Fiber Master Plan

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Executive Summary

i. Introduction

Progressive communities are relying upon municipal fiber-optic networks to thrive in the new digital world. As municipalities continue to adopt technology platforms, more emphasis is placed on meeting the growing demands of their constituents through digital systems. Municipalities that have invested in fiber infrastructure realize the importance of these assets to their governmental operations and are beginning to leverage them to bring next-generation broadband to their communities.

The City of Portsmouth, Virginia, the "City", currently owns minimal fiber-optic assets, but does maintain an underground conduit system along main thoroughfares, as well as wireless point-to-point systems to support traffic signalization and operations. Currently there are no additional uses of the existing conduit system and point-to-point wireless networks, as they solely support traffic operations. The City realizes fiber-optic infrastructure is a key asset and has deemed additional investment necessary. To pursue any future opportunities, a Fiber Master Plan is necessary to expand the City's fiber network for benefit of the greater municipal organization, its departments, and peer community partners such as Portsmouth Public Schools.

In 2016, the City contracted with Federal Engineering (***FE***) and Magellan Advisors for the development of a Fiber Master Plan (Plan) that identifies the connectivity needs of the City and its community partners. This Plan outlines a high-level network strategy, design, and payback model framework to support the needs of the City's departments and Portsmouth Public Schools. This Plan will enable the City to begin investing in broadband assets that will support the evolution of the Portsmouth community for decades to come.

The City's current annual telecom spend including Internet and network transport services is $390,284, while Portsmouth Public Schools spends an additional $608,964 annually, before E-rate[1] discounts, and Portsmouth Public Library system libraries spending $28,836 annually. For City taxpayers, this is the same bucket of tax dollars utilized for retail Internet and transport network services. Without the inclusion of federal E-rate monies, the overall community spend is more than $1,028,084 annually, for basic site to site and Internet connectivity for municipal and K-12 school district buildings, with no end in sight, as current services are contracted from incumbent providers and based on annual contracts. City leadership considers fiber-optic infrastructure as critical infrastructure to support the Portsmouth community, equivalent to water, sewer, and roads; and a direct investment in a City owned network is a venture that will drive City operations and support community needs for the next 30 to 50 years.

The City understands its communications needs will continue to grow from where they are today, and that upgrades in services will be required year over year. This will result in a drastically increased telecom spend, even before additional sites and circuits are added to the network. By making broadband infrastructure a long-term program where the City invests annually in a strategic buildout, the City will be able to transfer the costs for telecom from an annual operating expense (OPEX) cost to a capital program, just as it treats other key infrastructure programs, e.g. roads, storm water, parks. Additionally, it will be able to coordinate

[1] https://www.fcc.gov/consumers/guides/universal-service-program-schools-and-libraries-e-rate

the deployment of this network with other city capital projects such as road widenings, or utility construction projects, to reduce the overall cost of the program as it relates to construction.

This Plan outlines the backbone and lateral fiber segments required to interconnect all City and school sites, implementing a common network transport platform to provide secure, high-speed connections to all sites and facilities. In addition, it calls out all capital and operating costs over a six-year period, and provides an internal revenue model to provide for payback analysis. The Plan also outlines, at a high-level, additional future uses and considerations that should be a part of the City's broadband program as it begins to construct its network.

ii. Overview of Municipal Fiber Networks

Fiber networks are the gold standard for municipal communications, broadband services, and Internet access. Fiber networks permit transmission of large amounts of data securely over long distances with high reliability. They are flexible enough to support a wide range of applications and scalable enough to support nearly unlimited capacity and speed. Fiber networks are considered a capital infrastructure asset like water, roads, and electric infrastructure and have a lifespan of up to 50 years or more with the proper installation and maintenance.

Over 1,000 cities in the U.S. own some form of municipal fiber networks and have used them for decades to support their operations. These networks are becoming increasingly important to cope with the rapid growth in connected devices. These devices run the gamut from utility assets and street lights, to traffic signals and surveillance cameras. Cities that maintain these networks can accommodate these "smart city" technologies, which allow them to be more efficient, reduce costs, and increase the value they deliver to their constituents.

Within the past 15 years, some cities have expanded the use of these networks to enhance local broadband services in their communities. Broadband has become a key aspect to support economic development, education, healthcare, and other community functions, and cities have leveraged their networks to foster fiber-based broadband services, either directly, or, more often, through wholesale agreements with commercial providers for leasing of dark fiber, conduit, or lit transport services.

iii. Why a Fiber Master Plan is Important for Portsmouth

Cities across the country are investing in municipal fiber networks to support their growing demands for technology and community needs. Instead of leasing expensive connections from providers, they are building their own networks to reduce costs and maintain ownership in a long-term asset that can be used for a variety of other purposes. Over 1,000 cities across the U.S. already own fiber networks that they utilize to support their internal operations, connectivity to anchor organizations, and enhanced broadband services in their communities.

For the City, building a multi-purpose fiber network is an investment in the City's future. The City will own an asset that can accommodate smart and connected technologies as more municipal and community functions are carried out online. Smart City Technologies and the Internet of Things (IoT) are two growing trends that will change the way that cities carry out their missions as electronic government or e-government expands across many municipal functions. More devices, sensors, and people will be connected than ever before. By building a fiber backbone, the City will be more prepared to accommodate these emerging trends. The network will help the City adapt to the changing needs across the community by utilizing its fiber infrastructure to support high-speed communications across the City.

The City has existing conduit assets which can be utilized as the basis for the City network, while additional buildout of a backbone network would complete the segments necessary to connect all City and school sites across the City. The City is building fiber-optic infrastructure today, on a more limited project by project basis. A Master Plan will allow the City to make strategic investments based on long-term needs, allowing it to take a comprehensive approach as to how it invests in and deploys fiber assets. Fiber projects are currently buried in other capital projects or in other limited fiber construction efforts, while a strategic program will require a long-term (5-year) investment plan and a dedicated funding source. Fiber master planning will allow the City to define standards and specifications for the buildout of further assets and all departments to work together in a more collaborative fashion as the City deployment occurs.

iv. Opportunity Statement

The City understands that investment in broadband infrastructure will allow them to forego long-term operating contracts, instead directing capital investments into infrastructure programs. The City's fiber network will be an asset that will provide high-speed connectivity to support internal and external stakeholder needs. As the City continues to embrace technology within its operating departments and connect more sites and facilities, the City can expand its network to strengthen its operations and propel the City ahead to become a highly-connected community. The fiber network can become a key resource that the City, in partnership with the private sector, can leverage to drive value across a range of municipal and community functions, from economic development, to education, healthcare, and general quality of life.

The opportunities for the City to leverage the fiber network include:

Disaster Preparedness and Emergency Communications

- Support Emergency communications
- Enable remote surveillance of specific areas
- Expand Information Technology (IT) disaster recovery capabilities
- Collaboration with surrounding communities

Municipal Efficiencies

- Enhance IT capabilities
- Reduce recurring costs
- Enable more bandwidth to sites

Utilities

- Smart metering communications platform
- Backhaul for Supervisory Control and Data Acquisition (SCADA) and smart grid communications
- Improve security of utility infrastructure

Citizen Engagement

- Enable a backbone for public Wi-Fi deployment
- Support for online kiosks
- Expand Internet access in libraries

Smart City and Internet of Things

- Support weather sensor networks and early warning systems
- Expand Intelligent Traffic Systems (ITS) networks
- Support smart street lighting, automated trash cans, and connected bus stops

Economic Development

- Promote the City as a Gigabit Community
- Enable affordable fiber access in business corridors and parks
- Retain business within the City
- Support technology transfer from the university systems to new startups
- Attract high-tech business clusters
- Stabilize the costs that businesses pay for broadband

Quality of Life

- Enable a platform to support world-class broadband
- Ensure citizens have affordable access to the broadband services they need
- Enable public-private partnerships to make the City a Gigabit Community

Education

- Keep the City's schools connected at the fastest speeds available
- Support blended learning and digital classroom programs
- Stabilize the costs that schools pay for connectivity
- Support higher education's connectivity needs in the community

Healthcare

- Ensure healthcare providers have access to affordable broadband
- Own an infrastructure that could support future telehealth and telemedicine programs

i. Financial Overview

The City of Portsmouth has several options available as it contemplates how it will fund telecommunications services for City and school facilities. These connections are a necessity. Unfortunately, under the current arrangement, the City has little authority on how it deals with these very costly services, other than releasing a request for proposal (RFP) or purchasing off available Virginia Information Technologies Agency (VITA) contracts. The City realizes its needs will continue to increase through the years, both in the numbers of connections and bandwidth requirements. There is little doubt that the City's or school's network requirements will always evolve and will become more crucial as the digital age continues to emerge.

Through the commission of this Plan, the City sought to understand its current telecommunications cost structures for both City and school sites. Current costs were analyzed and form the foundation for Option 1, the "do nothing" baseline strategy – or "what Portsmouth does today."

Under Option 1, the City continues to increase bandwidth as budgets allow, or as providers upgrade their service offerings. Telecommunications services will always be considered an operating expense.

Option 2 is a high-growth model, which would assume a local incumbent provider would build, own, and operate the Portsmouth Community Broadband Network [PCBN] (as specified in this Plan), with the City leasing services. Under Option 2, the VITA contract rates for 1 Gbps and 10 Gbps services were used. Option 2 reflects a service provider leased network operating within the PCBN specifications outlined in this Plan. Telecommunications services will always be considered an operating expense.

Finally, Option 3 outlines a direct investment by the City to construct, own, and operate the PCBN. Under Option 3, the City would build its own network, provide access to Portsmouth City Schools, and lease any fiber capacity that it may deem excess.

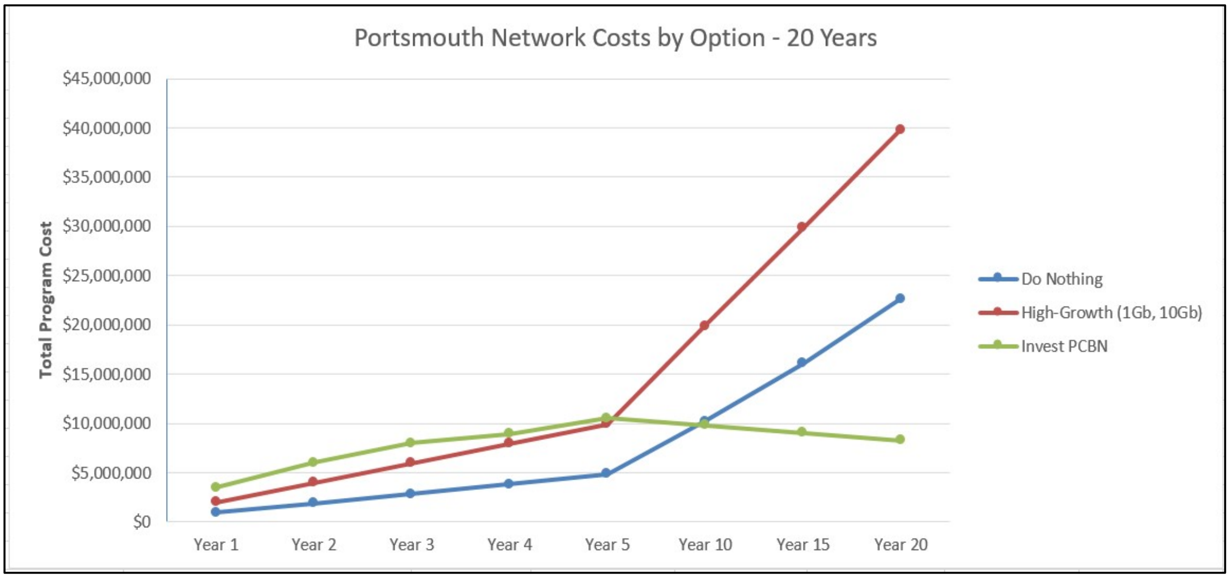
As outlined below in Table 1, each option has its own merits in the form of Ownership/Control, Operational Burden, OPEX, Capital Expense(CAPEX), and the total 20-Year Cost. Through City interviews and meetings with local leaders, it is clear the City believes fiber-optic infrastructure to be a critical and key component to further development of its community. If this is the case, then Option 3, PCBN Investment, is the clear choice as it provides the lowest cost service over the long-term and provides the most "upside" potential for the City. The tables and figures below outline how the City's telecom spend is analyzed, and planned/projected through a long-range planning effort. The City can make intelligent decisions on how and where it invests its taxpayer dollars – always taking the long-term approach to major infrastructure projects.

Table 1: Portsmouth Network Options Decision Support Matrix

Network Options	Description	Ownership/Control	Operational Burden	OPEX/CAPEX	20-Year Cost
Option 1	Do Nothing	None	Low	OPEX	**$22.6M**
Option 2	Estimated incumbent build of PCBN to spec	None	Low	OPEX	**$40M**
Option 3	PCBN investment	Yes – City Infrastructure	High – water, sewer, roads	CAPEX – permanently reduce operating costs	**$8.3M - $18.5M**

Under Option 1, the Portsmouth community will spend nearly $22.6 million on services it can afford, not what it needs. While Option 2 would meet the functional requirements outlined in this Plan, the City would spend over $40 million over the same 20-year period. Option 3 would require a sizeable capital investment over the initial 5-year period, however, it could expect to save significantly over the 20-year period. Option 3 program cost is between $8.3 million and $18.5 million, depending entirely on the City's ability to capture the E-rate reimbursement model chosen by schools and libraries. In addition, Option 3 provides the City of Portsmouth with additional upside as there are major opportunities to expand the initiative regionally, and to develop a potential revenue stream through leasing of excess capacity in the network.

Figure 1: Portsmouth Network Costs by Option - 20 Years



The City will contend with the need for faster network connections every year. Municipal government and education require ever increasing amounts of bandwidth, and this will not slow down as long as more devices, more people, and more components are connected and communicating. The City can forecast its needs, and through development of this Master Plan, take the long-term approach, turning communications services and their monthly recurring fees into an investment in infrastructure.

v. Conclusions and Next Steps

The City must evaluate this Fiber Master Plan and the recommended actions to ensure alignment with the City's goals and vision. This Plan outlines a core piece of community infrastructure which will enable the City to permanently reduce network communications costs for the City, Schools, and Libraries. Without these investments, the City, Schools, and Libraries are projected to spend nearly $23 million over the next 20 years, with no ownership interest in any network assets. The City believes a holistic view of communications, along with the development of this Master Plan, will save the region's local government entities millions of dollars over the same period. The planned fiber infrastructure may serve the community for the next 50 years, with proper maintenance.

The City's next steps include:

- Review and Adopt the City of Portsmouth Fiber Master Plan
- Finalize Staging, Budgets, Timelines, and Develop Project Implementation Plan
- Inventory Existing Broadband Assets
- Design Engineering of Outside Plant
- Issue RFP and Select Construction Firm to Build the PCBN
- Train and Equip Staff for New Operations
- Establish Operating Support Systems
- Establish Fiber Outside Plant (OSP) Operations and Maintenance (O&M) Contract

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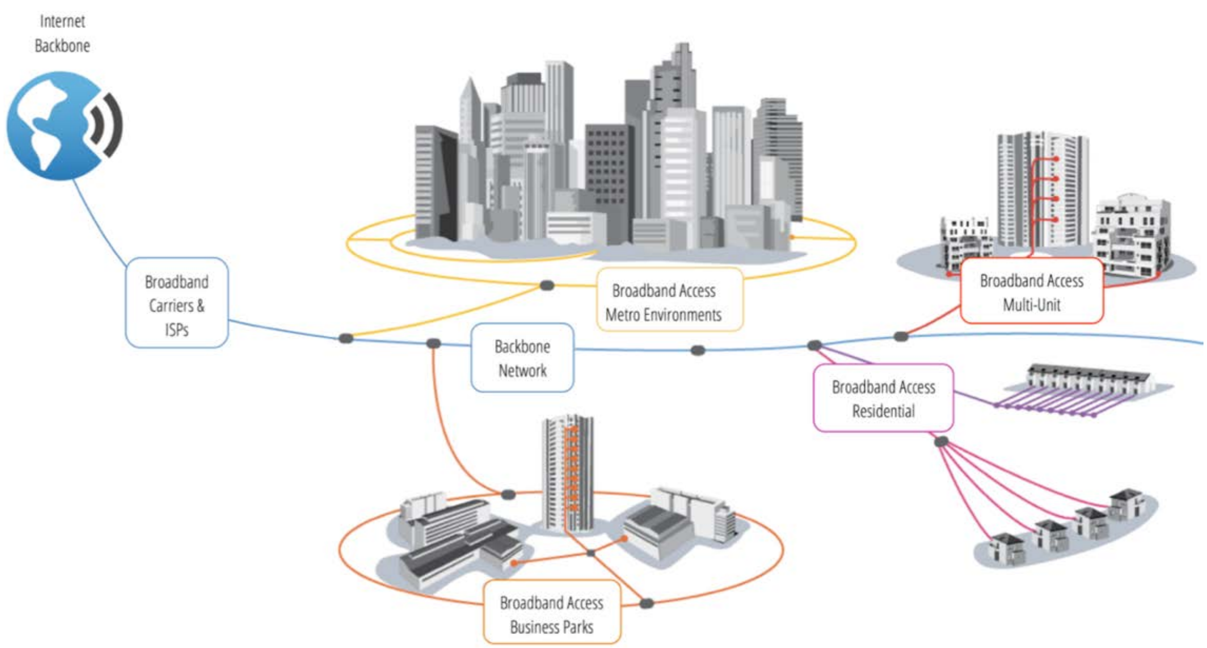
1.0 Analysis of Current Technical Environment

1.1 Overview of Internet Technologies

Broadband is deployed throughout communities as wired and wireless infrastructure that carries digital signals between end users and the content they want to access. The content comes in many forms and from many locations across the world in the networks that connect the local community to the Internet backbone. Websites, television, streaming video, videoconferencing, cloud services, and even telephone service are just a few types of content that are delivered across local broadband networks.

Access to this content is made available through the type of infrastructure and selection of connections available in the local network. Robust local infrastructure results in faster, more reliable access to content. Conversely, local infrastructure that is aging and built on older technologies results in slower, less reliable access to content.

Figure 2: How Fiber-optic Networks Connect Our Communities



1.1.1 Dial-up Access

Though not defined as a broadband technology due to speed and bandwidth limitations, dial-up access still exists in many areas of the world, including Portsmouth, Virginia. Dial-up Internet access is a form of Internet access that uses the facilities of the public switched telephone network (PSTN) to establish a connection to an Internet service provider (ISP) by dialing a telephone number on a conventional telephone line.

1.1.2 Digital subscriber line (DSL)

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

The following are types of DSL transmission technologies:

- Asymmetrical Digital Subscriber Line – Used primarily by customers who receive a lot of data but do not send much. ADSL typically provides faster speed in the downstream direction than the upstream direction. ADSL allows faster downstream data transmission over the same line used to provide voice service, without disrupting regular telephone calls on that line.
- Symmetrical Digital Subscriber Line – Used typically by businesses for services such as video conferencing, which need significant bandwidth both upstream and downstream.

1.1.3 Cable modem

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

1.1.4 Fiber-optics

Fiber-optic network technology converts electrical signals carrying data to light and sends the light through transparent glass fibers about the diameter of a human hair. Fiber transmits data at speeds far exceeding current DSL or cable modem speeds, typically by hundreds or even thousands of megabits per second. With fiber-optic broadband networks, speeds in the billions of bits per second range are possible.

The actual speed experienced will vary depending on a variety of factors, such as how close to the premise the service provider brings the fiber, how much bandwidth is configured, and the performance of Internet-based webservers being accessed. The same fiber providing broadband can also simultaneously deliver voice over IP circuits (VoIP) and video services, including video-on-demand.

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

- Fiber to the Node (FTTN) - Fiber to the Node technologies bring high-capacity fiber-optic cables to local service areas and then connect to existing DSL equipment. Rather than bringing fiber-optic cables to every home or business, the fiber is connected to the existing DSL network to increase its capacity. It allows these networks to carry more traffic; however, often the copper-based "last mile" DSL network, connecting homes and businesses to the local nodes, is still a bottleneck and results in subscribers' inability to access the true speeds of fiber-optic connections.
- Fiber to the Premise (FTTP) - Fiber to the Premise (FTTP), also referred to as Fiber to the Home (FTTH), is a technology for providing Internet access by running fiber-optic cable directly from an Internet Service Provider (ISP) to a customer's home or business. Fiber facilitates much faster speeds than DSL and most coaxial cable Internet connections, and generally needs to be serviced less. Fiber is considered one of the most "future proof" types of broadband technology, since there are no foreseeable devices that would exceed its transmission capacity.

Figure 3: Comparison of Internet Connections

Dial-Up – 56Kbps
- Legacy Technology
- Shared Technology
- ADSL – 10Mbps

First Generation of DSL
- Shared Technology
- ADSL2 – 24Mbps

Second Generation DSL
- Shared Technology
- Cable – 150Mbps
- Data Over Cable Service Interface Specification (DOCSIS 3.0)
- Shared Technology

Next Generation Fiber – 1Gbps
- Passive Optical Network (PON), Active Ethernet
- Shared and Dedicated Technology

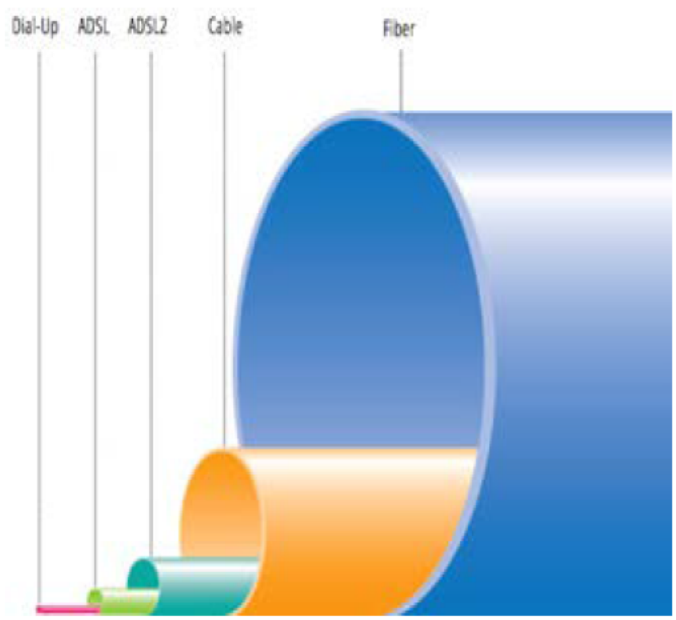


Figure 3 illustrates the relative differences between common Internet access technologies, beginning with basic dial-up service, through DSL, cable, and fiber. Whereas traditional broadband access technologies currently have an upper limit of about 2 Gbps, next-generation broadband that utilizes fiber-optic connections surpasses these limitations and can provide data throughputs of 10 Gbps and greater.[2]

1.1.5 Wireless

Wireless broadband connects a home or business to the Internet using a radio link between the customer's location and the service provider's facility. Wireless broadband can be mobile or fixed. Wireless technologies using longer-range directional equipment provide broadband service in remote or sparsely populated areas where DSL or cable modem service would be costly to provide. Speeds are generally comparable to DSL and cable modem. An external antenna is usually required.

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

Mobile wireless broadband services are also becoming available from mobile telephone service providers and others. These services are generally appropriate for highly mobile customers and require a special PC card with a built-in antenna that plugs into a user's laptop computer. Generally, they provide relatively lower speeds, in the range of several Mbps, e.g., Fourth Generation mobile broadband technology (4G) Long Term Evolution (LTE).

With Fifth Generation mobile broadband technology (5G) deployment in the early stages, we can assume this technology will begin to be utilized in last-mile deployments – if the planned throughput can be achieved. However, it's questionable whether 5G will support residential deployments where multiple high definition (HD) streams and dozens of devices could be connected to the Internet. In addition, while 5G is planned, the fiber providers are beginning to release 10 Gbps capable, fiber to the home networks.

While future wireless technologies hold promise for much faster speeds, it's likely they will continue to lag fiber-optics. Many community anchors (schools and hospitals) do not consider wireless to be an option to support their long-term needs; however, future wireless will be required as an overlay to a fiber-optic backbone. Remote connectivity and the numerous smart city devices coming to market will necessitate ubiquitous high-speed wireless coverage, with next-generation fiber-optic backhaul. As an example, in Santa Monica, CA, the City recently negotiated a small-cell distributed antenna system (DAS) deployment using City owned street lights and fiber connectivity at each DAS placement. Fiber-optic backhaul will continue to drive wireless deployment through 5G and beyond.

[2] Actual speed and quality of service will depend on the specific service contracted by the end user, whether using a traditional broadband service or a next-generation broadband service.

1.2 Portsmouth Network and Services

The City's current technology infrastructure, as that of most municipals, has evolved over the years without the holistic guidance of a strategic plan. Municipal applications tend to be niche and proprietary, fulfilling specific needs with limited ability to take advantage of the modern web-based cloud-centric Internet infrastructure. As such, the network consists of a hybrid mix of commercial services with minimal redundancy or route diversity. In addition, Portsmouth Public Schools and local libraries purchase services that, while funded by the City, are managed by contracts and systems separate from the City network. These services are reimbursable through the federal E-rate program.

The Hampton Roads region includes the following municipalities in Virginia: Chesapeake, Franklin, Gloucester County, Hampton, Isle of Wight County, James City County, Newport News, Norfolk, Poquoson, Portsmouth, Southampton County, Suffolk, Surry County, Virginia Beach, Williamsburg, and York County. The Hampton Roads region has several uncoordinated initiatives in progress involving multiple entities including the cities, the transit authority, the public-school systems, and fiber construction related to the trans-oceanic cable landing. The latter initiative has resulted in substantial fiber construction activity by private broadband companies and Hampton Roads cities alike.

The City currently operates a network incorporating a mix of both commercial and private telecom facilities connecting a total of 47 City buildings for Internet access and application services. The core and access network is built around older generation Cisco equipment. Wi-Fi access points from Aruba Networks are being deployed to replace older generation access points at several City facilities and public venues. Commercial facilities consist of metro Ethernet, Internet access, and Integrated Services Digital Network (ISDN) primary rate interface (PRI) services for voice trunking from Cox Communications. Commercial telecom services are currently sourced through the state of Virginia's VITA contracts. Private facilities consist of two fiber routes and unlicensed wireless facilities. One fiber route connects the city hall data center, E911 center, and the Police Department. This route and its connected facilities currently have no redundancy or diversity in the event of a fiber cut or service outage. City Traffic Engineering manages the second fiber route, that connects a subset of traffic lights for signal control and eight surveillance cameras for intersection monitoring. An additional five cameras are connected by Firetide® mesh radios using unlicensed wireless spectrum. The network supports a variety of applications and Internet access to the City departments. Limited public access to City Wi-Fi is available at a few locations.

1.3 Broadband Market Analysis

1.3.1 Current Market

FE/Magellan conducted research into the state of broadband and fiber networks in the City as related to the Fiber Master Plan. Through this assessment process, we identified the existence of several network operators offering IP access, transport, and dark fiber products.[3] In addition, one network operator expressed interest in talking with the City about their Master Plan and regional initiatives that can be jointly leveraged to gain right-of-way through the City and into the EdgeConneX data center in Norfolk.

Fiber-optic broadband services are available in some areas of the City through multiple providers. In many cases, fiber-optic routes are not available to retail subscribers because of their use as backhaul or metro ring fiber. Private companies own the fiber-based broadband facilities in the City. These companies include the incumbent cable TV MSO[4], the regional incumbent local exchange carrier (ILEC), regional competitive local exchange carriers (CLEC), and Tier 1[5]/Tier 2[6] global telecommunications providers.

1.3.2 Current Broadband Providers

A variety of companies provide broadband infrastructure in the retail markets of the Hampton Roads region.

Verizon is the incumbent local exchange carrier (LEC) provider in the City of Portsmouth. As the incumbent LEC, Verizon provides both retail services to consumers and wholesale services to other telecommunications providers. Verizon provides voice, Internet, and video services. Verizon maintains DSL services and has deployed FiOS selectively throughout the community. Verizon recently completed the acquisition of XO, an international provider of IP transit, Ethernet, VoIP, and cloud services.

Verizon has prioritized expansion of their wireless network and has effectively discontinued expansion of their FiOS markets.

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[3] Dark fiber refers to unused fiber-optic cable. Companies that own fiber-optic cable may “over build” the network capacity to avoid the cost of future expansion.

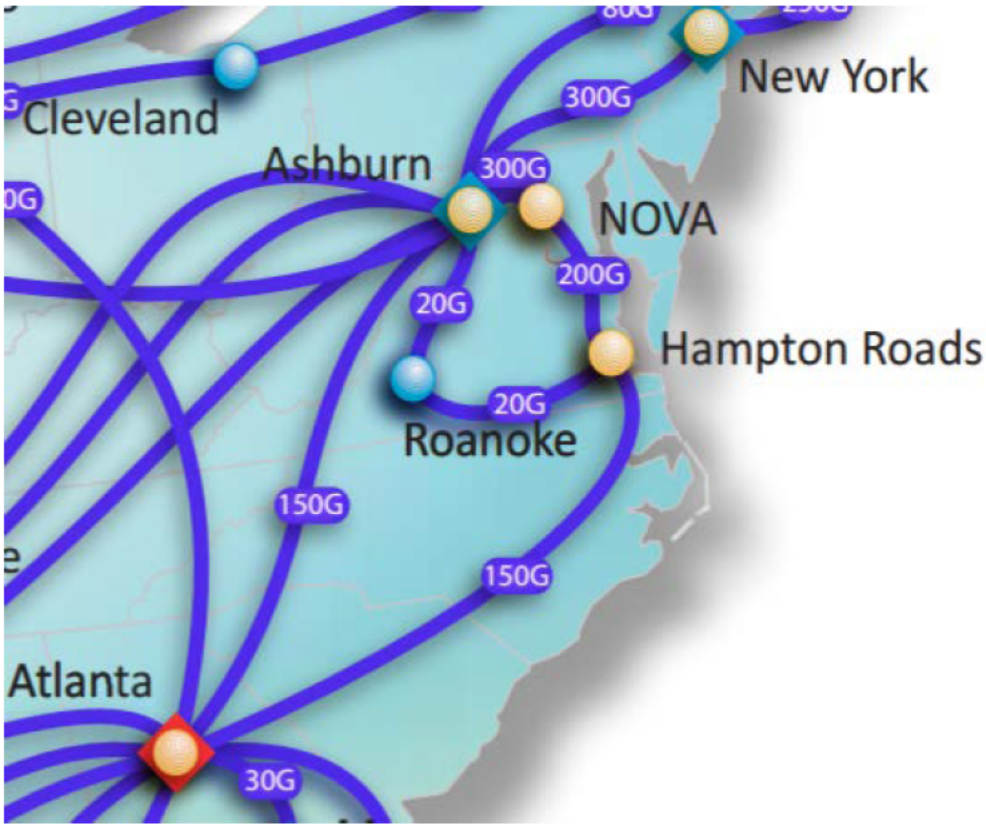
[4] MSO - multiple service operator, or an operator of multiple cable or satellite television systems

[5] Tier 1 - a carrier that owns a significant portion of the network infrastructure and is able to offer competitive service level agreements.

[6] Tier 2 – a carrier that engages in peering with other operators or purchases IP transit to reach some portions of the network.

Cox Communications is a cable TV MSO serving the City of Portsmouth and the greater Hampton Roads region. Cox maintains fiber routes throughout Norfolk County; however, its primary business and residential service offering is delivered to subscribers via coaxial cable. Cox offers voice, Internet, and video services. Gigabit fiber offerings are available in the City on an individual case basis.

Figure 3: Map of Cox Communications Network Connecting Hampton Roads [7]



[7] http://www.cox.com/wcm/en/business/datasheet/brc-backbone-map-q4-2013.pdf?campcode=brc_un_07_101513

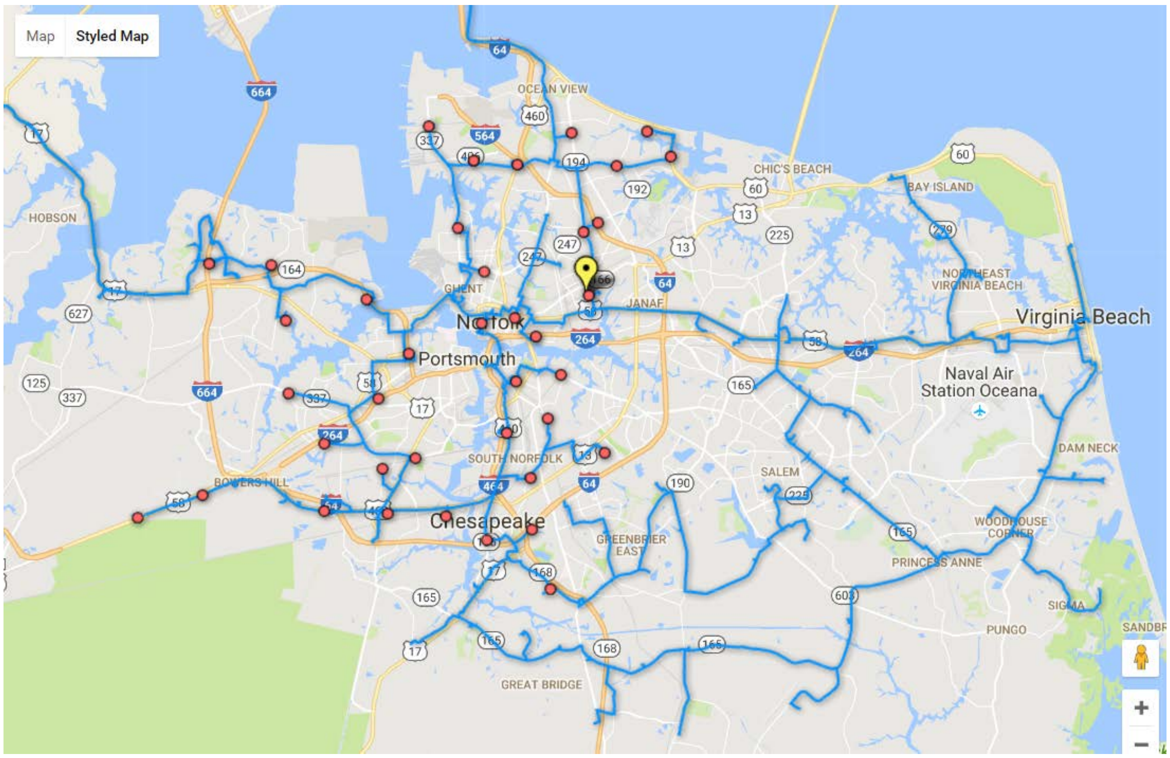
Level (3) Communications is a premiere global communications provider, providing communications services to enterprise, government, and carrier customers. Anchored by extensive fiber networks connecting six continents by undersea facilities, Level (3)'s global services platform features deep metro assets reaching more than 500 markets in over 60 countries. Level (3) maintains fiber routes through the Portsmouth area providing a portfolio of connectivity services including Internet, voice, transport, dark fiber, and other complimentary service offerings.

Figure 4: Map of Level (3) Communications Network Connecting Hampton Roads[8]

[8] http://www.level3.com/~/media/files/maps/en-network-services-level-3-network-map.ashx

Lumos Networks is a regional CLEC providing bandwidth infrastructure services including fiber, collocation, and cloud services. Their customer base includes wireless and wireline carriers, media and content companies, and finance, healthcare, and other large enterprises. Lumos' network in the U.S. provides extensive metro connectivity to thousands of buildings and data centers, in addition to high-capacity wavelength, Ethernet, and dark fiber solutions, Lumos offers cloud service and data center access.

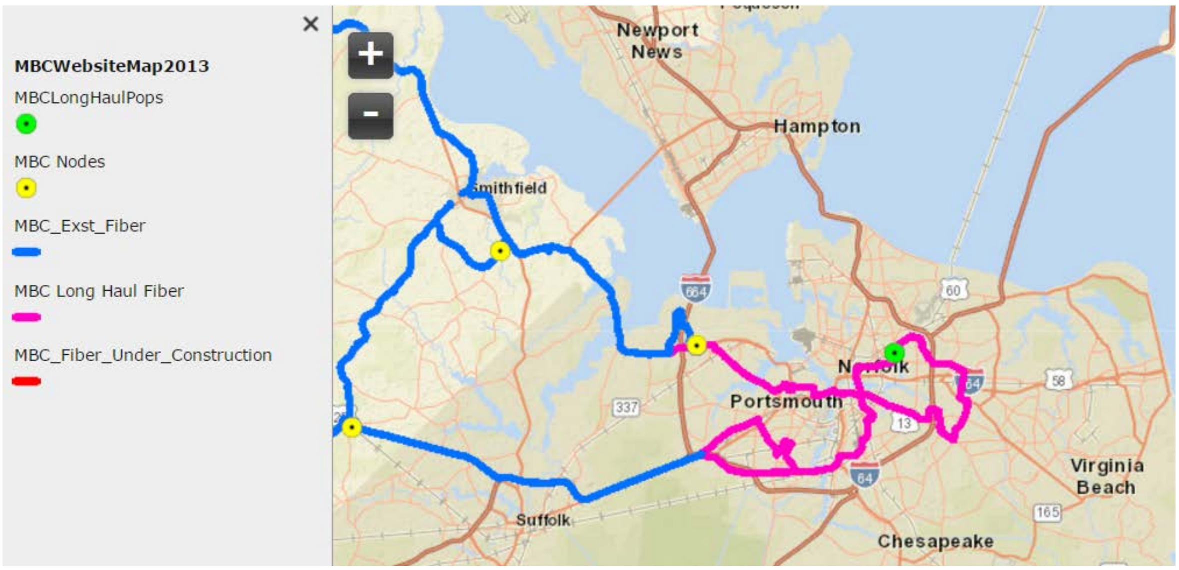
Figure 5: Map of Lumos Networks Network in Hampton Roads[9]



[9] https://www.lumosnetworks.com/business/fiber-maps

Mid-Atlantic Broadband (MBC) provides dark fiber and transport services throughout south and southwest Virginia. MBC was initially funded by the Virginia Tobacco Commission, and therefore has a vested interest in supporting broadband expansion efforts in Virginia. They have participated in a number of partnership opportunities with other fiber network operators to accomplish this goal, and expressed a specific interest in talking with the City about mutually beneficial opportunities to construct fiber routes through the lower Hamptons Road area to reach the project MAREA cable drop in Virginia Beach.

Figure 6: Map of Mid-Atlantic Broadband Network in Hampton Roads[10]



10 http://www.mbc-va.com/interactive-coverage-map/

LIT Networks is a partnership of seven regional fiber networks from Virginia to Georgia that provides seamless optical transport to major carrier collocation facilities and Internet peering points in the mid-Atlantic and Southeast area. This unique partnership of regional networks offers a high level of diversity for enterprise customers looking to connect with U.S. carriers, international carriers, and wireless tower sites. LIT Networks utilizes a common transport platform, which increases the value of its member networks by extending their ability to reach unserved and underserved markets.

Figure 7: Map of LIT Networks[11]

[11] http://www.litnetworks.com/

1.3.3 Data Center Providers

EdgeConneX specializes in providing purpose-built edge of network facilities that enable the fastest delivery of bandwidth intensive, latency sensitive content and applications to local consumers and enterprises. Edge Data Centers (EDC) enable distribution of content at the edge of the Internet. EdgeConneX operates a carrier neutral data center at 3800 Village Avenue, Suite C, Norfolk, Virginia 23502. The 100,100-sq. ft. facility has 5,100 sq. ft. of raised floor tenant racks and maintains first right of refusal on adjacent spaces. It is located three miles from the Norfolk International Airport and four miles from downtown. Customer workspaces are available along with space for secure customer storage. Wi-Fi and cell phone boosters/repeaters are placed throughout the facility. Power is concurrently maintained through parallel redundancy with the use of Power Distribution Units (PDU), Universal Power Supplies (UPS), and generators. The EDC in Norfolk can support 20+kW per rack or cabinet and 600 watts per square foot. The facility was designed to meet Service Organization Controls (SOC) 2 Type 2 standards as well as Open-IX certification. Optional services include, remote hands, design, build, implementation and maintenance of equipment infrastructure. The EDC also features EdgeOS, a data center operating system that provides real time visibility, including ticketing and SLA management. Network and cable operator partners include, COX, Lumos Networks, XO Communications, Cogent, Level 3, and Windstream.

1.3.4 Current Broadband Pricing

As municipal entities, the City, Schools, and Libraries have access to the VITA computing and telecommunication services contracts. Portsmouth and Portsmouth Public Schools currently purchase broadband and telecommunication services from Cox Communications, an approved VITA contractual provider. Other approved service providers are available based on zip code, although Cox is currently has connectivity through the metro-e ring. Figure 4 provides examples of the VITA fiber-based contract service tiers and pricing on certain services currently purchased by the City:

Figure 4: VITA Pricing for Fiber to the Premise Service Tiers[12]

Fiber to premise

Options for this technology in your area

Details	Tier 1	Tier 2	Tier 3	Tier 4	Tier 5	Tier 6	Tier 7	Tier 8	Tier 9	Tier 10	Tier 11	Tier 12	Tier 13	Tier 14	Tier 15	Tier 16
Download Speed, Minimum	<1 mbps	<5 mbps	10 mbps	20 mbps	40 mbps	100 mbps	200 mbps	400 mbps	600 mbps	800 mbps	1,000 mbps	2,000 mbps	4,000 mbps	6,000 mbps	8,000 mbps	10,000 mbps
Installation Fee	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
Monthly Service Fee	$350.00	$650.00	$750.00	$860.00	$1,115.00	$1,667.00	$2,754.00	$3,562.00	$3,888.00	$4,111.00	$4,393.00	$7,240.00	$13,932.00	$19,620.00	$25,637.00	$29,950.00
First Static IP Fee	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
Additional Static IP Fee	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
Voice Business Line Install Fee	$50.00	$50.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$50.00	$50.00	$50.00	$50.00	$50.00
Voice Business Line (w/LD)	$39.78	$29.68	$29.68	$29.68	$29.68	$29.68	$29.68	$29.68	$29.68	$29.68	$29.68	$39.78	$39.78	$39.78	$39.78	$39.78
Suppliers	2	3	5	5	5	5	5	5	5	5	5	3	3	3	3	3

Figure 5 shows that the VITA contract's lowest cost for 2 Gbps of Internet (Tier 12) is currently priced at $7,240 per month, or $3.62 per megabit (Mb). Retail rates for Internet access service are determined largely by the level of competition for a particular suite of broadband services within the Portsmouth market. Pricing is typically comprised of two components, including the IP transit service (IP port) and the metro/access network facilities that deliver those services to the customer premise (transport).

[12] http://vita2.virginia.gov/procurement/BroadBandZipSearch.cfm

Figure 5: VITA Pricing for 2Gbps Fiber-based Internet Access Service[13]

Fiber to premise - Tier 12 - Download Speed, Minimum 2,000 mbps

Vendor pricing detail

Fees	BrightStar Communications, Inc.	Cox Virginia Telcom, LLC	Lumos Networks, Inc.
Download Speed, Minimum	2,000 mbps	2,000 mbps	2,000 mbps
Upload Speed, Minimum	2000	2000	n/a
Installation Fee	$500.00	$125.00	$0.00
Monthly Service Fee	n/a	$11,000.00	$7,240.00
Installation Fee with 3 Year Contract	$500.00	n/a	$0.00
Monthly Service Fee with 3 Year Contract	$9,236.50	n/a	$6,694.00
First Static IP Fee	$0.00	$0.00	$0.00
Additional Static IP Fee	$10.00	$5.00	$0.00
Time and Materials Hourly Rate	$135.00	$125.00	n/a
Voice Installation Fee	n/a	$50.00	n/a
Unlimited Voice Fee	n/a	$39.78	n/a
View Contract	BrightStar Communications, Inc.	Cox Virginia Telcom, LLC	Lumos Networks, Inc.

**Brightstar Communications, Inc. is a network integrator/reseller and does not own network facilities in the City.

For purpose of example, we have priced IP transit directly from two carrier collocation data centers to demonstrate the variance in cost components.

The first example assumes the City has access to dark fiber and possibly collocation in the EdgeConneX data center in Norfolk, Virginia:

10 Gbps Ethernet Transport Service	$0 (allocation of dark fiber collocation)
2 Gbps IP Transit Service	$2,200 ($1.10 per Mb)
Cross-Connect	$400
Total 2 Gbps Internet Service	$2,600 ($1.30 per Mb)

13 http://vita2.virginia.gov/procurement/BroadBandZipSearch.cfm

This example provides 2 Gbps of Internet service at $2,600 per month, or $1.30 per Mb.

The second example is from Equinix in Ashburn VA, and assumes the City purchases 10Gbps transport from Mid-Atlantic Broadband:

10 Gbps Ethernet transport service	$4,250
2 Gbps IP transit service	$2,051 ($1.03 per Mb)
Cross-connect	$375
Total 2 Gbps Internet service	$6,676 ($3.34 per Mb)

This example provides 2 Gbps of Internet service at $6,676 per month, or $3.34 per Mb.

Note that both examples leave 8 Gbps of transport bandwidth available for IP transit growth at only the incremental cost per Mb. This would result in a full 10 Gbps Internet service cost of $11,400 per month ($1.14 per Mb) and $14,885 per month ($1.4 per Mb) respectively. We have priced bulk IP transit as low as $0.40 cents per Mb on a 36-month term where good competition exists within a collocation center.

Figure 6: VITA Pricing for 100Mbps Metro Ethernet Fiber Services[14]

Ethernet Private Line, Point to Point, Premium - Tier 6 - Download Speed, Minimum 100 mbps

Vendor pricing detail

Fees	BrightStar Communications, Inc.	Cox Virginia Telcom, LLC	Lumos Networks, Inc.
Download Speed, Minimum	100 mbps	100 mbps	100 mbps
Upload Speed, Minimum	100	100	n/a
Installation Fee	$500.00	$0.00	$0.00
Monthly Service Fee	n/a	$1,249.00	$1,288.00
Installation Fee with 3 Year Contract	$500.00	n/a	$0.00
Monthly Service Fee with 3 Year Contract	$1,374.75	n/a	$1,095.00
First Static IP Fee	$0.00	$0.00	$0.00
Additional Static IP Fee	$10.00	$5.00	$0.00
Time and Materials Hourly Rate	$135.00	$125.00	n/a
Voice Installation Fee	n/a	$50.00	n/a
Unlimited Voice Fee	n/a	$39.78	n/a
View Contract	BrightStar Communications, Inc.	Cox Virginia Telcom, LLC	Lumos Networks, Inc.

**Brightstar Communications, Inc. is a network integrator/reseller and does not own network facilities in the City.

[14] http://vita2.virginia.gov/procurement/BroadBandZipSearch.cfm

1.4 Broadband Needs Assessment

The surge of popularity of the Internet in recent years has led to a monumental increase in its capabilities and has tightly integrated its use into the everyday workings of both municipalities and their constituents. As municipalities and their constituents discover more beneficial applications, each of which require an increasing amount of bandwidth capacity, communities are finding that their broadband service needs are not being met. In response, communities are leveraging a variety of tools to stimulate broadband investment, with the goals of increasing access, adoption, and utilization of broadband.

As part of the needs assessment process, the ***FE***/Magellan Advisors' project team traveled to Portsmouth in October of 2016, and engaged in open and candid discussions with key City staff, educational community anchors, neighboring city leaders, and regional transportation agencies. The goal of the discussions was to focus on the long-term needs of the City for expanded fiber infrastructure to support communications, technology, wireless opportunities, disaster recovery, emergency communications, and transportation (mobility). Through these meetings, we were able to develop a more comprehensive understanding of their current and future broadband and technology needs with regard to the implementation of a Fiber Master Plan. The City's plan will outline a multi-year roadmap of tasks the City can undertake to develop a Broadband Infrastructure Program that will have significant positive effects on the Portsmouth community, including many of the organizations and groups that participated in the outreach meetings. All participants viewed high-speed broadband connectivity as a necessity for their organizations and explained what expanded access means to their specific operations.

1.4.1 Community Stakeholder Insight

1.4.1.1 Government and Public Services

The City understands the importance of broadband infrastructure and high-speed Internet to City facilities and community anchor locations. While the City does not currently own any significant fiber assets, it does have available conduit throughout many major corridors, much of it being occupied by legacy copper cables which are used to operate the City's traffic network, in support of signalization and operations.

The City currently owns some decorative light poles in the downtown area but Dominion Power owns the clear majority of pole line infrastructure within the City. There are two City owned data centers within the City. The main data center is in the City Hall building along with an additional disaster recovery site located at the Hampton Roads Regional Jail. The City Hall generator is at its load capacity, which leaves no room for any growth required by data center augmentation or City network expansion. The load capacity of the existing Hampton Roads Regional Jail generator is unknown. Furthermore, the current location of the City Hall generator is problematic. This generator is in the lower level parking garage, which is prone to flooding during heavy rain events, putting the equipment at risk for damage or ruin. This placement poses a significant risk to the City as the generator may be undependable under certain types of natural events.

The City of Portsmouth has one existing towers for the Land Mobile Radio (LMR) System with microwave backhaul from Fredrick Boulevard and City Hall/Jail, with plans to add a second tower. The City has also been approached by various vendors interested in leasing vertical assets with regard to small cell deployments in and around the City. At the time of this report, the City has not entered into any agreements with any of these vendors.

The City does own some fiber assets. It currently maintains fiber interconnecting City Hall, the Police Department, and the 911 Dispatch Center. The City also has two fiber loops (one complete and one in progress) connecting nearly 37 of its 122 traffic signals within the City. The City currently has a fiber project underway, as of the date of this report, to connect the Portsmouth Pavilion to City Hall. At this point all City policies regarding fiber infrastructure construction and "dig once method" initiatives are completely verbal. The City has monitored and controlled this primarily through its permitting process but the City agreed a formal policy needs to be in place moving forward to better manage and control future build outs.

In planning for this Fiber Master Plan, meetings with the City stakeholders produced the following goals:

1. Integrate all existing City fiber and conduit into the Fiber Master Plan being prepared by ***FE***/Magellan Advisors.
2. Plan to interconnect all existing and planned LMR tower sites with fiber backhaul to increase reliability and redundancy of the system.
3. Create a resilient fiber ring around the City connecting core facilities with laterals connecting secondary facilities as well as creating multiple redundancies for 911, public safety, and disaster response and recovery operations.
4. Prepare for connectivity demands that will be brought about through the trans-Atlantic fiber landing coming to Virginia Beach.
5. Develop City policies and procedures for "dig once" methodology and vertical asset leasing.

The objectives outlined in the Fiber Master Plan and the conceptual network backbone design will place the City in a position to interconnect with the other six Hampton Roads cities. These goals are valid and vital in the future scope of fiber connectivity and communications throughout the City and the greater region.

1.4.1.2 Engineering & Technical Services Department

The City Utilities Department has several divisions that include: administration, engineering, customer service, operations, and water production. The administration and engineering office is responsible for supporting and leading the departments operational division and provides project design, construction management, and contract administration for the department's construction projects. Customer service is responsible for meter reading, billing, and revenue collection. The operations division has two main responsibilities which are to operate and maintain water transmission and distribution systems as well as operate and maintain the City's sewage collection and transmission.

Twenty-four-hour emergency response is provided through field operations for water and sewage related issues in the City. The water production division maintains, delivers, and protects the City's water resources through various water quality initiatives. The utilities department does not have formal policies on dig once or conduit-in-trench; however, the department was responsible for installing conduit on a past project for the City's Police Department.

Sensus is the City's vendor for Advanced Metering Infrastructure (AMI) technology and currently over 32,000 meters are deployed throughout the City. Water levels, pumps, and pump stations are controlled and monitored through a Supervisory Control and Data Acquisition (SCADA) control system architecture. The utility departments' future technology strategy includes future mobile systems that would run off Wi-Fi or microwave. The City is also considering replacing the discontinued Automatic Vehicle Location (AVL) system in the first responder vehicles. The previous AVL system was discontinued through the suggestion of the City attorney for possible privacy violations. The City is considering replacement and extension throughout the City over a Wi-Fi mesh network with the fiber backbone.

1.4.1.3 Portsmouth Redevelopment and Housing Authority (PRHA)

The Portsmouth Redevelopment and Housing Authority (PRHA) has a total of 12 communities with numerous bedroom and layout configurations. Nine of the communities were developed under the HOPE VI Revitalization Program in conjunction with the United States Department of Housing and Urban Development (HUD). The mission of the PRHA is to create jobs, expand the City's tax base, and improve the quality of life for its citizens. It is staffed with over 100 resources and is governed by a seven-member Board of Commissioners. The PRHA is served by a COX based multi-protocol label switched (MPLS) system for phone and a 100 Mbps/20 Mbps asymmetrical Internet circuit.

There are approximately 3,600 total residents within the various communities. Currently, the Authority does not offer Internet services to its residents. There are some laptops and desktops available to residents but no formal program for Internet connectivity or access is in place. Wi-Fi was deployed at one point in the Westbury development but was later discontinued due to funding constraints. Future opportunities include structured wiring in the Administration office, public Wi-Fi available at the Parks and Recreation sites within the City, and Wi-Fi deployment in public areas of the housing units.

1.4.1.4 Portsmouth Public Schools

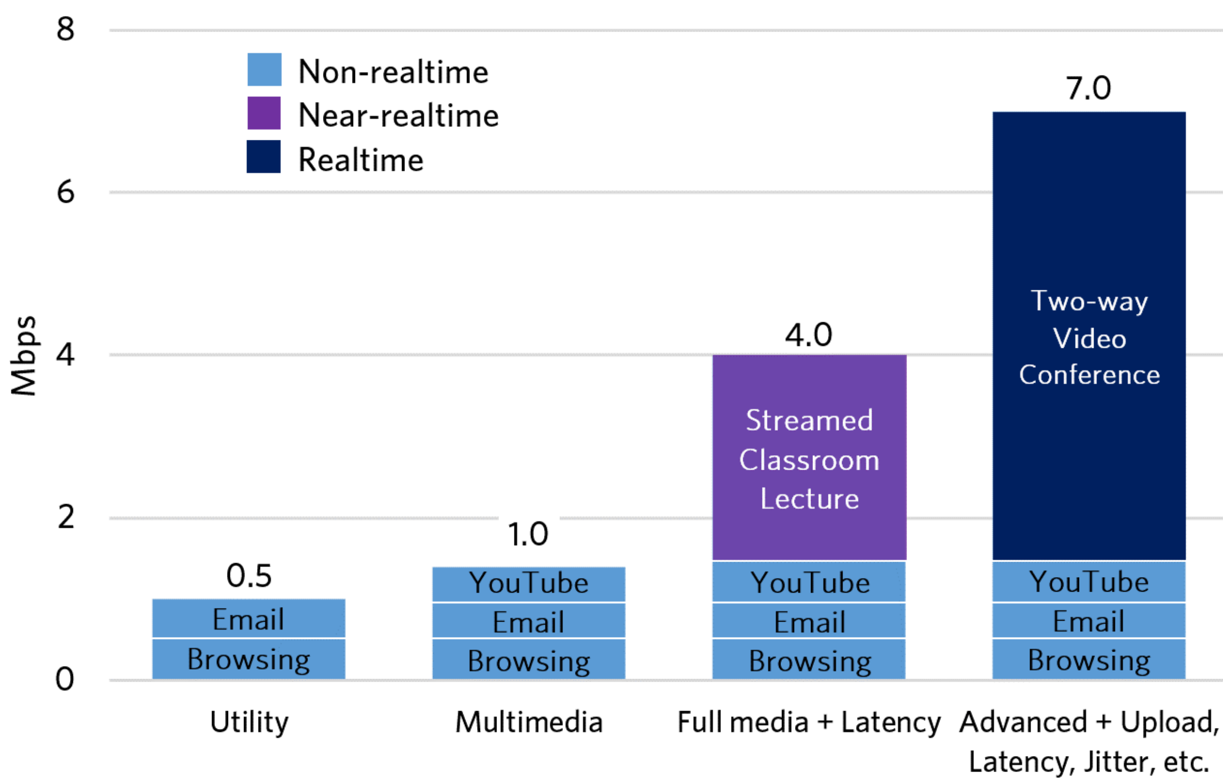
The Portsmouth Public School System operates a network incorporating commercial metro Ethernet services connecting 25 facilities comprised of three high schools, three middle schools, 14 elementary schools, and five special centers including an administration building and a data center. Data is stored locally at the schools and Wi-Fi is self-managed by the schools with wireless Cisco controllers. Applications managing student and staff information were originally hosted internally but has since been moved to the cloud. The school system's local area network can deliver 1 Gbps to the desktop, but the cost of wide area bandwidth places budgetary constraints on the effective delivery of that data rate.

Portsmouth Public Schools takes part in the Virginia E-learning backpack initiative. The initiative's goals are to improve student achievement, graduation rates, and extend learning capabilities through a tailored learning experience for at-risk schools. Through these initiatives, the City's students have nearly 4,000 devices in use. The technology strategy is partially funded through E-rate WAN (Wide Area Network) services and equipment. The possibility of acquiring additional funding from E-rate to fund future fiber infrastructure throughout the City, making the schools part of the municipal fiber ring, is viewed as a future opportunity.

In response to increased demand for integrating technology into the curriculum, Virginia and many other states have instituted requirements for online testing, creating an even greater need for high-quality broadband services for schools. Additionally, educational institutions are utilizing more online content to support their lesson plans, from streaming sources such as YouTube, TeacherTube©, Vimeo©, and Facebook©. Portsmouth Public Schools sees the need for increased bandwidth as these new academic programs and technologies demand significant amounts of bandwidth. School district technology goals include supporting virtual learning, learning through technology, and giving students the knowledge and skills they will need to be successful in college and in the future workforce. In addition, the schools view E-learning as a growing initiative with the majority of the devices in the hands of high school students; however, there is the possibly of this initiative making its way into the middle schools in the near future.

Figure 7 illustrates the bandwidth requirements per student for common educational applications and the quality and performance requirements of these applications. Basic educational tools, such as web browsing and YouTube can consume up to 1 Mbps per student. However, as Figure 7 demonstrates, moving up to more advanced educational technologies such as streamed classroom lectures and 2-way video teleconferences require significantly more bandwidth per student, when combined with the basic educational tools. In addition, these advanced tools require not only require more bandwidth but also strict broadband quality metrics that allow them to function properly, such as low latency and higher upload speeds.

Figure 7: Bandwidth Download Demands for Concurrent Applications



1.5 Regional Initiatives

1.5.1 Hampton Roads Transit

The Hampton Roads Transit (HRT) team discussed future initiatives to improve the transit system efficiency and passenger experience that, if fully realized, will require regional cooperation on a broadband strategy. The HRT modes of transportation include a 36 car / 274 stop bus system, a nine car / 4,500 passenger-per-day light rail system, and a ferry with three landings between the City and Norfolk. Two new ferries are planned with technology for electronic fare collection. A para-transit system is also available to passengers within ¾ mile of the bus routes. Surveillance security is currently recorded local to each vehicle. HRT plans to expand the system into Virginia Beach, and desires to conduct research on integrating transit systems with smart city initiatives. However, research funding is extremely limited.

While HRT owns some fiber along the transit rail system, these smart transit initiatives will require coordinated wired and wireless broadband support throughout the HRT system, and a real time AVL. AVL makes use of the Global Positioning System (GPS) to enable a business or agency to remotely track the location of its vehicle fleet by using the Internet. These devices combine GPS technology, cellular communications, street-level mapping, and an intuitive user interface, with the goal of improving fleet management and customer service. HRT could, for example, use an AVL system to pinpoint the longitude, latitude, ground speed, and course direction of a given passenger vehicle and provide information to passengers using a mobile app on the status and arrival of the vehicle. AVL systems could also enable HRT to structure passenger routes and schedules more efficiently through data acquisition and analytics.

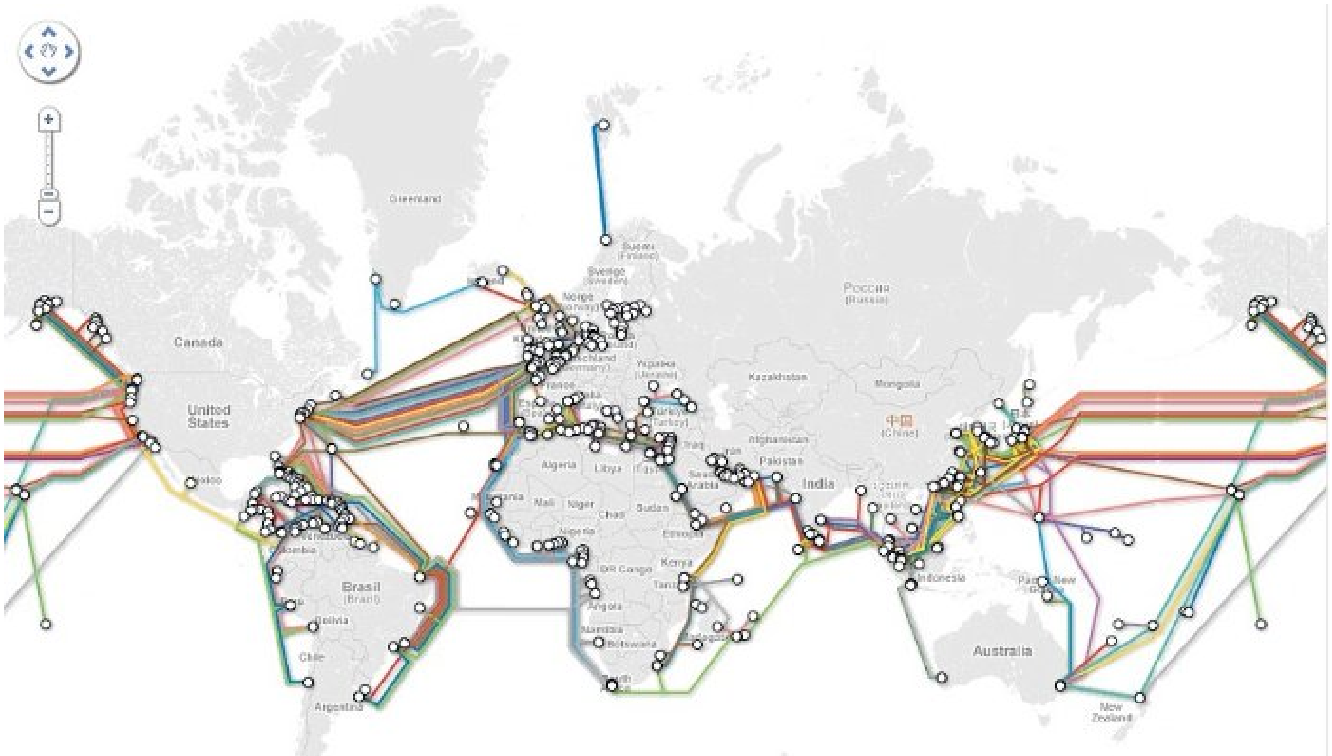
Potential passenger amenities discussed include services such as Wi-Fi on the transit vehicles, support for mobile payment systems, vehicle tracking, and smart signage. Regional cooperation on a fiber and wireless broadband strategy will be required to fully realize the potential of a smart transit system.

1.5.2 Project MAREA

Facebook and Microsoft collaborated with Telefonica International Wholesale Services USA Inc., to build the first transoceanic fiber cable station in the Mid-Atlantic at Corporate Landing Business Park near General Booth Boulevard. The project, called MAREA (Spanish for “tide”), will lay a trans-Atlantic fiber cable 6,600 kilometers from Virginia Beach, Virginia, to Bilbao, Spain. The cable will provide bandwidth of up to 160 terabits per second, and will provide intercontinental connectivity for the partner’s data centers and Telefonica’s global network. The companies commenced work in August 2016 and are expected to complete the project by October 2017.

Several broadband service providers are planning to capitalize on the growth in transport and data center services the project will foster by constructing fiber into the Hampton Roads area. Some of these carriers, such as Lumos Networks, will also provide competitive retail alternatives for WAN and Internet services. Other carriers, such as Mid-Atlantic Broadband Communities, will be looking for opportunities to collaborate with the Hampton Roads cities to create fiber route diversity and extend the cable drop to partner data centers located elsewhere in Virginia.

Figure 8: Map of Sub-Sea Cable Routes[15]



1.5.3 Hampton Roads Planning District Commission (HRPDC) Ring

The five counties and nine cities of the Hampton Roads area are ideally suited for a regional network and the benefits of cost savings in shared services it brings. The region's CIO's have discussed a fiber network connecting their nine cities and specific benefits to be realized, such as shared disaster recovery, public safety communications, data center access, and IP transit services. In addition, Tidewater Community College (TCC) has expressed an interest in connecting their campuses together in a private transport network, and to Old Dominion University for connectivity to the Internet2[16]. Dr. Edna Baehre-Kolovani, president of TCC, has led an effort to define two possible routes for a regional network. Mid-Atlantic Broadband has an interest in the northern route of a ring traversing the City into Norfolk, for entry into the EdgeConneX data center and termination at MAREA landing in Virginia Beach.

[15] http://pilotonline.com/news/local/microsoft-facebook-pick-virginia-beach-to-build-transoceanic-high-speed/article_7f8f4cfb-365b-5d9b-aec1-be69f104f4c9.html; http://www.bizjournals.com/sanjose/news/2016/05/27/facebook-and-microsoft-partner-to-lay-trans.html

[16] Internet2 is a member owned advanced technology community network funded by the nation's leading higher education institutions in 1996. http://www.internet2.edu/

2.0 Portsmouth Community Broadband Network

2.1 Fiber Expansion Initiatives

The City demonstrated vision, boldness, and fiscal responsibility in their pursuit of developing a strategic Fiber Master Plan. Understanding that a fiber network is a utility that can serve as a common physical communications infrastructure for all City services and community stakeholders provides a vision for the plan. Looking beyond the City's own needs by incorporating input from community and regional stakeholders demonstrates the collaboration needed to ensure buy in from all potential stakeholders. Fiscally responsible execution of the plan is achieved by creating uniform policies for fiber deployment, right-of-way management, leveraging existing infrastructure where possible, seeking out joint opportunities to construct and lease fiber with other regional and carrier partners, and to recover and retain E-rate monies within the community. From this perspective, the backbone network has been designed to support the City's growing broadband needs across a range of functions and public initiatives. Designing the network in this manner maximizes the City's opportunities to use the network for the purposes defined in the framework below.

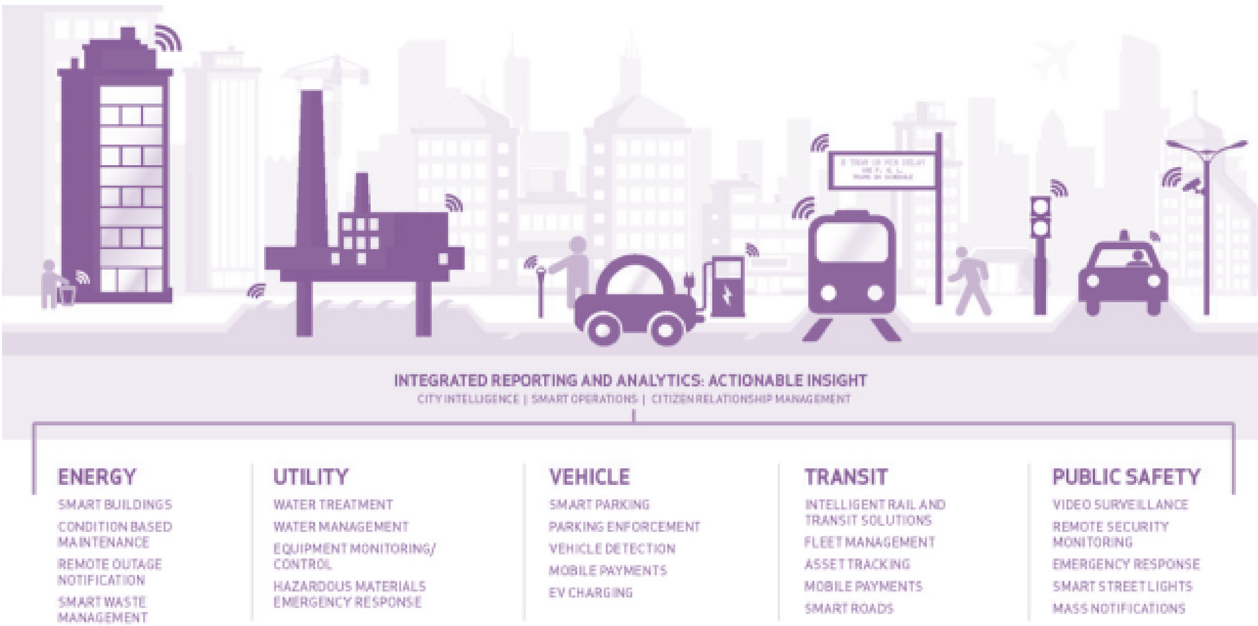
2.1.2 Disaster Preparedness and Emergency Communications

The fiber network is a critical communications infrastructure that allows the City to maintain communications during times of emergency, allowing first responders and public safety to maintain communications even when many of the commercial services are unavailable, due to power outages and downed lines. As the network expands, it may be used as a resource to enhance emergency operations, allowing any facilities connected to the network to communicate with one another. Expanding the network also facilitates the placement of additional surveillance cameras throughout the City, enabling public safety personnel to monitor conditions throughout the community. Furthermore, field connections to the network, or "hitching posts", can allow public safety personnel to attach to the network in key areas of the City permitting connections with the Police Department and Fire stations.

2.1.3 Municipal and Smart City Technologies

The network will support the City's current operations and is an asset to continue to drive efficiencies, reduce cost, and expand capabilities. The network as proposed is robust, redundant, and reliable. It may be employed as a tool that can be used between departments to support their business needs. With an eye towards the future, many applications and services that are collectively referred to as "Smart City" efforts are not possible without a well-designed fiber backbone. This backbone serves as a means of robust data collection and support infrastructure for identifying problems through data analysis.

Smart city technologies are emerging as municipal functions also evolve to become more connected. Smart city technologies are transforming many traditional municipal operations including transportation, public safety, development, education, governance, energy, and utilities. Nearly all smart city technologies require some type of connectivity, either wired or wireless. The City's network expansion should be able to accommodate these future smart city technologies as they are deployed across the City. This means greater capacity, more access points, unique routes and interconnection with vertical assets to support more wireless connectivity. Energy, utility, vehicle, transit, and public safety are all municipal functions that benefit from smart city initiatives; however, the network must be designed considering the principles supporting these services.



Network Design Principles Supporting Municipal and Smart City Services

1) Support City Utilities
    a. Determine opportunities to enhance SCADA systems with fiber connectivity
    b. Document utility district asset locations for potential connectivity
    c. Design the network to provide fiber access points to these locations
    d. Enable sufficient capacity in the network to support SCADA security and resiliency requirements

2) Support Connectivity to Parks and Recreation Facilities
    a. Pass City parks with fiber for future deployments of cameras
    b. Enable fiber access in City parks to support public Wi-Fi services

3) Support Future Smart City Technologies
    a. Design the network with sufficient strand capacity to support future applications
    b. Maximize fiber access points to support sensor network deployment and wireless connectivity
    c. Create splice points at all key intersections
    d. Plan fiber access points and termination for sensor networks
    e. Size fiber vaults, handholes, and splice cases appropriate to facilitate future growth in a multi-application environment

2.1.4 Economic Development

The network will become a platform that the City can use to support economic development programs that attract new businesses and retain existing ones. There are a variety of business models that the City could consider employing that allow businesses to access the City fiber. Some of these are executed through partnerships with broadband providers.

Network Design Principles Supporting Economic Development:

1) Attract New Business
    a. Identify commercial growth areas
    b. Design the fiber backbone network to commercial growth areas within the City
    c. Use fiber as part of the City's competitive advantage to complement other incentives
    d. Develop a strategy for last-mile infrastructure to connect new businesses to the backbone

2) Expand Local Industries
    a. Identify the locations and types of high demand broadband users
    b. Design the fiber backbone network to reach areas with the highest concentrations of these users and growth areas for these users
    c. Develop a plan to make affordable, high performance fiber connectivity available to these users

3) Retain and Expand Existing Businesses
    a. Identify areas of greatest revenues for the City
    b. Identify areas of greatest employment for the City
    c. Support redevelopment areas in neighborhood shopping centers
    d. Design the fiber backbone network to provide access into these areas
    e. Develop a plan to make affordable fiber connectivity services available to promote retention and growth of current businesses
    f. Work with Economic Development to aggregate demand for last-mile connectivity to the City's backbone network

4) Support Teleworking and Home-Based Businesses
    a. Use business data to identify concentrations of home-based businesses across the City
    b. Identify concentrations of home-based businesses in the City, commuting patterns, and teleworking trends
    c. Design the fiber backbone network along key residential thoroughfares that may provide future potential to connect neighborhoods in partnership with broadband providers
    d. Work with neighborhood organizations to aggregate demand for last-mile connectivity to the City's backbone network

5) Promote the City as a Connected Community
    a. Work with broadband providers to solicit interest in using the City's broadband infrastructure
    b. Develop a plan to interconnect the City network to local data centers

c. Identify immediate opportunities to use existing assets and small incremental investments that will show immediate progress and demonstrate City's capabilities to execute
d. Identify potential users within close proximity to existing network assets
e. Identify pilot projects and develop business cases
f. Market the network as a resource of the City that contributes to the City's status as a highly-connected community for business

2.1.5 Public Safety

Public safety agencies in the City could benefit from additional connectivity, interconnecting agencies with one another and providing added redundancy for mission critical applications. The network could supplement current connectivity in some areas and replace it in other areas, providing significantly higher speeds at similar costs. The connectivity improvements that could be seen from interconnecting the multiple public safety agencies on a single, robust dark fiber backbone include enhanced dispatch abilities, improved communication in the event of an emergency, and preserving opportunities for future enhancement.

In addition, the City is currently planning to construct a new 800MHz simulcast Land Mobile Radio system with Federal Engineering as its project manager. Fiber connectivity between all LMR sites would provide added redundancy to the microwave system that's scheduled to support that implementation.

Network Design Principles Supporting Public Safety

1) Support More Access to Video Applications
   a. Set aside capacity to support fiber connectivity at intersections for video cameras, in conjunction with intelligent traffic systems.

2) Support High Security, High Resiliency Communications
   a. Design fiber network to maintain compliance with law enforcement security standards
   b. Design high levels of redundancy into the network to support mission critical applications
   c. Interconnect LMR tower sites with fiber
   d. Facilitate communications and technology sharing between public safety organizations

2.1.6 Healthcare

Healthcare organizations are carrying out more of their business operations online. With the transition to electronic healthcare, these organizations and the residents they serve require access to high quality, reliable broadband services. As more virtual healthcare and telehealth services are deployed into residents' homes, these organizations will rely on their connectivity to ensure the health of their patients, which requires high quality broadband for healthcare organizations themselves and within patients' homes. The City's network will have future capabilities and capacity to support the City's healthcare organizations, enabling them with fiber connectivity to interconnect hospitals, doctor's offices, clinics, and imaging centers, supporting their implementation of digital healthcare programs for the City's citizens.

Network Design Principles Supporting Healthcare

1) Enable high-quality, resilient access to healthcare organizations
    a. Identify hospitals, clinics, doctor's offices, and other healthcare organizations across the City
    b. Design the network to pass as many of these organizations as is economically feasible
    c. Design the network to provide fiber access points to these locations
    d. Consider designs that create redundant ring connectivity to support redundancy to support mission critical healthcare needs
    e. Consider impact to neighborhoods to support telehealth applications

2.1.7 Education

The City's network can continue to serve educational needs by expanding to more public and private schools and institutions of higher education.

Network Design Principles Supporting Education

1) Support high-quality, resilient Internet access at school facilities
    a. Identify school facilities across the City
    b. Design the network to pass as many of these organizations as is economically feasible
    c. Design the network to provide fiber access points to these locations
    d. Design the network for potential regional interconnection with research and education networks, such as Internet2

2) Support increased access and adoption of Internet services for students
    a. Identify locations where public Internet access may be improved, including libraries, community centers, and Wi-Fi hotspots
    b. Design the network to provide fiber access points to these locations
    c. Allocate sufficient capacity and splice points to support Wi-Fi in public places, schools, and libraries that may facilitate more public access to the Internet
    d. In conjunction with the residential Network Design Criteria, design the network to pass neighborhoods to facilitate potential upgrades by broadband providers

2.1.8 Gigabit Broadband (Business and Residential)

A municipal backbone network could become a catalyst to accelerate deployment of leading edge broadband services in the City. Development of this network presents an opportunity for the City and private providers to work together to bring the latest fiber to the home technologies to City residents. By lowering cost barriers to deploy fiber to the home through its fiber backbone, the City can take an active role in expanding benefits of gigabit broadband to citizens. These partnerships could yield positive economic and social benefits to the Portsmouth community.

Network Design Principles Supporting Gigabit Broadband

1) Accelerate the deployment of fiber broadband technologies
    a. Identify locations where current broadband providers maintain facilities, huts, distribution points, dark fiber, and other assets
    b. Design the network to pass existing provider assets and plan interconnection points that may facilitate the use of the City's fiber
    c. Design the network to provide fiber access points to these locations
2) Support non-discriminatory access to the City's network to facilitate consumer choice
    a. Design the network to support sufficient capacity that enables multiple providers to utilize the City's fiber
    b. Develop policies and procedures to support open-access interconnection policies

2.2 Key Initiative 1: Develop Fiber-Friendly Public Policies

2.2.1 What are Fiber–Friendly Public Policy Tools?

Fiber-friendly public policies are tools that municipalities can utilize to accelerate deployment and reduce the cost of constructing broadband infrastructure within their jurisdictions. These policies align the City's utility and public works functions to provision for installation of broadband infrastructure whenever there is an opportunity. They utilize capital projects such as road widenings, water, sewer and street lighting improvements to facilitate the inclusion of underground conduit and in some cases fiber. By utilizing these projects, the cost of installing underground conduit is greatly reduced because in many cases, trenches have already been opened for other utility infrastructure or utility relocations. This affords the City to install underground conduit without the significant labor costs that would otherwise be borne in the construction. These policy tools are implemented according to each city's ordinances, processes and function; there is no "cookie cutter" approach to implementing them; however, there are a range of best practices and guidelines that many cities follow.

2.2.2 Comprehensive Broadband Standards and Joint Trenching Policies

Integrating broadband "utility" standards into the City's land development code will enable the City to incorporate basic broadband infrastructure requirements into the land development process and encourage broadband construction to occur in conjunction with other capital projects. Road widening, sidewalk, trail, and lighting projects all may be opportunities for the installation of basic conduit infrastructure at favorable costs. By installing conduit in concert with these related capital projects, the City can avoid incurring the significant costs of constructing this infrastructure by doing so when the ground is already open. Since the majority of costs to build broadband infrastructure in the City are incurred through trenching, boring, and restoration this strategy can alleviate some costs of constructing underground infrastructure. The City, in alignment with its Capital Improvement Plan (CIP), can determine which projects will benefit the construction of usable broadband infrastructure.

This process should also be coordinated with local service providers to minimize overbuilding and to ensure that service providers have an opportunity to collocate their infrastructure in the City's capital projects when feasible. Joint trenching policies between the City, utility companies and broadband providers can facilitate more opportunities to install conduit, fiber, and other infrastructure at much lower costs. Joint trenching agreements are developed between public and private organizations to minimize the cost of constructing conduit in the local area, by allowing each entity to take advantage of trenches that have been opened through each other's projects. Standardization of these agreements across all potential owners of underground infrastructure can be established to ensure all parties are aware of the joint trenching opportunities as they become available.

2.2.3 Record Keeping

As part of implementing broadband-friendly public policy measures, the City should require that Geographic Information System (GIS) documentation of all broadband infrastructure installations, upgrades, et al. be maintained and updated as incurred. This will allow the City to maintain a clear understanding of locations of the broadband infrastructure such as conduit, vaults, pull boxes, transitions, fiber-optic cable, and other outside plant resources. As the City grows its fiber, it may also want to consider investing in an asset management system specific to fiber networks. There are several Fiber Management Systems available that provide the functionality required to adequately document and record broadband infrastructure.

2.2.4 How Would the City Implement Broadband-Friendly Public Policy Tools?

Developing broadband-friendly pubic policies requires the City to evaluate current land use, permitting, construction and right-of-way policies to determine how these can be tailored to incentivize development of more broadband infrastructure in the City. Below is a basic guide explaining how cities have implemented these policies. Many cities adopt General Plan policies that incorporate broadband as a public utility and create a policy framework to promote its deployment in public and private projects as appropriate, including:

- Tailor draft policies and standards to the City's specific needs and adopt them into local policy, codes, and standards (including policies, dig-once, joint trenching, engineering standards, etc.);
- Incorporate broadband in the City's Development Impact Fee programs and Capital Improvement Plans (CIP) as appropriate and make a commitment to fund broadband infrastructure;
- Identify opportunities to install broadband infrastructure in conjunction with public and private construction projects as appropriate;
- Develop a process so that the Planning and Public Works Department coordinate with the City to identify projects that could install this infrastructure at reduced costs;

- Evaluate ways to streamline the broadband permitting processes within public rights-of-way to ensure broadband providers do not face unnecessary obstacles to building infrastructure;
- Evaluate fees levied on broadband providers for constructing broadband infrastructure to ensure they do not discourage broadband investment; and,
- Develop digital formats for all plans, as-built documentation and records that enable the City to easily retrieve information on its fiber network and manage these assets efficiently.

2.2.5 Sample Policies

Sample policy documents are provided in Appendix B to illustrate general plan communication policy, development standards, telecommunications infrastructure improvement ordinance, joint trenching agreements, and engineering outside plant standards.

BEST PRACTICE

Santa Cruz County, CA

Santa Cruz County enacted comprehensive broadband standards and policies to minimize obstacles and reduce costs of deploying underground infrastructure on a countywide basis. Dig once policies enabled the County and broadband providers to jointly install underground conduit in common trenches, reducing overall costs and speeding deployment of new broadband.

Benefits

- Streamlined permitting processes lead to faster installation
- More opportunities to install publicly-owned infrastructure
- Minimized restoration issues and multiple right of way disturbances
- Utility coordination that reduced delays in permitting and construction

2.2.6 Adopt Broadband Infrastructure and Fiber Optic Standards

The proposed fiber backbone, otherwise known as the "core network," provides high capacity fiber-optic cables throughout the major corridors of the City. Additional new construction proposed in this plan will deliver a robust, redundant, and reliable citywide backbone fiber network. Access points would be strategically placed throughout the fiber routes to allow easy interconnection with facilities, City assets, business districts, and neighborhoods.

The fiber backbone will generally consist of 288-count fiber-optic cable on major routes. This cable size will enable the City to allocate capacity among multiple applications, including:

- City municipal functions
- Future smart city applications
- Community anchor connections
- Broadband applications
- Spare capacity

Secondary or lateral fiber will consist of 12 to 24-strand cable connecting individual community organizations and other end user locations. The network will use an in-and-out splicing design that allows community anchors and points of interest to interconnect their locations in a "ring" topology that supports high redundancy for their communications. A range of specialized connections will be made to accommodate additional traffic signal, smart technology, and broadband applications that should be individually engineered based on the application.

General specifications of the backbone are found below. Actual specifications may change based on the forthcoming engineering design; however, it is important that the City maintain compliance with these key specifications to achieve the City's goals.

Fiber Specifications

- Backbone cable size – 288-count fiber
- Lateral cable size – 12-count to 24-count fiber generally, 1 to 2-count fiber for business or component connections
- Singlemode, loose-tube non-armored cable
- Jacketed central member
- Outer polyethylene jacket
- Sequential markings in meters
- All dielectric
- Gel-free/dry buffer tubes
- 12 fibers per buffer tube
- Color coded buffer tubes based on ANSI/TIA/EIA-598-B Standard Colors

Conduit Specifications

- 36" minimum acceptable depth
- (2) 2" outer conduit

Handhole Specifications

Each route (Backbone / Lateral) will require a unique design and exact box placement will depend on a variety of factors to be determined in the final engineering analysis. Boxes along the backbone are generally placed every 500' or at major intersections to allow for pulling in the fiber and splicing to adjacent buildings and infrastructure. Conduit sweeps into handholes shall enter in flush with the cut-out mouse holes aligned parallel to the bottom of the box, and come in perpendicular to the wall of the box. Conduits shall not enter at any angle other than near parallel. Sweeps from the mainline to the conduit shall be accomplished using radii recommended by the manufacturer. Handholes will be sized based on the size of cable(s) transiting the structures, the total number of cables, and the specific applications required by the City.

2.3 Key Initiative 2: Construct Resilient City Owned Fiber Network

A network's resiliency is a measure of its ability to maintain an acceptable level of service in the midst of equipment, cabling, and operational faults. This characteristic may also be referred to as network survivability. Threats to service impairment can range from simple equipment misconfiguration to large scale natural disasters and/or targeted distributed denial of service (DDoS) attacks. As such, a highly resilient network will consider the impact of physical, logical, human error, and malicious intent in its design and operation. To improve the resilience of a data network, potential challenges and risks must be identified and appropriate metrics defined for the desired level of service. Resiliency is essentially "insurance" in a general sense, and therefore has a significant cost vs. benefit consideration in the design and decision process. The City's current production network operates using minimum-redundancy configurations of Cisco hardware and commercial metro Ethernet services from Cox Communication. Aside from some basic equipment redundancy, there is no comprehensive redundancy or diversity designed into the network as a whole. This results in a low level of network resiliency, where relatively common faults such as network interface failures or fiber cuts can result in a total Internet or data center outage affecting all City operations. The City could request redundant metro circuits for critical sites; however, it would likely more than double the connectivity costs for those sites.

[redacted]

Backbone fiber will enter each node facility through diverse entrances and route to enclosures which will allow breakout of fiber to a rack assembly containing a carrier Ethernet switch. The switch will be configured for redundant power supplies and will have two 40 Gbps QFSP+ interfaces for backbone links. The ports will be configured in MPLS over IP mesh architecture, providing for 50 ms failover in the event of a fiber cut or port fault.

Lateral sites are designated as Priority 1, 2, or 3 to indicate their level of redundancy. Priority 1 laterals are provided in Table 2.

Table 4: PCBN Priority 3 Sites

[redacted]

2.4 Key Initiative 3: Reduce Operating Expenses

The City's gross telecom cost is more than $1,028,084 annually for basic PRI, site to site, and Internet connectivity for municipal departments and K-12 school district buildings before any E-Rate discounts are applied. This includes $390,284 for the City's own PRI, Internet, and network transport services and Portsmouth Public Schools spends an additional $608,964 annually, before E-rate[17] discounts, while the libraries spend $28,836. Of that amount, the City spends a net of $517,844 after E-rate discounts on the qualified portion of the services. The total annual spend is entirely funded by City taxpayers.

A significant portion of these network operating costs totaling $420,921 per year will be progressively reduced as the City migrates the targeted facilities to the PCBN over the five-year deployment of the Fiber Master Plan and disconnects the existing leased circuits. An additional $104,124 per year consisting of non-PCBN site and telephony services may be reduced through lower cost options and connecting additional facilities as the opportunity presents itself. The annual leased OPEX reductions are shown in Table 5. By investing in a community owned network, the City is opting to invest in network assets which will pay dividends for decades to come, while reducing/permanently eliminating the never-ending operating cost structures inherent in leased lines.

[17] https://www.fcc.gov/consumers/guides/universal-service-program-schools-and-libraries-e-rate

Table 5: Annual Leased OPEX Reduction

Operating Spend Offset Schedule		Year 1	Year 2	Year 3	Year 4	Year 5
City of Portsmouth Cost Offset Schedule		$293,361	$185,505	$162,940	$37,602	$14,460
Schools and Libraries Offset Schedule		$127,560	$73,802	$46,097	$30,295	$22,951

There are many successful examples of, and precedents for, the inherent benefits and savings to be realized in private municipal networks nationwide. In Virginia alone, the Institute for Local Self-Reliance (ILSR) highlighted several cities and counties in a January 2017 briefing.[18]

The City of Virginia Beach constructed a private community network that resulted in nearly $500,000 of annual savings on leased broadband services. These savings came as a result of connecting public schools, government buildings, police and fire station facilities, libraries, and recreation centers within the city.

Arlington County, Virginia was ranked one of the top 10 in the Center for Digital Government's 2015 Digital Counties Survey. The network initially connected county facilities and public schools. The network now supports economic development and public safety:

- Public safety officials have a secure, high-speed connection point at every traffic signal.
- The Virginia Tech Research Center uses the network to connect with research institutions throughout the state.
- Internet service providers and businesses can lease capacity to provide services.

Rockbridge County, Virginia is an example of a regional network providing shared services to the county facilities, joint access to data centers, and leasing to multiple Internet Service Providers who provide retail services using the network.

The ILSR briefing is included as an attachment in Appendix C.

2.5 Key Initiative 4: Retain E-Rate Reimbursement

E-Rate is the commonly used name for the Schools and Libraries Program of the Universal Service Fund, which is administered by the Universal Service Administrative Company (USAC) under the direction of the Federal Communications Commission (FCC). The program provides federally-subsidized discounts to help schools and libraries obtain affordable telecommunications and Internet access.

The E-Rate program is one of four federal programs funded through the Universal Service Fund fees that are charged to telecommunications companies that provide interstate and/or international services. This fee is passed on to consumers on their telecommunications bills. Since all households that subscribe to video and/or telephone services are required to pay into

[18] https://departments.arlingtonva.us/dts/

the Universal Service Fund, it is important that communities maximize their participation in the E-Rate program to help recoup the investment made by their residents that pay into the fund. The E-Rate subsidies for Portsmouth City Schools are 80% of qualified services, while reimbursement for traditional voice services reduced to 40% in 2017. It is important to note that traditional voice services are being phased out and will no longer be supported through the program over the next couple of years – this is following suit with the migration to IP-based services.

Clearly, the current E-Rate program offers a significant amount of money to the Portsmouth public schools annually. E-rate can benefit the PCBN program including construction and implementation of the network where it serves the school system facilities. Portsmouth can become an approved E-rate service provider by applying for and receiving a Service Provider Identification Number (SPIN). This will allow the federal E-rate subsidy dollars to be collected and utilized to provide fiber based services to the local schools. The PCBN should position itself to maximize the potential funds that could be applied locally through the E-Rate program.

The gross annual Portsmouth Public Schools and libraries telecom expenditure is $608,964 for the Schools and $28,836 for the libraries annually, before E-rate[19] discounts. Of this amount, $510,240 is reimbursed by E-Rate, and the balance of $127,560 is paid directly to the service provider from the City's funding of the school district budget. As a registered service provider in the Universal Services Administrative Company (USAC), the City can bid directly on Form 470 solicitations when they are posted under their service provider identification number (SPIN), and if awarded the contract, will receive the 80% reimbursement from the Schools and Libraries Program directly as the provider of record. Using the current service pricing as an example, this would be new revenue of $510,240 for the City in addition to the cost savings of $127,560. Table 6 includes the Portsmouth Public Schools E-rate Funding and Discounts.

Table 6: Portsmouth Public School District E-rate Funding and Discounts

Qualified Services	E-Rate Subsidy	Discount
$637,800	**$510,240**	**80%**

It is important to note the City will have to compete for E-Rate with other providers as the program requires a competitive bidding process. The City could set a broadband rate structure to follow the VITA schedule, but provide higher bandwidths for the same price. For example, the VITA schedule prices 2 Gbps of carrier Ethernet bandwidth at $3,281 per month. The PCBN could price the same 2 Gbps of bandwidth at the VITA 1 Gbps rate of $2,210. This would allow the school system to solicit Form 470 bids on higher bandwidth services at no increase in cost.

[19] https://www.fcc.gov/consumers/guides/universal-service-program-schools-and-libraries-e-rate

2.6 Key Initiative 5: Identify External Revenues and Grant Opportunities to Expand the Network

The City should work to identify additional uses and revenue opportunities for the PCBN. External revenue and grant opportunities are available to the City, which should be coordinated with the build schedule. These could positively impact the overall Return on Investment (ROI) of the PCBN and could accelerate the build schedule. New revenues and grants will ultimately reduce the overall program cost to the City of Portsmouth.

Revenue opportunities exist by providing third party access to network assets and transport capacity. As additional community stakeholders begin to take service from the PCBN and as private providers lease conduit and fiber from the City, new revenue will be gained through basic lease agreements for passive infrastructure (conduit, fiber, poles) or service agreements for LIT services. **The City would develop a rate structure for use of assets in a wholesale arrangement to any provider on non-discriminatory terms.**

There are many grant opportunities available at the regional, state and federal levels which can be used to construct network assets. These grants will normally be available for different types of uses, including healthcare, education, digital divide/inclusion programs, transportation/mobility and for serving unserved/underserved areas, among others.

Appendix D provides an overview of current grant opportunities; however, the City of Portsmouth would need to determine eligibility for the various grants.

2.7 Key Initiative 6: Identify Regional Opportunities to Build Infrastructure

Broadband and telecommunications initiatives are happening throughout the Hampton Roads region. There are several regional, municipal, and private planning efforts and actual investments being made throughout the area. The cities of Virginia Beach, Suffolk, Chesapeake, Norfolk and now Portsmouth, all have various broadband related programs in progress. In addition, the Hampton Roads Planning District and Tidewater Community College system have all expressed interest in regional broadband projects.

Private investment is active in the region as well. All regional incumbent providers are making improvements in their infrastructures, while competitive providers like Lumos Networks and MBC are also moving forward with expansion plans of their own. Project MAREA is a major telecommunications project, built in partnership by Microsoft and Facebook, landing a submarine cable from Bilbao, Spain into Virginia Beach. The MAREA project is due to be completed in October 2017 and will include 6,600-kilometers of undersea cable.

2.7.1 Connect to the EdgeConneX Data Center in Norfolk

The City's backbone network should ideally be connected to at least one collocation facility in the Hampton Roads region. By connecting the fiber network to a collocation facility, the City would be able to interconnect with a number of broadband providers residing in the facility. This enables any organization connected to the City's fiber network to also potentially be connected to the facility, reaching multiple providers. The City's fiber could be used as the last-mile network to connect community anchors to providers that reside in the facility. This creates important benefits to the City and its economic development efforts including:

- It will provide a significant reduction in Internet service costs
- It will facilitate direct cross-connect access to several regional and national carrier networks
- It will enable private access to cloud service providers
- It will improve resiliency of the City's network

Based on initial research, only one facility was identified in the city of Norfolk, operated by EdgeConneX headquartered in Herndon VA. EdgeConneX Norfolk is primarily a wholesale-focused data center facility, catering primarily to large collocations, content providers and cloud service providers. Their tenant facilities-based service providers include Cox, Level 3, and Lumos Networks. In addition, near-net fiber facilities are also available from Windstream and XO. The opportunity for the PCBN is in terminating dark fiber to a distribution panel within the EdgeConneX facility and/or collocating an edge router for service cross-connects to the tenant service providers. This would provide the City options for direct cross-connect to the tenant service providers for access to lower cost IP transit service and content peering in addition to service path diversity.

We recommend the City explore a partnership with the city of Norfolk to lease or construct about two miles of fiber along the Martin Luther King Freeway through the Downtown Tunnel into Norfolk, then lease or trade dark fiber from Norfolk into EdgeConneX for use in cross-connecting to the service provider tenants. Lumos Networks has recently constructed fiber into the Hampton Roads area, and has a dark fiber business model that may be available to the City for the tunnel crossing. This will facilitate competition, lower cost for broadband services, and will provide path diversity from other service delivery points for Internet access. The mutual benefit to the city of Norfolk will be to gain access to the MBC PoP's at the TCC Campus and Bowers Hill for service route diversity, increased options for IP transit, and interconnection to the City for shared service opportunities.

BEST PRACTICE

Santa Monica CityNET

The City of Santa Monica connected its municipal fiber optic network to the One Wilshire Data Center in Downtown Los Angeles. By doing so, businesses connected to the City's network were able to reach hundreds of broadband and cloud providers. It also allowed the City to benefit from direct data center access for its cloud, storage and disaster recovery needs.

Benefits

- More competition and choice of providers
- More affordable broadband services
- Branding the City as a connected community, "ready for business"
- Marketing the City's broadband to site selectors and developers
- Supported data storage and cloud computing opportunities

2.7.2 Hampton Roads Planning District Commission Network (HRPDCN)

The idea of regionally shared telecom services is not new, and can be traced back to efforts such as shared instructional programming on the WHRO-TV station by HRETA, a private nonprofit educational corporation formed in 1968 by the Hampton Roads' 19 school districts. The concept of a regional fiber ring was formalized in a document distributed by Dr. Edna Baehre-Kolovani, President of Tidewater Community College (TCC). The document consisted of a series of conceptual and actual fiber route maps and associated narrative. Such a regional broadband network, owned and operated by the Hampton Roads municipal stakeholders who use its services, would provide many significant benefits to the region including:

- Shared access to computing resources and disaster recovery facilities
- Metro transport for Internet access and carrier Ethernet services
- Interconnection of municipal service networks such as transit and traffic control
- Interconnection of municipal Wi-Fi hotspots
- Creation of educational consortia to leverage E-rate services and grant opportunities

The HRPDCN would be organized as a non-profit entity, with a management structure created to provide network operations and administrative functions including service provisioning, monitoring, trouble management, equipment maintenance, and order processing. HRPDCN membership would consist of the Hampton Roads municipals who contribute assets and expertise to the management organization. In return, the members would be able to purchase low cost regional metro Ethernet services to access commercial broadband providers, data centers, E-rate services, and intra-city connectivity for resource sharing and future smart city services. HRPDCN management would be provided by a rotating committee of the Hampton Roads City CIO's.

E-rate funding is also available for education consortia and for the lease or construction of dark fiber. This presents an opportunity for HRETA to pursue regional broadband initiatives that will qualify under the E-rate program and serve it's 19 school systems more effectively than they are able to on an individual level.

Each HRPDCN member city would provide two fibers in their designated portion of the ring route, a carrier Ethernet switch, and space in a 7'x23" rack within one of their secured network nodes. The cities of Portsmouth, Suffolk, Chesapeake, Norfolk, and Virginia Beach currently have significant fiber assets in place or planned for construction. The southern section of the HRPDCN ring could be accomplished through coordination by these cities to extend and splice existing fiber to create the ring with diverse meet points at Mid-Atlantic Broadband PoP's at TCC Tri-Cities and Bowers Hill. Where fiber does not currently exist, capital construction or leasing could be considered and planned to span gaps.

Figure 13: HRPDC Network – Southern Ring

[redacted]

2.7.3 Coordinate Regionally on Dark Fiber Opportunities

Project MAREA is expected to generate continued interest among domestic and international carriers and cloud infrastructure operators wishing to extend their reach to overseas markets or transport overseas service providers to US-based points of presence. Some of this interest will manifest in dark fiber opportunities for transport from the cable drop facility across the Hampton Roads region. In addition, regional dark fiber opportunities for private point-to-point connectivity will increase as organizations strive to reduce their operating costs by moving leased LIT services to private network facilities. While the individual Hampton Roads cities will find it difficult to participate individually in these opportunities, their success in doing so will be increased by working as a single entity within the recommended HRPDCN organizational structure. The HRPDCN would serve as a central point of contact for dark fiber leases spanning multiple Hampton Roads cities.

Carriers typically require dark fiber for specific customer or project opportunities, and must be able to both quantify the associated financials and plan around specific availability and maintenance assumptions. Therefore, carriers requiring multi-city dark fiber solutions are more likely to construct their own fiber or lease from a commercial provider rather than negotiate fiber access and pricing with each individual city. The HRPDCN would provide that single point of contact with unified access policies, consistent maintenance procedures, and market-based pricing schedules. The member cities would identify and allocate fiber inventory to be used in dark fiber opportunities and negotiations through HRPDCN.

We recommend the City organize a joint meeting with MBC, the HRPDC, the HRETA, and TCC leadership, in addition to the cities of Norfolk, Suffolk, Chesapeake, and Virginia Beach to discuss the HRPDCN concept. This meeting would be a venue to collectively develop the idea of a regional network and educate the leadership group on the benefits a regional ring. Portsmouth would serve as a model city in their development of a fiber master plan with a regional view, the HRPDC, HRETA, and TCC would provide the leadership to push the concept at a regional level, and MBC would provide insight as a carrier who has "been there/done that" as a Virginia Tobacco Commission (VTC) funded operator with a mission to grow broadband access in Virginia.

3.0 Roadmap and Action Plan

3.1 Six-Year Network Deployment

Municipalities that have deployed fiber networks often utilize a staged approach that builds capacity and competency in their fiber programs over a long-term horizon. An excellent example of this approach is found in the City of Santa Monica, California, where the CityNet network was deployed in a long-term plan to first reduce cost and connect community organizations, then expand access to businesses, and finally create a platform to deploy a range of public Wi-Fi and other community services. A second example is found in the City of Palm Coast, FL, where the City employed a multi-year plan to build out its fiber backbone throughout the City. Its initial goals included reducing ongoing connectivity costs and improving the City's communications resiliency. Following the initial deployment, the City connected 17 local schools with 10 Gigabit fiber connectivity. Finally, the City deployed an open-access network that today is being used by multiple service providers to deliver leading Internet services to about 200 local businesses to support the City's economic development goals.

At each stage in the development of its network, the City will have the opportunity to evaluate the deployment of the network based on its original goals to ensure that the network is serving the community as anticipated. This should be a methodological approach that assesses the realized value of the network to the City and its community. Some key questions will include:

- How has the deployment positively impacted the community?
- What have we learned through our initial expansion?
- Did we plan for needs and opportunities correctly?
- Has the network accomplished its objectives?
- What could we have done better?
- How will we improve future deployments based on what we have learned?

Many cities have found success using the process below that focuses first on expanding the existing network and connecting internal and external stakeholders, followed by extension of the network to the business community, followed by a greater expansion of the network to support residential broadband needs. In some cases, cities have chosen to do so on their own and provide services directly, whereas in other cases, they have chosen to partner with private broadband operators who take on the responsibility for providing retail services using the municipal network. The City will need to explore a range of deployment strategies and business models that depend on its overall priorities in the community and needs of the stakeholders.

BEST PRACTICE

City of Palm Coast

The City of Palm Coast enacted a 5-year plan to build a citywide fiber-optic network to support its municipal and economic development needs. As the network expanded, the City earmarked funding to make fiber available at key technology parks where the City was actively marketing to prospective businesses. The City made fiber available in these areas and through its open-access network, allowed businesses to select from multiple providers to serve their Internet needs. In addition, the City makes maps of its fiber network and serving areas publicly available on its website www.palmcoastgov.com.

Benefits

- Market fiber as a differentiator in the community
- Use fiber as part of larger economic incentive packages to attract business
- Retain more businesses by ensuring that broadband is affordable

Proposed Backbone Routes

The following backbone fiber routes, shown in Figure 14, have been identified for deployment of the PCBN, routed to optimize the connections to city buildings, public school facilities, data center locations, and other key connection points throughout the area. As depicted below, the backbone routes include two fiber rings that are routed through key areas of the City's urban core.

[redacted]

technologies. Each facility will connect its existing local area network (LAN) to one of two user-network interfaces (UNI) for access to private Ethernet or Internet services.

CPE - $5,493 per connected facility including rack and UPS

3.3 Financial Analysis

Through implementation of the PCBN, the City of Portsmouth can permanently reduce its telecommunications operating costs (OPEX) for decades to come. Today, the City and the schools both contract for services through incumbent service providers for connectivity between their sites and facilities. There is no local decision making or ownership in any of the infrastructure that is built through these user fees – fees that gross nearly $1 million in annual telecom charges. It is important to note that this Plan represents a snapshot in time of current City budgets and spending and does not include any additional, future, or proposed network connections. The City's long-term costs whether leased or owned will undoubtedly rise beyond these projections due to increased bandwidth requirements and additional broadband services that will be placed upon the City's IT Department. The issue for City leaders is how much control the City desires to have over these costs.

The City has three options related to ongoing investment in telecommunications costs, services, and assets.

Table 13: Summary of Options

		Year 1 2018	Year 2 2019	Year 3 2020	Year 4 2021	Year 5 2022	Year 10 2027	Year 15 2032	Year 20 2037	Totals
Option 1 - Current Speeds										
Do Nothing (annual increase)	2%	$ 931,161	$ 949,784	$ 968,780	$ 988,155	$ 1,007,918	$1,112,823	$1,228,647	$1,356,525	$ 22,624,754
Option 2 - Incumbent build PCBN										
High-Growth (1Gb or 10Gb)		$ 1,990,868	$1,990,868	$1,990,868	$1,990,868	$ 1,990,868	$1,990,868	$1,990,868	$1,990,868	$ 39,817,368
Option 3 - Investment										
PCBN Investment										
Capital		$ 2,822,498	$2,242,161	$1,770,179	$ 956,756	$ 1,622,032		$ -	$ -	$ 9,413,626
Operating		$ 214,250	$ 287,259	$ 311,949	$ 332,693	$ 346,989	$ 357,809	$ 357,809	$ 357,809	$ 6,860,276
Total Annual PCBN Program Cost		$ 3,036,748	$2,529,420	$2,082,128	$1,289,449	$ 1,969,021	$ 357,809	$ 357,809	$ 357,809	$ 16,273,902

Option 1

The City could continue contracting for services as it does today, purchasing circuits constrained by cost more so than what is most desirable. As outlined in the previous sections, most circuits to City sites are at sub-Gigabit speeds, and many remain below 100 Mbps due directly to the high-cost of leased services.

Option 1 is considered the baseline – status quo – nothing changes. The City would slowly grow Internet access and site bandwidth as additional capacity is forced by application and content requirements, or when a business case could be made to upgrade a site's service. Option 1 would continue to cost the City and schools nearly $1 million per year before federal E-Rate subsidies for as long as the City would require service. Furthermore, future bandwidth needs and new services would continue to increase this total.

Over the 20-year period, assuming a conservative average 2% annual increase in growth-induced cost, Option 1 would cost the City $13.6 million in local tax dollars, and federal E-Rate subsidies of $9 million in outside funding that could be made available to support the development of the PCBN. As detailed in earlier sections, E-Rate subsidies are derived from the USF fee on voice products – this is as well, taxpayer money. In short, Option 1 would continue to cost the City over $22 million in taxpayer dollars and subsidies, which through local investment could be captured and kept in Portsmouth.

20 YEAR COST	**$22,624,754**

Option 2

Under Option 2, the City would contract for the high bandwidth services required at all sites, so that no site is constrained in accessing any applications and services desired. The network designed under this assumption would provide a minimum of 10 Gbps to all data center and department aggregation sites, and 1 Gbps to all satellite sites. To calculate the projected 20-year cost of Option 2, the published VITA rate schedule for “Ethernet, Private Line” services can be used. While the carriers could provide this level of service, it is likely they would need to construct fiber access laterals into many of the facilities currently serviced by coax and copper cables, and that the construction costs would be passed on to the City in the form of non-recurring and/or higher monthly recurring charges.

Table 14: VITA Ethernet, Private Line Contract Pricing

Ethernet Private Line, Point to Point, Premium

Options for this technology in your area

Details	Tier 1	Tier 2	Tier 3	Tier 4	Tier 5	Tier 6	Tier 7	Tier 8	Tier 9	Tier 10	Tier 11	Tier 12	Tier 13	Tier 14	Tier 15	Tier 16
Download Speed, Minimum	<1 mbps	<5 mbps	10 mbps	20 mbps	40 mbps	100 mbps	200 mbps	400 mbps	600 mbps	800 mbps	1,000 mbps	2,000 mbps	4,000 mbps	6,000 mbps	8,000 mbps	10,000 mbps
Installation Fee	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
Monthly Service Fee	$587.00	$535.00	$587.00	$703.00	$847.00	$1,249.00	$1,530.00	$1,740.00	$1,900.00	$2,060.00	$2,210.00	$3,281.00	$3,331.00	$3,380.00	$3,429.00	$3,477.00
First Static IP Fee	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
Additional Static IP Fee	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
Voice Business Line Install Fee	n/a	$50.00	$50.00	$50.00	$50.00	$50.00	$50.00	$50.00	$50.00	$50.00	$50.00	n/a	n/a	n/a	n/a	n/a
Voice Business Line (w/LD)	n/a	$39.78	$39.78	$39.78	$39.78	$39.78	$39.78	$39.78	$39.78	$39.78	$39.78	n/a	n/a	n/a	n/a	n/a
Suppliers	1	2	3	3	3	3	3	3	3	3	3	2	2	2	2	2
	Supplier Detail	Supplier Detail	Supplier Detail	Supplier Detail	Supplier Detail	Supplier Detail	Supplier Detail	Supplier Detail	Supplier Detail	Supplier Detail	Supplier Detail	Supplier Detail	Supplier Detail	Supplier Detail	Supplier Detail	Supplier Detail

These services would be delivered over provider fiber and would offer equivalent speeds to that of the PCBN – 1 Gbps and 10 Gbps speeds. However, rates for these services are priced at what the market will bear – not what the network costs to build and operate. Option 2 would cost the City nearly $40 million over the same 20-year period, which assumes 80% of the existing City and school sites will be upgraded to 1 Gbps service, and the remaining 20% will be upgraded to 10 Gbps. A 1 Gbps baseline service is not unrealistic in light of the growing requirement for, and bandwidth demands of, streaming video traffic. These projections also do not assume bandwidth and service growth over the same period as Option 1 does.

Option 2 is considered the high-speed model – increasing bandwidth to 1Gb and 10Gb levels. Under Option 2 the City and school fees increase annually to nearly $2 million per year, a 214% increase in gross annual operating costs from today's current spend outlined in Option 1. Furthermore, considering the federal E-Rate reimbursement as with Option 1, over $39 million in taxpayer dollars and subsidies are leaving the Portsmouth community.

20 YEAR COST **$39,817,36[redacted]**

Option 3

The City treats telecommunications as an infrastructure project and invests in building out a fiber backbone to serve the needs of the City and schools through its municipal CIP process. The City invests in a capital asset over a 5-year period, and forgoes annual monthly recurring costs that never end. The City experiences a payback of approximately 10 years, on an asset that will provide decades of use to the greater Portsmouth community.

The City would lower its long-term costs by $4.1 and $16.3 million over 20 years through making smart capital investments in community broadband assets.

20 YEAR COST **$16,273,902 - $18,473,90[redacted]**

Option 3 will require the City to increase their current capital refresh for technology to cover the PCBN core and CPE equipment. Core routing and switching equipment should be refreshed on 8-year intervals, and CPE should be refreshed for five successive years beginning in Year 6. Each refresh is estimated to cost $1.1 million for a total of $2.2 million over the course of 20 years. This does not include any additional connections beyond the first set of sites and facilities identified through this Plan.

Option Analysis

The City has three options, as outlined above, to plan for its network connectivity requirements. Each option, as indicated in Figure 23, requires the City to budget and plan for network services. It is important to realize the costs associated with all three options, which is a reality all communities and municipalities must consider. The decision is how to navigate ownership vs. lease of their network solution effectively – a solution that will continue to grow in size, complexity, and cost.

Through the commission of this Plan, the City understands the importance of its communications capabilities and the true cost of its services over the next 20 years. With the data outlined in this report, the City of Portsmouth can make informed decisions on how to manage its communications needs – with a "community first" vision, making capital investments into long-term infrastructure.

Cities and counties across North America are making investments in fiber infrastructure that many consider critical to the development of their communities. Many make these decisions due to ownership or control issues, while others realize the long-term value and benefit that can be derived from public ownership of these assets.

The charts in Figure 22 and Table 15, clearly indicate that direct investment in the asset provides the most cost effective solution over the long term, between the three options outlined.

Figure 22: Portsmouth Network Costs by Option - 20 Years

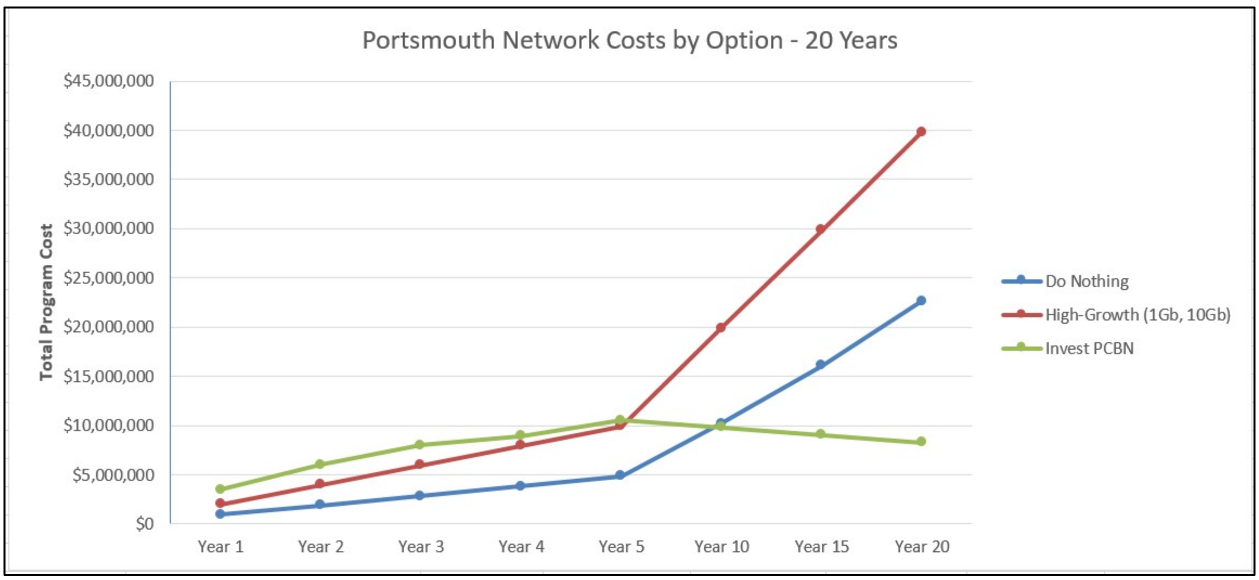


Table 15: Portsmouth Network Options Decision Support Matrix

Network Options	Description	Ownership/Control	Operational Burden	OPEX/CAPEX	20-YR Cost
Option 1	Do Nothing	None	Low	OPEX	**$22.6M**
Option 2	Estimated incumbent build of PCBN to spec	None	Low	OPEX	**$40M**
Option 3	PCBN investment	Yes – City Infrastructure	High – water, sewer, roads	CAPEX – permanently reduce operating costs	**$8.3M - $18.5M**

The City of Portsmouth will contend with the need for additional faster network connections every year. Municipal government and education require ever increasing amounts of bandwidth, and this will not slow down as long as more devices, more people, and more components are connected and communicating. The City has the ability to forecast its needs, and through development of this Master Plan, can take the long-term approach, turning communications services and their monthly recurring fees into an investment in infrastructure.

3.4 E-Rate Service Provider and Reimbursement Retention

The Schools and Libraries (E-rate) Program provides discounts on eligible telecommunication services including data transmission, Internet access, voice, internal connections, managed internal broadband and equipment, and basic maintenance on equipment for eligible schools and libraries. Funding is provided under two categories of service: Category One services include Data Transmission Services and Internet Access, and Voice Services. Category Two services include Internal Connections, Managed Internal Broadband Services, and Basic Maintenance of Internal Connections. Discounts for support depend on the category of service requested, the level of poverty, and the urban/rural status of the appropriate school district. Discounts range from 20 percent to 90 percent of the costs of eligible services. Eligible schools and libraries can also form consortia, such as state networks or regional library service systems. The consortium leader may or may not be eligible for discounts. Certain school and library buildings may also be eligible for discounts, such as non-instructional facilities (NIFs), non-traditional elementary and secondary education, and Educational Service Agencies (ESAs).

To be considered an E-rate service provider, the City must obtain a service provider identification number (SPIN). To obtain a SPIN, the City must complete an FCC Form 498 (Service Provider and Billed Entity Identification Number and General Contact Information Form) and submit it to USAC. After completing this form, USAC will set up a user name and password for the City to manage their Form 498 information and certain applicant-filed forms online.[20] E-rate funding is also available for education consortia, and for the lease or construction of dark fiber.

[20] http://www.usac.org/sl/service-providers/

The City would be exempted from filing FCC Form 499-A as a provider offering telecommunications services for a fee exclusively on a non-common carrier basis, and their status as an entity that provides telecommunications services only to themselves or to commonly-owned affiliates.[21]

The addition of Schools and Libraries E-rate services to the IT Department's operational responsibilities would require modification of current processes to accommodate the additional level of customer support required by the served organizations. While no additional staffing is anticipated at this time, the City would need to commit to providing a level of support at least equal to that of the current E-rate commercial service providers.

[21] http://www.usac.org/cont/filers/who-must-file.aspx#who

4.0 Recommendations and Next Steps

Leaders of the City recognize fiber-optic infrastructure as an important part of the Portsmouth community, since connectivity affects every aspect of and part of a community – whether in municipal operations, education, healthcare, or public safety. Today, this infrastructure also plays a crucial role in economic development, and will be pivotal in the future as an enabler of long term sustainability.

Due to these impacts, the City has considered including a fiber-optic infrastructure buildout in its municipal CIP (Capital improvement Plan) as a capital project – just like any other infrastructure project. This project has high stakes for the City, however, it also sees the future opportunity to permanently reduce or eliminate the costs of providing connectivity to City and school sites and related municipal infrastructure. The model presented in this Plan provides the City with a roadmap to construct the Portsmouth Community Broadband Network, and a framework to drive down its current network operating costs, allowing the City to determine what is served, at what speeds, and at what cost – without the need of third-party service providers.

As the City continues to make progress in bringing this project to fruition, there are a number of key tasks to consider that will validate the project's cost structures and will assist the City in planning for how these assets will be constructed and utilized.

The City should take the following next steps outlined below.

4.1 Review and Adopt the City of Portsmouth Fiber Master Plan

City Management and elected leaders should have the opportunity to review, comment, and provide direction on this Fiber Master Plan. The roadmap outlined in this document requires funding and resources and should be vetted in this manner. Construction and ownership of broadband infrastructure at this proposed scale is new to the City of Portsmouth, and will be a new program the City must support.

4.2 Finalize Staging, Budgets, Timelines, and Develop Implementation Plan

City leadership will have to determine when funding can be committed to begin construction of the network as outlined in this Plan. Before actual timelines are identified, City leadership must provide details as to how and when this program will be incorporated into the City's overall plan and budget.

- Review funding requirements
- Develop budget and funding requests for project funding
- Develop implementation plan with project timelines, including all procurement timelines and tasks

4.3 Inventory Existing Broadband Assets

The City has existing traffic conduit and fiber systems that could provide useable assets which would drive down costs of this project. The assessment of these assets was outside the scope of this engagement; however, we have received existing conduit maps and have overlaid them into the project's GIS map. This map has been provided in KMZ file format to the City. These assets should be viewed as City communications assets and utilized where possible.

Fiber-optic networks can be designed for multi-service/multi-application use. Organizations that deploy fiber-optic infrastructure have the ability to assign fibers to each service or application, or depending on the complexity of the network, to provision LIT data service by specific use. ITS, or Advanced Traffic Management Systems (ATMS) as it is becoming known, is a subset within the ITS domain. ITS or ATMS systems depend on high-speed connectivity to provide a top-down management perspective that integrates technology primarily to improve the flow of vehicle traffic and improve safety. Real-time traffic data from devices such as cameras and speed sensors, flow into a Transportation Management Center where it is integrated and processed (e.g., for incident detection), and may result in actions taken (e.g., traffic routing, DMS messages) with the goal of improving traffic flow. These systems are designed for IP (Internet Protocol) capabilities that are independent of the transport media, whether copper, fiber, or wireless. In addition to supporting traffic systems, these networks also provide the foundation for other major technologies which include surveillance, sensors, wireless, municipal connectivity, and fiber to the premise applications.

Should the City determine that it will begin to move forward with additional investments in broadband infrastructure, there will be a point in time when the existing corridors will need to be equipped with fiber-optic infrastructure. The City would have to determine the best method to equip the corridors, and would have two options available to it - 1. New Construction or 2. Repurpose of existing traffic conduit. New construction would be considered an overbuild, constructing conduit "on top" of existing City owned conduit at a substantial cost. Should the City decide to repurpose the existing conduit by retiring the legacy copper cable, the City could potentially equip these corridors with fiber-optic cable at a major discount to new construction. While new construction costs are estimated at up to $26 per foot, the repurposing of existing conduit, such as the City's traffic conduit, can costs upwards of $5 per foot, offering a substantial savings.

While this Plan is estimated using 100% new underground construction as the basis for the PCBN, this is considered a conservative estimate. The City should identify any opportunity to reduce the capital outlay to construct the PCBN – utilizing existing City assets is a key first step. **We recommend the City inventory and inspect, if necessary, all existing and planned traffic conduit and traffic cabinets to determine their usability.**

The City also has existing data centers at the City Hall facility and Hampton Roads Regional Jail. The City Hall generator is currently at capacity and will require augmentation or replacement to support the PCBN node equipment required for deployment. The HRRJ also has a generator, but existing load is unknown and would need to be audited to determine if augmentation is possible or replacement is indicated.

4.4 Design Engineering of Outside Plant

Once existing assets have been identified and inventoried, the City should move forward with design/engineering of the PCBN, including all backbone routes, laterals, and facilities. During the design/engineering process, actual routes will be solidified, engineers' estimates will be developed, and project costs can be refined.

Conceptual route design as conducted in this Plan are meant to provide capital cost ranges or estimates based on potential routes. An actual design will provide a construction ready design document with supporting levels of detail to move the project directly into Year 1 construction. With these new estimates, the City will be able to update the financial model that has been developed through this Plan, and continually refine the strategic goals and direction of the project.

A full design engineering package of the proposed outside plant will allow the City to prepare to release an RFP for construction of the PCBN. A design engineering timeline for this size of project should be completed within a 5-month time period.

In addition, the design engineering process will allow the City to “value engineer” the network, taking into account any newly identified assets (traffic conduit) or existing dark fiber, and allowing the routes to be optimized based on true ROW conditions. The overall project cost can be reduced significantly given a change in any of these positive conditions. The City should be able to estimate the overall build costs once the design engineering is complete. The City’s Fiber Master Plan (this document) and its accompanying financials should be updated regularly as major project events take place always capturing true costs and revising the Plan as needed.

4.5 Issue RFP and Select Construction Firm to Build the PCBN

Upon completion of OSP design-engineering, the City would issue an RFP for the 5-year construction schedule of the PCBN. The RFP would include all specifications and requirements of the OSP design-engineering deliverable; maps including all fiber routes and PCBN network facilities; compliance and bonding requirements of the selected contractor; previous experience and references for similar OSP construction projects; and detailed requirements on the OSP documentation and modeling in the City’s GIS or selected fiber management system.

The RFP should be released per Virginia Procurement guidelines, with a 4-week response window to allow for scheduled site visits and thorough responses. A respondent should be selected based on predetermined weighting criteria, and a contract negotiated to follow the City’s 5-year CIP schedule. A project manager should be assigned to oversee the project and report status updates to the City. The project manager would be responsible for coordinating with the selected contractor on the project schedule, lateral facility managers for building access, and with relevant City departments for traffic control and right-of-way access.

4.6 Train and Equip Staff for New Operation

The City should require and participate in formal training of PCBN staff by the selected network integrator. Formal training should be conducted offsite in a classroom environment to avoid onsite work-related distractions. The PCBN staff should also make every effort to shadow the network integrator during the equipment installation and turn-up to ensure comprehensive field-level knowledge transfer of the actual network installation and configuration.

The City should acquire appropriate tools to test OSP integrity, including an optical power meter to measure optical power levels and an optical time domain reflectometer (OTDR) to measure fiber continuity and identify the location of fiber micro-bends and breaks.

City staff will also have to train on process, policy and procedure as it relates to supporting the LIT service offerings provided by the PCBN to the City and school sites, while also providing industry acceptable SLAs on all assets leased through any third-party agreement. The network must be operated and supported to carrier grade specifications as this platform will now provide critical network services to all sites connected.

4.7 Establish Operating Support Systems

The City should consider investing in a telecom-centric facility management system that provides documentation, inventory, work orders, and other relevant information about the PCBN's physical plant assets. These assets include outside plant, equipment, contracts, and other relevant assets. This system will provide documentation, inventory, tracking, processes, and management of network assets throughout the system. The system is particularly important in management of the outside plant fiber-optic network to ensure that PCBN has valid documentation and control of as-built documents, assignments, splice plans, work orders, changes, and other information pertaining to the outside plant network. Availability of this information is crucial for both managing the existing network and future system expansion. These systems are also important for tracking and depreciating assets with a long economic life, such as conduit, fiber, towers, and facilities. The cost for such a system is not included in the PCBN capital budget.

Established providers of telecom facility management systems include:

- **ETI Software** - http://etisoftware.com/
- **Enghouse Networks -** www.enghousenetworks.com
- **Telvent -** www.telvent.com

4.9 Establish Fiber Outside Plant (OSP) O&M Contract

The City of Portsmouth would issue an RFP for a multi-year O&M (Operations & Maintenance) contract, for a construction firm that would provide emergency restoration of the fiber infrastructure, and would be available to expand the network as needed. Through this contract, all incremental construction, splicing, and other tasks would be performed ensuring the fiber and supporting passive components are functioning at optimal levels at all times. Any CAI or wholesale carrier will require the City to offer industry standard Service Level Agreements (SLA) on the fiber infrastructure and transport network ensuring their ability to guarantee its services to its downstream retail customers.

The City's contractor would have the necessary expertise and equipment available to maintain the PCBN fiber-optic infrastructure. The contractor would be required to respond to emergency fiber cuts and service outages within an agreed upon service level, i.e., response within 1 hour, onsite within 3. Due to the redundant nature of the design, fiber cuts along core routes and between PCBN nodes will recover immediately using ring protection services. However, fiber cuts in the route or laterals to customers are subject to extended periods of outages affecting service, unless additional redundancy is built to specific customers who may be requesting this service. It will be important for the partner to be local to the region and with adequate staff and equipment to deploy at any time.

The OSP contractor would likely be responsible for all aspects of OSP operations and maintenance. The responsibility would include adds, moves, and changes associated with the network as well as standard fiber maintenance. These tasks could include:

- Adding or changing fiber routes and patching requirements
- Extending service drops to customers
- Extending backbone and lateral segments, as required
- Relocating fiber routes due to roadway construction activity
- Tree trimming, as necessary
- Maintaining accurate documentation on network and all modifications (adds/changes)
- Maintaining splicing diagrams
- Emergency repair services (24x7x365)
- Design, engineering as necessary
- Fiber locating

5.0 Additional Opportunities

The City should look for every option available to drive down the costs of constructing the PCBN. This could include additional passive revenue opportunities or grants. The City should take measured approaches as it deploys the network, looking to partner with regional organizations that may have similar interests.

While the PCBN would be designed to meet the needs of the City and Schools, there would be an extensive amount of "excess capacity" in the fiber cables constructed. The options below outline potential opportunities for the City to consider as additional uses of the network. Some of these would generate revenue opportunities for the City, while others would improve the overall communications capabilities of the region, while supporting the health, safety, and welfare of City residents.

5.1 Develop BIP for Dark Fiber Leases and LIT Services

The City of Portsmouth should consider development of a Broadband Infrastructure Program (BIP), focused on meeting the needs and demands of the City operations, bringing value to the greater community, and monetizing any broadband assets that are available as the network is constructed. A Broadband Infrastructure Program would be new to the City of Portsmouth and requires a formal structure to be successful.

There are several tasks required in order for the City to formalize this program, including:

- Document and maintain an inventory of available assets
- Implement a fiber management system
- Develop and standardize agreements for fiber and conduit leasing
- Develop pricing policies for fiber and conduit leasing
- Publish rates and terms
- Create a City enterprise fund to maintain proper budgets, cost accounting, and to track revenues of the program
- Create a capital fund to cover costs of building infrastructure

At this stage in development of the City's Fiber Master Plan, it can be difficult to forecast future revenues which would support the deployment of the proposed fiber network. This document details benefits and opportunities which the City can capitalize on once the network is constructed; however, development of the City's backbone fiber ring is the "minimum ante." Once the City moves forward with development of the network, and decisions around the implementation of a Broadband Infrastructure Program (as outlined in the following subsection) are made, the City can begin to review internal and external revenue opportunities. Internal revenue would include contributions from City departments in support of enhanced network access or in support of new initiatives, while external revenue would include revenues generated through agreements with third-parties.

External revenues from the City's dark fiber and conduit lease program are also difficult to project at this point. However, revenues can be projected utilizing basic assumptions around fiber leasing rates, quantities of potential fiber strand leases, and other variables. For cities, similar to Portsmouth. that consist of small and dense areas, it generally makes more sense to lease a fiber path (connecting two points on the network), than it does to lease per fiber strand mile. Using a fiber path rate of $1,100 per month as an example, the City would provision a dark fiber segment between two points on the City's fiber network, regardless of distance.

As shown in Figure 24, the City has the opportunity to generate significant revenues from strictly leasing dark fiber. Adding 10 fiber path leases per year should be a realistic target for the City given the difficulty and costs associated with constructing fiber in the area, and given the current rates structures offered in Portsmouth. The years outlined in Figure 24 should match the development of the Broadband Infrastructure Program and is not meant to match to the build years of the actual network. The City will have to make assets available for lease, and this cannot be done until the network is built and ready for third-party use.

Table 16: Fiber Path Revenue Projections

	Year 1	Year 2	Year 3	Year 4	Year 5
Fiber Paths Leased	10	20	30	40	50
Fiber Path Rate (monthly)	$1,100	$1,100	$1,100	$1,100	$1,100
Total Gross Revenue	$132,000	$264,000	$396,000	$528,000	$660,000
	Total 5 Year Gross Revenue: $1,980,000				

Future phases of the City's Broadband Infrastructure Plan include the layering of advance services and LIT circuits to meet the needs of the community, and full FTTH deployment. These additional phases are opportunity based, and are not currently included in the roadmap timeline as these phases build on Phase I and are solely driven based on initial success and overall demand in the market.

The City should expect additional costs in future phases as this would include additional buildout of City owned assets and infrastructure. Again, these future deployments should focus entirely on potential return-on-investment (ROI) and should only be funded when a clear opportunity is presented.

5.2 Develop Plan for Wireless Service Provider Requests and Projects DAS/5G, vertical asset leases

The City of Portsmouth is being targeted by wireless site development companies today. These companies seek access to City infrastructure and ROW access through licensing agreements. In turn, these site development companies will "lock up" these public assets and sell them to actual wireless service providers who are deploying 5G technology. In these types of deals, the City would forfeit significant revenue to the site developer – in some cases as high as 40%, for the marketing, negotiation, and management of all site leasing.

The City should identify the public assets that could be useful to expedite the deployment of 5G and should work to negotiate directly with the actual wireless carriers. In addition to vertical assets (light poles, traffic poles, camera poles, buildings), the providers will require dark fiber to each structure. Under the right framework, the City would include these assets into the Broadband Infrastructure Program and would make them available for lease. Revenue from these types of opportunities should be analyzed as they could provide a significant revenue stream to the City's broadband program.

5.3 Explore Opportunities for FTTx and Carrier Wholesale

The City could explore opportunities for providing Fiber-to-the-X (FTTx) and carrier wholesale services on the network. These services could be provided as network bandwidth and made available to other community anchors, local businesses, or carriers. The network as conceptualized has a significant amount of excess bandwidth and capacity available for these types of uses.

5.4 Tie-in Digital City Trends

A municipal fiber network is foundational to all digital city trends and provides the basic infrastructure that all facets of a community will utilize to communicate. It can be used as a digital city ecosystem tying users to service providers and supporting key initiatives that deal with economic development, community sustainability, and mobility/transportation.

As these digital ecosystems continue to develop, partners are emerging that can provide computing components or data analysis programs that will help communities determine long term sustainability.

Appendix A: Glossary

3G – Third Generation	The third generation of mobile broadband technology, used by smart phones, tablets, and other mobile devices to access the web.
4G – Fourth Generation	The fourth generation of mobile broadband technology, used by smart phones, tablets, and other mobile devices to access the web.
ADSL – Asymmetric Digital Subscriber Line	DSL service with a larger portion of the capacity devoted to downstream communications, less to upstream. Typically thought of as a residential service.
ADSS – All-Dieletric Self-Supporting	A type of optical fiber cable that contains no conductive metal elements.
AMR/AMI – Automatic Meter Reading/Advanced Metering Infrastructure	Electrical meters that measure more than simple consumption and an associated communication network to report the measurements.
ATM – Asynchronous Transfer Mode	A data service offering that can be used for interconnection of customer's LAN. ATM provides service from 1 Mbps to 145 Mbps utilizing Cell Relay Packets.
Bandwidth	The amount of data transmitted in a given amount of time; usually measured in bits per second, kilobits per second (kbps), and Megabits per second (Mbps).
Bit	A single unit of data, either a one or a zero. In the world of broadband, bits are used to refer to the amount of transmitted data. A kilobit (Kb) is approximately 1,000 bits. A Megabit (Mb) is approximately 1,000,000 bits. There are 8 bits in a byte (which is the unit used to measure storage space), therefore a 1 Mbps connection takes about 8 seconds to transfer 1 megabyte of data (about the size of a typical digital camera photo).
BPL – Broadband over Powerline	A technology that provides broadband service over existing electrical power lines.
BPON – Broadband Passive Optical Network	BPON is a point-to-multipoint fiber-lean architecture network system which uses passive splitters to deliver signals to multiple users. Instead of running a separate strand of fiber from the CO to every customer, BPON uses a single strand of fiber to serve up to 32 subscribers.
Broadband	A descriptive term for evolving digital technologies that provide consumers with integrated access to voice, high-speed data service, video-demand services, and interactive delivery services (e.g. DSL, Cable Internet).
CAD – Computer Aided Design	The use of computer systems to assist in the creation, modification, analysis, or optimization of a design.
CAI – Community Anchor Institutions	The National Telecommunications and Information Administration defined CAIs in its SBDD program as "Schools, libraries, medical and healthcare providers, public safety entities, community colleges and other institutions of higher education, and other community support organizations and entities." Universities, colleges, community colleges, K-12 schools, libraries, health care facilities, social service providers, public safety entities, government and municipal offices are all community anchor institutions.
CAP – Competitive Access Provider	(or "Bypass Carrier") A Company that provides network links between the customer and the Inter-Exchange Carrier or even directly to the Internet Service Provider. CAPs operate private networks independent of Local Exchange Carriers.
Cellular	A mobile communications system that uses a combination of radio transmission and conventional telephone switching to permit telephone communications to and from mobile users within a specified area.
CLEC – Competitive Local Exchange Carrier	Wireline service provider that is authorized under state and Federal rules to compete with ILECs to provide local telephone service. CLECs provide telephone services in one of three ways or a combination thereof: 1) by building or rebuilding telecommunications facilities of their own, 2) by leasing capacity from another local telephone company (typically an ILEC) and reselling it, and 3) by leasing discrete parts of the ILEC network referred to as UNEs.
CO – Central Office	A circuit switch where the phone lines in a geographical area come together, usually housed in a small building.
Coaxial Cable	A type of cable that can carry large amounts of bandwidth over long distances. Cable TV and cable modem service both utilize this technology.
CPE – Customer Premise Equipment	Any terminal and associated equipment located at a subscriber's premises and connected with a carrier's telecommunication channel at the demarcation point ("demarc").

CWDM – Coarse Wavelength Division Multiplexing	A technology similar to DWDM only utilizing less wavelengths in a more customer-facing application whereby less bandwidth is required per fiber.
Demarcation Point ("demarc")	The point at which the public switched telephone network ends and connects with the customer's on-premises wiring.
Dial-Up	A technology that provides customers with access to the Internet over an existing telephone line.
DLEC – Data Local Exchange Carrier	DLECs deliver high-speed access to the Internet, not voice. Examples of DLECs include Covad, Northpoint and Rhythms.
Downstream	Data flowing from the Internet to a computer (Surfing the net, getting E-mail, downloading a file).
DSL – Digital Subscriber Line	The use of a copper telephone line to deliver "always on" broadband Internet service.
DSLAM – Digital Subscriber Line Access Multiplier	A piece of technology installed at a telephone company's Central Office (CO) and connects the carrier to the subscriber loop (and ultimately the customer's PC).
DWDM – Dense Wavelength Division Multiplexing	An optical technology used to increase bandwidth over existing fiber-optic networks. DWDM works by combining and transmitting multiple signals simultaneously at different wavelengths on the same fiber. In effect, one fiber is transformed into multiple virtual fibers.
E-Rate	A Federal program that provides subsidy for voice and data circuits as well as internal network connections to qualified schools and libraries. The subsidy is based on a percentage designated by the FCC.
EON – Ethernet Optical Network	The use of Ethernet LAN packets running over a fiber network.
EvDO – Evolution Data Only	EvDO is a wireless technology that provides data connections that are 10 times as fast as a traditional modem. This has been overtaken by 4G LTE.
FCC – Federal Communications Commission	A Federal regulatory agency that is responsible for regulating interstate and international communications by radio, television, wire, satellite and cable in all 50 states, the District of Rock Falls, and U.S. territories.
FDH – Fiber Distribution Hub	A connection and distribution point for optical fiber cables.
FTTN – Fiber to the Neighborhood	A hybrid network architecture involving optical fiber from the carrier network, terminating in a neighborhood cabinet which converts the signal from optical to electrical.
FTTP – Fiber to the premise (or FTTB – Fiber to the building)	A fiber-optic system that connects directly from the carrier network to the user premises.
FTTx – Fiber to the X	All fiber optic topologies from a provider to its customers, based on the location of the fiber's termination point
GIS – Geographic Information Systems	A system designed to capture, store, manipulate, analyze, manage, and present all types of geographical data.
GPON- Gigabit-Capable Passive Optical Network	Similar to BPON, GPON allows for greater bandwidth through the use of a faster approach (up to 2.5 Gbps in current products) than BPON.
GPS – Global Positioning System	a space-based satellite navigation system that provides location and time information in all weather conditions, anywhere on or near the Earth where there is an unobstructed line of sight to four or more GPS satellites.
GSM – Global System for Mobile Communications	This is the current radio/telephone standard developed in Europe and implemented globally except in Japan and South Korea.
HD – High Definition (Video)	Video of substantially higher resolution than standard definition.
HFC – Hybrid Fiber Coaxial	An outside plant distribution cabling concept employing both fiber-optic and coaxial cable.
ICT – Information and Communications Technology	Often used as an extended synonym for information technology (IT), but it is more specific term that stresses the role of unified communications and the integration of telecommunications, computers as well as necessary enterprise software, middleware, storage, and audio-visual systems, which enable users to access, store, transmit, and manipulate information.
IEEE – Institute of Electrical Engineers	A professional association headquartered in New York City that is dedicated to advancing technological innovation and excellence.
ILEC – Incumbent Local Exchange Carrier	The traditional wireline telephone service providers within defined geographic areas. Prior to 1996, ILECs operated as monopolies having exclusive right and responsibility for providing local and local toll telephone service within LATAs.
IP-VPN – Internet Protocol-Virtual Private Network	A software-defined network offering the appearance, functionality, and usefulness of a dedicated private network.

ISDN – Integrated Services Digital Network	An alternative method to simultaneously carry voice, data, and other traffic, using the switched telephone network.
ISP – Internet Service Provider	A company providing Internet access to consumers and businesses, acting as a bridge between customer (end-user) and infrastructure owners for dial-up, cable modem and DSL services.
ITS – Intelligent Traffic System	Advanced applications which, without embodying intelligence as such, aim to provide innovative services relating to different modes of transport and traffic management and enable various users to be better informed and make safer, more coordinated, and 'smarter' use of transport networks.
Kbps – Kilobits per second	1,000 bits per second. A measure of how fast data can be transmitted.
LAN – Local Area Network	A geographically localized network consisting of both hardware and software. The network can link workstations within a building or multiple computers with a single wireless Internet connection.
LATA – Local Access and Transport Areas	A geographic area within a divested Regional Bell Operating Company is permitted to offer exchange telecommunications and exchange access service. Calls between LATAs are often thought of as long distance service. Calls within a LATA (IntraLATA) typically include local and local toll services.
Local Loop	A generic term for the connection between the customer's premises (home, office, etc.) and the provider's serving central office. Historically, this has been a copper wire connection; but in many areas it has transitioned to fiber optic. Also, wireless options are increasingly available for local loop capacity.
MAN – Metropolitan Area Network	A high-speed intra-city network that links multiple locations with a campus, city or LATA. A MAN typically extends as far as 30 miles.
Mbps – Megabits per second	1,000,000 bits per second. A measure of how fast data can be transmitted.
MPLS – Multiprotocol Label Switching	A mechanism in high-performance telecommunications networks that directs data from one network node to the next based on short path labels rather than long network addresses, avoiding complex lookups in a routing table.
ONT – Optical Network Terminal	Used to terminate the fiber-optic line, demultiplex the signal into its component parts (voice telephone, television, and Internet), and provide power to customer telephones.
Overbuilding	The practice of building excess capacity. In this context, it involves investment in additional infrastructure projects to provide competition.
OVS – Open Video Systems	OVS is a new option for those looking to offer cable television service outside the current framework of traditional regulation. It would allow more flexibility in providing service by reducing the build out requirements of new carriers.
PON – Passive Optical Network	A Passive Optical Network consists of an optical line terminator located at the Central Office and a set of associated optical network terminals located at the customer's premise. Between them lies the optical distribution network comprised of fibers and passive splitters or couplers. In a PON network, a single piece of fiber can be run from the serving exchange out to a subdivision or office park, and then individual fiber strands to each building or serving equipment can be split from the main fiber using passive splitters / couplers. This allows for an expensive piece of fiber cable from the exchange to the customer to be shared among many customers, thereby dramatically lowering the overall costs of deployment for fiber to the business (FTTB) or fiber to the home (FTTH) applications.
PPP – Public-Private Partnership	A Public–Private Partnership (PPP) is a government service or private business venture that is funded and operated through a collaborative partnership between a government and one or more private sector organizations. In addition to being referred to as a PPP, they are sometimes called a P3, or P^3.
QOS – Quality of Service	QoS (Quality of Service) refers to a broad collection of networking technologies and techniques. The goal of QoS is to provide guarantees on the ability of a network to deliver predictable results, which are reflected in Service Level Agreements or SLAs. Elements of network performance within the scope of QoS often include availability (uptime), bandwidth (throughput), latency (delay), and error rate. QoS involves prioritization of network traffic.
RF – Radio Frequency	a rate of oscillation in the range of about 3 kHz to 300 GHz, which corresponds to the frequency of radio waves, and the alternating currents which carry radio signals.
Right-of-Way	A legal right of passage over land owned by another. Carriers and service providers must obtain right-of-way to dig trenches or plant poles for cable systems, and to place wireless antennas.

RMS – Resource Management System	A system used to track telecommunications assets.
RPR – Resilient Packet Ring	Also known as IEEE 802.17, is a protocol standard designed for the optimized transport of data traffic over optical fiber ring networks.
RUS – Rural Utility Service	A division of the United States Department of Agriculture, it promotes universal service in unserved and underserved areas of the country with grants, loans, and financing. Formerly known as “REA” or the Rural Electrification Administration.
SCADA – Supervisory Control and Data Acquisition	A type of industrial control system (ICS). Industrial control systems are computer controlled systems that monitor and control industrial processes that exist in the physical world.
SNMP – Simple Network Management Protocol	An Internet-standard protocol for managing devices on IP networks.
SONET – Synchronous Optical Network	A family of fiber-optic transmission rates.
Streaming	Streamed data is any information/data delivered from a server to a host where the data represents information that must be delivered in real time. This could be video, audio, graphics, slide shows, web tours, combinations of these, or any other real time application.
Subscribership	Subscribership is how many customers have subscribed for a particular telecommunications service.
Switched Network	A domestic telecommunications network usually accessed by telephone, key telephone systems, private branch exchange trunks, and data arrangements.
T-1 – Trunk Level 1	A digital transmission link with a total signaling speed of 1.544 Mbps. It is a standard for digital transmission in North America.
T-3 – Trunk Level 3	28 T1 lines or 44.736 Mbps.
UNE – Unbundled Network Element	Leased portions of a carrier’s (typically an ILEC’s) network used by another carrier to provide service to customers. Over time, the obligation to provide UNEs has been greatly narrowed, such that the most common UNE now is the UNE-Loop.
Universal Service	The idea of providing every home in the United States with basic telephone service.
Upstream	Data flowing from your computer to the Internet (sending E-mail, uploading a file).
UPS – Uninterruptable Power Supply	An electrical apparatus that provides emergency power to a load when the input power source, typically main power, fails.
USAC – Universal Service Administrative Company	An independent American nonprofit corporation designated as the administrator of the Federal Universal Service Fund (USF) by the Federal Communications Commission.
VDSL – Very High Data Rate Digital Subscriber Line	A developing digital subscriber line (DSL) technology providing data transmission faster than ADSL over a single flat untwisted or twisted pair of copper wires (up to 52 Mbit/s downstream and 16 Mbit/s upstream), and on coaxial cable (up to 85 Mbit/s down and upstream); using the frequency band from 25 kHz to 12 MHz.
Video on Demand	A service that allows users to remotely choose a movie from a digital library whenever they like and be able to pause, fast-forward, and rewind their selection.
VLAN – Virtual Local Area Network	In computer networking, a single layer-2 network may be partitioned to create multiple distinct broadcast domains, which are mutually isolated so that packets can only pass between them via one or more routers; such a domain is referred to as a Virtual Local Area Network, Virtual LAN or VLAN.
VoIP – Voice over Internet Protocol	An application that employs a data network (using a broadband connection) to transmit voice conversations using Internet Protocol.
VPN – Virtual Private Network	A virtual private network (VPN) extends a private network across a public network, such as the Internet. It enables a computer to send and receive data across shared or public networks as if it were directly connected to the private network, while benefitting from the functionality, security and management policies of the private network. This is done by establishing a virtual point-to-point connection through the use of dedicated connections, encryption, or a combination of the two.
WAN – Wide Area Network	A network that covers a broad area (i.e., any telecommunications network that links across metropolitan, regional, or national boundaries) using private or public network transports.

Wi-Fi	Wi-Fi is a popular technology that allows an electronic device to exchange data or connect to the Internet wirelessly using radio waves. The Wi-Fi Alliance defines Wi-Fi as any "wireless local area network (WLAN) products that are based on the Institute of Electrical and Electronics Engineers' (IEEE) 802.11 standards".
WiMAX	WiMAX is a wireless technology that provides high-throughput broadband connections over long distances. WiMAX can be used for a number of applications, including “last mile” broadband connections, hotspot and cellular backhaul, and high speed enterprise connectivity for businesses.
Wireless	Telephone service transmitted via cellular, PCS, satellite, or other technologies that do not require the telephone to be connected to a land-based line.
Wireless Internet	1) Internet applications and access using mobile devices such as cell phones and palm devices. 2) Broadband Internet service provided via wireless connection, such as satellite or tower transmitters.
Wireline	Service based on infrastructure on or near the ground, such as copper telephone wires or coaxial cable underground or on telephone poles.

Appendix B: Sample Policies

Provided electronically within file *Portsmouth Fiber Master PLN Appendices B_C_D 20170215.pdf*

Appendix C: Institute for Local Self-Reliance Virginia Fact Sheet

Provided electronically within file *Portsmouth Fiber Master PLN Appendices B_C_D 20170215.pdf*

Appendix D: Grant Opportunities

Provided electronically within file *Portsmouth Fiber Master PLN Appendices B_C_D 20170215.pdf*