-Home (FTTH), fixed wireless, and Hybrid-Fiber-Coax (HFC), were discussed to determine which would be the appropriate solution to enable FPB to achieve its vision for infrastructure improvements that can deliver more reliable and robust services to its customers. Competitive challenges from existing competitors like AT&T were discussed, as well as the potential for new competitors to gain access to the market via the fiber facilities available through the new Kentucky Wired program.

A FTTH network design emerged as the most desirable long-term infrastructure solution for the eventual replacement of FPB's HFC system that will be approaching its end of life over the next several years. A high level design and cost estimate has been developed for a FTTH network to be deployed within FPB's existing service footprint and provide additional fibers that can be extended into future expansion areas. An interim solution to expand the channel capacity and improve the reliability of FPB's existing HFC plant was also examined as the HFC system will remain in service for FPB's customers while a long-range FTTH project is being considered, planned, and deployed.

The proposed FTTH infrastructure will position FPB's Cable/Telecom Division for at least 30 years with a low-maintenance fiber optic network that will have the immediate bandwidth capacity to handle all modes of digital video, data, and voice traffic. The FTTH network will have the flexibility to easily increase for its bandwidth capacities to satisfy future customer demand by a reasonable investment to replace end-point electronic components, which can be done network-wide or for individual customers or classes of customers.

2. Infrastructure Study Scope of Work

The infrastructure study involved several areas of discussion and development that led toward the final conclusions and recommendations in this Report. The Consultants endeavored to create a collaborative end-product that represents the combination of the broad base of operational experience and knowledge of the FPB management and staff with the technical expertise and perspectives of the consultant team. The following describes how each component in the study's scope of work was developed and collectively forms the improvement plan that the Consultants are presenting to the FPB Board of Directors and Management team.

3. Creating a Broadband Vision

Traditional cable television service is undergoing significant change as customers are shifting to new sources for video programming and modes of delivery. Customers are using their Internet connections to stream or download movies and off-network series programming from services like Netflix that they can watch "on-demand" at their convenience. Netflix now boasts that it has more subscribers than the number of U.S. cable households. In growing numbers, cable customers are "cutting the cord" and discontinuing their cable subscription in favor of on-line content providers like Hulu, Sling TV, PlayStation Vue, and others that offer smaller line-ups of the most popular cable networks at a lower monthly cost, delivered through the customer's Internet connection. FPB has experienced a steady decline in its cable television subscribers during recent years as customers are migrating to these alternative on-line services, and FPB anticipates that this migration will continue unabated into the future.

The impact of this migration to on-line video providers is not felt just through the loss of FPB's cable television subscription revenues, but also the growing bandwidth demand by FPB's Internet customers. Streaming video content from Netflix and other on-line providers consumes a significant amount of bandwidth, particularly for high definition programming. As the migration to on-line video providers continues, the level of Internet traffic on FPB's will continue to grow. Adding to this are the tens of millions of YouTube videos that are streamed daily.

Beyond video, FPB's Internet customers use their data connections for commercial applications and transactions, business and personal email communication, education, entertainment, social media, and many other applications. Layering on this is the machine-to-machine Internet traffic that may control appliances, security systems, or enable devices to communicate with each other (referred to as the Internet of Things). Today, a typical household with multiple connected devices (televisions, iPads, PCs, etc.) can be adequately served with a 30-40 Mbps connection. However, telecommunications equipment manufacturer Cisco Systems released a study in June 2017 that predicts that Global Internet traffic will triple by 2021, due primarily to the growth of Internet-delivered video content and machine-to-machine inter-communication (Internet of Things, IoT). (See Exhibit # A) This represents an approaching situation of serious concern for FPB.

Residential telephone subscriptions have also fallen over the past few years as more and more consumers have discontinued their land lines and are relying solely on their cell telephones for voice communications. However, commercial telephone customers have the potential to grow as businesses continue to use land line telephone systems for their business communications and lucrative new products like cloud-based Hosted PBX are growing in popularity. FPB has announced plans to roll out Hosted PBX services on August 1, 2017.

FPB's Internet service subscribers today outnumber its video subscribers. The declining cable television and residential telephone subscriber growth patterns described above, while disconcerting, may not be problematic as it appears. The ascending services (Internet and commercial telephone) are FPB's highest margin services, and those with the lower margins (Cable and residential telephone) are declining in numbers. FPB's recent core service growth projections are illustrated in Exhibit B. The Consultants believe that FPB's projections are somewhat conservative and there may be upside growth potential for FPB to increase both its Internet and commercial telephone subscriber bases through its infrastructure improvements.

Many traditional cable operators are already transitioning to become primarily an Internet Service Provider (ISP) that also provides video and other services. In a competitive marketplace, the successful ISP will be the one who can deliver the most bandwidth, with the greatest reliability, and at the best value. A Gigabit service subscription level (1,000 Megabits per Second, or Mbps) is the current industry standard, and is expected to be sufficient to accommodate the growth in Internet traffic for the coming five years. FTTH network equipment capable of delivering 10 Gigabits of bandwidth will be commonly available by that time and will provide additional capability for anticipated growth in consumer bandwidth demand. This will be FPB's future, and this Infrastructure study is timely to chart this course.

4. Inventory of Telecom Assets

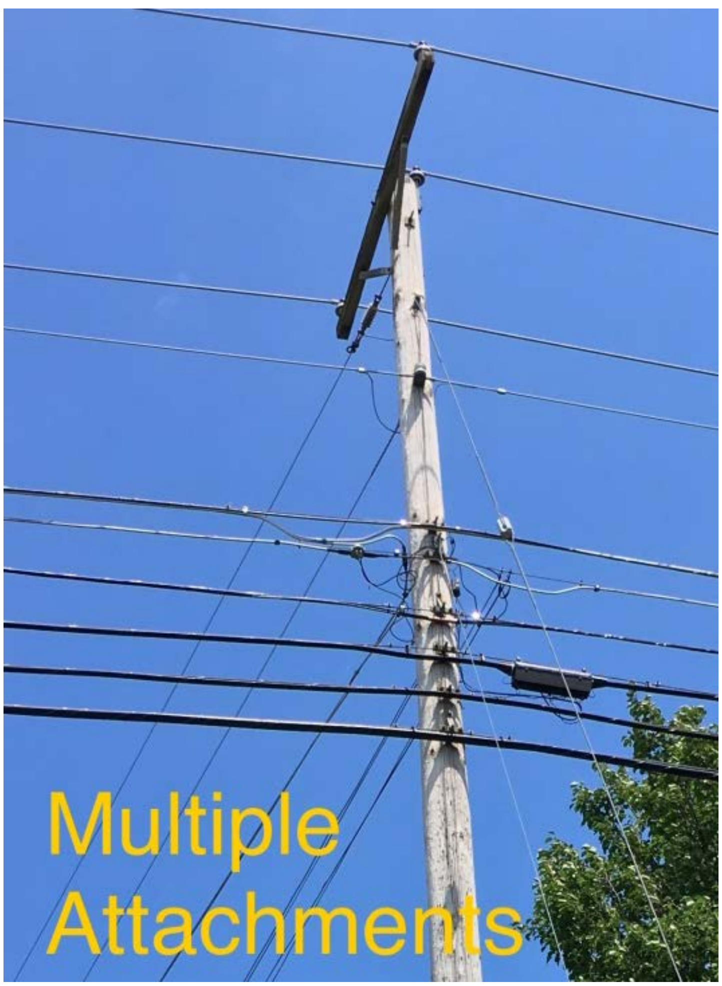
Currently, FPB's Hybrid-Fiber-Coax (HFC) cable system is designed with a 750 Megahertz (MHz) operating range of frequencies. The 750 MHz range contains 116 channels (6 MHz frequency slots), which can be used to carry analog or digital video programming or provide bandwidth for Internet traffic. FPB has sixteen of the total 116 channels dedicated to its Internet bandwidth, with nearly all of the remaining channels used for video programming. The 16 channels dedicated to Internet service create 600 Mbps of bandwidth that is shared typically by 150-200 customers within each neighborhood service area across the system. With the limitations of its 750 MHz design, FPB will need to aggressively manage its operating spectrum to carve out additional channels to expand its Internet bandwidth to keep pace with consumer demand, while at the same time satisfying requests for additional cable programming. As an example, this August, FPB plans to change the compression ratio of several of its HD television signals from 2:1 to 3:1, which will enable more HD signals to be carried in a single 6 MHz channel space. This reorganization of HD signals will free up 8 more QAM channels that FPB can dedicate to Internet bandwidth, increasing the total from 16 to 24 channels and expanding Internet bandwidth from 600 Mbps to 900 Mbps. The bandwidth expansion will also require a $225K upgrade of FPB's Cable Modem Termination System (CMTS) head end equipment, which FPB has budgeted in the FY 2018 budget as part of its $450K broadband upgrade plans.

The HFC system utilizes fiber optic lines to efficiently transport its signals from its head end to the various neighborhoods within its service area with minimal signal loss and interference. The fiber terminates in the neighborhood area at a node unit, which converts the light signals from the fiber into electrical signals that are transmitted from the node through a series of amplifiers and line extenders along the copper coaxial cable path to the customer's premise. The HFC system was built in 1999 and the age and eroding condition of the HFC node equipment, trunk amplifiers and line extender began to affect the reliability and quality of FPB's services and resulted in growing customer dissatisfaction because of unreliability and poor quality issues. To address these problems, FPB recently invested over $7 Million to build a new head end facility with enhanced back-up powering and structural integrity and also in 2016 replaced their end-of-life fiber node units that were a major factor in FPB's system reliability issues. Also, as part of the $7+ Million investment, FPB upgraded its CMTS Internet equipment in the head end to enable it to expand its bandwidth capacity to 600 Mbps at each node location. By increasing their Internet bandwidth for each group of node customers to 600 Mbps, FPB was able to effectively double their customers' speed levels, and did so without increasing its Internet rates. The planned Internet speed increase this August to 900 Mbps, along with the head end rebuild, CMTS Internet equipment upgrades, and node replacement, will give FPB some temporary relief from the growing customer dissatisfaction issues. The new nodes that were replaced are designed to operate at 1 Gigahertz, which increases the number of channels from 116 to 158, however, the 750 MHz amplifiers and line extenders located beyond the nodes limit the availability of the additional channel capacity in the node units. As bandwidth demand will continue to grow, FPB will struggle to free up channels to keep pace with the demand, unless it can expand its system's operating frequency range beyond its current 750 MHz design.

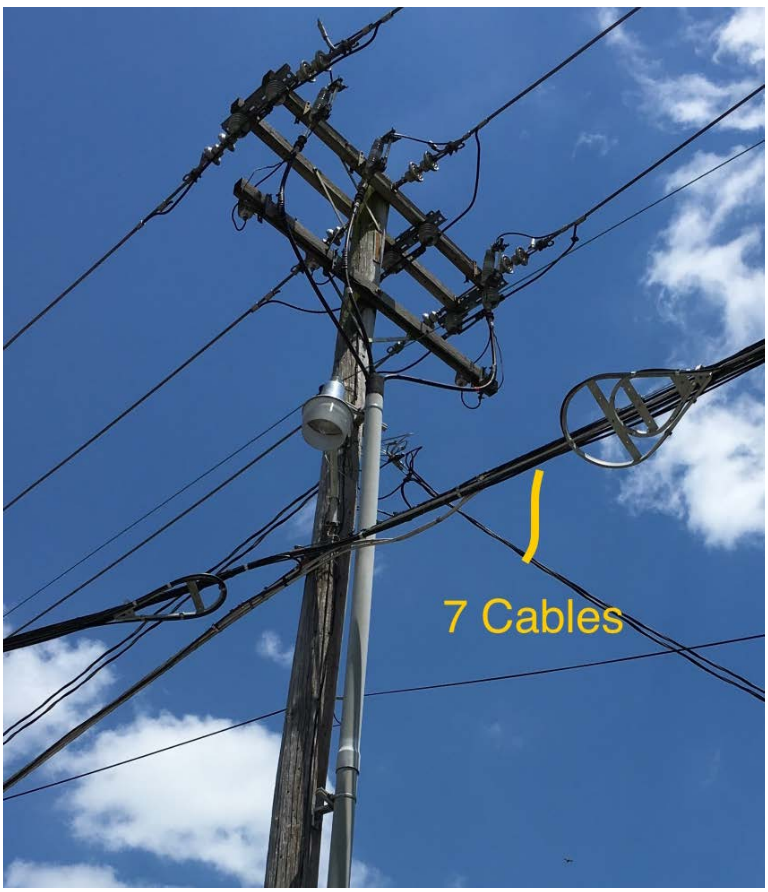
The Consultants understand that the FPB Cable/Telecom Division has budgeted $2,180,000 in the current fiscal year for the maintenance replacement of its remaining 750 MHz amplifiers and line extenders to new 1 GHz equipment. This maintenance upgrade will enable FPB to dedicate 16 more channels to its Internet service (taking the total dedicated Internet channels to 40 from 24), make 1.5

Gigabit of bandwidth available at each node location, and offer additional channel capacity for more video programming, including 4K and ATSC 3.0 programming from broadcasters. The Consultants recommend these improvement plans for the HFC plant as a prudent option to enable FPB to retain and grow its Internet customer base and provide a high level of service quality and reliability during the planning and deployment of the FTTH network project.

In examining the physical cable plant, FPB provided the Consultants with extensive system maps that detailed all of the trunk routes within FPB's service territory, which extend beyond the corporate limits of Frankfort into surrounding county areas served by Kentucky Utilities and Bluegrass Energy Cooperative. Additional maps were provided that identified the boundaries of the node areas throughout the service territory. Nodes that only served a single building, such as a hotel, were not considered in this study leaving 71 node areas as candidates for a FTTH upgrade. The Consultants worked closely with FPB's cable engineering staff to identify the number of active and spare fibers at each node location, as well as the number of active and spare fiber strands within FPB's Metro Ethernet network ring. It was determined that there are not sufficient spare fiber strands in either the HFC cables or the Metro Ethernet network to support a FTTH network. A typical HFC node requires 8 strands of fiber, while FTTH design may call for as many as 48 fiber (or more) at the same location.



The Consultants rode through portions of the service area with FPB field supervisors to examine the general layout of the HFC plant, note typical pole loading and available pole space for make-ready requirements, identify the location of hub sites and the downtown IT/central office facility, and tour FPB's new head end facility. The ride-out also included stops at representative node and system power supply locations. The Consultants found that the general plant condition is in fairly good shape, although there are obvious signs of age. They observed several areas within the older downtown area of the City where poles were very heavily loaded with multiple electric, cable, and telephone lines (see photo left) and do not have sufficient space for new fiber cables to be attached and meet the safe spacing requirements of the National Electric Safety Code (NESC). Any new strand and fiber that is to be built within these areas will require a significant amount of utility pole make- ready to either change out shorter poles to taller poles with more space, or direct the other entities on the pole, predominately AT&T, to relocate their attachments to accommodate new FPB strand and fiber. FPB estimates the typical cost to set a taller pole will be $4,000 per location, which includes labor and materials. Within the FPB electric areas outside of the older downtown sections and in the areas of the other electric providers, the make-ready requirements did not appear to be as significant. However, the cost of make- ready work to be performed by the other pole owners (Kentucky Utilities, Bluegrass Energy Cooperative, and AT&T) is anticipated to be much greater, and the scheduled completion times much longer. The Consultants and FPB engineering staff estimate the percentage of poles that will require some amount of make-ready work (either pole replacement or attachment relocation) to be an average of 30% across the entire system, with a higher percentage in the downtown areas and lower amounts in the outlying neighborhood areas. This amount represents the Consultant's best estimate, with the actual number of poles requiring make-ready work to be identified in the future if and when FPB contracts for engineering design and field measurements.



Also observed in the downtown area were sections of the HFC system where the cable plant's support strand was over-lashed with several fiber and coaxial cables. Concern was expressed that the ¼" steel strand that is in place cannot support the weight of any additional fiber cables that would be used for a FTTH network. The photo to the left shows seven fiber cables and coaxial cables lashed to that section of strand. To create adequate space for a separate new strand to be attached for a FTTH fiber cable, this pole will need to be replaced with a taller pole.

Rights of way and easement access were also observed with large portions of the downtown plant located on rear easements behind houses and businesses. This may provide impediments to access plant construction.

5. Define the Service Gap

FPB's ability to grow and retain its lucrative Internet customer base has been improved by its recent increase in downstream bandwidth capacity at each node to 600 Mbps that has allowed FPB to upgrade the speeds of all of its Internet service packages, effectively doubling the download (receiving) speeds across the board. Upload (sending) speeds were improved somewhat, yet remain at significantly lower speeds than downloading. FPB's entry level speed package is now 10 Mbps download by 1 Mbps upload (10x1 Mbps) and its top end speed level is 100 Mbps down by 10 Mbps up (100x10 Mbps), with intermediate levels of 25x3 Mbps and 50x5 Mbps. Following its planned Internet bandwidth expansion in August to 900 Mbps, FPB intends to increase its top-end Internet service level from 100x10 Mbps to 250x15 Mbps.

In its current state, FPB's recent Internet bandwidth upgrade is expected to provide only short-term relief for two to three years from potential Internet traffic congestion. The rapid growth of Internet video streaming, as evidenced by the proliferation of on-line video providers and as described in the aforementioned Cisco study on overall Internet traffic growth, will place heavy demands on FPB's Internet capacity and result ultimately in a slowing down of Internet speeds for individual consumers and less than satisfactory customer experiences if no other improvements are implemented.

The relatively modest investment for a 1 Gigahertz frequency maintenance upgrade discussed earlier to acquire more channel capacity and Internet bandwidth is a necessary next step for FPB to gain more capacity as it plans for future infrastructure improvements. <u>However, the 1 Gigahertz upgrade to the HFC plant is not to be construed as an alternative to a FTTH network infrastructure improvement, but rather as necessary investment for FPB to protect and sustain its revenue base during the period that the FTTH infrastructure is being planned and built.</u> The HFC upgrade will also give FPB additional time if it needs to reduce current debt levels or line up outside funding prior to proceeding with a FTTH network investment.

Ultimately, the desired future state for FPB's Internet service is the ability to offer Gigabit speed as an individual service level option. While individual Gigabit speeds are overkill today, it is widely recognized within the telecommunications industry that Gigabit service will eventually be necessary to handle the level of Internet traffic by a typical American household with multiple streaming devices, tablets, and computers, as well as appliances and household systems that utilize the Internet for remote monitoring and controlling.

FTTH systems are the logical solution for delivering an increasing level of Internet service to customers. Unlike copper cable plant, fiber optic cable has the capability to transmit a virtually unlimited amount of bandwidth with minimal loss of signal quality over greater distances than copper lines. Contemporary fiber optic network access equipment is designed to provide 2 Gigabits of downstream capacity and 1 Gigabit of upstream capacity to individual customers or small customer groups. Next-Generation access equipment featuring 10 Gigabit by 10 Gigabit symmetrical capacity (upstream and downstream the same) will be the standard within five years or less at comparable pricing to today's Gigabit equipment. Further improvements in access equipment bandwidth capacity are anticipated, and like the upcoming 10 Gigabit upgrade, will not require changes to the fiber optic network itself. Only the access electronic components at the head end and the customer's premise will need to be replaced, a relatively minor process.

The following sections discuss a high level design solution for a FTTH network and the high level estimated cost of designing and building a FTTH network throughout FPB's service territory.

6. High Level Design for a Network Solution

The Consultants, in discussions with FPB management and staff, have developed a conceptual high level design for a FTTH network to replace FPB's existing HFC system over time. The FTTH network will be a Passive Optical Network (PON), which means that the outside fiber plant will have no active electronic components (hence the term "passive") and will consist solely of fiber optic lines from the origination point at the new FPB head end directly to the customers' premises. The network electronic equipment that will transmit and receive the light signals that will travel over the fiber will be located at either end of the fiber circuit – in the head end or at the customers' premise. Unlike the current HFC network that has thousands of active electronic nodes, amplifiers, line extenders, and power supplies in its network, the FTTH PON network will be less costly to operate and maintain, and will have fewer failure points, without the active components. Fiber optic cables also have the inherent ability to transmit its light signals over greater distances and with virtually no signal distortion than is possible with copper coaxial cables. This design approach represents a long-term solution that can serve the FPB community for approximately 30 years.

The FTTH network plant will be designed and constructed as a discrete network, physically and operationally separate from the current HFC system. Initially, consideration was given to integrating the FTTH network with the HFC plant and utilizing any available spare HFC node fibers or lashing the new fiber to the HFC support strand cables to save on the deployment costs. However, analysis of the remaining HFC spare fibers indicates that there are not a sufficient number of available fibers, and larger trunk fibers will be needed to serve existing node areas and to extend the fiber network into new expansion areas. Operationally, there will be less risk of disrupting service to the customers still served by the HFC system during the phased deployment of the FTTH network if the limited number of spare fibers within the HFC system is not accessed.

Further, the heavy loading of the ¼" HFC support strand with multiple large fiber and coaxial cables in several sections of the system is a concern to the integrity of HFC plant if additional fibers are over-lashed to that strand. Large areas of HFC customers would be affected if the bundles of multiple fibers and coax cables were damaged due to the support stand breaking under the strain of new fiber additions. Also, the thousands of coax service drops, many of which are anchored to the support strand, are in the way of new fiber that would be lashed to the existing strand.

To build a separate, discrete FTTH network over the existing HFC system, FPB will need to attach the new FTTH strand and fiber to the utility poles with the proper amount of clearance from other surrounding attachments in compliance with NESC requirements. As discussed in the Inventory of Telecom Assets section above, a large number of utility poles will require some amount of make-ready work (either existing attachment relocation or pole change-out) to create the sufficient safety space necessary to attach new fiber lines within NESC code. The amount of make-ready work associated with this FTTH project is expected to be substantial component of the construction cost. This make-ready cost, along with a mitigation alternative, will be discussed in more detail under the following section that details the estimated cost of the FTTH project.

The FTTH network high level design incorporates standard Gigabit network access equipment that transmits 2 Gigabits per second (2 GBPS, or 2,000 Mbps) of downstream bandwidth (head end to customer premise) to customer locations and 1 Gigabit per second (1 Gbps, or 1,000 Mbps) of upstream bandwidth (customer premise to the head end), making the network a Gigabit PON, or GPON. It should be noted that the standard Gigabit access equipment (2 Gbps x 1 Gbps) is in general availability by several manufacturers at competitive pricing. This is the access platform most commonly used in the FTTH industry today. However, Next-Generation platforms offering symmetrical 10 Gbps x 10 Gbps bandwidth are under development, and some manufacturers have early versions available at significantly higher pricing. It is anticipated that within the next five years, 10 Gbps will be the standard platform and will be available at current pricing for today's Gigabit equipment. Typically, new generation equipment is backward compatible with earlier deployment platforms, eliminating the stranding of the initial equipment investments.

From the FPB head end, Optical Line Transmitters (OLTs) use low-power lasers to send out 2 Gbps of downstream bandwidth along each of several individual fiber optic strands within Feeder Trunk fiber cables of various sizes (288-strand count, 144-strand count, 72-strand count, etc.) built out to neighborhood Fiber Distribution Hub (FDH) cabinets that serve areas similar in size to FPB's current node areas. Each individual fiber strand carrying 2 Gbps is connected to an optical splitter that will be shared by customers on neighborhood distribution fibers that come back to that FDH cabinet. A splitter ratio of 1:8 will be used for business customers that may require higher bandwidth levels with heavier, more constant use throughout the day, and 1:32 splitters will be used for residential customers with lighter demands. Each of the individual distribution fiber strands will be assigned to a potential customer address and will be connected to individual interface ports in the FDH cabinet. The output legs of the optical splitter will be cross-connected to the interface port for the appropriate customer's address (think of an old telephone switchboard). Tap enclosures along the neighborhood distribution fiber routes will allow the fiber to be accessed to run fiber service drops to the customers' premises. Exhibits C and D respectively show the proposed feeder trunk fiber routes throughout FPB's Cable/Telcom service area and also detail of fiber distribution cables in a typical node area.

At the customer's premise, an Optical Network Terminal (ONT) receives the optical light signal and converts it to standard electrical signals that can be sent through the customer's inside copper wiring (coax for RF video, Cat-5 for data, or twisted pair for voice). The ONT also transmits up to 1 Gbps of return signals upstream, after converting the electrical signals to light wave transmissions.

Although FTTH networks can transmit video, voice and data signals, FPB management and the Consultants expressed a preference to use the FTTH network initially to provide only data services, and to keep its cable and telephone services on its HFC system while the new FTTH network is constructed. This approach simplifies the customer transition process and allows additional time for the evolution and migration of traditional cable programming services to alternative on-line video programming delivery to progress.

The FTTH network will take approximately five years to plan and build, if completed as a single entity, or longer if completed in phases. Over this time period, cable programming is expected to continue the transition to Internet Protocol (IP)-based delivery via the customer's data service subscription and the decrease in residential telephone subscribers is expected to continue. Over the next 5 -10 years, the decrease in cable and telephone subscribers is likely to plateau and remaining service can be moved to the FTTH network allowing the existing Hybrid Fiber Coax network to be removed from service and dismantled.

This approach will also result in cost savings for the FTTH network project. ONTs for processing data only signals cost substantially less than those that designed for RF video, standard telephone and data services. Recent bid pricing for triple-play ONTs are in the $199 - $239 range, versus data-only ONTs at

$70-$90. In addition, moving RF video cable and telephone HFC customers over to the FTTH network in their current format will incur contract installation labor costs per service moved along with the cost of new advanced set-top boxes.

The chart below illustrates the $1.5 Million investment that FPB would need to make if it transitioned its current-format RF video and telephone services to the FTTH network over a five-year build out period. The incremental cost of the triple-play ONT is projected to be $135 more than data-only ONT, and contract labor is estimated at $40/service, based on recent bid pricing from other networks. The cable and telephone subscribers are at projected levels beginning in FY 2020 and beyond, based primarily on FPB's internal estimates. The $1.5 Million investment to include RF video cable and telephone in the FTTH network services offerings is not included in the overall high level FTTH network cost estimate described later.

RF Cable and Telephone on FTTH	**FY 2020**	**FY 2021**	**FY 2022**	**FY 2023**	**FY 2024**	**Total**
(Assumes 5 year deployment timeframe)				Consultant's Estimates		
Cable Subscribers	9218	8287	7470	7100	6900	
Telephone Subscribers	4342	3947	3556	3100	2800	
% installed each year	20%	20%	20%	20%	20%	
ONT Price Difference w/RF Cable and Telephone	$135	$135	$135	$135	$135	
Contract Labor to install Cable or Phone	$40	$40	$40	$40	$40	
ONT Cost (based on cable units)	$248,886	$223,749	$201,690	$191,700	$186,300	
Labor to connect cable outlets to ONT	$73,744	$66,296	$59,760	$56,800	$55,200	
Labor to connect telephone jacks to ONT	$34,736	$31,576	$28,448	$24,800	$22,400	
Total Investment Cost	**$357,366**	**$321,621**	**$289,898**	**$273,300**	**$263,900**	**$1,506,085**

Other HFC system operators who are upgrading their infrastructure to FTTH networks are also following the same plan to offer only data services on their new fiber plant and leave their declining cable television and residential telephone services on their HFC systems while those services evolve. Mr. Kersey is working with the Barbourville, KY Utility Commission (BUC) to plan and implement an overbuild of its HFC plant with a FTTH network. BUC will continue to operate its HFC plant for its video service and offer enhanced data services through its new fiber facilities. Within five years, BUC anticipates that it will decommission its HFC plant and bring over any remaining video customers to its fiber network. Construction for this project is expected to begin in August of 2017. Private cable operators in Massillon, Ohio and in Hagerstown, Maryland have recently announced that they are building FTTH networks to replace their HFC systems, and will begin those new networks with data-only services for the reasons described above for FPB (see Massillon announcement in Exhibit #E).

7. High Level Cost Estimate of a Network Solution

Working closely with the FPB Cable/Telecom Division Engineering team to gather existing plant layouts, component quantities, and other pertinent information from FPB's network maps, Mr. Tom Grigg, with the assistance of additional Engineering Associates staff, developed a high level cost estimate for the high level FTTH network design, based on the design assumptions described above. The Pricing Summary Spreadsheet was used to calculate the plant construction costs for each of FPB's 71 nodes plus the cost to connect all of FPB's Internet customers within each node. Additionally, general costs not associated with specific nodes for design/engineering, pole make-ready, feeder trunk fiber cables, and GPON network access electronics were estimated and added to the total costs.

The high level cost estimate summarized below represents budgetary composite pricing which combines labor and materials for the various plant components in the FTTH network. The composite pricing is presented as an average of the multiple unit sizes of items within each component category, such as multiple sizes of aerial and underground fiber cable (288-ct., 144-ct., 72-ct., etc.), different sizes of Fiber Distribution Hub cabinets, underground vaults (hand holes), and fiber service drop tap terminals, and so forth. Labor and material pricing will vary based on availability, driven by the level of construction activity in the industry at the time of a project. For example, fiber cable can sharply increase or decrease in price and delivery time if demand is high or low, and construction and engineering contractors will bid their pricing based on whether they are looking for work or more selective in the projects they consider. It is the Consultant's intention to provide a "safe" estimate of the project cost that establishes reasonable expectations and avoids potential surprises from overly aggressive assumptions or optimistic pricing.

8. FTTH Network Cost Estimate Summary

The following describes each of the network components and provides an estimated cost of construction for that component.

Network Component/Activity	Estimated Cost
Engineering and Design Based on 2,661,787 ft. @ $1.10/ft.	**$ 2,927,966**

This includes the development of a Master Plan design for the entire Network area that can be subdivided for phased deployment so that later phases built over time will align properly with earlier completed areas. Final design for construction activity will include staking and walk-out (to measure pole attachment heights, pole GPS locations, identify make-ready requirements, determine routes and available easements, etc.), design and completion of construction maps for contractors, and As-Built maps detailing completed and approved construction.

Make-Ready Pole Replacement/Attachment Relocation	**$9,504,000**

The Consultants conferred with FPB Engineering staff to determine the percentage of FPB poles that would require some degree of make-ready work to create safe attachment space for the FTTH network. It was projected that 30% of FPB's 6,421 poles, or 1,926, would require replacement or attachment relocation at an overall average cost of $4,000/pole. This will be particularly true in the older and downtown Frankfort areas and along major arteries within the city limits. The estimated 3,000 poles in the Kentucky Utilities and Bluegrass Electric Cooperative areas will require less make-ready, with 15% of those poles, or 450, needing work at the $4,000/pole average rate. This estimate is made on the best information available, and a true assessment of poles requiring rearrangement or replacement will come out of the staking/walk-out engineering work performed during the network design phase. Another important consideration with make-ready is the time that other entities will take to complete the make-ready requests by FPB. Competitive providers, such as AT&T, or other utilities with different priorities/time tables can cause major disruption to construction if their make-ready work is delayed.

Feeder Trunk Fiber Cable Construction Based on 478,004 ft. @ $5.34/ft.	**$2,554,678**

Feeder trunk fiber cables are routed from the FPB head end to deliver Gigabit bandwidth out to the various Fiber Distribution Hub cabinets located generally near FPB's current HFC node locations. The Feeder fiber cables are larger cables with either 288 or 144 fiber strands in each. Cost per foot includes labor and material costs.

Distribution Fiber Cable Construction Based on 2,183,783 ft. @ $8.33/ft.	**$18,194,416**

The Distribution fiber plant encompasses the customer side of the network from the Fiber Distribution Hubs along neighborhood streets to customers' premises. The Distribution plant includes nearly 2.2 million feet of aerial and underground fiber cable, with varying fiber strand count, ranging in size from 24-ct. up to 144-ct., 72 Distribution Fiber Hub cabinets, 790 underground vaults, and 3,653 fiber service drop taps. The Distribution plant will also require 75,682 fiber splices to connect all fiber strands to the Distribution plant components.

Network GPON Access Equipment Sufficient for 15,000 customers	**$1,587,940**

This Gigabit PON network access equipment is sufficiently sized to serve up to 15,000 customers in a mix of 10,000 single family units, 3,800 multi-dwelling units, and 1,200 businesses.

Customer Installations 15,000 data installations @ $654.30/customer	**$9,814,500**

The design assumes that outdoor ONTs will be installed using a $229.00 ONT and an outside power supply. The average 400' service drops costs are blended at a 70% aerial and 30% underground mix. The installation labor costs are based on recent installation bid responses from other projects in the region.

Total FTTH Network Estimated Cost	**$44,583,500**

The Consultants have provided a Summary of the FTTH network deployment costs broken down by node areas in Exhibit F.

9. Opportunities for Potential Reduction of Project Cost

The high level pricing estimate is based on budgetary pricing for labor and materials, a general review FPB's system maps, system ride-outs, and discussions with FPB management and engineering staff. The actual total cost is expected to change after design is completed and contractor and supplier pricing is bid. While the Consultants were conservative in developing their "safe" estimate of the project cost, there are factors and potential efficiencies in construction methods and internal resources not present in this estimate that may materialize to reduce the project's overall cost. These factors and efficiencies, by category, include:

A. Design and Engineering

- The final design may reflect lower actual footages amounts for various cable sizes and fewer hardware material quantities that will lower the final Bill of Materials amount.
- Field engineering during the staking/walk-out process may identify a lesser amount of make-ready requirements that initially estimated.
- If the FTTH network project is built in phases, after an outside design/engineering firm completes the Master Plan and the design of the first one or two construction phases, FPB's engineering staff may complete the design of the remaining phases in-house, saving a significant amount of outside labor cost.

The amount of savings is to be determined, but could conceivably be 30% of the estimated design/engineering cost.

B. Make-Ready Pole Replacement and Attachment Relocation

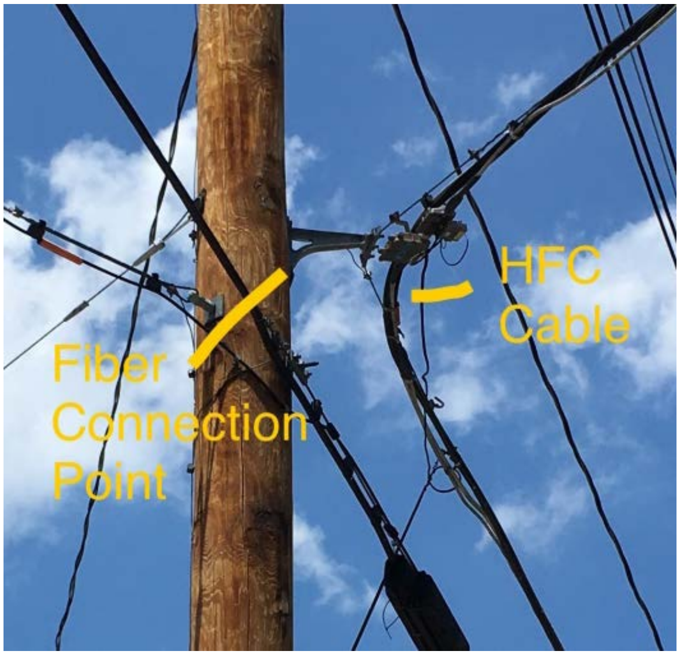
Make-ready is a significant cost factor that is typically present in most FTTH network projects that deploy aerial cable. Make-ready requirements can be addressed in the traditional manner of utility pole replacement and attachment relocation as indicated in the project cost estimate above. This method is typically used with dealing with attachment requests between non-affiliated entities, and can be very costly and result in time delays for construction work. However, there is an alternative method, described below, that FPB may use to significantly reduce the cost and timing of make-ready requirements.

C. Stand-off Brackets

Another method to achieve proper spacing from other communication attachments is to attach the cables to a stand-off bracket instead of the pole itself, as shown in the photo below. The photo shows a stand-off bracket used for FPB's HFC plant in downtown Frankfort and illustrates the concept of horizontal placement.

The stand-off bracket that would potentially be used for the FTTH project would be designed to accommodate two attachments, one at the end of the bracket arm as shown in the photo, and a second attachment at the bottom of the bracket base where it is anchored to the pole (not shown).

FPB would move its existing HFC cables out to the end of the bracket arm and use the bracket attachment point next to the pole for the new fiber cable. At the point in the future when FPB decides to decommission its HFC system and remove the coaxial cable, it will be more easily accomplished if those cables are on the outside of the bracket. FPB will likely leave the old HFC support strand in place to be used for additional fiber cables or service drops.



Stand-off brackets can be used in all areas of FPB's HFC service territory, including the areas of the other electric utilities on whose poles the HFC system is also attached.

FPB assumes that some situations, such as dead end poles, may not be suitable to use the stand-off brackets and that some make-ready expense will be incurred. The FPB engineering and operations team determined that if the existing amplifiers are replaced during the HFC upgrade by in-house resources, these same resources will install the stand-off brackets and relocate existing cable to the end of the bracket arm while in the area. This would free up space on a majority of the pole and allow the FTTH construction to move much quicker.

It is estimated that the use of stand-off brackets, where applicable, could reduce the overall make-ready cost of the FTTH project by as much as 75%, and this reduction could be even greater if FPB is able to use in-house labor resources to deploy all or some portion of the stand-off brackets.

D. Plant Construction Costs

- The project's estimated plant costs are based on budgetary pricing, and costs are expected to be lower after competitive bidding. Further, labor and material costs fluctuate based on demand and supply for current construction activity in the industry. Timing of the project may occur at a time when industry-wide activity is lower, resulting in more favorable labor and material bid pricing.
- FPB may utilize in-house resources for some portion of the plant build-out, especially if the project is being completed in smaller, more manageable phases over a longer period of time, thus reducing outside contract labor.
- The project's estimate reflects the assumption that all new fiber will be lashed to new support strand that is attached to poles in existing available space above FPB's HFC plant, or in new space created by required make-ready work. In areas where the loading of HFC cables on existing support strand is low (particularly in the distribution side of FDH in lower density areas) the new fiber cable may be able to be over-lashed to the existing HFC support strand, reducing make-ready work requirements and labor costs and material costs for new strand construction.

Aggressive bidding of labor and material costs and the potential use of in-house labor resources could reduce the plant construction by an estimated 10% to 20%.

E. Network GPON Access Electronics

- The cost of the GPON network electronics are expected to be lower after an aggressive competitive bidding process.
- Next-Generation 10 Gigabit equipment may be generally available at the time that the network access equipment will need to be ordered. This circumstance may allow FPB to acquire newer equipment with greater capability, and skip over the purchase of an older technology generation product.

F. Customer Installations

- Customer service drop installations and inside wiring of new fiber-delivered services is assumed in the FTTH project cost estimate to be performed by contract labor. FPB may elect to do all or some portion of this work with its existing field personnel, particularly if the project is deployed in several smaller and more manageable phases. As an example, FPB may use contract labor to run fiber service drops from fiber taps to customer homes during the plant construction process, and utilize in-house crews to complete the inside wiring and conversion activity through scheduled work orders. This two-step process would not only reduce outside contract labor cost, but would also reduce the time that the customer would be required to be present for the inside installation work.

- The project estimate assumes that outdoor ONTs and power supplies will be used for all customer installations. FPB may elect to use indoor ONT equipment with a substantial cost savings versus outdoor units (avg. $75 indoor versus $229 for outdoor).

Customer installation costs could be sharply reduced by 30% if indoor ONTs were used for just half of the customer installations.

G. Overall Project Cost Savings Summary

The Consultants believe that the overall FTTH project cost can be reduced by 15% to 25% if FPB is able to implement some of the suggested actions in the areas of design/engineering, pole make-ready, plant construction, and customer installation.

10. Considerations for Planning and Phased Investment Approach to Deployment

FPB has requested that the Consultants develop a strategy for a phased investment approach to deploying their recommended infrastructure improvements. How and when FPB determines to proceed with these investments and the schedule for the phased deployments of a FTTH network will depend upon a number of factors and considerations, including but not limited to:

- The capital cost of the improvement plans
- Engineering and design time.
- The availability of plan financing, either through internal cash flow and/or outside funding.
- FPB's current debt requirements.
- The technical integrity and performance of the existing HFC plant.
- The acceleration of bandwidth demand and FPB's ability to meet that demand.
- The growth and/or decline of subscriber levels in core categories.
- Changes in the competitive landscape.
- Political considerations in regard to where and when phased deployment occurs.
- Potential for customer growth within each node area.
- Make-ready requirements and timing.
- The availability of long lead-time materials such as fiber.

Based on the Consultants' experience with other municipal FTTH start-up projects of similar size and nature, the timeline for FPB's FTTH project from the date that FPB decides to proceed with the project to the activation of its first subscriber is expected to be three years. The subsequent and remaining phases of the FTTH project will be deployed over a schedule determined by FPB, in consideration of the above factors.

The first phase deployment will involve the following steps, with estimated completion times shown for each step. Note that some steps may overlap somewhat or be completed simultaneously, as indicated.

A. Project Implementation Steps

i. Project Inception (date TBD by FPB Board)

This will occur when the FPB Board of Directors gives approval to FPB's Cable/Telecom division management team to begin preparation of a FTTH project feasibility study, financial model and/or business plan for presentation to the Board for implementation approval.

ii. Feasibility Study/Financial Model/Business Plan (3-6 months)

This may involve a RFP search/ selection for a qualified independent consultant to conduct a feasibility study and assist in the preparation of a financial model and business plan to be presented to the Board for final approval to proceed. It is recommended that this consultant act as the project consultant for implementation if the Board approves the project.

iii. Planning and Financing Acquisition (12 months)

The project consultant will begin the project planning with the preparation of RFPs for a design firm and/or construction contractors, installation contractors, vendors for network access equipment, fiber and materials suppliers, and ancillary products and services as identified. This will also include RFP proposal review, Board approval, and contract negotiation and approval with selected contractor/supplier. Concurrent with this activity will be solicitation by FPB of outside funding from local community stakeholders, beneficiaries, grant programs, or private lending institutions (if desired).

iv. Master Plan/Phase One Engineering and Design (12 months)

Immediately after the letting of a design and/or construction contract, FPB will initiate the development of a Master Design Plan for the overall FTTH network, followed by the walk-out of the plant routes, staking (pole measurements and locations), and initial design for the first phase area. The overall Master Plan, which will take approximately 90 days, should be completed prior to design of any of the phases to ensure that the continuity of the plant design in subsequent phases is maintained. The staking phase is expected to take a considerable portion of time due to the amount an anticipated make-ready work that will occur. As utility poles that require replacement or relocation are identified during staking, it is recommended that this make-ready work commence immediately to clear the way for later construction activity. Due to the long lead-time for ordering certain materials, such as fiber cable, at least the first three phases should be designed at this time to create their bills of material. Subsequent phases may be designed later with the appropriate lead time for materials ordering.

v. Materials Ordering /Acquisition (6 months)

Each designed phase will include a Bill of Materials for the fiber cables, hardware, and other materials needed for construction. Lead times for fiber cables vary based on demand, from 3 months to 6 months (or longer), and most other items are generally available with 60 days or less. Following completion of the Master Design Plan, but prior to the first phase design, FPB should order an estimated quantity of fiber in various sizes sufficient to complete the first three phases. When those first three phases are designed and their bill of materials is completed, the fiber orders can be adjusted as needed.

In any case, lead time for ordering and receiving materials should be planned.

vi. Plant Construction of First Phase (3 Months)

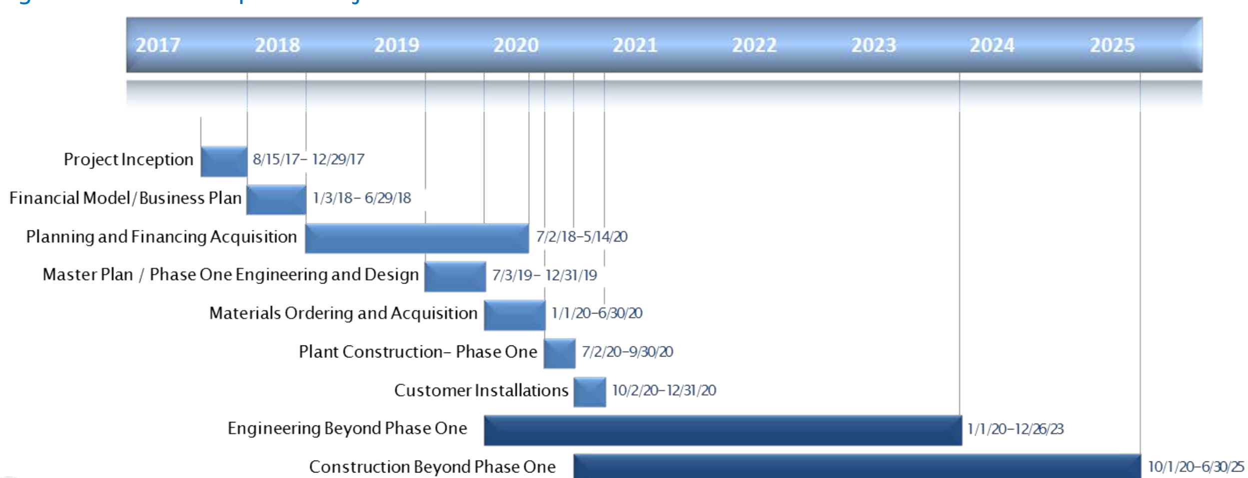
The size of the first phase is unknown, but three months should be adequate time to allot for this construction. This activity will be impacted by the amount of make-ready that will be required in the first phase area, however, there will be approximately 9 months of from the staking work to construction start to complete any required pole change-outs.

vii. Customer Installations (3 Months)

As soon as construction activity in the first phase begins, customers to be converted to the fiber plant should be contacted to inform them of the construction activity in their area and to let them know that they will be moved to the fiber network. Separate fiber drop crews can run fiber service drops to customers' houses following the construction crews, but the inside connections of services will need to be scheduled with the customer and completed by other installation teams. The scheduling appointments for the inside activity is the most time-consuming portion of this portion of the installation process.

Even with some activities within the above steps over-lapping or being completed concurrently with activities in other steps, the completion time for the first phase of the FTTH project from whenever the FPB Board gives its initial project approval to the installation of the first fiber customer will be at least three years. The Gantt chart below illustrates the three-year timeline of the FTTH project from inception through completion of its first phase, and then beyond to the remaining phases.

Figure 10-1: FPB Proposed Project Timeline



Using the High Level Design and Per-Node Cost Estimation as a guide, FPB may make decisions as to how to size the subsequent phases to be designed and built. With the anticipated demand for Internet bandwidth that will be available through the FTTH network, the overall completion of the remaining phases of the FTTH project should not exceed five years after the initial phase completion. FPB should aware of the capital requirements of this overall deployment schedule as it considers this project.

11. Consultants' Recommendations for Infrastructure Improvements and Deployment Strategy

In the coming years, FPB will transition from a Cable Television Operator that also provides data, telephone and other services to an Internet Service Provider that offers high speed connections for voice, video, and data services from a variety of content providers using IP-based delivery. FPB is likely to face increased competition from other service providers, either existing or new to the market. The successful ISP will be the one who can provide the fastest, more reliable Internet connections, with the best customer support, and at the most competitive price. Strategically, FPB must ensure that its infrastructure can keep pace with the market demands for faster, more reliable data services.

The Consultants and FPB Management and staff discussed various options for achieving lasting infrastructure improvements that could serve FPB's customers for decades to come. Fixed wireless did not offer the reliability, bandwidth capacity, and coverage reach to overcome the terrain and foliage within FPB's service area. A DOCSIS 3.1 upgrade, while delivering robust bandwidth in the short term, would still be dependent on FPB's aging copper plant and would involve significant service disruptions during the wholesale re-spacing of the HFC field equipment. Neither of these options represented the long-term solution the FPB desires.

Recommendation: FTTH Network

Ultimately, FPB will be faced with a replacement of its HFC infrastructure. A FTTH solution represents the most robust and forward-thinking option as the telecommunications industry moves toward IP-based delivery of FPB's core services. As stated in this Report, fiber optics offers the most reliable and highest quality signal transmission, and is the most flexible medium to adapt to changes in bandwidth demand.

Starting around 2004, the FTTH industry now has over 1,000 FTTH providers in the U.S. whose networks are available to over 30 Million premises. The majority of this growth has occurred during the past nine years, and as of September 2016, nearly 14 Million households and businesses enjoy the benefits of FTTH. Although FTTH networks have been in operation for a relatively short period of time, some advantages of FTTH have been noted. Cities with a strong FTTH penetration experience higher population growth rates than cities with no or limited FTTH presence. The availability of FTTH in communities has been demonstrated to increase home values by 3% and apartment rent values by 6% over similar areas without FTTH.

Many other FTTH benefits are intuitive by nature and will be tracked over longer periods of time to substantiate their value. Recently, Mr. Michael Render of market research firm RVA LLC presented a study on the State of North American Broadband 2017 at the Fiber Broadband Association's annual conference in Orlando, FL. The presentation slides, shown in Exhibit G, point out the benefits of FTTH to consumers and businesses and the drivers to FTTH growth in the U.S. and Canada.

The correlation between local economic development and FTTH networks during the relatively brief time they have been in operation is also being studied. Mr. Jim Baller, a nationally-known communications attorney and FTTH advocate put forth his thoughts and observations in an article on FTTH Economic Development for Broadband Properties magazine in 2016. Mr. Baller identifies economic development as the "killer application" that justifies a progressive community's decision to build a FTTH network to attract new jobs, support existing local businesses and foster an environment of economic well-being. The article describes how several communities have used their FTTH networks to accomplish these outcomes. A copy of his article is included in this Report as Exhibit H.

This Infrastructure Study Report has provided FPB with a High Level Design and Cost Estimate for a FTTH network, broken down granularly into FPB's current node areas. The study also identifies the obstacles that will need to be addressed in the path to improvements, along with other internal and external factors that will impact FPB's consideration as to when and how these infrastructure improvements will be implemented.

When is the right time to replace FPB's HFC plant with a FTTH network? That future date will be determined after FPB addresses the obstacles and considers the factors outlined above, but the Consultants believe that the HFC plant can remain in service for several more years, even if the Board's decision to deploy a FTTH network is immediate. With the three-year lead time for initial FTTH implementation as described above, and a phased deployment of the remainder of the FTTH network over at least a few more years, FPB will need to operate its HFC plant until the last HFC area is transitioned to fiber.

With a relatively modest investment, FPB has the opportunity to improve the performance and extend the life of its HFC system through the period of a phased FTTH network deployment. The HFC investment will strengthen the system's service integrity and provide enough additional bandwidth capacity to offer respectable bandwidth speed packages and maintain customer satisfaction during the interim until FTTH service conversion.

12. Proposed Schedule

The Consultants suggest the following plan of action for improving its existing HFC system while planning and building a FTTH network in phases over several years.

FY 2017-2018

- FPB should continue to make reasonable levels of investment in its HFC plant to maintain the highest level of service content and quality possible while it considers the timing and scope of its future FTTH infrastructure improvement. This will include the budgeted maintenance upgrade of its remaining HFC amplifiers and line extenders to the new 1 Gigahertz frequency equipment, and the upgrade to its DOCSIS 3.0 platform to accommodate the additional HFC bandwidth for 1.5 Gbps capability at FPB's nodes.

- FPB should engage a design/engineering firm to develop a Master Plan design for a FTTH network, as an estimated cost of $100,000. This will support/substantiate the high level design of this Infrastructure study and identify phase areas that can be built over an extended deployment schedule.
- FPB should begin to address any obvious make-ready situations that may require pole replacement within the downtown areas and along the Feeder trunk routes identified in the Master Plan.
- FPB should complete the installation of all of the stand-off brackets within the first areas to be constructed, and the installation of as many stand-off brackets in other areas as possible during the HFC upgrade activity.

FY 2018–2019

- From the Master Plan phase areas, identify the two or three areas that offer the greatest revenue growth potential (commercial areas, high Internet customer density areas) and commence design and engineering activity to complete that design, yielding accurate bill of material costs, make- ready requirements, and construction timing. This will require substantial design/engineering costs.
- Focus make-ready work to complete requirements in these designed areas.
- Determine the amount of capital investment required to complete these two or three initial phases, and the source of that capital.
- If sufficient internal funding is available to begin construction of the initial phases, identify contractor and supplier resources for labor and materials. Order long lead-time materials.

FY 2019–2020

- Commence construction of the initial phases.
- Begin conversion of HFC Internet customers to new FTTH network in initial phases.
- Continue design and engineering of the next phases, prioritized by revenue potential and available funding.
- Order materials as needed for subsequent phases.

FY 2020 and Beyond

- Continue the process of design and construction of additional phases as available funding permits.

13. Exhibit A: Cisco Systems June 2017 Global Internet Traffic Growth Study

cisco the network
Cisco's Technology News Site

Cisco Visual Networking Index Predicts Global Annual IP Traffic to Exceed Three Zettabytes by 2021

IoT applications will represent more than 50 Percent of global devices and connections by 2021

Link to Article

JUNE 08, 2017

San Jose, Calif., June 8, 2017—Over the next five years (2016 – 2021), global digital transformation will continue to have a significant impact on the demands and requirements of IP networks according to today's release of the Cisco Visual Networking Index™ (VNI) Complete Forecast. Top-level indicators include the projected increase in **Internet users**—from 3.3 to 4.6 billion or 58 percent of the global population[1], greater adoption of **personal devices and machine-to-machine (M2M) connections**—from 17.1 billion to 27.1 billion from 2016- 2021, average **broadband speed** advances—from 27.5 Mbps to 53.0 Mbps, and more **video viewing**—from 73 percent to 82 percent of total IP traffic. Over the forecast period, global IP traffic is expected to increase three-fold reaching an annual run rate of 3.3 zettabytes by 2021, up from an annual run rate of 1.2 zettabytes in 2016.

For the first time in the 12 years of the forecast, M2M connections that support Internet of Things (IoT) applications are calculated to be more than half of the total 27.1 billion devices and connections and will account for five percent of global IP traffic by 2021. IoT innovations in connected home, connected healthcare, smart cars/transportation and a host of other next-generation M2M services are driving this incremental growth—a 2.4-fold increase from 5.8 billion in 2016 to 13.7 billion by 2021. With the rise of connected applications such as health monitors, medicine dispensers, and first-responder connectivity, the health vertical will be fastest-growing industry segment (30 percent CAGR). The connected car and connected cities applications will have the second-fastest growth (29 percent CAGRs respectively).

Video will continue to dominate IP traffic and overall Internet traffic growth—representing 80 percent of all Internet traffic by 2021, up from 67 percent in 2016. Globally, there will be nearly 1.9 billion Internet video users (excluding mobile-only) by 2021, up from 1.4 billion in 2016. The world will reach three trillion Internet video minutes per month by 2021, which is five million years of video per month, or about one million video minutes every second.

Emerging mediums such as live Internet video will increase 15-fold and reach 13 percent of Internet video traffic by 2021—meaning more streaming of TV apps and personal live streaming on social networks. While live streaming video is reshaping today's online entertainment patterns, virtual reality (VR) and augmented reality (AR) are also gaining traction. By 2021, VR/AR traffic will increase 20-fold and represent one percent of global entertainment traffic.

"As global digital transformation continues to impact billions of consumers and businesses, the network and security will be essential to support the future of the Internet," said Yvette Kanouff, SVP and GM of Service Provider Business, Cisco. "Driving network innovation with service providers will be key for Cisco to support the needs of their customers who want reliable, secure, and high quality connected experiences."

2017 VNI Complete Forecast Key Predictions and Major Milestones

Global IP will grow three-fold from 2016 to 2021.

- Global IP traffic is expected to reach 278 exabytes per month by 2021, up from 96 exabytes per month in 2016. Global IP traffic is expected to reach an annual run rate of 3.3 zettabytes by 2021.
- Busy hour Internet traffic is increasing faster than average Internet traffic. Busy hour Internet traffic will grow 4.6-fold (35 percent CAGR) from 2016 to 2021, reaching 4.3 Pbps by 2021, compared to average Internet traffic that will grow 3.2-fold (26 percent CAGR) over the same period reaching 717 Tbps by 2021.

Wi-Fi and mobile-connected devices will generate 73 percent of Internet traffic by 2021

- 2021 Internet access percentages - Wi-Fi: 53 percent; cellular: 20 percent; fixed: 27 percent
- 2016 Internet access percentages - Wi-Fi = 52 percent; cellular: 10 percent; fixed: 38 percent

Globally, total public W-Fi hotspots (including homespots) will grow 6-fold from 2016 to 2021 from 94 million in 2016 to 541.6 million by 2021.

- Globally, total Wi-Fi homespots will grow from 85 million in 2016 to 526.2 million by 2021.
- Leading hotspot countries: China (170 million by 2021), US (86 million by 2021), Japan (33 million by 2021), and France (30 million by 2021).

By 2021, more than half (56 percent) of connected flat panel TV sets will be 4K up from 15 percent in 2016

- Installed/In-service 4K TV sets will increase from 85M in 2016 to 663M by 2021.

Cord-Cutting household traffic is 86 percent higher than average Internet households

- "Cord cutting" refers to the trend in which traditional and subscription television viewing is increasingly being supplanted by other means of video viewing, such as online and mobile video, which are available to viewers through fixed and mobile Internet connections.
- A global cord-cutting household generates 117 GB per month in 2017, compared to 63 GB per month for an average Internet household.

End-User Internet traffic is moving closer to the edge—over one-third of traffic will bypass core by 2021

- Globally, 35 percent of Internet traffic will be carried metro-to-metro by 2021, up from 22 percent in 2016.
- Globally, 23 percent of Internet traffic will be carried on regional backbones (without touching cross-country backbones) by 2021, compared to 20 percent in 2016.
- Globally, 41 percent of Internet traffic will traverse cross-country backbones by 2021, compared to 58 percent in 2016.

Global enterprise SD-WAN traffic

- SD-WAN traffic will grow at a CAGR of 44 percent compared to five percent for traditional WAN.

- SD-WAN will increase six-fold over the forecast period and represent 25 percent of WAN traffic by 2021.

Average DDoS (Distributed Denial of Service) attacks size increasing steadily and approaching 1.2 Gbps—enough to take most organizations completely offline

- DDoS incidents can paralyze networks by flooding servers and network devices with traffic from multiple IP sources.
- The peak attack size increased 60 percent year over year and represents up to 18 percent of a country's total Internet traffic while they are occurring.
- Average DDoS attack size increased to 22 percent, which is relatively the same rate as Internet traffic at 29 percent year over year.
- The number of DDoS attacks grew 172 percent in 2016 and will increase 2.5-fold to 3.1 million by 2021 globally.

Regional IP Traffic Growth Details (2016 – 2021)

- APAC: 107.7 exabytes/month by 2021, 26 percent CAGR, 3.2-fold growth
- North America: 85 exabytes/month by 2021, 20 percent CAGR, 2.5-fold growth
- Western Europe: 37.4 exabytes/month 2021, 22 percent CAGR, 2.7-fold growth
- Central Europe: 17.1 exabytes/month by 2021, 22 percent CAGR, 2.75-fold growth
- Latin America: 12.9 exabytes/month by 2021, 21 percent CAGR, 2.6-fold growth
- Middle East and Africa: 15.5 exabytes/month by 2021, 42 percent CAGR, 5.8-fold growth

Cisco VNI Methodology

The Cisco VNI™ Complete Forecast for 2016 to 2021 relies upon independent analyst forecasts and real-world network usage data. Upon this foundation are layered Cisco's own estimates for global IP traffic and service adoption. A detailed methodology description is included in the complete report. Over its 12-year history, Cisco® VNI research has become a highly regarded measure of the Internet's growth. National governments, network regulators, academic researchers, telecommunications companies, technology experts and industry/business press and analysts rely on the annual study to help plan for the digital future.

Supporting Images

- Infographic: "VNI Complete Forecast Update, 2016-2021"

Additional Supporting Resources

- Cisco VNI Traffic Forecast homepage
- Register to the webcast: Americas/EMEAR or Asia Pacific (time zones)
- Cisco VNI blog post: "Analyze, Strategize, Digitize
  Three Internet Trends that Warrant Global Service Provider Attention (and Action)"
- Read the complete Cisco VNI Complete IP Traffic Forecast Update, 2016–2021 white paper
- Read the Zettabyte Era Trends and Analysis white paper
- Read the Cisco VNI Frequently Asked Questions document
- Launch the Cisco VNI Complete Forecast Highlights Tool
- Follow Cisco's VNI news and activities on Twitter: **#VNI and @CiscoVNI**
- For more information about Cisco's service provider news and activities, visit the SP360 Blog

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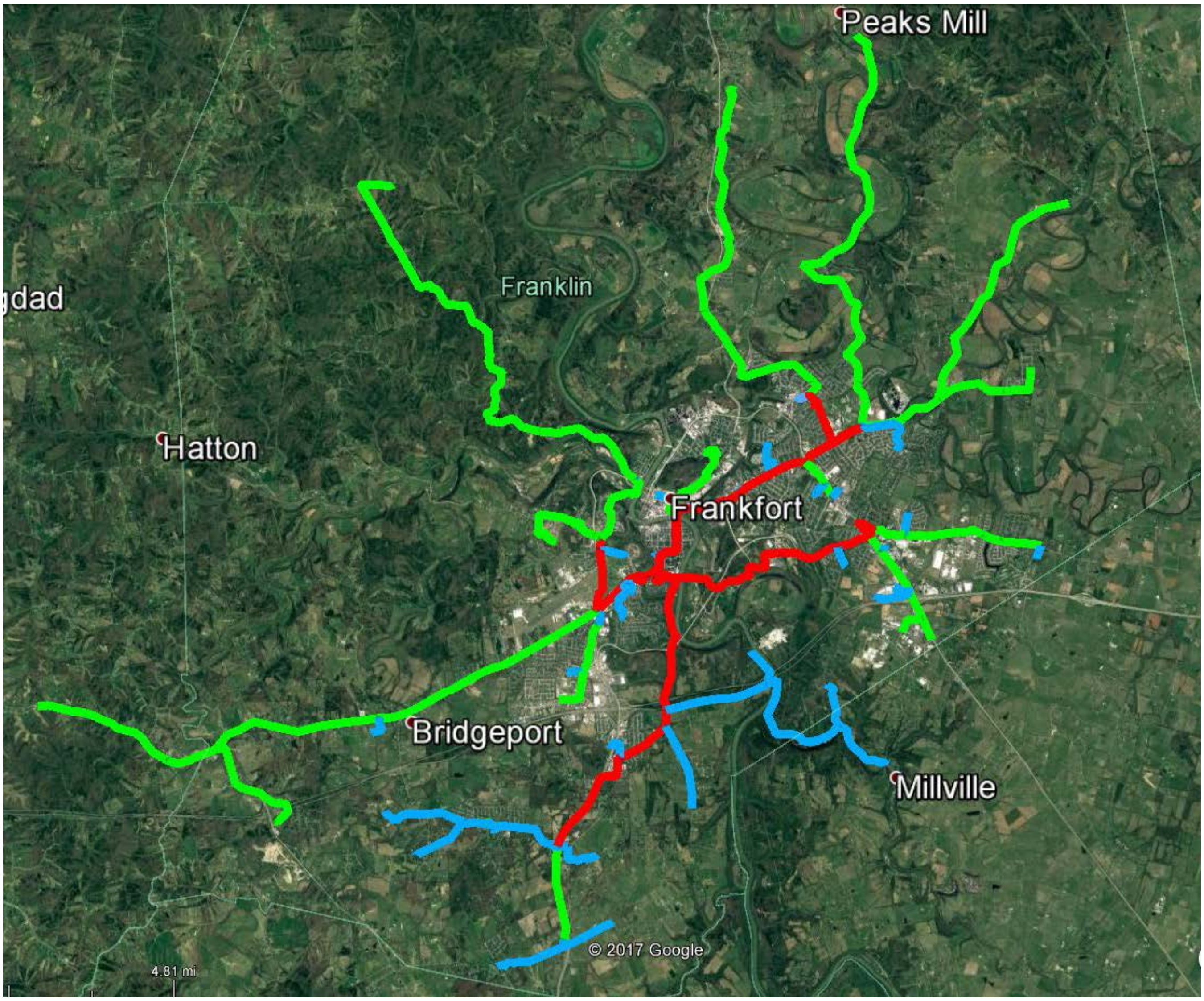
[1] 7.8 billion people by 2021, *source: Population Division of the Dept. of Economic & Social Affairs of the United Nations*

14. Exhibit B: FPB Five Year Customer Growth Projections

G/L	July 2018	July 2019	Growth	July 2020	Growth	July 2021	Growth	July 2022	Growth
Cable - Limited Cable (U)	540	579	7.3%	621	7.3%	667	7.3%	716	7.3%
Cable - Classic Cable (U)	10942	9699	-11.4%	8597	-11.4%	7620	-11.4%	6754	-11.4%
Cable - Preferred Cable Service (U)	4438	3853	-13.2%	3346	-13.2%	2905	-13.2%	2523	-13.2%
Cable - HD Plus (U)	619	583	-5.8%	549	-5.8%	517	-5.8%	487	-5.8%
Cable - Sports Plus (U)	72	72	0.0%	72	0.0%	72	0.0%	72	0.0%
Cable - HBO (U)	1049	858	-18.2%	741	-13.6%	670	-9.5%	607	-9.5%
Cable - Cinemax (U)	274	236	-14.0%	203	-14.0%	174	-14.0%	150	-14.0%
Cable - Showtime-TMC (U)	575	564	-2.0%	553	-2.0%	542	-2.0%	531	-2.0%
Cable - Digital-Encore-Starz (U)	792	717	-9.6%	648	-9.6%	586	-9.6%	530	-9.5%
Cable - Digital To Analog Converter (U)	7639	5467	-28.4%	3912	-28.4%	2799	-28.4%	2003	-28.4%
Cable - Digital Set-Top Converter (U)	3039	2766	-9.0%	2684	-3.0%	2605	-3.0%	2527	-3.0%
Cable - HD Set-Top Converter (U)	2188	2126	-2.8%	2101	-1.2%	2076	-1.2%	2051	-1.2%
Cable - HD/DVR Set-Top Converter (U)	6322	5646	-10.7%	5479	-3.0%	5317	-3.0%	5159	-3.0%
TiVo Households	46	310	576.0%	563	81.7%	695	23.5%	827	19.0%
TiVo Minis	46	310	576.0%	563	81.7%	695	23.5%	827	19.0%
Data Business	875	891	1.7%	927	4.1%	964	4.1%	1004	4.1%
Data Residential	13529	13658	1.0%	13725	0.5%	13794	0.5%	13862	0.5%
Phone Biz	758	758	0.0%	758	0.0%	758	0.0%	758	0.0%
Phone Residential	4720	4,142	-12.3%	3634	-12.3%	3189	-12.3%	2798	-12.3%

15. Exhibit C: FTTH Proposed Feeder Trunk Map



16. Exhibit D: FTTH Proposed Distribution Node Maps

Figure 17-1: Typical FTTH Dense Suburban Design

Figure 17-2: Typical FTTH Rural Design

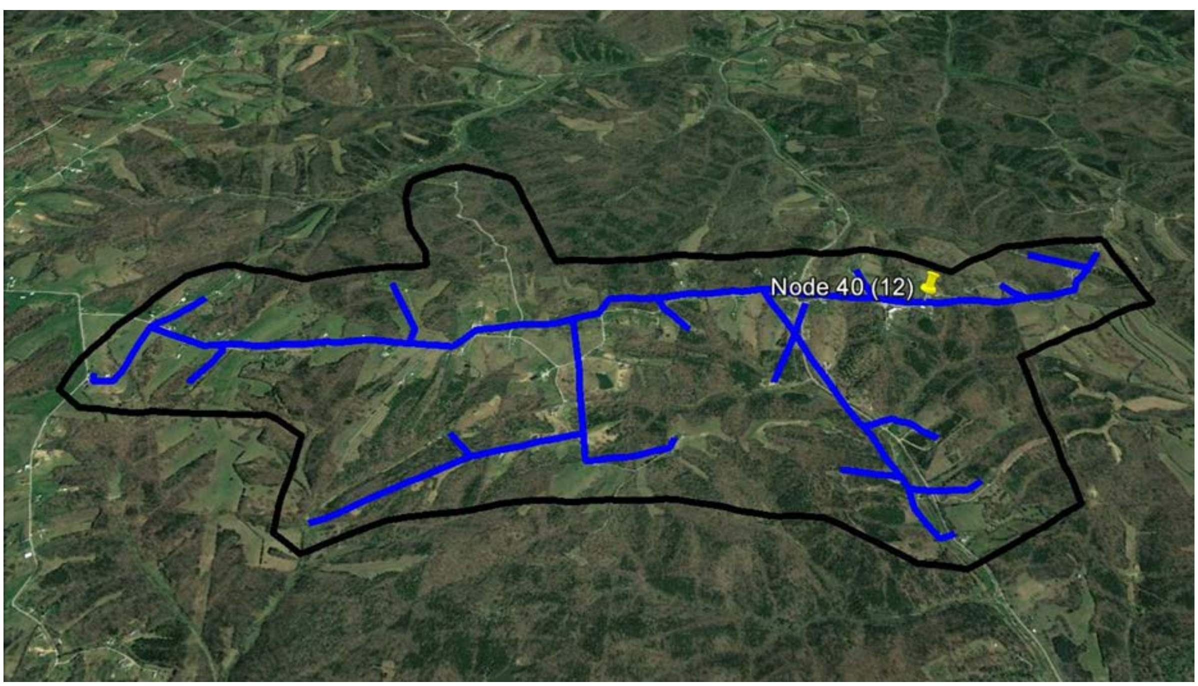


Figure 17-3: Typical FTTH Urban Design

17. Exhibit E: MCTV FTTH Article

Multichannel NEWS

BROADBAND

MCTV Pushes Fiber-to-the-Premises Overlay with 'Excellerate' Initiative

Operator to sidestep DOCSIS 3.1 as it moves on $20 million plan to deploy 1,400 miles of fiber (Updated)

Link to Article

6/19/2017 12:00 PM Eastern
Last updated at 6/20/2017 4:09 PM

By: Jeff Baumgartner

Following a deep analysis of its next-generation network options, MCTV has opted to go with an ambitious fiber-to-the-premises deployment that will result in a GPON network that will overlay its existing hybrid fiber/coax (HFC) plant.

The initiative, branded by MCTV as "Excellerate," will initially focus on speedy broadband services and will essentially sidestep a move to DOCSIS 3.1, the new gigabit-class technology for HFC networks. Altice USA is plowing ahead with a similar strategy in its Optimum footprint (the systems acquired from Cablevision Systems) and the bulk of the systems it acquired from Suddenlink Communications.

MCTV's plan is to overlay its entire network with a GPON-based fiber-to-the-premises network over the next two to three years. The Massillon, Ohio-based operator, which serves more than 47,000 homes and businesses, announced Monday that its Excellerate-powered network is currently available to residential customers in “select areas” in Stark and Wayne counties in the northeastern part of the state. MCTV said it will notify customers when the new offering is available in their neighborhoods.

MCTV presented its plans earlier today at a conference featuring MCTV president Robert Gessner; Jonathan McGee, president of the Ohio Cable Telecommunication Association; Matt Polka, president and CEO of the American Cable Association (ACA); and U.S. Rep. Bob Gibbs (R-OH).

MCTV estimates that the Excellerate project encompasses a $20 million investment that will factor in 1,400 miles of fiber, 79,920 miles of “glass,” 220,000 hours of manpower, 120,000 splices, 14,000 drop enclosures, and 14 communities.

“The crux of this is to build our next-generation network,” Gessner said.

“Our plan is over next couple of years to overlay the entire system with PON...We’re betting on the ten-year plan rather than the three-to-five plan,” he added, noting that MCTV isn’t yet faced with a “pressing need” for the new PON overlay.

Though many cable operators, including Comcast, WideOpenWest, RCN and Mediacom Communications, are betting heavily on DOCSIS 3.1, MCTV’s analysis, Gessner said, showed that moving to FTTP made the most sense for the operator.

Gessner said MCTV, which has already been deploying a GPON FTTP in select rural greenfield scenarios, has some fairly large nodes on its HFC network, including some portions that had four to five amplifiers running between the last fiber-fed node and customer homes.

“To do DOCSIS 3.1 well, we’re going to have to run a lot of fiber,” Gessner explained. “It just seemed like that was the better option for us, given our situation.”

MCTV found that it would be no more expensive, or maybe just a little more expensive, to go with GPON and FTTP than it was to get to a node-plus-one HFC architecture.

Update: In an email, Gessner noted that the $20 million investment is the estimated cost to complete the network, including elements such as fiber construction, cabinets, splice enclosures and splicing, and does not include the cost of fiber drops and the customer premises equipment.

Regarding which parts of the footprint are being targeted first, he added that the plan is to reach a variety of areas, including rural greenfields, suburban brownfields, city centers and overbuild scenarios. MCTV is also selecting areas based on how quickly the operator can design the area and where it wants to eliminate the bandwidth load on the HFC plant.

MCTV also has lots of fiber expertise to draw from.

In addition to its recent PON-based activity, MCTV has also been running some FTTP networks in some rural areas using RF-over-Glass an SCTE-standardized technology and platform that allows MSOs to run fiber to the premises while retaining it backoffice systems and use of DOCSIS modems for high-speed data and legacy set-top boxes for video.

“Internally, our staff is very familiar and comfortable with the idea of running and deploying fiber drops all the way to the home,” Kelly Rehm, the company’s tech ops manager, said, noting that MCTV has been actively cross-training its workforce to handle FTTP deployments.

MCTV, which is working with Adtran on the Excellerate initiative, also reasons that it will be able to keep many costs in check because it will keep the bulk of that work in-house, requiring only a small portion of the network construction to outside contractors.

Gessner said MCTV also has the benefit of deploying the new FTTP network at its own pace, as the company has already converted many employees over to handle elements such as mapping, splicing, construction and field engineering.

"It's really gratifying to see everyone accept the inventible change that is coming and to adopt new roles at the company,” he said. “I’m really proud of our folks for putting their shoulder to the wheel and really accepting this huge project."

And using an overlay network will also ensure that MCTV will be able to transition customers to the PON-based offering without disrupting service. “It’s an attractive reason for building a network like this,” Rehm said.

Additionally, in neighborhoods with heavy residential or business users, MSTV has the ability to transition them more rapidly to the PON network and relieve pressure on the legacy HFC plant, noted Nick Provost, MCTV’s outside plant manager.

Though MCTV's FTTP network will be capable of delivering gigabit speeds, it will initially focus on a high-end offering that delivers symmetrical speeds of 100 Mbps while also matching its pricing for its DOCSIS-based high-speed internet services. Today, for example, MCTV sells a 100 Mbps down/5 Mbps up service for $89.95 per month when it's purchased as a stand-alone.

MCTV will continue to deliver QAM-based video services on its HFC legacy network, even as it starts to consider a migration to IPTV much further down the road.

"At this point, we are proceeding along a path that says the [HFC] system is working great for delivering television, so let's keeping using it," Gessner said.

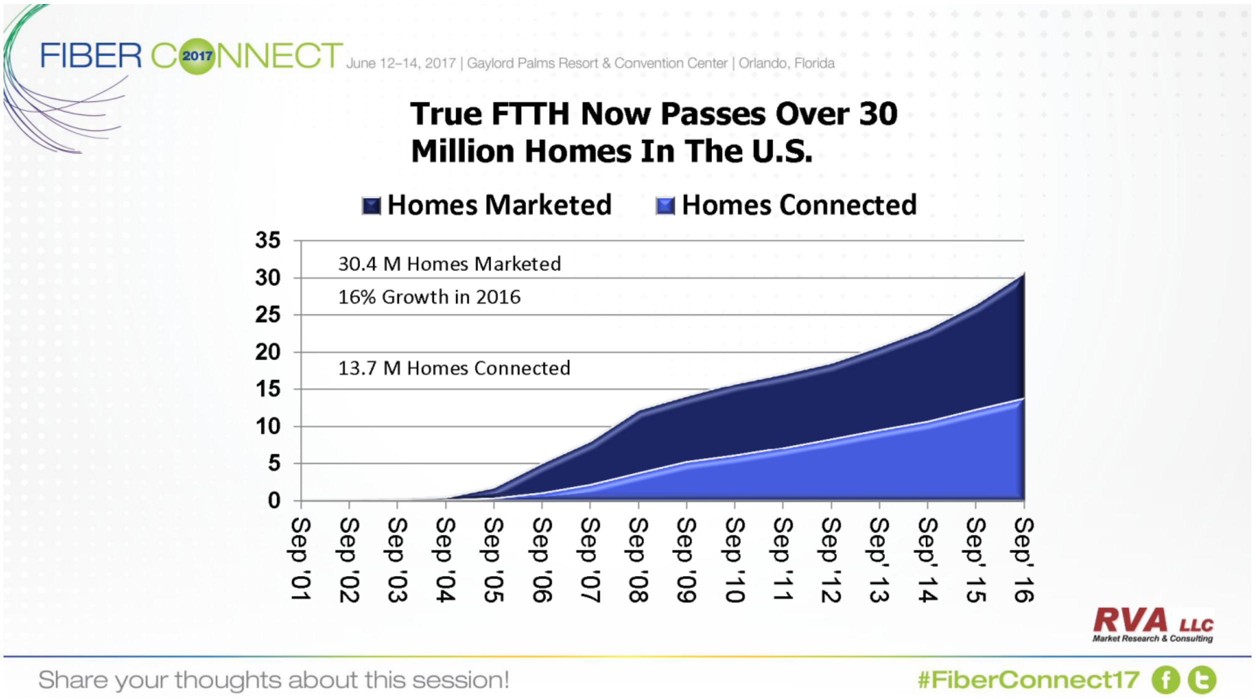
For its limited FTTP deployments in greenfield scenarios, MCTV has been using an IPTV platform.

18. Exhibit F: FTTH Network Cost Summary by Node Area

Node	Address Count	Active Subscribers	Cable Quantity in Ft (Aerial)	Cable Quantity in Ft (UG)	Engineering	Distribution Plant Costs (Installed)	Customer Installation Costs	Total Cost Per Node
1	769	407	12174	8822	$23,095.60	$263,043.62	$225,486.96	$511,626.18
2	510	458	35649	0	$39,213.90	$317,128.31	$253,742.08	$610,084.29
3	904	606	25374	0	$27,911.40	$288,100.39	$335,737.34	$651,749.13
4	774	476	14665	0	$16,131.50	$208,253.15	$263,714.48	$488,099.13
5	1068	622	33929	0	$37,321.90	$345,976.92	$344,601.69	$727,900.51
6	1128	571	38960	0	$42,856.00	$448,098.60	$316,346.57	$807,301.17
7	826	681	34914	0	$38,405.40	$288,427.78	$377,288.99	$704,122.17
8	879	661	46752	2733	$54,433.50	$406,434.29	$366,208.55	$827,076.34
9	304	284	0	54828	$60,310.80	$901,737.64	$157,342.25	$1,119,390.69
10	931	601	26388	0	$29,026.80	$271,711.94	$332,967.23	$633,705.97
11	785	565	41440	486	$46,118.60	$336,516.63	$313,022.44	$695,657.67
12	928	699	0	57147	$62,861.70	$1,125,903.99	$387,261.39	$1,576,027.08
13	883	602	30080	13993	$48,480.30	$478,180.75	$333,521.25	$860,182.30
14	888	672	25594	19880	$50,021.40	$564,922.36	$372,302.79	$987,246.55
15	669	511	38166	0	$41,982.60	$313,496.94	$283,105.25	$638,584.79
16	761	544	56209	8177	$70,824.60	$517,896.73	$301,387.98	$890,109.31
17	170	132	47102	0	$51,812.20	$259,276.13	$73,130.91	$384,219.24
18	284	164	18067	0	$19,873.70	$143,019.76	$90,859.61	$253,753.07
19	180	108	18622	753	$21,312.50	$236,011.76	$59,834.38	$317,158.64
20	704	535	83558	9260	$102,099.80	$702,229.05	$296,401.78	$1,100,730.63
21	183	151	47582	0	$52,340.20	$284,984.85	$83,657.32	$420,982.37
22	395	372	14031	16130	$33,177.10	$334,919.38	$206,096.19	$574,192.67
23	355	214	15870	0	$17,457.00	$123,692.50	$118,560.71	$259,710.21
24	94	57	19761	0	$21,737.10	$118,315.54	$31,579.25	$171,631.89
25	106	75	33046	1794	$38,324.00	$192,776.20	$41,551.65	$272,651.85
26	217	169	49942	8938	$64,768.00	$413,573.02	$93,629.72	$571,970.74
27	791	592	144718	0	$159,189.80	$866,867.85	$327,981.03	$1,354,038.68
28	244	197	6843	19579	$29,064.20	$323,547.02	$109,142.34	$461,753.56
29	108	82	23658	0	$26,023.80	$132,342.30	$45,429.81	$203,795.91
30	327	219	28147	0	$30,961.70	$193,031.71	$121,330.82	$345,324.23
31	172	150	17488	0	$19,236.80	$119,655.43	$83,103.30	$221,995.53
32	161	119	30787	0	$33,865.70	$174,065.32	$65,928.62	$273,859.64
33	82	67	13896	0	$15,285.60	$86,567.99	$37,119.48	$138,973.07
34	590	448	70484	0	$77,532.40	$454,099.44	$248,201.86	$779,833.70
35	795	505	45271	0	$49,798.10	$324,921.71	$279,781.12	$654,500.93
36	1004	670	57156	0	$62,871.60	$470,359.36	$371,194.75	$904,425.71
37	953	676	41332	4252	$50,142.40	$355,991.96	$374,518.88	$780,653.24
38	88	25	0	4261	$4,687.10	$55,161.55	$13,850.55	$73,699.20

39	179		1496	6211	$8,477.70	$105,933.75	$0.00	$114,411.45
40	97	61	34558	0	$38,013.80	$174,380.30	$33,795.34	$246,189.44
41	47	31	10781	0	$11,859.10	$62,534.35	$17,174.68	$91,568.13
42	370	268	13859	7907	$23,942.60	$200,620.90	$148,477.90	$373,041.40
43	187	130	35680	9402	$49,590.20	$316,751.17	$72,022.86	$438,364.23
44	66	52	16934	0	$18,627.40	$93,726.90	$28,809.14	$141,163.44
45	192	142	34662	0	$38,128.20	$200,873.32	$78,671.13	$317,672.65
46	103	83	31338	0	$34,471.80	$162,118.30	$45,983.83	$242,573.93
47	257	185	30850	0	$33,935.00	$189,677.62	$102,494.07	$326,106.69
50	108	81	22803	0	$25,083.30	$142,201.45	$44,875.78	$212,160.53
52	112	71	32415	0	$35,656.50	$179,035.71	$39,335.56	$254,027.77
53	102	53	25911	0	$28,502.10	$145,785.59	$29,363.17	$203,650.86
55	69	63	24496	2674	$29,887.00	$158,423.70	$34,903.39	$223,214.09
56	17	6	8510	0	$9,361.00	$48,482.50	$3,324.13	$61,167.63
57	8	8	270	3618	$4,276.80	$51,930.20	$4,432.18	$60,639.18
61	151	107	13946	0	$15,340.60	$99,923.76	$59,280.36	$174,544.72
62	145	86	11910	0	$13,101.00	$86,638.41	$47,645.89	$147,385.30
63	312	94	16791	0	$18,470.10	$124,191.76	$52,078.07	$194,739.93
64	278	178	43442	3853	$52,024.50	$288,900.54	$98,615.92	$439,540.96
65	128	76	19942	0	$21,936.20	$122,533.75	$42,105.67	$186,575.62
66	430	242	17704	15352	$36,361.60	$419,793.22	$134,073.33	$590,228.15
67	287	128	21304	9977	$34,409.10	$273,905.84	$70,914.82	$379,229.76
68	37	19	0	3784	$4,162.40	$62,012.60	$10,526.42	$76,701.42
69	332	207	24726	0	$27,198.60	$187,783.66	$114,682.56	$329,664.82
71	120	80	1438	5377	$7,496.50	$99,625.35	$44,321.76	$151,443.61
72	302	257	0	4284	$4,712.40	$88,980.60	$142,383.66	$236,076.66
73	76	77	18687	920	$21,567.70	$123,186.45	$42,659.70	$187,413.85
80	27	18	2846	863	$4,079.90	$38,272.05	$9,972.40	$52,324.35
83	53	28	16453	0	$18,098.30	$102,819.66	$15,512.62	$136,430.58
87	135	54	8195	2789	$12,082.40	$101,511.89	$29,917.19	$143,511.48
88	44	7	7409	0	$8,149.90	$60,801.25	$3,878.15	$72,829.30
90	35	15	3537	1754	$5,820.10	$50,998.05	$8,310.33	$65,128.48
94	208	121	33437	0	$36,780.70	$188,821.95	$67,036.66	$292,639.31
Sub-Totals	26024	17715	1873985	309798	$2,402,161.30	$18,194,416.42	$9,814,500.00	$30,411,077.72
			Cable Quantity in Ft (Aerial)		**Engineering**	**Feeder Plant Costs (Installed)**		
Feeder Cable (Installed)			478004	0	$525,804.40	$2,554,678.04		$3,080,482.44
Make Ready Pole Replacement & Re-Location								$9,504,000.00
Network Equipment (Installed)								$1,587,940.00
Total FTTH Project Costs								$44,583,500.16

19. Exhibit G: RVA LLC State of North American Broadband 2017 Presentation


FIBER CONNECT 2017 June 12–14, 2017 | Gaylord Palms Resort & Convention Center | Orlando, Florida
True FTTH Now Passes Over 30 Million Homes In The U.S.
Homes Marketed
Homes Connected
30.4 M Homes Marketed
16% Growth in 2016
13.7 M Homes Connected
35
30
25
20
15
10
5
0
Sep '01
Sep '02
Sep '03
Sep '04
Sep '05
Sep '06
Sep '07
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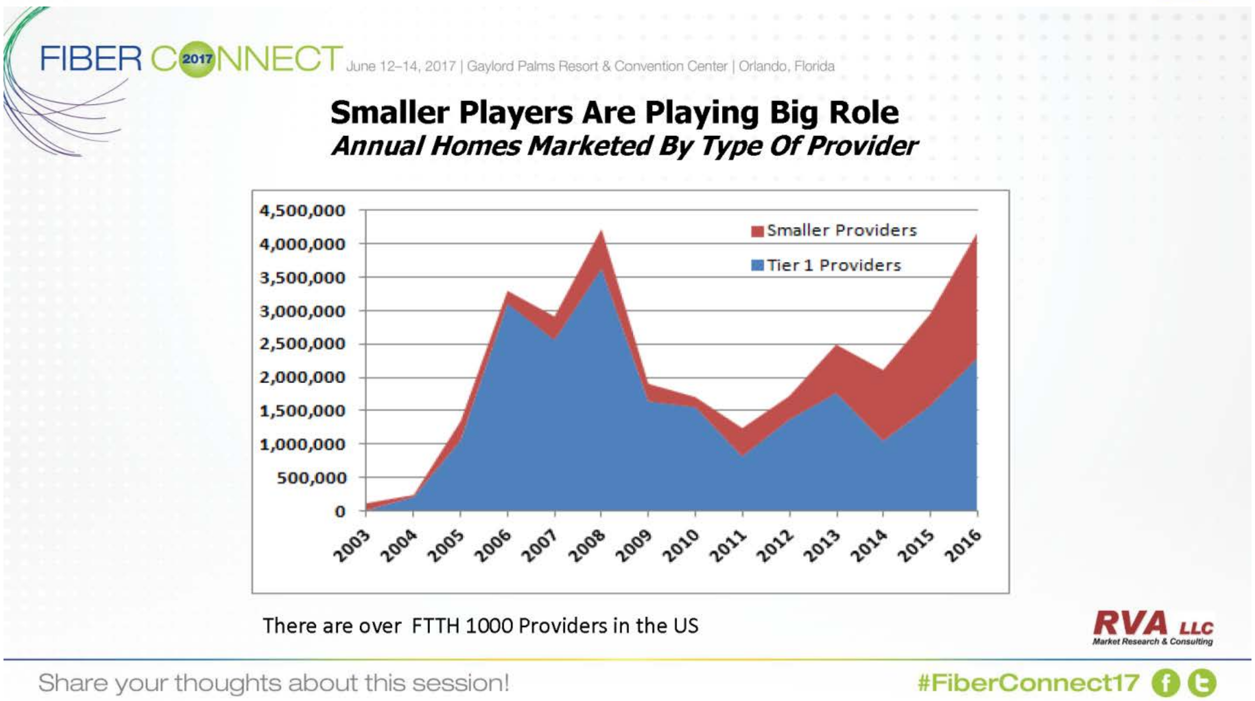
FIBER CONNECT 2017 June 12–14, 2017 | Gaylord Palms Resort & Convention Center | Orlando, Florida
Smaller Players Are Playing Big Role
Annual Homes Marketed By Type Of Provider
Smaller Providers
Tier 1 Providers
4,500,000
4,000,000
3,500,000
3,000,000
2,500,000
2,000,000
1,500,000
1,000,000
500,000
0
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
There are over FTTH 1000 Providers in the US
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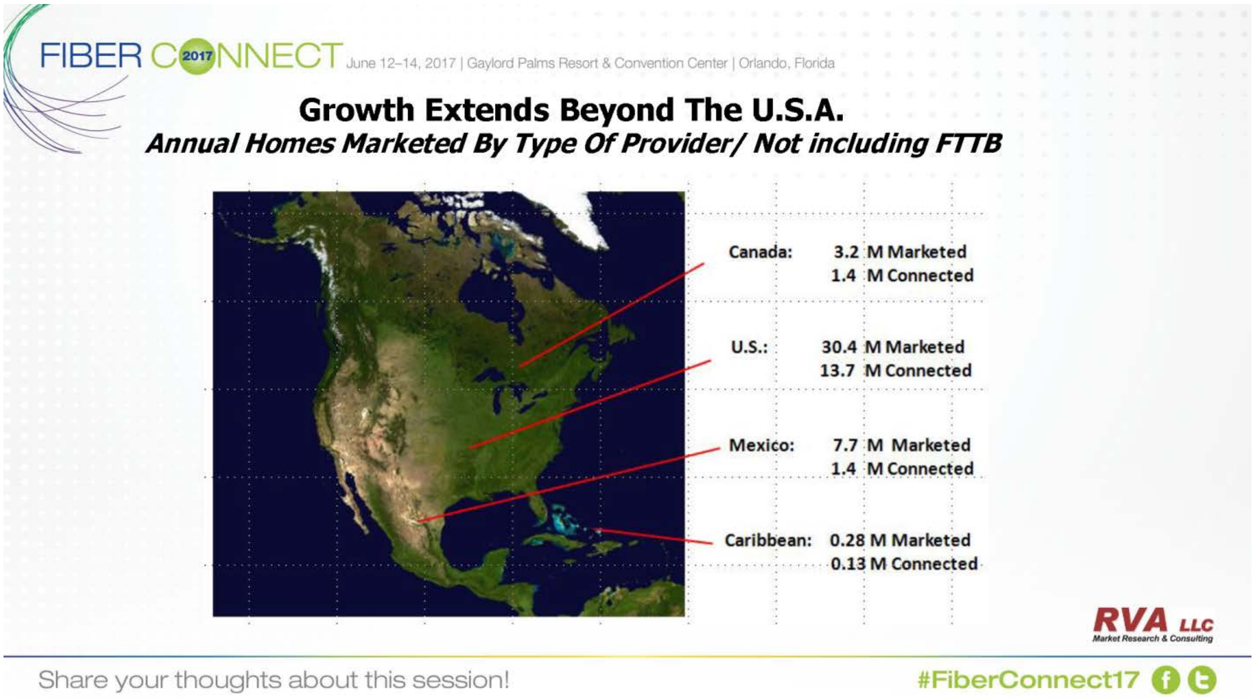
FIBER CONNECT 2017 June 12–14, 2017 | Gaylord Palms Resort & Convention Center | Orlando, Florida
Growth Extends Beyond The U.S.A.
Annual Homes Marketed By Type Of Provider/ Not including FTTB
Canada: 3.2 M Marketed
1.4 M Connected
U.S.: 30.4 M Marketed
13.7 M Connected
Mexico: 7.7 M Marketed
1.4 M Connected
Caribbean: 0.28 M Marketed
0.13 M Connected
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FIBER CONNECT 2017 June 12–14, 2017 | Gaylord Palms Resort & Convention Center | Orlando, Florida
Broadband Is Very Important To Living
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Our Time Is Important
Most spend about 5.2 hours (312 minutes) per day online at home.
Online consumers currently estimate they spend nearly 30 minutes of wasted time per day … waiting for things to load / “gears turning”.
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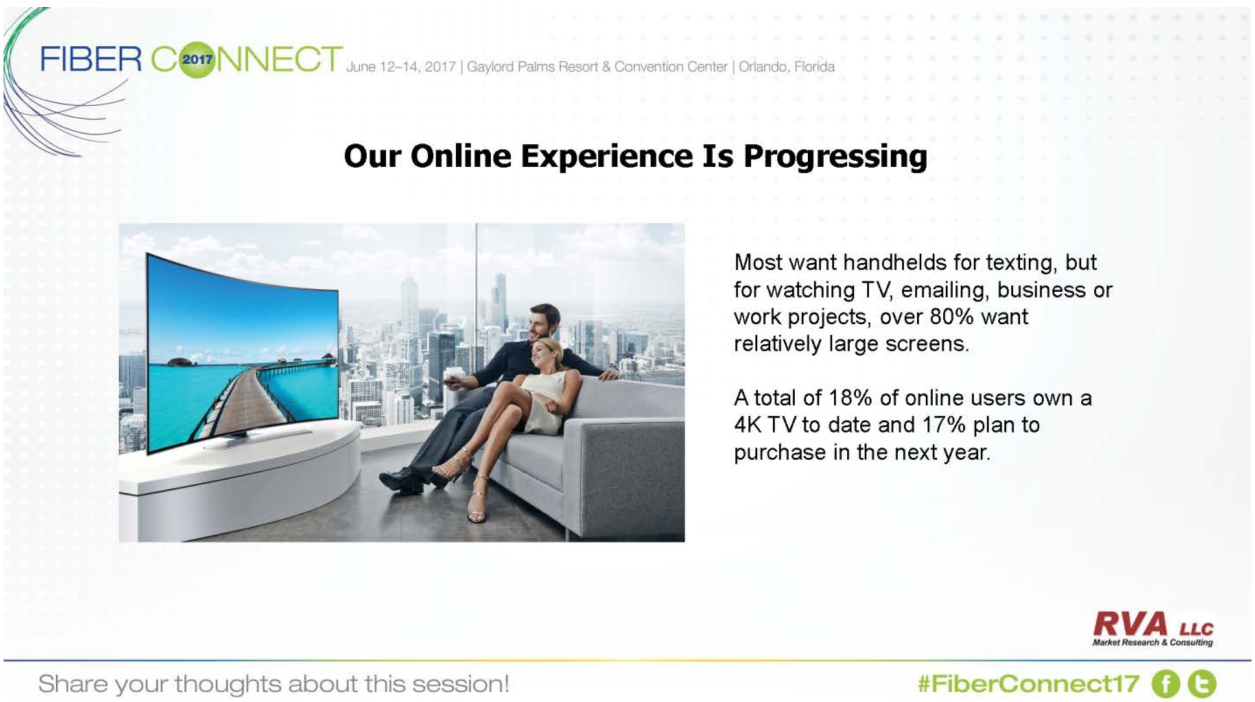
FIBER CONNECT 2017
June 12–14, 2017 | Gaylord Palms Resort & Convention Center | Orlando, Florida
Our Online Experience Is Progressing
Most want handhelds for texting, but for watching TV, emailing, business or work projects, over 80% want relatively large screens.
A total of 18% of online users own a 4K TV to date and 17% plan to purchase in the next year.
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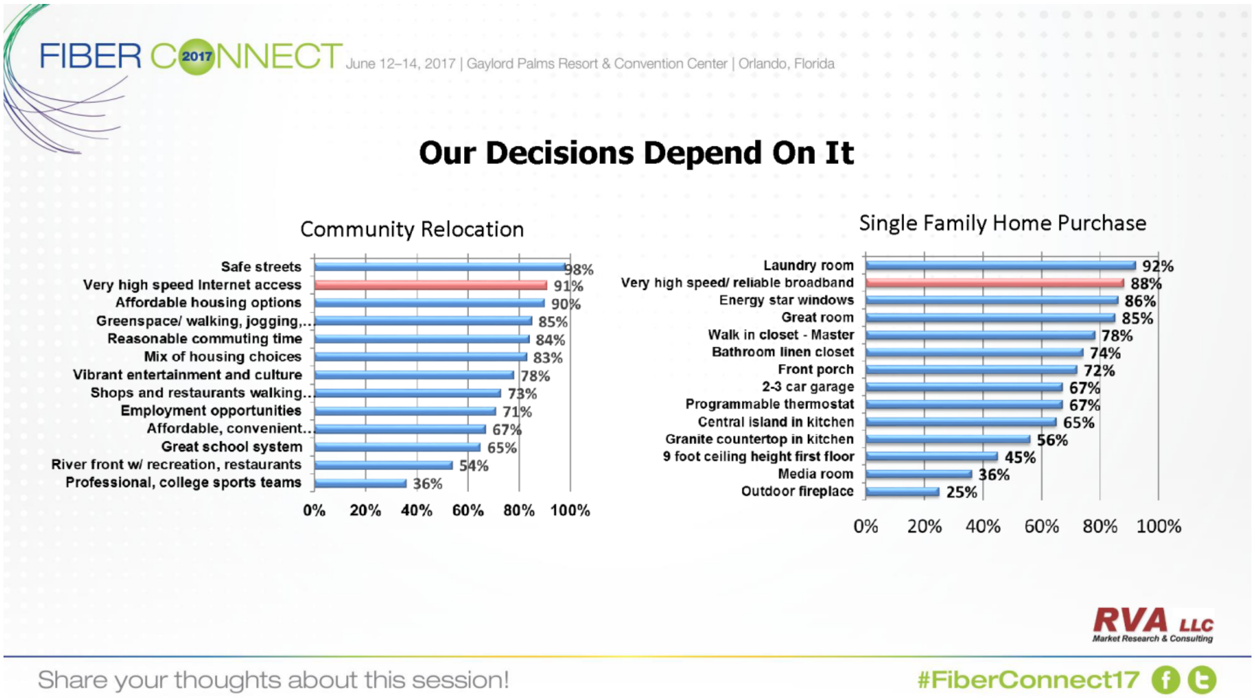
FIBER CONNECT 2017 June 12–14, 2017 | Gaylord Palms Resort & Convention Center | Orlando, Florida
Our Decisions Depend On It
Community Relocation
Safe streets 98%
Very high speed Internet access 91%
Affordable housing options 90%
Greenspace/ walking, jogging,.. 85%
Reasonable commuting time 84%
Mix of housing choices 83%
Vibrant entertainment and culture 78%
Shops and restaurants walking.. 73%
Employment opportunities 71%
Affordable, convenient.. 67%
Great school system 65%
River front w/ recreation, restaurants 54%
Professional, college sports teams 36%
0% 20% 40% 60% 80% 100%
Single Family Home Purchase
Laundry room 92%
Very high speed/ reliable broadband 88%
Energy star windows 86%
Great room 85%
Walk in closet - Master 78%
Bathroom linen closet 74%
Front porch 72%
2-3 car garage 67%
Programmable thermostat 67%
Central island in kitchen 65%
Granite countertop in kitchen 56%
9 foot ceiling height first floor 45%
Media room 36%
Outdoor fireplace 25%
0% 20% 40% 60% 80% 100%
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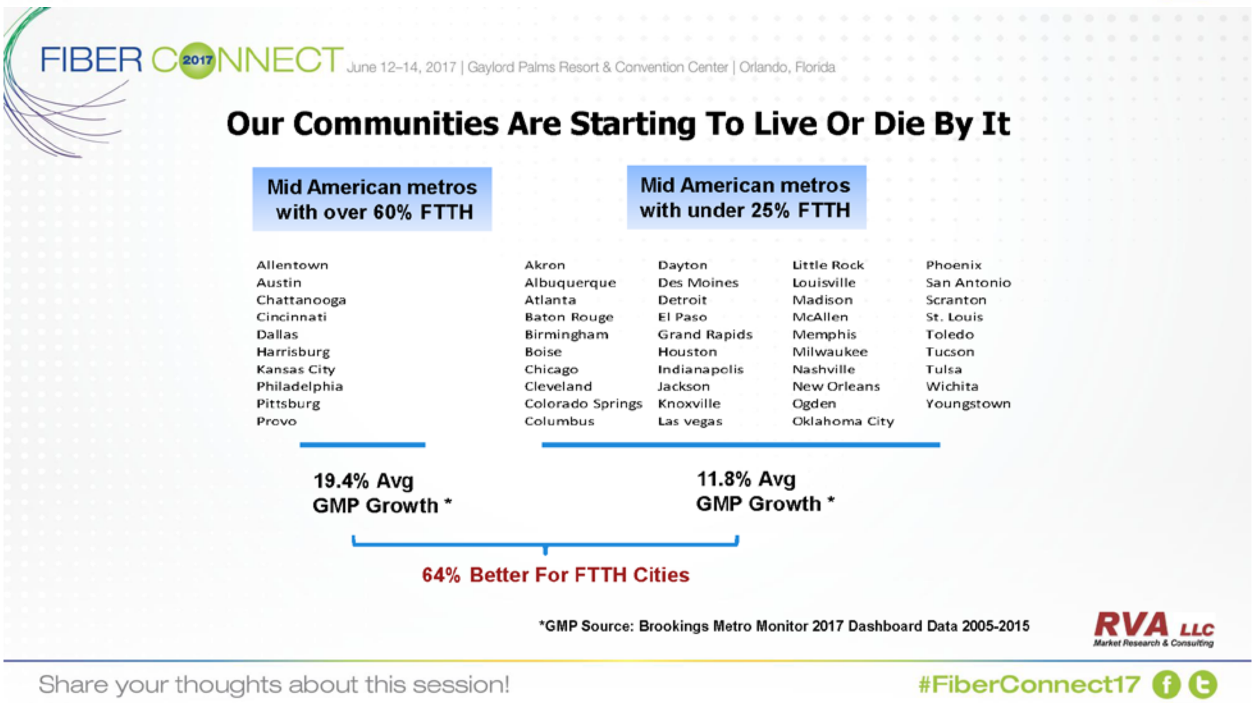
FIBER CONNECT 2017 June 12–14, 2017 | Gaylord Palms Resort & Convention Center | Orlando, Florida
Our Communities Are Starting To Live Or Die By It
Mid American metros with over 60% FTTH
Mid American metros with under 25% FTTH
Allentown
Austin
Chattanooga
Cincinnati
Dallas
Harrisburg
Kansas City
Philadelphia
Pittsburg
Provo
Akron
Albuquerque
Atlanta
Baton Rouge
Birmingham
Boise
Chicago
Cleveland
Colorado Springs
Columbus
Dayton
Des Moines
Detroit
El Paso
Grand Rapids
Houston
Indianapolis
Jackson
Knoxville
Las vegas
Little Rock
Louisville
Madison
McAllen
Memphis
Milwaukee
Nashville
New Orleans
Ogden
Oklahoma City
Phoenix
San Antonio
Scranton
St. Louis
Toledo
Tucson
Tulsa
Wichita
Youngstown
19.4% Avg GMP Growth *
11.8% Avg GMP Growth *
64% Better For FTTH Cities
*GMP Source: Brookings Metro Monitor 2017 Dashboard Data 2005-2015
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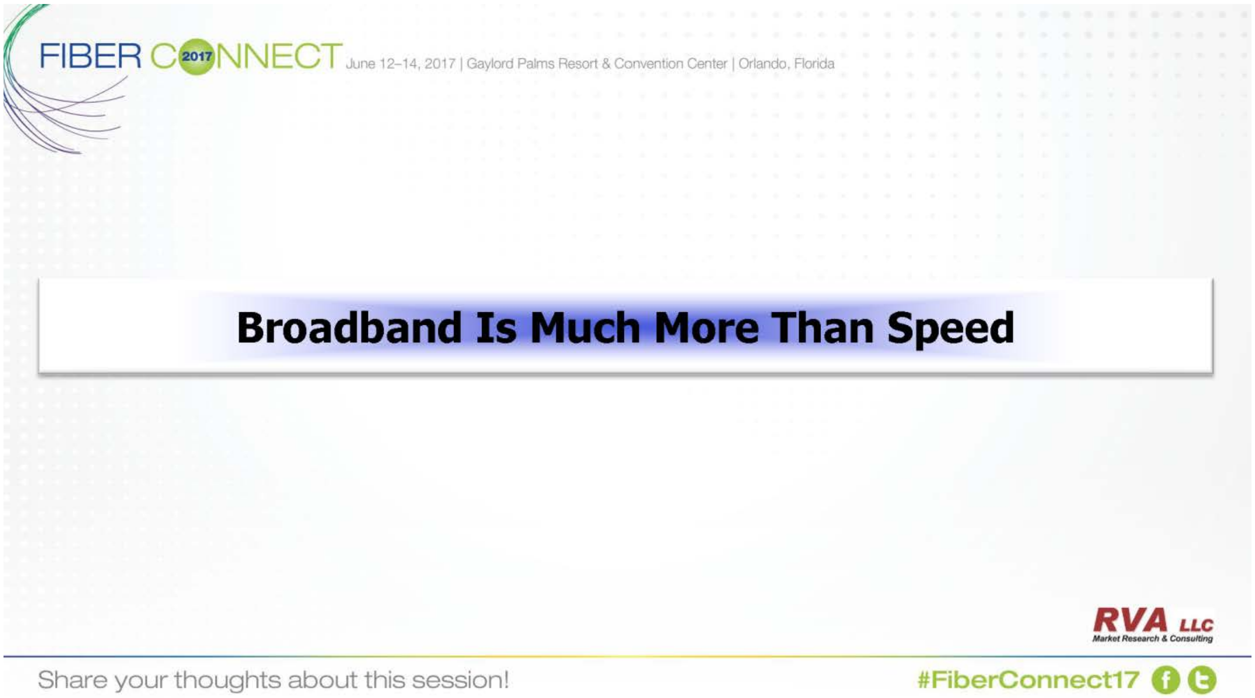
FIBER C2017NNECT June 12–14, 2017 | Gaylord Palms Resort & Convention Center | Orlando, Florida
Broadband Is Much More Than Speed
RVA LLC
Market Research & Consulting
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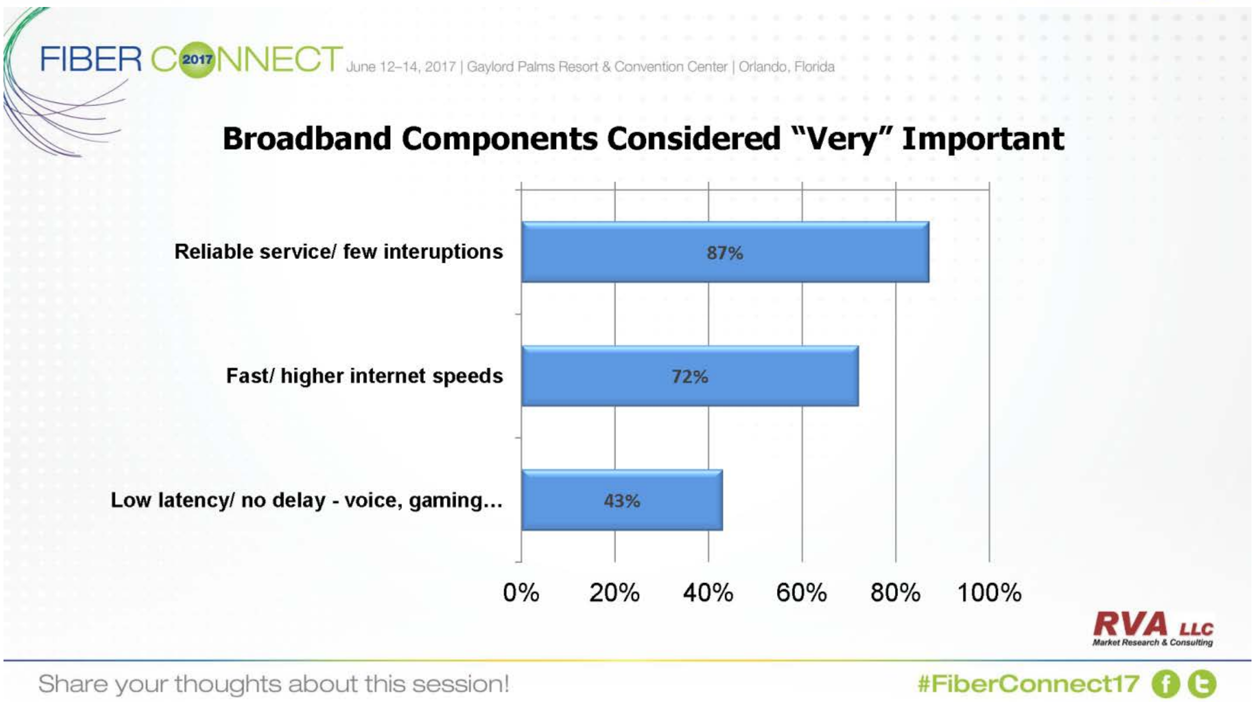
FIBER C2017NNECT June 12–14, 2017 | Gaylord Palms Resort & Convention Center | Orlando, Florida
Broadband Components Considered "Very" Important
Reliable service/ few interuptions
87%
Fast/ higher internet speeds
72%
Low latency/ no delay - voice, gaming…
43%
0%
20%
40%
60%
80%
100%
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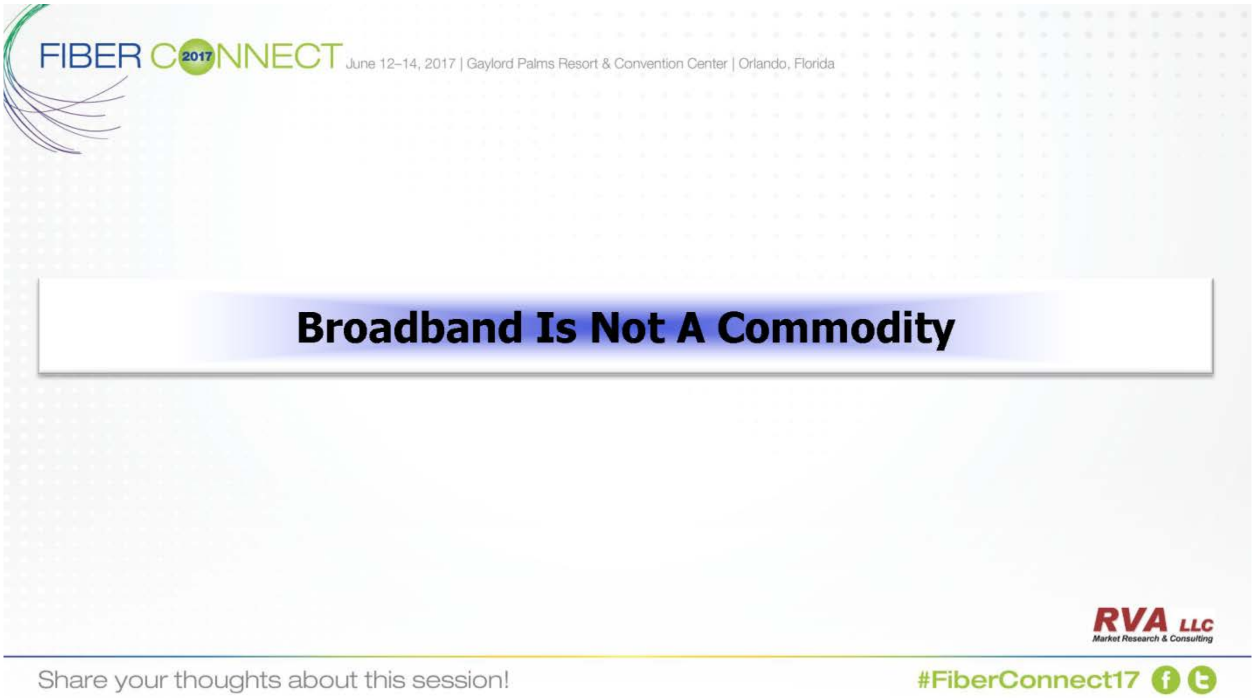
FIBER CONNECT 2017
June 12–14, 2017 | Gaylord Palms Resort & Convention Center | Orlando, Florida
Broadband Is Not A Commodity
RVA LLC
Market Research & Consulting
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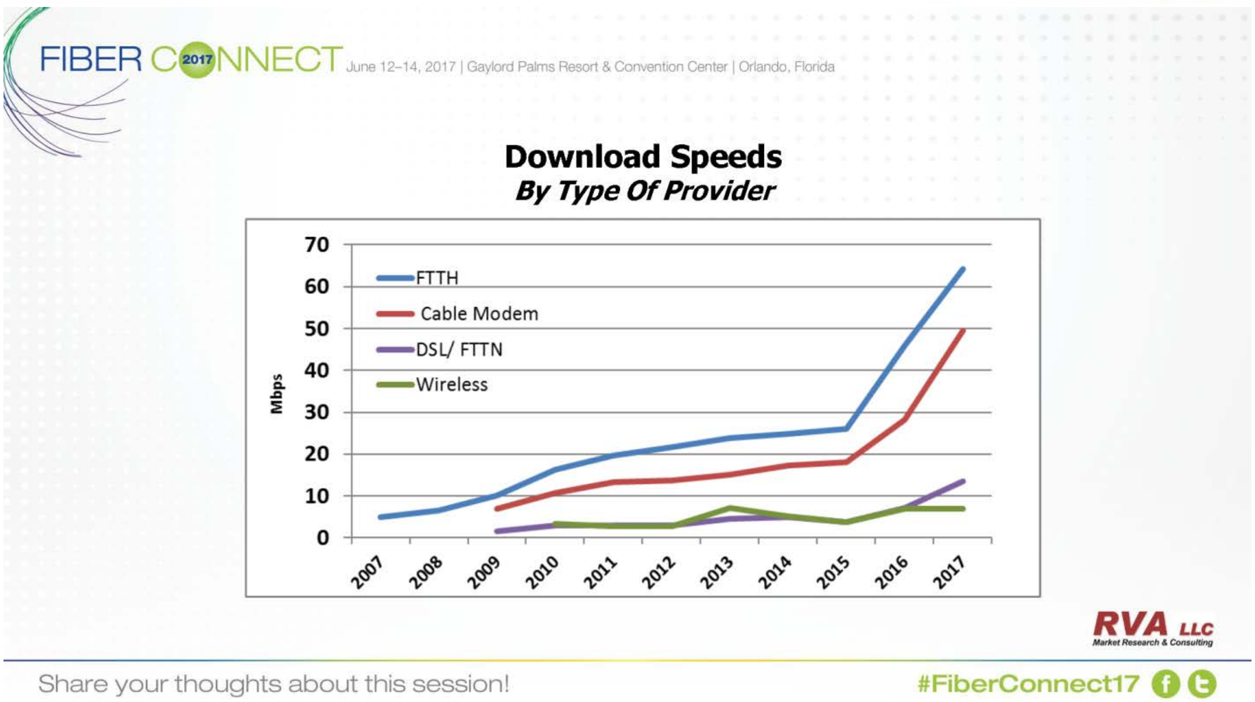
FIBER CONNECT 2017
June 12–14, 2017 | Gaylord Palms Resort & Convention Center | Orlando, Florida
Download Speeds
By Type Of Provider
Mbps
70
60
50
40
30
20
10
0
FTTH
Cable Modem
DSL/ FTTN
Wireless
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
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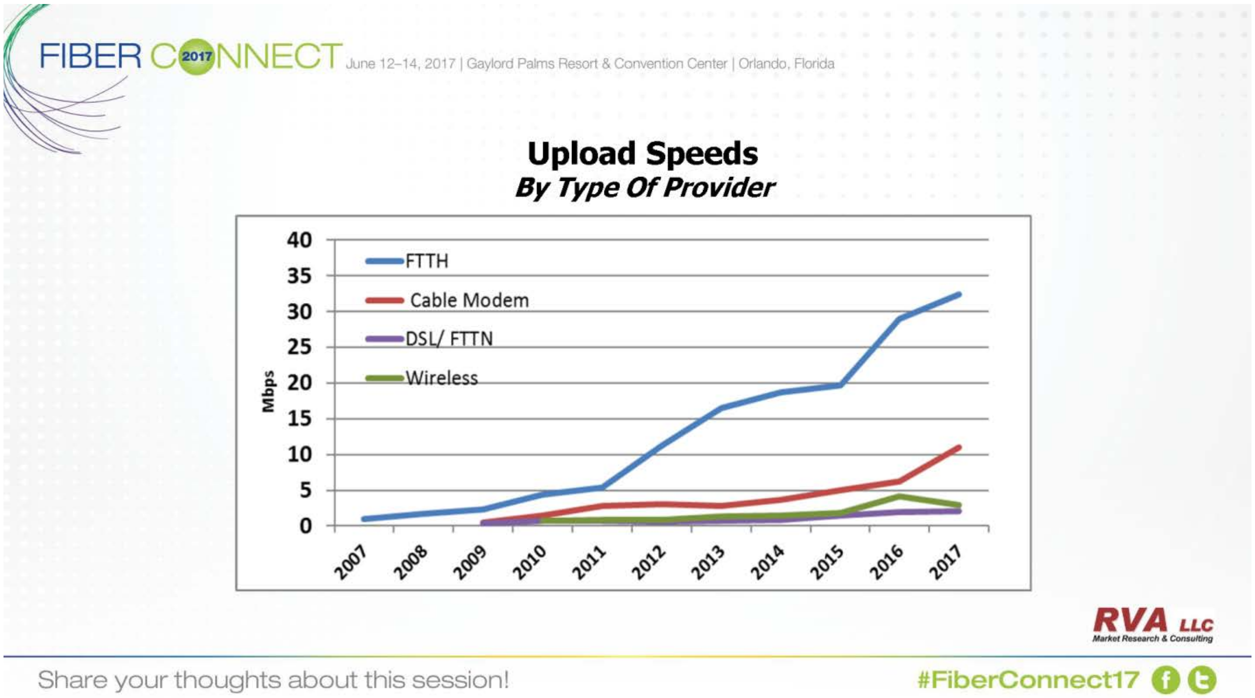
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Upload Speeds
By Type Of Provider
Mbps
40
35
30
25
20
15
10
5
0
FTTH
Cable Modem
DSL/ FTTN
Wireless
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
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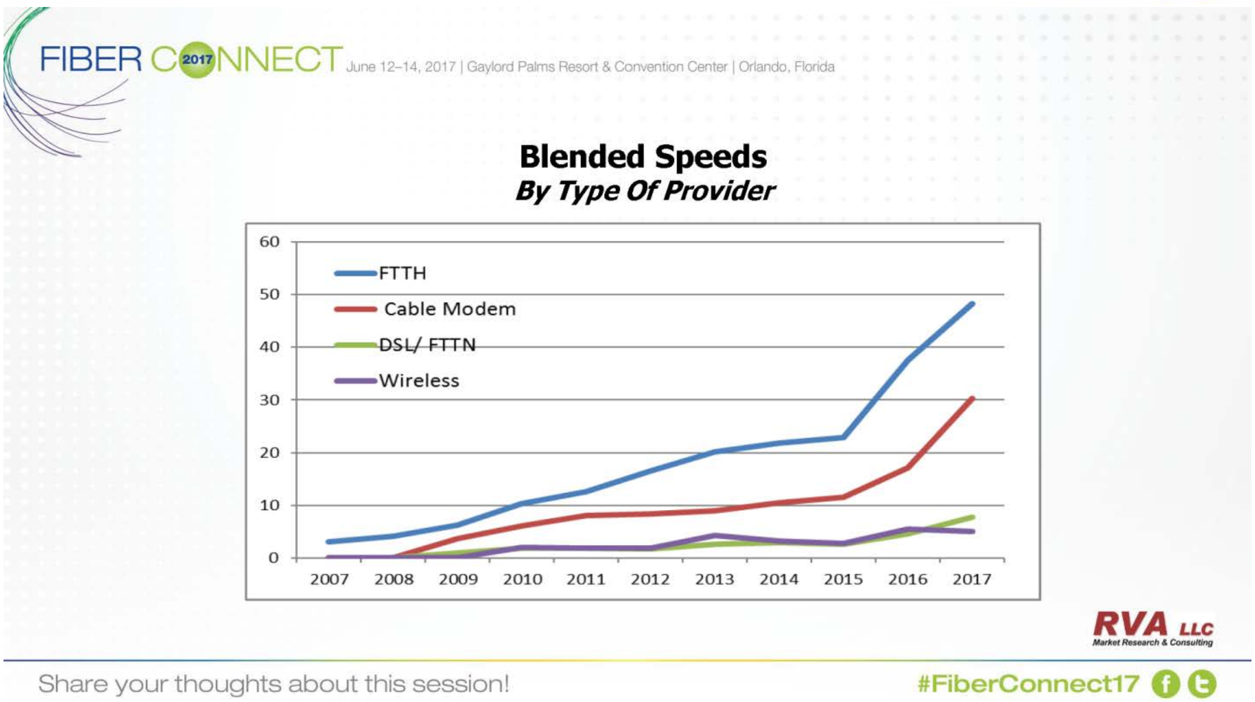
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Blended Speeds
By Type Of Provider
60
50
40
30
20
10
0
FTTH
Cable Modem
DSL/ FTTN
Wireless
2007
2008
2009
2010
2011
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2014
2015
2016
2017
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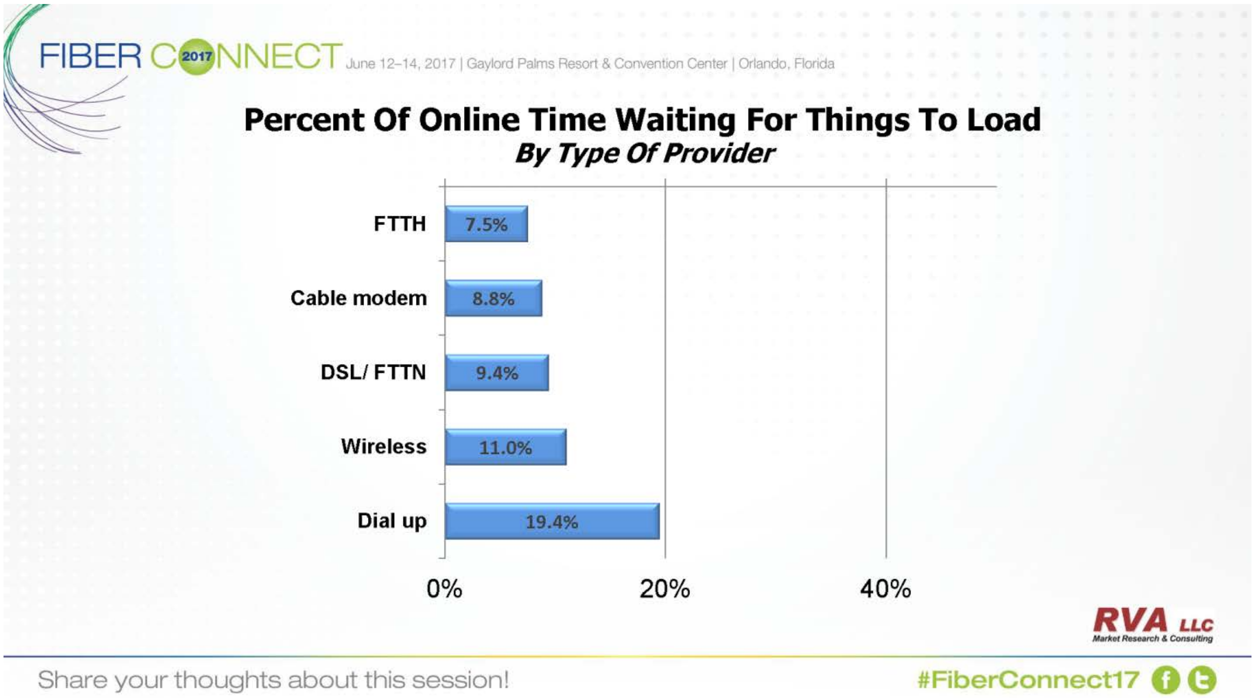
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Percent Of Online Time Waiting For Things To Load
By Type Of Provider
FTTH
7.5%
Cable modem
8.8%
DSL/ FTTN
9.4%
Wireless
11.0%
Dial up
19.4%
0%
20%
40%
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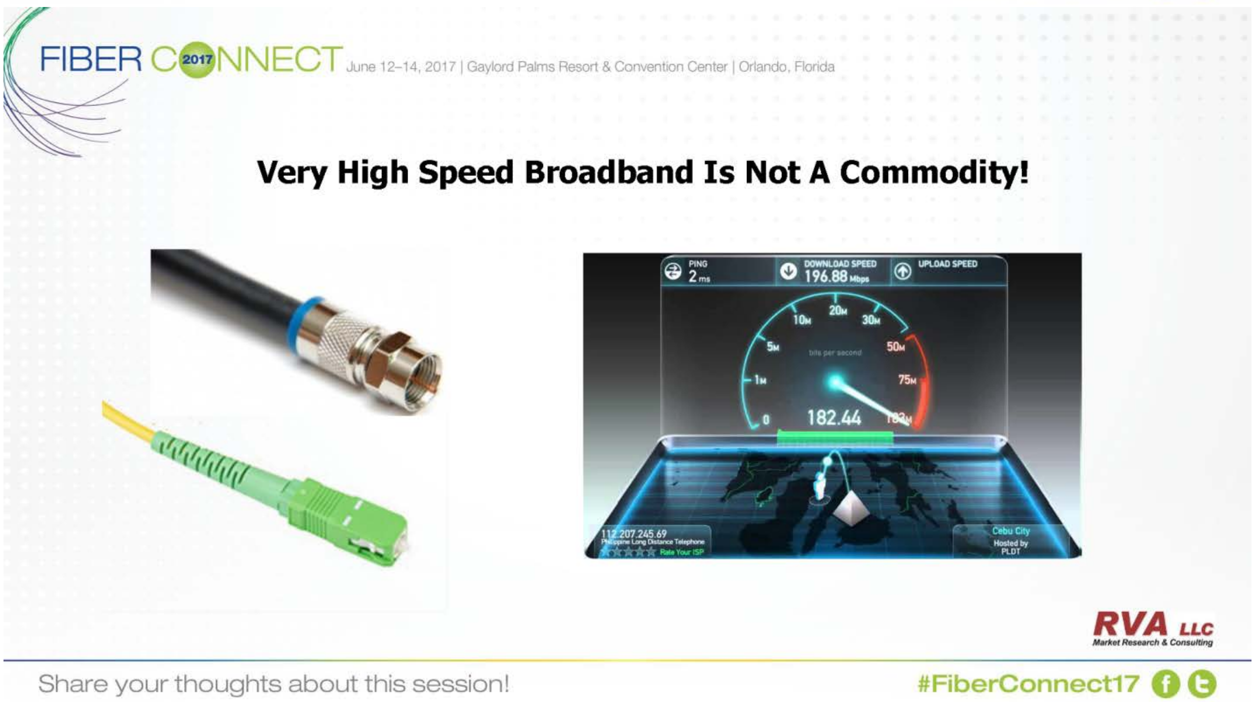
FIBER CONNECT 2017
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Very High Speed Broadband Is Not A Commodity!
PING
2 ms
DOWNLOAD SPEED
196.88 Mbps
UPLOAD SPEED
182.44
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Measures Of Download

Among Those Measuring Over 100 Mbps down

	FTTH	Cable	Winner
Measured Average Download Speed	**107**	101	Virtually tied
% Time Waiting For Things To Load	**7.5%**	**7.5%**	Virtually tied

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Measures Of Reliability

Among Those Measuring Over 100 Mbps down

	FTTH	Cable	Winner
# Reboots Required Per Month	**0.9**	1.8	FTTH 2.0 times better
# Calls To Customer Service Required Per Year	**1.3**	2.3	FTTH 1.6 times better
% Rating Reliability/ Uptime Very Good	**57%**	48%	FTTH 1.2 times better

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Measures Of Upload

Among Those Measuring Over 100 Mbps down

	FTTH	Cable	Winner
Measured Average Upload Speed	**32.7**	11.5	FTTH 2.8 times better
% Rating Upload Speeds Very Good	**61%**	38%	FTTH 1.6 times better

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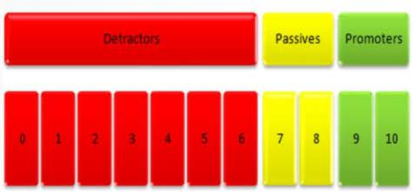
Net Promoter Score

Among Those Measuring Over 100 Mbps down

	FTTH	Cable	Winner
Net Promoter Score	**27.1**	-6.3	FTTH 4.3 times better



Net Promoter Score = "Promoters" Less "Detractors"

"How likely would you be to recommend your internet service to a friend who needs similar services?"

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20. Exhibit H: Economic Development: The Killer App for Local Fiber Networks

Economic Development Is The Killer App For Local Fiber Networks

More and more communities are taking proactive steps to ensure that their communities are equipped with next-generation internet infrastructure. Their economic livelihood depends on it.

By Jim Baller, Joanne Hovis and Ashley Stelfox / *Coalition for Local Internet Choice* and Masha Zager / Broadband Communities

In the November-December 2014 edition of Broadband Communities, the authors reviewed the available economic research and other evidence on the relationship between broadband and economic development and concluded that economic development was the "killer app" for local fiber networks. In this article, we update the research and other evidence to reflect new developments in the last two years, and we arrive at the same conclusion.

For almost two decades, nearly every U.S. community that has developed a fiber optic broadband network has put economic development at the top of its list of reasons for doing so. To be sure, communities also recognize that fiber networks provide critical benefits for education, public safety, health care, transportation, energy, environmental protection, urban revitalization, government service and much more. Ultimately, however, the promise of economic development, including both attraction and retention of opportunities for meaningful and well-paying work, combined with the fear of falling behind other communities in the United States and around the world, unites local communities across political, economic, cultural, educational and other divides.

In short, just as communities a century ago found electrification essential to their survival and quality of life, communities today have increasingly come to recognize that their citizens can survive and thrive in the modern economy only if they have affordable access to high-capacity internet connections.

THE LINK BETWEEN BROADBAND AND ECONOMIC DEVELOPMENT

The availability of broadband networks is one factor that organizations take into account when deciding whether to move to or remain in a particular community. Other significant considerations include energy costs, ease of doing business, taxes, labor costs, education levels and availability of water – which may contribute in varying degrees from case to case. As a result, it is difficult to make broad, data-driven generalizations about the precise role of broadband networks in stimulating economic development. Even so, several formal economic studies have sought to shed light on the relationship between broadband networks and economic development.

The first wave of these studies, which focused on first-generation, low-capacity broadband networks, suggested that there was at least an association, and probably even a causal relationship, between broadband and economic development. As one of these studies concluded, "the internet plays an integral role in helping small businesses achieve their strategic goals, improve competitiveness and efficiency and interact with customers and vendors." These early studies also confirmed that broadband expansion can dramatically increase state GDP and tax receipts.

Similarly, in a 2005 study, George S. Ford and Thomas M. Koutsky concluded that "broadband infrastructure can be a significant contributor to economic growth ... [and] efforts to restrict municipal broadband investment could deny communities an important tool in promoting economic development." The study "quantif[ied] the effect on economic development resulting from a community's investment in a broadband network" by looking at Lake County, Florida, which developed a municipal broadband network in 2001 and provided access to the network to private businesses.

In comparing Lake County with similar communities in Florida that did not have municipal broadband networks, Ford and Koutsky found that Lake County had "experienced 100 percent – a doubling – in economic growth relative to its Florida peer counties" since the deployment of the municipal network. The study points out that this doubling occurred despite the fact that these other counties "no doubt" had private broadband networks during the evaluation period.

WHAT IS ECONOMIC DEVELOPMENT?

Economic development comes in many forms, serves multiple purposes and means different things in different contexts. According to the U.S. Economic Development Administration,

> **Economic Development creates the conditions for economic growth** and improved quality of life by expanding the capacity of individuals, firms and communities to maximize the use of their talents and skills to support innovation, lower transaction costs and responsibly produce and trade valuable goods and services. Economic Development requires effective, collaborative institutions focused on advancing mutual gain for the public and the private sector. Economic Development is essential to ensuring our economic future.

The World Bank defines economic development as follows:

> The purpose of local economic development is to build up the economic

capacity of a local area to improve its economic future and the quality of life for all. It is a process by which public, business and nongovernmental sector partners work collectively to create better conditions for economic growth and employment generation.

The International Economic Development Council adopted a goal-oriented approach to economic development, which it describes as "improving the economic well being of a community through efforts that entail job creation, job retention, tax base enhancements and quality of life."

Given the expansive definition of economic development, it is no surprise that there is no single strategy to support economic development. Indeed, a community's particular circumstances and goals will heavily influence its economic development strategies and options.

Communities can focus on increasing the profitability of local businesses, increasing the number of local jobs, increasing the quality of local jobs or striking a balance among these goals. They can seek to attract or retain a relatively small number of large companies, a larger number of small to medium-sized businesses or a combination of both. Communities can concentrate on their local economies, cooperate with neighboring communities or involve themselves in regional initiatives. They can attempt to support the growth of all local industries or target particular industries, such as high tech, health care, data centers, biosciences and so forth.

Once communities decide what they want to do, they typically have a wide choice of tools with which to work. They can offer tax incentives or loans and other financial enticements. They can establish improvement districts, enterprise zones and other kinds of development areas. They can improve roads, sewers, water facilities and other infrastructure. They can offer favorable terms and accelerate approval of franchises, permits and other necessary authorizations. They can support workforce development and training. They can use local government purchasing power to increase a targeted company's sales, thereby reducing its risks. They can help aggregate demand within the community. They can seek grants, loans and other support from federal and state agencies, foundations and other organizations.

An increasingly important development tool is improving access to affordable, high-capacity broadband infrastructure. Even here, communities often have multiple options. They can work with willing incumbents, enter into public-private partnerships with new entrants, establish advanced communications networks of their own or develop other innovative approaches that work for them.

In another 2005 study, analyzing data from 1998–2002, Sharon Gillett, William Lehr, Carlos Osorio and Marvin Sirbu found that communities in which mass-market broadband became available by December 1999 "experienced more rapid growth in employment, number of businesses overall and businesses in IT-intensive sectors. Likewise, in a 2007 study, Robert Crandall, William Lehr and Robert Litan concluded that broadband increased nongovernmental employment by 0.2 to 0.3 percent and had a positive impact on GDP.

When communities lack good broadband access, corporate site selectors cross them off their lists and residents move away in search of better jobs.

In 2010, Jed Kolko found a "positive relationship" – one that "leans in the direction of a causal relationship, though not definitively" – between broadband expansion and local economic growth. Kolko's study revealed that almost all industries showed a positive relationship between broadband expansion and local economic growth, particularly in industries that rely on information technology, such as utilities, information, finance and insurance, technical services, management of companies and administrative and business support services.

In their 2013 study, Brian Whitacre, Roberto Gallardo and Sharon Strover focused on the impact of broadband on the economic health of rural areas. Though they did not find a positive impact for broadband availability, they found that "high levels of broadband adoption in rural areas do causally (and positively) impact income growth ... as well as (negatively) influence poverty and unemployment growth. Similarly, low levels of broadband adoption in rural areas lead to declines in the number of firms and total employment numbers in the county."

Another economic benefit of broadband is that it enables existing businesses in a locality to expand their operations. The research firm Strategic Networks Group examines economic growth from this viewpoint. It identifies specific internet-related practices (such as web-based customer service or advertising) that businesses use to drive growth, and it relates them to incremental GDP, taxes and jobs. This bottom-up approach predicts varying economic impacts in different localities from increasing business internet usage.

A 2016 report published by the Internet Innovation Alliance found that broadband internet, and the information and communications technologies that comprise and support it, when considered in the aggregate, produced $1,019.2 billion in value added for the U.S. economy.

A study by the Hudson Institute looked specifically at the economic impact of rural broadband. It found that rural broadband companies contributed $24.1 billion to the economies of the states in which they operated – $17.2 billion through their own operations and $6.9 billion through the follow-on impact of their operations – although the economic impact spread into urban areas of the same state. The study also concluded that the economic activity that rural broadband creates had supported 69,595 jobs, spread throughout the U.S. economy.

Looking more closely at the economic development benefits a fiber network has on a particular community, Dr. Bento Lobo released a study in 2015 analyzing the effects Chattanooga's fiber network had on the city. His analysis considered the effects of broadband on four categories: household effects, community effects, business effects, and utility effects. For example, in household effects, Lobo used studies that showed how much consumers would be willing to pay for various levels of internet services. He then compared those numbers with what consumers pay in Chattanooga to demonstrate consumers' surplus savings per month. His results show consumer surplus related to high-speed internet access ranges from $33.2 million to $76.2 million annually. Overall, Lobo's findings conclude that Chattanooga's fiber infrastructure generated economic and social benefits ranging from $865.3 million to $1.3 billion and created between 2,800 and 5,200 new jobs.

LACK OF BROADBAND AND ECONOMIC DECLINE

The studies discussed above focus on the benefits of broadband networks, but as broadband becomes both more necessary and more widely available, the disadvantages of lacking such networks have become easier to identify than the benefits of having them. Site selectors report that communities that lack suitable broadband infrastructure are routinely eliminated from consideration as potential sites for location or relocation. In other words, although the presence of a robust broadband network may not itself be sufficient to persuade an organization to come to or stay in a community, the absence of such a network guarantees that potential employers will go elsewhere.

In a series of articles for this magazine, the most recent of which is on p. 71 of this issue, editor-at-large Steven S. Ross compared population growth or loss (as a proxy for job growth or loss) with broadband availability in all U.S. counties. He found that population in counties in the bottom half of their states in terms of access to at least 25 Mbps broadband grew at one-tenth the rate of the counties in the top half. The bottom 10 percent of counties in each state, in aggregate, actually lost population.

FIBER NETWORKS AND THE ECONOMY

The available economic research clearly demonstrates that broadband supports economic activity and growth. So far, however, only limited data exists on the impact that a high-capacity fiber network have or can have on a local economy. The absence of more such data is not surprising, given the relatively recent emergence of fiber networks. The fact is, though, that one cannot yet make statistically rigorous general statements about the overall relationship between fiber networks and economic development.

One can, however, focus on more discrete questions. For example, it is clear that fiber networks enable hundreds of thousands of individuals to work from home, adding tens of billions of dollars annually to the U.S. economy. Many respondents to a 2010 survey by RVA LLC stated that fiber's reliability and speed made their employers more willing to allow them to telecommute or that fiber connections were necessary for their home-based businesses to succeed. In addition, fiber connectivity adds between $5,000 and $6,000 to the value of a $300,000 home in the United States.

A series of studies conducted at the Chalmers University of Technology in Gothenburg, Sweden, specifically addressed the effects of broadband speed. In their first report, published in 2011, the researchers concluded that increases in broadband speeds contributed significantly to economic growth. In a report published in 2013, the same researchers concluded that, in developed countries, the threshold level for broadband to have any impact on household income was 2 Mbps; gaining 4 Mbps of broadband increased household income by $2,100 per year. Given that fiber networks are capable of nearly unlimited speed, it appears that their potential economic impact is significantly higher than that of lower- capacity broadband.

Strategic Networks Group has looked at the impact of broadband speeds on individual small and mid- sized businesses. Its surveys showed that a minimum of 4 Mbps upload speed was necessary for these businesses to fully utilize the internet and increase their revenues significantly. About 71 percent of fiber users have access to 4 Mbps or higher upload speed, compared with much smaller percentages of cable or DSL users.

A study commissioned by the Fiber to the Home Council Americas in 2014 compared economic activity in 14 metropolitan statistical areas (MSAs) in which gigabit-speed connectivity was available to more to than 50 percent of the households with economic activity in 41 similarly sized MSAs in the same states in which gigabit speeds were not available. According to the study's investigators, "our model suggests that for the MSAs with widely available gigabit services, the per capita GDP is approximately 1.1 percent higher than in MSAs with little or no availability of gigabit services. These results suggest that the 14 gigabit broadband communities in our study enjoyed approximately $1.4 billion in additional GDP when gigabit broadband became widely available." Although this study focused on "early evidence" and was far from conclusive, it was consistent with the field experience of many communities.

What formal studies do not yet reveal is how many units of economic development a community can expect from a specific dollar investment in a fiber network under the unique conditions present in that community. Neither the data nor the analytical tools to do this will be available in the foreseeable future.

THE VIEW FROM THE TRENCHES

A huge and rapidly growing body of evidence confirms that, at least in some localities, advanced broadband networks can indeed spur positive economic development and create jobs. In nearly all communities, industries are increasingly reliant on high-bandwidth connectivity. The communities cited here have taken differing approaches based on their individual resources and economic development needs. Some make fiber available to businesses; others serve households as well. Some are more concerned with increasing the availability of broadband, and others focus on reducing its price. Some try to retain existing large employers, and others aim to attract new startups.

The common thread is that economic development officials are working closely with existing and potential employers to

> Cedar Falls, Iowa, was one of the first U.S. cities to offer fiber connections to businesses. In 20 years, the number of businesses in the town increased six fold.

identify, understand and meet their needs for advanced communications capabilities.

- **Brainerd Lakes, Minnesota**
  In the early 2000s, this area made substantial strides toward establishing itself as a tech center when the private sector, educators and local economic development agencies collaborated to bring high-speed fiber optics to the area. That proved to be a significant move and caught the attention of many tech companies looking for a place to expand or locate. The fiber optics, along with the area's high quality of life, trained workforce, available building sites and existing office space established the Brainerd Lakes area as one of the most advanced technological markets in Minnesota and continues to garner widespread attention for that reason.
- **Brookings, South Dakota**
  Brookings' fiber-to-the-home network is operated by the Brookings Municipal Utilities business branch, Swiftel. Steve Meyer, Swiftel's general manager, attributes the network's success to the following: "We like to think our advantage comes from great employees, and we've invested in state-of-the-art infrastructure, and we have the experience of serving customers for more than 100 years." Although the fiber network gets less press, it is one of the key factors driving growth in this university city. In 2014, 3M announced it would invest $57.6 million in new, high-tech, automated equipment to manufacture medical tapes and dressings. The expansion adds 60 jobs, bringing total employment to more than 1,000 employees. Brookings is also home to Daktronics, which makes scoreboards and displays for sports teams and employs 1,600 people. It has also become a hub for protein development companies.
- **Cedar Falls, Iowa**
  In the 1990s, Cedar Falls Utilities built a citywide municipal hybrid fiber- coaxial network and provided fiber connections to commercial and industrial customers in both the city and the industrial park. Over the years, Cedar Falls watched businesses from neighboring towns relocate to the area, in part because of the need for more bandwidth and greater internet capabilities. Cedar Falls has now made the transition to all fiber and became the state's first gigabit city in 2014. Jim Krieg, general manager of Cedar Falls Utilities, noted the growth fiber optics had generated: "Twenty years ago, [Cedar Falls] had 27 businesses and $5 million in taxable valuation; today, there are 160 businesses and $270 million in valuation."

Lafayette, Louisiana, has garnered attention in the tech sector, and both startups and established companies relocated to the area because of its internet connectivity.

- **Chattanooga, Tennessee:**
  With its fiber-to-the-home network offering gigabit speeds throughout the city, Chattanooga has attracted several major companies, including Volkswagen, which has already spent more than $1 billion building factories in the area and created 12,000 new jobs, as well as Homeserve USA and Amazon. Chattanooga's innovative, high-speed fiber network has also created an entrepreneurial boom in the city.
- **Cumberland, Maryland**
  Cumberland, Allegany County and the county board of education have partnered for 15 years on an innovative wireless infrastructure program that delivers high-quality services to government users and makes available both middle-mile and last-mile wireless capabilities for private ISPs that serve residential, business and health care customers. The availability of these services, particularly in the most rural parts of the county, distinguishes the county from other rural areas. It has enabled the development of home- based businesses and attracted second-home buyers who otherwise would not have chosen to locate in the county.
- **The Dalles, Oregon**
  The Dalles, a city of 11,873 residents in the picturesque Columbia River Gorge, operates a 17-mile municipal fiber optic network. In 2005, as a direct result of The Dalles' municipal networking capabilities, Google decided to purchase an industrial site there for $1.87 million to house high-tech equipment that would be connected to the rest of the company's network. According to the man who coordinated the deal with Google, "It was visionary – this little town with no tax revenues had figured out that if you want to transform an economy from manufacturing to information, you've got to pull fiber." The project was expected to create "between 50 and 100 jobs over a matter of time, earning an estimated average of $60,000 annually in wages and benefits." The Dalles succeeded so well that it recently paid off its network debt well ahead of schedule.
- **Danville, Virginia**
  In contrast to The Dalles, Danville did not have a fiber network when AOL came looking for a site for a new data center. As a result, AOL struck Danville off its list of potential sites and located the center in Prince William County, Virginia. After this setback, Danville developed a fiber network of its own. Now known as the "Comeback City," Danville used its fiber network to revitalize its economy, once the worst in the state with a 19 percent unemployment rate, and made the city a site of robust

economic development, attracting Microsoft, IKEA and many other new, high- tech businesses.

- **Kendall County, Texas**
  A cooperative telephone company, GVTC, began building out FTTH in the Texas Hill Country in 2004. It works closely with the Kendall County Economic Development Corporation to promote the network to businesses. As a result, the region's growth has outpaced the rest of Texas by 4 percentage points. Corporate site selection committees no longer reject sites in the county. An economic development official said, "If I don't have fiber, I'm eliminated – not just fiber to the business, because the executives are commuting to San Antonio and want to work from home because of gas prices. Fiber allows throughput and security." Software companies, medical companies and aerospace companies have relocated to or stayed in the area because of the fiber network. Even Hill Country wineries, which constitute a small but tenacious local industry dating back to early German settlers, are now putting towns such as Fredericksburg and Boerne on vintners' maps.
- **Lafayette, Louisiana**
  "When NuComm International needed to locate a new call center – one that would add 1,000 jobs ... to the local economy – it chose Lafayette, Louisiana, because the city is building a massive fiber network to connect everyone." Lafayette has garnered attention in the tech sector, and many companies relocated to the area because of internet connectivity. In one example, "Scott Eric Olivier moved his tech startup firm, Skyscraper Holding, from Los Angeles to Lafayette when he heard of the speeds and service offered by LUS Fiber." Olivier says the same 100 Mbps connectivity that costs him $200 per month in Lafayette, enabling him to move large files across the web, would cost him several thousand dollars a month anywhere else. In the past few months, Lafayette attracted three new employers that will bring 1,300 jobs into the city.
- **Martinsville, Virginia**
  Martinsville's fiber network enabled it to attract major businesses, such as defense contractor SPARTA Inc.'s research center, Mehler Texnologies, American Distribution and Warehousing and ICF International (500-plus jobs).
- **Mesa, Arizona**
  In the early 2000s, Mesa started placing conduit in its rights-of-way during capital construction projects and any other time a road was open. The city built a critical mass of conduit and fiber over a decade and a half, and it partners actively with private entities seeking access to conduit and fiber. Apple located a silicon research lab in Mesa, and the city credits the direct fiber connection to that facility as a significant part of the inducement

for Apple and other entities to locate in Mesa.

- **Montgomery County** Maryland: In the mid-1990s, Montgomery County developed a sophisticated revitalization and cultural plan for downtown Silver Spring, which had experienced steady economic deterioration and high retail and office vacancy rates. An important part of its vision for new opportunity and cultural vitality was attracting cultural institutions as anchors and creating means for schoolchildren in the county to benefit from those institutions. The county developed a strategy to connect potential cultural anchors over dark fiber and enable connectivity between the cultural anchors and public schools so students could see and experience events at the anchors. One of the first anchors the county connected with dark fiber was the American Film Institute (AFI); in subsequent years it connected other institutions, such as the Fillmore theater. This economic and cultural revitalization has been enormously successful, and the AFI Silver Theatre and Cultural Center and other fiber-connected cultural anchors have proved essential to the redevelopment of Silver Spring.
- **Powell, Wyoming** In anticipation of the construction of a fiber-to- the-home system in rural Powell, a South Korean venture capital firm agreed to pay up to $5.5 million to engage 150 certified teachers, working from their homes, to teach English to students in South Korea using high-speed videoconferencing. The FTTH system has been so successful that the city was able to buy out its investors 18 years ahead of schedule.
- **Princeton, Illinois** Princeton built a fiber network to retain Ingersoll- Rand as a major local employer; it now has more than 75 commercial customers, and most banks in town are connected with fiber. The broadband utility is regarded as attractive for potential employers.
- **Pulaski, Tennessee** Local economic development leadership has begun marketing Pulaski Electric System’s services to nearby Huntsville, Alabama, home to a large number of defense and space industries. Before PES built its network, the community had never attempted to approach the defense or aerospace companies because it had little to offer that met their special needs. The FTTH network has allowed several existing industries to receive superior service at much lower prices than they paid previously. The system has become a focus of community pride and an example of the community’s willingness to invest in the future.
- **Reedsburg, Wisconsin** Reedsburg’s FTTH system has allowed Lands’ End to develop a virtual call center in which many of its customer service representatives work out of their homes.

- **RS Fiber Cooperative, Minnesota**
  RS Fiber brought together 17 townships and 10 cities to build a fiber network that will bring high-speed internet to 6,000 homes and businesses in the region. Though construction is ongoing, the economic impact is already being felt. The Minnesota College of Osteopathic Medicine will set up in a former school building in RS Fiber's footprint. School officials credit the fiber network with providing the necessary technological infrastructure to enable the college to locate in the area.
- **San Leandro, California**
  San Leandro, located in the San Francisco Bay Area, competes with such tech giants as Silicon Valley for local businesses. In 2012, with the goal of attracting modern, technology-based industries to San Leandro, the city established a partnership with a local business owner to create an ultra-high-speed fiber broadband network. The network, Lit San Leandro, is largely privately funded but utilizes the city's conduits to run the underground fiber network. Lit San Leandro is already attracting businesses to the area. For example, a 3D printing firm moved from San Francisco to a factory in San Leandro after considering more than 50 other locations. Similarly, a Kaiser hospital was built on the site of a former grocery distribution center, and the Westlake/OSIsoft Technology Complex, which includes three six-story, 300,000-square-foot tech offices, is located in a former Del Monte cannery.
- **Sandy, Oregon**
  SandyNet began when the city hall could not get a DSL connection, and city leaders realized businesses and residents faced the same problem. In 2015, Sandy, Oregon, completed construction of its FTTP network. Though it may be too soon to know whether businesses will relocate to Sandy as a result of the network, reactions from existing businesses and residents have been positive. There may also be a new brewery in town soon.
- **Santa Monica, California**
  Santa Monica's Information Systems Department mapped out a plan for the creation and expansion of its broadband network in 1998. Since then, the city has been slowly and methodically implementing its plan, saving city government $700,000 a year in communications costs as well as making advanced communications capabilities available to private entities. In 2014, the city upgraded its fiber optic network speed to 100 Gbps. The network has already contributed significantly to the city's economic growth.
- **South Bend, Indiana**
  In the early 2000s, South Bend began researching how to improve its telecommunications networks. South Bend had fiber networks in place, but it was not in a position to

The gigabit network in Wilson, North Carolina, has spurred an influx of creative-class entrepreneurs whose livelihoods depend on maximum upload capacity.

develop and operate the networks itself. Because no existing providers were interested in establishing vendor-neutral fiber services through the city's infrastructure, South Bend worked with local partners to establish Metronet, a nonprofit, dark fiber network that serves government, educational and other nonprofit entities. Its for-profit subsidiary, St. Joe Valley Metronet (SJVM), provides fiber access to banks, manufacturers and other businesses. The profits from SJVM are paid to Metronet through dividends and help subsidize Metronet's continued operations and expansion. SJVM has helped draw technology businesses to South Bend, from the GramTel data center in 2009 to the 2013 launch of a new coworking and meeting/conference space in the downtown area.

- **Westminster, Maryland**
  The city of Westminster developed a plan to build a fiber-to-the-home network itself and partnered with a private company to operate the network. Although the network is still under construction, the city has hit the ground the running, bringing new businesses to the community through its business incubator, MAGIC, and a new Smart Home project. These projects "explore new technologies that use the gigabit services available on the Westminster Fiber Network."
- **Wilson, North Carolina**
  Since 2008, Wilson has owned and operated a gigabit, symmetrical, fiber-to-the-home network that is available to every home and business in the community. The network has moved Wilson to the top of the list for places that offer affordable, modern, next-generation lifestyles. The community has experienced an influx of creative-class entrepreneurs whose livelihoods depend on maximum upload capacity. Examples include ExodusFX.com, a special effects film company, whose founders scoured the world for affordable housing and high capacity symmetrical broadband service and chose Wilson; radiologists who moved to Wilson because they wanted to work from home; and web designers, video artists and photographers who could finally upload their massive data files in minutes, not days.

These are a small handful of the many projects across the country that use advanced communications capabilities to support economic development and at the same time use the benefits of economic development to fund their networks and make them sustainable.

NEXT STEPS

The federal broadband stimulus programs invested billions of dollars in hundreds of middle-mile and last-mile projects across the United States. Most of these projects were completed only recently, and once they have a few years of operating experience under their belts, they will produce a wealth of information about what worked well and what did not in stimulating economic development.

The growing interest in gigabit networks is also likely to increase the understanding of how widespread availability of gigabit speeds affects economic development. Google Fiber's entry into the market, the gigabit projects of numerous community networks, and recent gigabit announcements by such private players as AT&T, C Spire Fiber, CenturyLink, Cox Communications and others have made "gigabit" a household word. In many communities, organizations such as the Mayors' Bistate Innovation Team (formed by the mayors of Kansas City, Kansas, and Kansas City, Missouri) are emerging to analyze and stimulate economic development and other uses for the new gigabit connectivity.

Useful analytical approaches and devices are emerging to help communities reap the economic benefits of advanced broadband. For example, Strategic Networks Group has developed tools to measure and analyze broadband utilization and benefits to businesses, organizations and households. These tools, backed by a growing database that currently covers more than 16,000 businesses and 12,000 households, can provide detailed analyses of the economic impacts of broadband utilization and enable businesses and organizations to compare themselves with other entities of comparable size and other characteristics. As the databases grow, they will become increasingly valuable.

In addition, communities that have advanced communications capabilities are increasingly talking to one another, sharing resources and lessons learned, and collaborating when possible. **Broadband Communities** has sought to facilitate such exchanges by hosting a series of national and regional economic development conferences. Communities also share experiences through forums organized by such organizations as the Coalition for Local Internet Choice, Next Century Cities and the Fiber to the Home Council Americas. Over time, the path from broadband investments to economic development should be faster, more efficient and less costly to navigate.

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Endnotes are available in the digital edition of this article at www.bbcmag.com.