Broadband Expansion Through Use Of Right-of-Way
Disclaimer

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Acknowledgements

This document was prepared by the graduate students of George Mason University’s Schar School of Policy and Government during the Spring of 2019, Master of Arts in Transportation Policy, Operations, and Logistics Practicum (TPOL).

This group wishes to recognize Dr. Jonathan Gifford for his contributions toward the development of this report. His expertise in transportation and public policy provided great value to our work and we are thankful for his time and patience.

The group also wants to show appreciation to the following individuals. We are thankful for the invalueable expertise and insight that you contributed to this project.

- Virginia’s Director of Research and Innovation, Catherine McGhee
- Then Acting Deputy Secretary of Transportation, Morteza Farajian
- VDOT Program Manager, Feleshia Ballou Thornton
- VDOT Director of Land Use Office, Robert Hofrichter
- GDOT Director of Operations, John Hibbard
- Representative from the Pennsylvania Turnpike Commission, Dale B. Witmer
- Senior Network Engineer, Brett Johnson
- Black and Viech Representatives, Pual Pishal and Fred Ellermeier

Special thanks to the Virginia Secretary of Transportation’s Office for requesting this report. We are grateful for the opportunity to work with a Virginia Department of Transportation who provides the highest quality transportation in Virginia and leads innovation across the country.

The following students collaborated on this project:

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Executive Summary

In January 2019, the George Mason University (GMU) Transportation Policy and Operational Logistics (TPOL) project team began evaluating the Virginia Department of Transportation’s ability to leverage existing resources with private partners. The goal was to formulate recommendations that would allow VDOT to expand its current fiber network. The client of this project is Virginia’s Office of the Secretary of Transportation. The Director of Research and Innovation, Catherine McGhee and then Acting Deputy Secretary of Transportation Morteza Farajian, represented and provided guidance on the project’s scope of work. The project team utilized other states’ fiber optic deployment projects as case studies.

Current VDOT Fiber deployment initiatives were investigated to provide the basis for further analysis:

- Virginia A Governor and Secretary of Transportation’s Fiber Goals
- VDOT’s Resource Sharing Program
- VDOT’s Land Use permitting process
- VDOT’s current initiatives in asset inventory and Communications Plan
- VDOT’s Communications Plan

Other States’ fiber deployment projects offered additional insights for this report in the following areas:

- Solicited Fiber Optic projects
- Design, Build, Finance, Operate, Maintenance (DBFOM) P3 delivery method
- Availability Payments
- Statewide Fiber Initiatives
- Wholesale Fiber
- Private industry insight

Fiber deployment projects in Georgia, Kentucky, Pennsylvania and Virginia were analyzed based on the project’s goals, delivery method, financials and challenges and evaluated on criteria identified by the project team. The criteria were selected to help the team find recommendations that were innovative yet cognizant of Virginia’s legal, political and fiscal
constraints. This process helped the team develop recommendations based on the lessons learned from each case.

The team found that Virginia’s resource sharing agreements are viable low-risk options for growing a fiber network; public-private partnerships with availability payments transfers financial risks to the public sector; and agency stakeholder involvement can help states determine existing assets eligible for resource sharing. The recommendations solidify Virginia’s success in fiber deployment and offer ways in which the organization can improve and expand its current fiber network.

The Recommendations are:

- VDOT’s Resource Sharing Program should continue to be utilized to expand it’s fiber network
- VDOT’s Resource Sharing Program should consider transitioning its program to utilize a solicited approach
- The Secretary of Transportation should explore opportunities to build on the Governor’s ongoing multi-agency initiatives to capture the value of a holistic approach
List of Abbreviations

American Association of State Highway and Transportation Officials (AASHTO)
Achieving Connectivity Everywhere (ACE)
Digital Subscriber line (DSL)
Federal Highway Administration (FHWA)
Georgia Department of Transportation (GDOT)
Intelligent Transportation System (ITS)
Internet Service Providers (ISP)
Kentucky Communications Network Authority (KCNA)
KentuckyWired (KYW)
Mega Byte per Second (MBPS)
Resource Sharing Agreements (RSA)
Right of Way (ROW)
Pennsylvania Turnpike Commission (PTC)
Tactical Operations Center (TOC)
United States Department of Transportation (USDOT)
Virginia Department of Transportation (VDOT)
Definitions

**Telecommunications**: Also known as telecom, is the exchange of information over significant distances by electronic means and refers to all types of voice, data and video transmission.

**Broadband**: Wide bandwidth data transmission which transports multiple signals and traffic types. The medium can be coaxial cable, optic fiber, radio, or twisted pair. In the context of internet access, broadband is used to mean any high-speed internet access that is always on and faster that dial-up access over traditional analog or ISDN PSTN services.

**Fiber Optics**: A technology that uses glass (or plastic) threads (fibers) to transmit data. A fiber optic cable consists of a bundle of glass threads, each of which is capable of transmitting messages modulated onto light waves.

**Dark Fiber**: Also known as unlit fiber is an unused optical fiber, available for use in fiber-optic communication. Dark fiber originally referred to the potential network capacity of telecommunication infrastructure. Dark fiber may be leased from a network service provider.

**Aerial Fiber**: Manufactured for installation outdoors, being suspended from pole to pole. Its jacketing is designed to resist weather and sunshine exposure. It also includes a quarter galvanized messenger wire for stability in suspended applications from rooftop to rooftop.

**Underground Conduit**: Conduit may be installed underground between buildings, structures, or devices to allow installation of power and communication cables. An assembly of these conduits, often called a duct bank, may either be directly buried in earth, or encased in concrete.

**Wireless Communications**: The transfer of information or power between two or more points that are not connected by an electrical conductor. The most common wireless technologies use radio waves.

**Right-of-way (ROW)**: A right to make a way over a piece of land, usually to and from another piece of land. A right of way is a type of easement granted of reserved over the land of transportation purposes, such as highways, public footpath, rail transport, canal, as well as electrical transmission lines, oil and gas pipelines.

**Limited Access ROW**: Refers to facilities such as interstate highways and expressways. This limits public access to interchange connection-points designed with entrance and exit ramps and limits access to motorized vehicular traffic.

**Prescriptive Easement**: Also known as easements by prescription, is property acquired by continued use without the permission of the owner for a statutorily prescribed number of years.

**Fiber Backbone**: A larger transmission line that carries data gathered from smaller lines that interconnect with it. A backbone is a line or set of lines that local area networks connect to for a wide area network connection or within a local area network to span distances efficiently.

**Middle Mile Network**: The segment of a telecommunications network linking a network operator’s core network to the local network plant. It is an industry term that describes the network infrastructure that connects last mile.
**Last Mile Network:** A phrase widely used in the telecommunications, cable television and internet industries to refer to the final leg of the telecommunications networks that deliver telecommunication services to retail end-users.

**Unsolicited Proposal:** A written proposal for a new or innovative idea that is submitted to an agency on the initiative of the offeror for the purpose of obtaining a contract with the Government.

**Solicited Proposal:** Document submitted to the prospective funding source outlining the entire program, including goals, objectives, methods, time lines, expertise committed, and program budget.

**P3 Industry Forum:** An opportunity to showcase any proposed project, explore creative approaches to project development, and seek early input from attendees on procurement design and cost saving ideas. Typically used for large projects. Forums attract a wide array of participants including global contractors and developers, engineering and design firms, investors and lenders and local, DBE, and specialty contractors.

**P3 Request for Information (RFI):** A standard business process whose purpose is to seek information, qualifications and input from private parties interested in potentially entering into a Public-Private Partnership

**Public-Private Partnership (P3) concessions model:** A cooperative arrangement between two or more public and private sectors, typically of a long-term nature.

**Design Build Finance Operate Maintain (DBFOM) Concessions:** Future revenues are leveraged to issue bonds or other debt that provide funds for capital and project development costs. Often they are also supplemented by public sector grants in the form of money or contributions in kind, such as right-of-way.

**Availability Payment:** Where the concessionaire receives a periodic "availability" payment from the public partner based on the availability of a facility at the specified performance level.

**Wholesale leasing (fiber):** A client will lease unused strands of ‘dark’ fiber optic cable to create their own privately-operated optical fiber network rather than just leasing bandwidth. The Dark Fiber network is separate from the main network and is controlled by the client rather than the network provider.
Introduction

Fiber optics can contribute to states’ intelligent transportation systems (ITS) to improve system operations by reducing congestion and improving safety, which are high priority issues for federal, state, and local transportation departments. ITS applies “well-established technologies in communications, control, electronics and computer hardware and software to improve surface transportation system performance” (Peyrebrune & Cerreño, 2002). ITS involves sensing, communicating, computing and algorithms to maximize a transportation network’s performance.

Fiber optics provide the capacity needed to carry the large amounts of data that ITS generate. A strong fiber network can enable ITS to help reduce congestion, enhance safety, mitigate the environmental impacts of transportation systems, enhance energy performance, and improve productivity (Peyrebrune & Cerreño, 2002). Fiber optics can spur productivity by also providing economic benefits, improved healthcare, and education.

The Virginia Department of Transportation (VDOT) currently leverages existing right-of-way (ROW) and for sharing it with other entities in exchange for fiber resources. Virginia shares fiber with both telecom providers and city agencies which is made possible through VDOT’s Land Use Policy. This policy governs how the state’s ROW applies to utilities. The policy states that utilities cannot build across VDOT’s ROW on interstates; however, it does allow for an exception for utility access to limited ROW by resource sharing.

VDOT’s Operations Division leads the Fiber Optic Resource Sharing Program in which resource sharing agreements (RSAs) are executed with telecom providers or city agencies to participate in resource sharing. RSAs come at no cost to the Department unless VDOT is exchanging VDOT conduit for fiber resources. The fiber resources exchanged have enabled
VDOT to support ITS, traffic signals and communication between its traffic operations centers throughout the state. VDOT has built a network that covers much of the Commonwealth without any upfront funds or ongoing maintenance investment. The network consists of over 3,700 miles of fiber; however, the use of resource sharing has created a patchwork network.

Our client, the Virginia Secretary of Transportation, has tasked George Mason University’s Spring 2019 semester Practicum class in Transportation Policy, Operations and Logistics to evaluate the effectiveness of strategies to enhance VDOT’s ability to leverage its ROW and existing infrastructure. Our group will determine how VDOT can better utilize its assets to expand and connect gaps in its current fiber network while also providing the state with a middle-mile network the governor’s objective to deploy broadband to rural Virginia. The objective is to identify strategies to incentivize the expansion of the fiber network across Virginia by enhancing both the middle mile and the existing fiber network to enable successful last mile deployments that benefit transportation, the economy, and citizens.

Methodology

The Virginia Department of Transportation seeks to close its current gaps and expand its existing fiber network at a low risk and cost to the Commonwealth. Our research team identified four case studies, including Virginia, to assess the application and impacts of fiber optic deployment methods. The states identified for analysis all took a public-private partnership approach, but each case study varied in project goals and the level of deployment. Statewide fiber optic initiatives are a fairly new concept and it would have been challenging to obtain data and provide additional case studies due to the lack of readily available data.

The states that were analyzed are Georgia, Kentucky, Pennsylvania Turnpike, and Virginia. Each case study includes the following sections: the project’s background, goals,
structure, ownership, benefits, challenges. The team used these case studies as a basis to determine the ideal approach for VDOT to enhance its fiber network. Our team used qualitative data collection methods through interviews conducted with state employees, industry experts, localities, state policies, state legislation, various project websites, and other open source websites which enabled our team to evaluate the case studies.

Case studies were evaluated on the following criteria: population benefit, the amount of public funding, political viability, legality, and estimated time to completion (Figure 1). Each project received a score from one to four, one being the lowest, and four being the highest desired outcome. The population benefit is determined by the size of the completed network and its potential to reach the overall population. Political viability is the political support that the program receives from the state. Funding from the public sector is the amount of public funds utilized for the construction and operation of the fiber network. Legality determines if the state model can legally apply in Virginia. The estimated time of completion evaluates the amount of time the project is projected to take to complete. Each score is added together for the final score. States were evaluated on the successes and failures of their projects. The team would like to note that the findings and conclusions derived from the Georgia case study is based on presumed success not actual experience derived from the project.
Broadband Basics

Broadband access is a requirement in almost all aspects of everyday life including work, medical treatment, education, and countless other uses. As of 2016, approximately 27.2 million Americans did not have access to high speed internet (Reese N., 2019). The upload and download speed commonly define service quality in the network. U.S. Federal Communication Commission (FCC) defines basic service as 3-8 megabits per second (MBPS) (Commission, 2018). High definition video streaming requires a minimum of 5-8 MBPS and file downloading requires 10 MBPS. A school or public library would generally require 100 MBPS to accomodate for several users, while a household with basic usage and video streaming would typically use 25 MBPS depending on the number of users and upload and download activity (Kruger, 2017). Figure 2 shows the FCC broadband speed guide to complete different activities. States face a lack of quality in broadband, especially in rural communities (Kruger, 2017).

There are several different types of broadband technology including fiber optic, cable, wireless, satellite, and digital subscriber line (DSL) (Kruger, 2017). These technologies can communicate and are capable of communicating with each other enabling the development of a more extensive network. This report will primarily focus on fiber optic technology because it is the
primary technology that each state is pursing. Fiber optic technology takes electric signals and converts them to light pulses that travel through glass fibers to transmit information. Modern fiber optic infrastructure far exceeds the next closest technology’s data transfer capability on a 1 MBPS to 1,000 MBPS ratio (Kruger, 2017).

Telecommunication networks have different segments known as the backbone, middle mile, and last mile. The backbone consists of large capacity infrastructure capable of transmitting large amounts of data over long distances almost always fiber optic. Middle mile links the backbone to internet service providers or works as a telecommunication exchange. Last mile networks provide a connection from internet service providers to homes or small businesses (Network, 2014) (Figure 3).

The focus of this report is fiber which is the current technology for middle mile deployment. Each network is generally designed in a circular pattern or with two separate connections to large population centers to ensure network redundancy. A broadband network operates similarly to a roadway network, if one section is closed to traffic then traffic is rerouted to another section of the network (Tay, 2006).
Fiber Optic Economic Development

Fiber optics enables telecommunication networks to transmit information quickly and more reliably over longer distances than other broadband technologies, such as DSL. Fiber optics can be considered the next generation of technology due to its ability to quickly transfer data. In the future, many believe that broadband will no longer be considered a luxury and will be needed for economies to grow within the Information Age. Today’s society has an economy based on information technology and communities are attempting to invest in infrastructure that can support economic growth. There are of thousands of residents in each state without access to adequate broadband service (Figure 4) (Reese N., 2019). Several states are attempting to use partnerships with the private sector to cost effectively expand their broadband networks. Each case study identified is pursuing fiber optics for one or more of the following reasons: economic development, enhanced transportation network, healthcare, education, and workforce opportunities. States can offer in-kind contributions in an exchange with private parties to construct and/or expand a fiber optic network. The states selected for study are all pursuing the use of state-owned ROW to install and expand their broadband networks.

Right-of-Way

One for the key features of fiber optic networks is that they require access to connected, continuous terrain where the fiber can be installed. Highway and road networks share this feature, and hence provide a potentially invaluable opportunity for shared use. A right of way is a type of easement granted or DOT owned land meant for transportation purposes, such as highways, public walkway, rail transport, canal, as well as electrical transmission lines, oil and gas pipelines. ROW
is generally reserved for maintenance or expansion of existing services. (Virginia Department of Transportation, 2018) An exception can be made to approve the ROW for other uses, as long as the uses are determined to be in the public interest and will not interfere with highway operations or impair the safety of the roadway (Virginia Department of Transportation, 2011).

*Use of ROW for Utilities*

Each state has its own rules and regulations about the use of the highway ROW. Maintaining the safety and access to the roadway is a priority. In Virginia utilities are installed along ROW, so the utilities do not interfere with maintenance operations. There are exceptions to this rule; densely populated areas commonly construct utilities under the roadway due to lack of ROW (Virginia Department of Transportation, 2018). Interstate ROW may be appealing to telecommunication companies and other types of utility companies because of its linearity.

Acquiring access to interstate ROW often requires less negotiation than privately-owned land. Interstate ROW connects cross-state and regional corridors that are prime markets for telecommunication services, has fewer cross roads and provides open areas for construction. Use of freeway ROW significantly lowers costs in obtaining easements to use private property or lease space on other rights of way such as railroad ROW (Virginia Department of Transportation, 2018). Many states allow utilities to place their infrastructure on highway ROW at no charge.

ROW usage can also require monetary or an in-kind compensation. In the case of broadband utilities, this could be the use of conduit, fiber optics, communication service, or a combination of the above (Virginia Department of Transportation, 2018). Private companies may engage in an RSA with a public agency to install their fiber infrastructure. Under this arrangement, the public agency charges the utility for the use of the ROW and allows them to access it as needed.
The private company also bears most of the construction and maintenance costs (Virginia Department of Transportation, 2018).
Case Study Synopsis
The team has provided a synopsis of each case study to reflect each state’s project’s structure, delivery method and challenges. Each case study can be read in full in the referenced Appendices.

- Commonwealth of Virginia Case Study – Appendix A
- Georgia Case Study – Appendix B
- Kentucky Case Study – Appendix C
- Pennsylvania Case Study – Appendix D

Commonwealth of Virginia
VDOT has expanded its broadband network along its ROW using unsolicited proposals from the private sector and sometimes city agencies. These unsolicited proposals are managed by VDOT’s Operation division under its Resource Sharing Program. The RSA Program allows communication providers to install fiber optic networks along limited access ROW, and in exchange, the companies provide VDOT with a portion of fiber resources. As of 2018, VDOT has deployed about 3,700 miles of fiber optic network along its ROW. Of the 3,700 miles, VDOT only owns and maintains approximately 700 miles of the fiber (Gustafson, 2018).

Currently, the fiber obtained through the agreements cannot be leased, sold or used by other entities or agencies. VDOT does not bear any costs related to RSA fiber other than minor costs associated with project design reviews. In February 2018, the P3 Office provided estimates of cost savings to the Department from RSAs. VDOT has saved $200,000-$260,000/mile in construction costs of the fiber obtained through agreements (Farajian, 2018).

The unsolicited proposal approach has enabled the Department to obtain an incomplete fiber network with gaps. VDOT currently faces challenges of finding marketable ROW to close gaps in its network. VDOT’s P3 Office is leading an effort to find marketable ROW within the
58,000 miles of VDOT ROW on highway, primary and secondary roads that can be leveraged for resource sharing. The Department also attempting to estimate the value of all its existing assets including its ROW and VDOT-owned fiber; this can difficult because true value can only be determined at the point of sale or exchange.

**Georgia Case Study**

GDOT has an existing combined fiber optic and wireless network along the ROW around freeways in Atlanta and Macon areas. The existing network consists of 307 centerline miles of fiber optic cable, 2,000 intelligent transportation system poles (ITS), over 4,000 access points, 25 GDOT regeneration locations (Hibbard, VanMeter, Heath, & Hoenig, 2018). The Department intends to expand its current network through a solicited public-private partnership (P3) design, build, finance, operate, and maintenance (DBFOM) agreement. GDOT intends to only provide in-kind contributions of ROW and its existing fiber network in hopes that the private sector will be able to recoup costs through leasing rights to the broadband network (Hibbard, VanMeter, Heath, & Hoenig, 2018). Currently, the cost of building and maintaining fiber optic network is not publicly available.

The challenges related to GDOT’s fiber deployment project are asset visibility and ROW rights. GDOT faced difficulty in confirming all of GDOT owned assets and the current condition of equipment. Georgia has anticipated ROW issues that relate to municipalities that own and operate their own road networks. The localities would have to allow GDOT access to its ROW in order to construct fiber infrastructure. Currently, the GDOT project is has halted due to the need for undisclosed changes in the procurement process; however, the state intends to pursue its fiber expansion through a similar P3 process (Hibbard, VanMeter, Heath, & Hoenig, 2018).
Kentucky Case Study
Kentucky seeks to bring 3,200-mile statewide open-access high-speed, high-capacity fiber optic internet connectivity to all counties. “Under the project plan, over 1,000 network operating and managing sites will be connected throughout the commonwealth with 85 percent of the fiber optic cables attached to telephone poles, and 15 percent of the cables running underground” (PACE DEVELOPER, 2016). The state has approached fiber deployment through a Public-Private Partnership (P3) concessions model. The state signed an agreement with Macquarie Capital to assume all responsibilities - including design, build, finance, operate, and maintain (DBFOM) - for the highway for 30 years in exchange for availability payments from the state (Federal Highway Administration, 2018). The agreement has a wholesaler provision that will allow for wholesale leasing over the next 30 years. Kentucky speculates that the wholesale leasing will allow them to generate enough revenue to cover the costs of the project in the long term.

The challenges that Kentucky faced are related to ROW acquisition. The project faced delays and political pushback after difficulties arose in obtaining agreements with telephone pole owners to hang aerial fiber and easements from private landowners to bury cable underground. The ROW issues delayed the project by two years. The delays also have caused the project to face increased ROW costs to the state and a $93 million payment to their concessionaire. The state originally expected to provide an in-kind match of $30 million and a $23.5 million federal grant; however, the state has paid an additional $88 million for pole attachment agreements in addition to the $93 million concessionaire payment (Miller, 2018).

Pennsylvania Case Study
The Pennsylvania Turnpike currently operates on a communications network of microwave technology, wireless antennas and fiber optic cable. The Pennsylvania Turnpike
Commission (PTC) intended to expand its current network through a solicited public-private partnership (P3) design, build, finance, operate, and maintenance (DBFOM) agreement. The network was to be a 552-mile fiber optic network that would be installed through “new conduit, existing PTC conduit, fiber optic cable, junction boxes, communications shelters, server racks, and related infrastructure” (Taylor, 2017, p. 7). The Turnpike Commission would not have owned the network, but would have received access to perform all of its operational needs for the turnpike facility. The Turnpike hoped to leverage its existing network and ROW, in exchange for a private firm to build, finance, operate and maintain the new network. The Commission projected the network to cost between $250 million to $300 million and is currently seeking $60 million in federal funds and expected the project to require little to no cost to the state (Krawczeniuk, 2018). The developer would be allowed to market and lease any excess communications capacity to recoup the cost of the project.

The challenges that the Pennsylvania Turnpike Commission faced has caused the project to be canceled. Attempting to obtain a private-partnership agreement to build an extensive network at low cost to the public sector has been the most critical challenge in this case study. The PTC solicited requests for proposal with a maximum bid amount. The proposals were deemed unresponsive (DeFebo, 2018). Proposers stated that “the commercial revenue was viewed as being uncertain; proposers were unable to get signed contracts for service essentially three years in advance and proposers were unable to speculatively borrow the funds needed to build the project” (Witmer, 2019). The state decided to cancel the project in December 2018 in order to reevaluate its approach considering no proposal could fit within the Authority’s desired financial restraints (DeFebo, 2018).
Case Study Analysis

Case Study Strategy Comparison

Every case study had a statewide initiative from the Governor to encourage broadband expansion for economic and broadband expansion. As part of the statewide initiatives, the states created state policies that encouraged the use of state assets to install broadband infrastructure. Each case study created a strategy to accomplish these goals utilizing a P3 agreement. There are two main strategies; solicited and unsolicited P3 agreements. Georgia, Pennsylvania, and Kentucky are using solicited P3 agreements, and Virginia is using unsolicited resource sharing agreements.

The solicited agreements have generated a large amount of interest from the private sector. Despite the interest in the DBFOM P3 agreement, Kentucky is the only state to execute an agreement and has begun construction. Georgia is currently redrafting its solicitation to present to the private sector. Pennsylvania Turnpike Commission has decided to pursue a reduced-scope project using Turnpike Funds.

The Pennsylvania Turnpike Commission overestimated the value of the turnpike ROW. It was expected that the private sector would upgrade and expand its outdated communications network. A large portion of the turnpike is in rural areas and lack a large customer base for a broadband network. The Pennsylvania Turnpike project might have been more successful if the project was segmented into smaller individual projects like the Georgia case study.

The Kentucky case has successfully installed broadband infrastructure using a DBFOM P3 agreement. It appears that Kentucky relied heavily on the hope that private ROW easements would be easily attainable. The project faced several delays due to easement issues. The delays increased ROW costs to the state and a $93 million payment to their concessionaire, and have caused state officials to question the value in completing the network (Miller, 2018).
Virginia is the only case that successfully installed broadband infrastructure at little to no cost to the state. The RSAs have had a large amount of success in Virginia, building over 3,700 miles of broadband infrastructure along the state’s ROW. Unsolicited resource sharing agreements allowed private businesses to seek out VDOT to establish and expand a fiber network in mutually desirable locations. The unsolicited agreements limited network expansion in locations that are undesirable to the private sector including rural and underserved areas and limited market competition.

Criteria Comparison (Figure 5)
Population benefit

The Kentucky case study showed most likely success in the population benefit criterion. The project was designed to reach every county in Kentucky. Kentucky will also own the network which would increase the state's role in increasing expansion for last mile deployment. Virginia’s networks span the entire state along interstates and major highways. Georgia’s network will cover a majority of the state but is limited to the interstates. Both Georgia and Virginia have limited population benefits since the network will only reach a specific population and were primarily designed for transportation needs. The Pennsylvania Turnpike is ranked lowest because it is the smallest network affecting a small portion of the state.
**Funding from the Public Sector**

Georgia and Virginia ranked highly in funding requiring little from the public sector. Virginia has provided little or no funding to construct or maintain the broadband network. Even though Georgia has not executed a P3 agreement for its project, it expects to contribute only in-kind contributions such as ROW. The KentuckyWired project has had a large cost to the state. The project rates low in this criterion because of its high initial costs increased costs due to acquiring easement agreements and project delays.

**Political Viability**

Virginia’s project has the highest score on the political viability criterion. The project score was related directly to the low-risk and high-benefit of the Resource Sharing Program. Virginia and potentially Georgia provide little to no state funding for network installation and maintenance in exchange for state ROW. All of the states have policies and legislation that support broadband expansion. The Pennsylvania Turnpike case was scored lower because of the overall project failure. Kentucky started with high political support; however, due to high project cost, cost overruns, and delays the project became highly controversial. Both Pennsylvania and Kentucky projects were scored low because of the public criticism of the projects and loss of support they have received due to delays and additional funding.

**Legality**

Pennsylvania Turnpike, Georgia, and Kentucky changed state laws so that the state could allow leasing (from the private and/or public sector) of their broadband network. VDOT is limited to using its RSA fiber for transportation purposes only and not be used for profit, leasing or used by other state agencies. Virginia has scored higher due to not having to change its law to allow leasing of its fiber.
**Estimated Time of Completion**

Kentucky’s project was scored low because of significant project delays that has pushed the project back two years from its original completion date. Georgia’s project is currently delayed but the expected project completion will be within five years from the start date which is faster than other projects. Pennsylvania Turnpike project was unsuccessful and had no estimated completion date. Virginia has the largest fiberoptic network of any state, but they do not have an estimated completion date because their broadband expansion is dependent on private sector interest. Virginia has been working on its network since the 1990s which is why the project has a relative low score.

**Overall Evaluation**

Virginia’s fiber initiative has been successful in installing 3,708 miles of broadband along with its rights of way; more than any other state. It received the highest score because of overall project success. Figure 6 displays the amount of installed broadband infrastructure for each case. If Georgia is successful in with it's in completing its DBFOM P3 agreement this case would be the next most applicable in Virginia. They are offering the private sector a similar resource sharing to the Virginia RSAs in a solicited agreement. Pennsylvania Turnpike unsuccessfully attempted to use a similar model, emphasizing the importance of properly understanding the value of the network.
The KentuckyWired project was the costliest; the state overestimated its access to their ROW, demonstrating the importance of asset visibility of any current fiber assets and public access to ROW. Kentucky’s broadband network was designed to expand into rural and underserved areas, a goal other projects have been unable to achieve. The Governor’s cabinet stakeholder board was the key success to ensure that agencies throughout the state weren’t duplicating efforts.

Findings and Recommendations

Resource Sharing Agreements are a Viable Low-Risk Option

The Secretary of Transportation’s objective is to execute a strategy that upgrades Virginia’s infrastructure, operations that supports the growing economy of Virginia. After examining the cases of Kentucky, Georgia, and the Pennsylvania Turnpike, we recommend that VDOT should continue utilizing Resource Sharing Agreements. Georgia, Kentucky and the Pennsylvania Turnpike Authority chose a Public-Private partnership approach through design, build, finance, operation, and maintenance agreement. Kentucky state is the only state that has executed an agreement and has begun construction under the agreement. Both Georgia and Pennsylvania have restarted the procurement process for their fiber initiatives. Kentucky and Pennsylvania Turnpike faced issues within the P3 process that revolved around the lack of desire to invest a large amount of public funds as well as ROW issues. We predict that Georgia could face similar issues that Pennsylvania faced if its ROW is not adequately valued. Pennsylvania attempted to estimate the value of ROW that would exchanged; however, the challenge is that the estimates often times do not reflect the actual market value.

The Department has enjoyed the "free ride” that the Resource Sharing agreements have provided them over the years and it has proven to be a success when comparing network mileage
with the other cases. Virginia has successfully installed fiber optic cable in the rights-of-way of roadways at no cost to the Department by exchanging ROW for fiber strands. The current policy has been a success and may still show success in the future.

This recommendation may not fully meet the goal of reaching rural areas due to lack of interest in rural markets. The biggest obstacle to closing fiber gaps that go through rural areas is the density of housing compared to the length of fiber needed. Private service providers lack an incentive to invest in high construction costs to provide service to a low number of customers.

Public-Private Partnership with Availability Payments Transfers Risk to the Public

While the case studies have shown that the public-private partnership model has been difficult for Kentucky and Pennsylvania, our team believes that a P3 process should be considered in Virginia. This is a strategy that could be explored by VDOT’s P3 Office, but may be difficult due to the current procurement laws of Virginia. Georgia, Kentucky, and Pennsylvania Turnpike Commission attempted their fiber initiatives with DBFOM availability payment agreements. Kentucky is the only case in which a state successfully finalized a DBFOM P3 agreement. PTC ultimately decided against a P3 model to finance their project due to the potential high costs associated with availability payments. Georgia is currently in the process of reworking their procurement of their DBFOM P3.

Availability payment P3 projects have serious debt implications for the public sector. There is a misconception that availability payment P3s are “free money” and require no capital investment from the public sector. “In a P3, any financing arrangement or equity contribution from the private consortium must be paid back by the governmental entity with the very same sources for which all infrastructure is ultimately funded: taxes, tolls, and/or user fees” (In the Public Interest, 2018). Availability payment P3s are long-term financial commitments for the
public sector. They require the private sector to build, operate and maintain a system and in exchange, the public sector is responsible for paying completion payments during the construction period as well as annual availability payments based on the system’s performance once operational (In the Public Interest, 2018). A common theme in P3 telecommunication P3 partnerships is that public partners expect the private sector to bear the costs and oftentimes overestimate the value they bring to the negotiating table in the form of ROW or potential revenue from leasing fiber.

Kentucky hoped to generate enough revenue from leased fiber to cover the availability payments. If not, the availability payment concession obligations are long term budgetary obligations for the states which can be compared to debt. Kentucky has already spent more funding than it had originally planned due to contingent liabilities associated with acquiring ROW. Kentucky policymakers have determined that the project is “too big” to fail and it has become a political controversy. As of late April 2019, the PTC plans to address its needs by utilizing a combination of leased lines, its existing microwave network west of Harrisburg and constructing two Design-Build projects to complete fiber segments totaling 222 miles along the Turnpike. A DBFOM availability P3 may not be viable for Virginia; however, we recommend Virginia consider a new approach to their RSAs. Lessons learned from Kentucky, Georgia, and Pennsylvania has provided us with the following recommendations:

- VDOT can further its Resource Sharing program by soliciting specific routes to current agreement holders or new internet service providers.
- VDOT should identify which segments might have enough value to justify a new RSA approach.
• Identify and account for potential contingent liabilities that could cause public costs to increase.

Agency Stakeholder Involvement Can Help States Understand the Value of Existing Assets

While the Virginia Department of Transportation does not seek to own and maintain its fiber network, the Department can accomplish its goal of closing its fiber network gaps by collaboratively working with other state agencies. It is recommended that the Secretary of Transportation work with other departments in the Governor’s office to oversee fiber deployment in order to determine the value of existing assets that can be exchanged with the private sector. An authority was created in Kentucky to solve service gap issues across the state and is managed by a Board. The Board is made up of stakeholders in the network including the Secretary of the Governor’s Executive Cabinet who shall serve as Chair of the Board, the State Budget Director, the Secretary of the Transportation Cabinet, the Secretary of the Economic Development Cabinet, the Secretary of the Justice and Public Safety Cabinet, the Commissioner of the Department for Local Government and a representative from the Center for Rural Development.

It is recommended that if multiple state agencies are pursuing fiber initiatives, it may be feasible that a stakeholder group is developed to approach the issue as a statewide effort. This would allow state agencies to offer information and resources, and to help identify opportunities to share facilities, ROW or other resources related to broadband deployment and adoption. A holistic approach to fiber network expansion could allow state agencies to share costs and resources in reaching similar initiatives in supporting the Governor’s goal of making sure every home has broadband access.
Appendix A

Commonwealth of Virginia’s Fiber Optic Resources Sharing

Background

The VDOT Operations Division manages the Fiber Optics Resource Sharing Program where communications providers can install fiber optic networks along limited access ROW, and in exchange, the company provides VDOT with a portion of fiber resources. VDOT has been engaged in resource sharing since 1998 and believes that it will be able to accelerate the ITS program statewide (Farajian, 2018). The Virginia Department of Transportation ROW has provided unique sites that are suitable for installation of the fiber optic cable; however, the method has enabled the Department to obtain an incomplete system with gaps within its fiber network. Currently, the fiber obtained through the agreements are not leased, sold or used by other entities or agencies. The Private Public Partnership (P3) office, under its New Technology Program, is currently looking at the value of fiber and VDOT’s fiber assets in order to fill the agency’s fiber network gaps (Farajian, 2018).

Project Goals

The Department of Transportation’s goal is to expand its communications network which supports VDOT’s Operations program. The fiber optic network is intended to enable high-speed broadband access for intelligent infrastructure and statewide operations centers. VDOT’s Operations Program includes increasing the sharing of information between VDOT’s five Traffic Operation Centers (TOCs), roadside technology devices, and district offices. Some secondary goals would be to maximize the economic opportunities associated with fiber optics and to give VDOT the flexibility to institute an intelligent transportation system (Farajian, 2018).
Project Structure
As of 2018, VDOT has deployed 3,708 miles of fiber optic network along its ROW. VDOT has expanded its broadband network along its ROW using unsolicited proposals from the private sector and sometimes city agencies. The private sector is able to utilize resource sharing agreements (RSA) which allow them limited access to install and operate utilities along VDOT’s ROW. VDOT land use permits allows the Department to exchange access of the ROW for cash and/or services (Farajian, 2018). The Resource Sharing Fiber Network map displayed above shows the fiber gained through the resource sharing agreements. The white lines indicate the fiber where VDOT has access and the blue represent Virginia’s major highway network (Figure 6).

The Department has been using compensation from RSAs to expand the fiber optic network across the state. VDOT receives compensation in the form of fiber access in exchange for access to its ROW. Virginia only offers non-exclusive agreements to the private sector, and these agreements must comply with the VDOT Operations Program. Furthermore, private sector compensation must meet the value determined by VDOT, and the agreements are required to be reviewed by the Attorney General.

VDOT is creating a full statewide Communication Plan and assessing the value of the available network to be completed and verified not later than June 2019. Full access to the Plan
is restricted for security reasons. The research team reviewed publicly available reviews of the plan presented in June 2018 (Farajian, 2018).

Ownership

VDOT is the legal owner of the ROW or conduit in some cases; however, the service provider is the legal owner of all network facilities installed under an RSA. VDOT can agree with a city agency to share or exchange fiber resources. The resources can include VDOT-owned fiber shared with a city in exchange for access to fiber within the city’s network, or vice versa. The agency that owns the fiber resource is responsible for maintaining it. When VDOT gains access to city-owned fiber, this exchange typically includes access to “dark fibers” or unused fiber to help VDOT build out its network (Athey Creek Consultants, 2016).

Financials

If VDOT enters into an RSA, the service provider is solely responsible for the cost and expenses associated with work related to the fiber network, including but not limited to design, construction, installation, management, operation, repair, and all maintenance. VDOT does not bear any costs related to the project other than design reviews. In February 2018, the P3 Office provided estimates of cost savings to the Department has saved from RSAs. VDOT has saved $200,000-$260,000/mile in construction costs of the fiber obtained through agreements (Gustafson, 2018). In terms of maintenance costs, VDOT has saved $1,800/mile/yr. VDOT currently operates 1,000 miles of shared fiber that would cost $200M-$260M to build, and $1.8M annually to maintain (Farajian, 2018).

Benefits

VDOT operates an extensive Intelligent Transportation System (ITS) network utilizing a combination of dedicated fiber optic cables, wireless communications and leased telecommunication services that provide connectivity to its TOCs and ITS devices statewide.
With the continued expansion of VDOT’s Operations program, the demand for VDOT’s communications resources will also continue to increase (Gustafson, 2018).

The Fiber Optic Resource Sharing Program supports and expands VDOT’s Operations program and ITS Network, without the significant costs and time associated with constructing and maintaining a VDOT-owned network. Fiber sharing benefits VDOT not only in terms of cost savings, but it also increases the sharing of information among the TOCs providing greater operational coordination and center-to-center communications (Farajian, 2018).

**Challenges**

The Department has made fiber deployment attainable through leveraging its ROW to private telecommunications and public partner; however, VDOT faces the challenge to close gaps in its current fiber network. These challenges deal with ROW issues and obtaining an adequate asset inventory. The Office of Land Use and VDOT Residency offices are responsible for land use permits for fiber. While the permit is financially feasible and requires no continuing maintenance fees, there are prescriptive easement issues due to the lack of publicly owned ROW. Easement issues can be costly and very time consuming to the construction of fiber. Most of the rural routes are prescriptive easements where the utility company does not have the same rights as they would in ROW. These issues have caused landowner/utility company disputes and forces the utility company to acquire their easements which adds a significant expense or stops a build. VDOT requires utilities to be installed behind ditches, so there is no interference with maintenance operations. In rural areas where ROW is limited, getting behind a ditch can be challenging. In urban areas, the issue is the concern for overcrowding of ROW because of the limited space available for any additional utilities.

VDOT has four parties currently collecting data on fiber optics: Office of Land Use, Residency Offices, Operations Division and the P3 Office. The Office of Land Use has fiber permit data.
dating back to the early 2000s and relies on the Residency offices, VDOT’s local field offices, to keep track of fiber laid by permit issuance. The Operations Division is responsible for managing the Fiber Optic Resource Sharing Program and manages data on the location of fiber obtained through these agreements. Currently, the data being collected does not show an accurate representation of VDOT’s assets; which is why the P3 Office is leading an effort to make an inventory of all VDOT’s assets. In order to fill the agency’s network gaps, it is crucial that the Department has an accurate picture of what is available to leverage for statewide deployment.
Appendix B

Georgia Case Study

Background

Georgia has 693,000 underserved residents without broadband or with limited coverage (Reese N., 2019). Georgia has a state broadband initiative to expand its broadband network across the state to increase economic, social, and educational opportunity for Georgia citizens and business (Affairs, 2018). Economic and educational benefits from broadband access are critical to Georgia’s population with the eighth highest poverty rate in the United States at 16.9% in 2018 (WelfareInfo, 2019). State Senator Steve Gooch stated, “the government needs to help areas in desperate need of internet service.” The state passed the Achieving Connectivity Everywhere (ACE) Act that allows the government to use the right of way on interstate and limited access roads to install broadband lines. ACE allows the state to charge internet providers for access to the network across the state (Niesse, 2018). The ACE Act encouraged the expansion of broadband, but the act did not allocate any state funds for construction of the infrastructure (Gooch, Cowsert, Kennedy, Miller, & Ginn, 2018).

Project goals

Georgia Department of Transportation’s (GDOT) primary goal was to spread the NaviGAtor traffic asset system (GDOT’s intelligent transportation system) across the state to enable safer roadways and access to the broadband system for transportation purposes. The system would create safety and reliability for the citizens in Georgia and expands the current broadband network. GDOT’s objective is to create a mutually beneficial relationship with the private sector to fund the development and maintenance of the fiber optic and wireless broadband networks along interstate roads. In the future, GDOT hopes to connect the fiberoptic network to neighboring states (Hibbard, VanMeter, Heath, & Hoenig, 2018).
GDOT has an existing combined fiberoptic and wireless network along the ROW around freeways in Atlanta and Macon areas. The existing network consists of 307 centerline miles of fiber optic cable, 2,000 intelligent transportation system (ITS) poles, over 4,000 access points, and 25 GDOT regeneration locations. GDOT also conducts ongoing asset inventory for all broadband infrastructure.

Current and future broadband infrastructure is displayed in Figure 8 (Hibbard, VanMeter, Heath, & Hoenig, 2018).

GDOT intends to expand the current network along all interstate ROW over the next five years. They intend to use a solicited public-private partnership (P3) to complete the project. GDOT is offering its ROW and current broadband network to the private sector in exchange for the private sector to design, build, finance, operate and maintain (DBFOM) the completed network. The P3 agreements will be offered for 18 segments of ROW for the existing and future fiber optic network. The segments of ROW are between 5 and 142 miles long (Hibbard, VanMeter, Heath, & Hoenig, 2018). It is anticipated that the private sector would receive access to develop and the right to maintain a fiberoptic hardwired and wireless network for a contracted period of 20 years or more under the potential agreement (Hibbard, VanMeter, Heath, & Hoenig, 2018).
Ownership
GDOT would maintain full ownership of the current fiberoptic network, NaviGAtor traffic asset system, and access to the broadband network to operate all GDOT systems. Under the scope of the P3 agreement, the private partner is responsible for the design, building, financing, operations, and maintenance of the network within their segment during the contracted timeframe (Hibbard, VanMeter, Heath, & Hoenig, 2018). The private sector is responsible for the total cost of the project; they also have leasing rights to the broadband network. The agreement would allow the private partner to recoup investment cost and earn profit from the network by providing access to Georgia localities (Hibbard, VanMeter, Heath, & Hoenig, 2018). If the existing network is leased to the private sector and profits exceed the cost to maintain the network all profits go to the Georgia State Funds under the ACE (Gooch, Cowsert, Kennedy, Miller, & Ginn, 2018).

Financials
Georgia intends to use a DBFOM P3 agreement with the private sector to fund the entire project. Currently, the estimated cost of building and maintaining fiber optic network is not publicly available. GDOT projects that the existing broadband network raises 30 to 35 million dollars a year. The total value of the completed network is projected to raise between 80 and 100 million (Georgia Department of Transportation, 2017).
A financial study examined the value of the fiberoptic and wireless network all interstates in Georgia using data from the United States Census, Federal Communication Commission, previous P3 projects, white papers, GDOT, and Bureau of Labor statistics (Georgia Department of Transportation, 2017). The data was analyzed in GIS to combine the data and access the market value along each section of the interstate. Each interstate was assigned a value based on how marketable the network was in the area. Values were based on population, current broadband use, access to the broadband network, and several other variables. Figure 7 above represents the value assigned to each interstate based on more or less financially attractive portions of the interstate (Georgia Department of Transportation, 2017).

As stated above, any revenue raised that exceeded the cost of the network would contribute to Georgia State Funds. While this does not apply to many of the current agreements after the initial contract period because of the cost of constructing the infrastructure, the network could be a source of state revenue in the future (Gooch, Cowsert, Kennedy, Miller, & Ginn, 2018).

Benefits
This project model could greatly benefit Georgia and GDOT with almost no cost to the state and could become a source of revenue for the state if successfully executed. However, it is important to note that both cases in Kentucky and Pennsylvania also intended to obtain a network at no or little cost to the state and failed. The network expansion would bring economic opportunity to Georgia in addition to increased access to broadband across the state.

In a phone interview with the Director of Operations for GDOT, John Hibbard said that one of the project’s early successes was the industry forum. The industry forum was conducted to inform the private sector about the project and generate interest. The forum generated a vast
outpouring of interest from the private sector with over 150 attendees; a typical industry forum has about 25 attendees. The private sector would benefit from the ability to quickly expand the broadband network utilizing the ROW and the opportunity to profit by providing last-mile network access.

**Challenges**

The biggest challenge for this project was asset visibility and ROW rights. GDOT faced difficulty in confirming all of GDOT owned assets and the current condition of equipment. The Department wanted to resolve these issues prior to soliciting the proposal for the P3 agreement. The GDOT project has halted due to the need for undisclosed changes in the procurement process discovered during the negotiation process. The state still intends to pursue broadband expansion through a similar P3 process.

The conditions of the agreement would give the private sector all operational rights for the term of the contract. The private sector goals might not align with GDOT's goals to provide internet access to rural Georgia. The private sector is not required to expand into rural areas or provide last mile access to underserved populations. The private sector may choose to expand the network into large population centers in order to make the maximum return on their investment.

**Application in Virginia**

The critical difference between Virginia’s current project and Georgia’s project is that the Georgia P3 project is a solicited P3 project. If Virginia pursues a solicited project, an industry forum could also be beneficial for VDOT to obtain private industry knowledge of telecommunication P3 projects. Virginia has a more extensive established network than Georgia but does not fall under the same leasing laws. Using the ACE Act to install and expand the broadband network using ROW allows the GDOT network to be leased the network for profit (Gooch, Cowsert, Kennedy, Miller, & Ginn, 2018). Virginia policy prohibits VDOT from legally
leasing or use its established broadband network established under RSA’s for anything other than transportation purposes. Like GDOT, VDOT is currently using its network to enable it’s ITS across the state.
Appendix C

KentuckyWired Open-Access Fiber Public-Private Initiative

Background

The State of Kentucky faces issues similar to those most states face regarding statewide deployment of fiber. Gaps in availability of high-speed service in the state are a major problem. In 2016, Federal Communications Commissions reported that “334,000 people in Kentucky cannot access internet service with a download speed of 25 megabytes per second, which is the federal standard for broadband” (Estep, 2016). The state is working to close service gaps in the state in order to bring economic growth to some of the poorest communities. Kentucky is one of the poorest states in the United States with 17.2 percent of the population living in poverty in 2017 (U.S. Census Bureau, 2019) Eastern Kentucky is considered to have some of the poorest communities and could benefit from the economic benefits derived from high-speed internet.

Kentucky’s statewide fiber project, KentuckyWired, was born as a concept in East Kentucky, where policymakers saw high-speed internet access as a gateway for a region that is suffering from a dying coal industry (Capps, 2018). Rural communities tend to suffer most from lack of broadband availability. Of the nearly 700,000 people without broadband access in Kentucky, 90 percent live in rural areas like the communities located in Eastern Kentucky (Sanchez, 2007). Private companies lack the incentive to provide high-cost fiber networks to low-density areas such as Eastern Kentucky localities. In order to gain a return on the investment, Internet service providers would have to charge their few rural customers high rates. State agencies face broadband challenges too. In 2013, multiple state agencies submitted budget requests for increased funding to support fiber networks in order to pursue their own business needs (Federal Highway Adminstration, 2018). Rather than attacking the issue through multiple
state agency initiatives, the state focused on a coordinated effort to leverage increased capacity across the state.

In 2015, the KentuckyWired (KYW) project was developed to solve the state’s service gap and affordability issues. The project is managed by the Kentucky Communications Network Authority (KCNA). The Authority is part of the Governor’s Office and made up of the following stakeholders: “the Secretary of the Governor's Executive Cabinet who shall serve as Chair of the Board, the State Budget Director, the Secretary of the Transportation Cabinet, the Secretary of the Economic Development Cabinet, the Secretary of the Justice and Public Safety Cabinet, the Commissioner of the Department for Local Government and a representative from the Center for Rural Development” (Kentucky Communications Network Authority, 2017). This project not only involves state agency stakeholders but also, private stakeholders. Kentucky’s project is the largest P3 Telecom project in the United States (The Center for Rural Development, 2019). The success of the project requires all stakeholders to understand the value and benefits a fiber network could offer all parties involved.

*Project Goals*

In 2017, Kentucky ranked 47th in the country in broadband speed and capacity (KentuckyWired, 2019). Kentucky seeks to improve its rating and to become a national leader in fiber deployment if the project is successful. The middle-mile will promote economic development, enhance education and research capabilities, ensure public safety, improve healthcare delivery, and augment connectivity for libraries and communities (KentuckyWired, 2019). The project also aims to provide an open-access fiber network that is constructed through every county in the state.
The statewide fiber optic network initiative is geared to encourage last-mile deployment to individual homes and businesses. This middle-mile approach will allow cities, partnerships, private companies or other groups to acquire access to these middle-mile lines, but does not provide last mile services to individual homes or businesses (KentuckyWired, 2019). KentuckyWired will enable private internet service providers and cellular companies to expand their services to areas previously unserved, especially rural regions. By constructing a fiber backbone through every single county, the state hopes to stimulate the benefits of fiber across the state rather than only in the metro areas, where it already exists.

Project Structure
Mainly through the deployment of aerial fiber, KentuckyWired seeks to bring 3,200-mile statewide open-access high-speed, high-capacity fiber optic internet connectivity to all counties. “Under the project plan, over 1,000 network operating and managing sites will be connected throughout the commonwealth with 85 percent of the fiber optic cables attached to telephone poles, and 15 percent of the cables running underground” (KentuckyWired, 2016). After network development the state plans to offer fiber strands for commercial use. “Approximately 50 percent of the fiber strands installed by KentuckyWired will be available for commercial use, by large scale enterprises and internet service providers” (Bipartisan Policy Center, 2017).
In 2015, work began simultaneously in various parts of the state. “The completed network will be comprised of six regional “rings” made of fiber optic wire that will eventually connect all 120 counties in the state (The Lane Report, 2018) (Figure 9).

The project was originally scheduled to be complete in September 2018, but it is now expecting completion in October 2020. So far, the project has successfully installed over 1,000 miles of the network by aerial poles and underground conduit (Lutke, 2019). The state has also managed to utilize existing fiber infrastructure wherever possible to minimize additional cost overruns. “The Commonwealth has already entered into agreements with Cincinnati Bell, East Kentucky Network (EKN) and Bluegrass Network (BGN) to lease their fiber rather than build new” and as of April 2019, Kentucky has gained additional partners (Kentucky Communications Network Authority, 2017).

The state is simultaneously working with local governments to help them become fiber ready for last-mile deployment. The state operates various programs meant to encourage broadband strategic planning. The Kentucky Communications Network Authority (KCNA) has grant funding that allows counties to plan how to best prepare for taking advantage of the
KentuckyWired high-speed broadband network currently under construction (KentuckyWired, 2016). The project has also encouraged service providers to construct last-mile projects to increase connection points throughout the state. Service providers can enter into agreements with KentuckyWired to become last-mile partners (figure 10). The state issued two Requests for Proposals (RFPs) in 2015 to allow businesses to partner with KYW. “KentuckyWired is unique in that it is an open access network—meaning local public or private Internet service providers (ISPs) can tap into the system and run broadband to businesses and homes” (Kentuckywired, 2015) A. The project has already enabled the formation of last-mile connections. Dense cities such as Lexington have entered into agreements with providers to bring more last-mile connections within the city.

Ownership

The state of Kentucky decided that the best method to approach fiber was through the Public-Private Partnership (P3) concessions model of project delivery. An agreement was finalized in 2015 with Macquarie Capital that would assume all responsibilities - including design, build, finance, operate, and maintain (DBFOM) - for the highway for 30 years in exchange for availability milestone payments from the state (Federal Highway Administration, 2018). The project has equity investors, a design-build team and communications network team.
While Macquarie is the lead developer of the project, a consortium was established with several private companies to handle parts of the project. “Ledcor Group of Companies and Overland Contracting Inc., a Black & Veatch Company, make up the Design Build Team (NG-KIH DBLLC Contractors) and have signed definitive agreements rolling up to the Commonwealth to help develop, design, and build the network. Ledcor will operate and maintain the network for the next 30 years” (KentuckyWired, 2016). “Macquarie Capital is charging escalating “availability payments” that amount to $33.4 million in 2019 fiscal year and $34.2 million in the 2020 fiscal year” (Barton, 2018). The Kentucky Wired model has a wholesaler provision allowing for wholesale leasing over the next 30 years as a source of revenue. “Macquarie Capital will lead the formation of a network wholesaler to market this excess capacity to ISPs and plan to share a substantial portion of revenues generated from that activity with the Commonwealth” (Bipartisan Policy Center, 2017). Fujitsu Network Communications Inc is responsible for the communications network portion of the project. The company is responsible for network design, equipment, operations and maintenance, and equipment refresh (Federal Highway Adminstration, 2018). This approach is anticipated to allow the project to generate revenue to cover a portion of costs of the project in the long term. The P3 agreement will allow the state to gain economic benefits by generating revenue by wholesale leasing half of the fiber to private companies. “The Commonwealth service fees will move from the carriers that hold current service contracts to KentuckyWired allowing both the investment group and the state to share revenues from the sale of dark fiber (KentuckyWired, 2016).
**Benefits**

The overall end goal of this project is to spur socioeconomic growth for businesses and communities. When completed, “this network will connect directly to approximately 1,100 government facilities (including K-12 schools, community colleges, and public universities), which will result in dramatically faster internet speeds in both rural and urban communities” (Bipartisan Policy Center, 2017) (figure 12).

**Challenges**

The project faced challenges when the state failed to quickly obtain agreements with telephone pole owners to hang aerial fiber. The developer faced issues securing easements from government facilities.
private-landowners to bury cables underground. These issues caused the project schedule to be pushed back to 2020. In 2017, “the state had agreements to make attachments to 88 percent of the poles that it needs but lacked agreements for about 6,600 poles” (Barton, 2018). The 6,600 poles were owned by private utility companies, municipal utilities, and telecommunication companies. “Approximately 70 telecommunications, electric and municipal utilities across the state are important partners for access to poles” (Federal Highway Administration, 2018).

Kentucky was required to pay a $93 million settlement with its private partners because of the project ROW delays. In the view of some, the agreement negotiations were utilized by pole owners to stifle competition. “In order to delay the deployment as a way to stave off competition from a municipal network project, the incumbent might drag their feet on an agreement or make unreasonable demands” (Barton, 2018). The two years’ worth of ROW delays increased budget costs and caused some policymakers to question whether or not to halt the project altogether.

Increased costs of the project and the speculative revenue it is expected to generate has caused the project to become extremely political. A report from Kentucky’s State Auditor noted that the partnership agreement was revamped and the changes took advantage of tax-exempt bonds to cut costs, but made Kentucky ultimately liable for the debt, tying the state's future bond rating to the fate of the project (Miller, 2018). A common theme in telecommunication P3 partnerships is that public partners expect the private sector to bear the costs and often overestimate the value that they bring to the negotiating table.

Application in Virginia
If VDOT were to apply Kentucky’s method of fiber optic deployment, legal, cost, time, and procurement issues should be considered. Currently, VDOT is utilizing ROW and Resource
Sharing Agreements to obtain fiber solely for the Department’s operational needs. The Kentucky approach is a statewide initiative that has required the state to put up a substantial amount of funding to bring state-owned fiber to every single county in the state. While VDOT is pursuing fiber for transportation needs, the Kentucky approach fits within the Virginia Governor’s and Secretary’s vision of bringing broadband to underserved areas. In order to reach that goal, it may be necessary that VDOT work with other state agencies to determine whether there are overlaps in needs statewide to help close the current network gap. The Department has obtained over 3,000 miles of fiber through RSAs, at no out of pocket cost to the Department. The Kentucky approach would require VDOT to develop a P3 to close gaps that may not be of interest to service providers. While this approach would potentially cut down time since RSAs are initiated by service providers, it would mean that the state would need to put up funds to build out the expanded network. However, VDOT would need to determine the locations of existing RSA and VDOT-owned fiber assets.

The concerns and challenges that have derived from the KentuckyWired project should be taken into consideration if it is applied in Virginia. One of the issues that Virginia currently faces is limited ROW, so Virginia could potentially run into the same issues that Kentucky is facing in obtaining rights to the property to install fiber. A VDOT Assistant Resident Engineer discussed the ROW issues that VDOT currently has. Most of the rural routes are prescriptive easements, which have caused landowner/utility company disputes and forces the utility company to acquire easements, which adds significant expense or stops a build. In regards to using existing easements for electric cooperatives to use as fiber easements, the Assistant noted that similar issues might derive if easements are specific to electricity. Virginia would need to be willing to take on the time, costs, and political implications that come with this approach. This
approach would mean that VDOT would own the infrastructure after completion. At the June 2018 Commonwealth Transportation Board meeting, the P3 Office noted that a state-owned network or purchasing fiber access from private companies were not viable options for VDOT to consider due to costs and legal issues (state and federal funding requirements).
Appendix D
Pennsylvania Turnpike Case Study

Background
The Pennsylvania Turnpike is pursuing a fiber initiative that would improve the Turnpike’s operations and further economic development in the region. The turnpike is a major transportation route in the state, and a key link in the eastern U.S. road network and a fiber network would allow Pennsylvania to meet future communications and travel-related needs. Pennsylvania Turnpike currently utilizes old microwave technology to operate the E-Z Pass tolling systems on the turnpike. The microwave technology system is overworked and cannot process data at the capacity required to operate and maintain the turnpike (Taylor, 2017).

A fully functioning communications network is a vital part of the Turnpike’s operations. “The backbone [microwave network] is one of our most critical communications tools, carrying tolling data and connecting traffic management devices such as intelligent transportation systems and will improve the Commission’s ability to collect and report on road travel conditions to motorists and offer alternate routes” (National Council for Public Private Partnership, 2016). The microwave technology infrastructure is only estimated to remain operational for another four years. The Turnpike has used tolling systems to fund maintenance, update infrastructure, and technology; however, upgrading to a fiber network would require additional funding and specialized expertise. Pennsylvania Turnpike Commission (PTC) unsuccessfully pursued a Public-Private Partnership in order to upgrade and expand its existing telecommunications network to fiber optics.

Project Goals
The project’s main goal is to establish a 552-mile broadband communication network for long term savings and a potential source of future revenue. The purpose of the network would be to reduce costs, decrease maintenance, eliminate the need for microwave system upgrades, and provide a reliable network with redundancies to operate turnpike infrastructure.

The turnpike anticipated that the private sector would expand the broadband network throughout Pennsylvania and into rural areas stimulating economic development. The broadband network would have enabled the bandwidth capacity for smart infrastructure and autonomous vehicle operations as well as increased economic development benefits for the state of Pennsylvania (Taylor, 2017, p. 4) (Figure 13).

**Project Structure**

The Pennsylvania Turnpike Commission (PTC) intended to use a solicited P3 deal to finance construction, maintenance, and operations of a 552-mile broadband network along the Pennsylvania Turnpike. The public benefit from this model was the increased service and capacity of the network for agency needs, and the private benefit was the ability to build and run a major backbone fiber optic system while avoiding ROW compensation. The current network consists of microwave towers for backhaul, microwave hub locations (typically at maintenance buildings and offices), and a combination of methods connecting field devices to hub locations including wireless antennas and fiber optic cable. The new fiber network would primarily have
been installed through “new conduit, existing PTC conduit, fiber optic cable, junction boxes, communications shelters, server racks, and related infrastructure” (Taylor, 2017, p. 7).

The developer would have been required to construct a network that would include parts or all of the turnpike’s six segments and upgrade all of the turnpike infrastructure to ensure that it would be compatible with the broadband network (Figure 14) (Taylor, 2017).

The fiber network would primarily be installed through the use of new conduit. The turnpike would receive access to the network to perform all of its operational needs including; tolling, command center communications, etc. Provisions of the agreement would make “a minimum number of fiber optic cables and conduits reserved exclusively for PTC’s use and physically separated from the developer’s fiber optic network” (Taylor, 2017, p. 7).

Ownership

The PTC attempted to approach fiber through a long-term agreement with a developer to design, build, finance, maintain and gain rights to commercialize the fiber network. The Turnpike Commission would only have rights to 288 strands of fiber optic cable for its own use while the developer would operate and maintain the entire the network. The developer would be responsible for maintaining the complete fiber optic network and all related infrastructure, including conduit, fiber optic cable, optic regeneration devices, junction boxes, communications structures, and all related appurtenances (Taylor, 2017, p. 14). Since the project was cancelled
Pennsylvania still owns and operates the current network of communications and intends to reduce the project scale and pursue the project as a design-build project with their own funds.

**Financial**
Under the planned P3 approach, the Commission wanted a developer to finance and maintain its new fiber network. The Commission projected the network to cost between $250 million to $300 million and is currently seeking $60 million in federal funds (Krawczeniuk, 2018). The developer would be allowed to market and lease any excess communications capacity to recoup the cost of the project. If not, “the Commission would be responsible for making a majority of its direct contributions in the form of progress payments which would be paid during the construction period of the project” (Pennsylvania Turnpike Commission, 2017, p. 5). As of December 2018, the Commission has decided to cancel the project in order to reassess its approach. Other than a construction estimate, no other financial information was made available to the public.

**Challenges**
Pennsylvania Turnpike Authority announced in 2016 its plan to build a 550-mile fiber network at little to no cost to the agency. Attempting to obtain a private-partnership agreement to build an extensive network at low cost to the public sector has been the most critical challenge in this case study. “After announcing the project over two years ago, the agency had dropped the idea by early 2017 that the broadband system could be built at little to no cost to the agency” (Torrance, 2018). The Commission hoped to solve its financial concerns by soliciting a request for proposal with an established maximum bid amount. While proposers stated that there was commercial value in the project, the potential revenue was not sufficient to offset the proposers’ cost to build and maintain the system to the extent that they could provide proposals below the
maximum bid amount. “The commercial revenue was viewed as being uncertain; proposers were unable to get signed contracts for service essentially three years in advance and proposers were unable to speculatively borrow the funds needed to build the project” said Dale B. Witmer PTC, Representative.

Pennsylvania also faced difficulty in monetizing the worth of its ROW. The Authority expected that it’s ROW value could offset the amount of public funds that the project would require. Fiber optic cable is expensive to install and determining a value of any exchange in ROW should be considered before any state undertaking a statewide fiber optic project. The state decided to cancel the project in December 2018 in order to reevaluate its approach considering no proposal could fit within the Authority’s desired financial constraints.

*Benefits*

Communications infrastructure is vital to the Commission’s daily operations and its ability to meet future needs. The main benefits of this project are that it supports PTC’s expansion of cashless toll collection, administrative building connectivity, maintenance shed connectivity, tolling systems traffic cameras, dynamic message signs, and potentially connected vehicle/automated vehicle technology.

*Application to Virginia*

The lessons learned from the Pennsylvania Turnpike has allowed the project team to get a better understanding of telecommunications P3 projects. The lesson learned from this case study was that they failed to attract bids within their budget, resulting in the termination of the project. PTC avoided the potential high risks associated with exchanging assets for a fiber network. PTC hoped to accomplish a large and costly project with little public capital investment. VDOT could
pursue a similar P3 method that would allow the agency to own fiber strands without owning or maintaining the network. But they would likely face similar challenges to PTC.

A process should be designed that allows VDOT to work with the private sector to discover and take maximal advantage of the value of its network. PTC failed to provide ROW that was attractive for commercial needs of the private sector. The project could have been successful if the Turnpike split up the network into smaller segments for the private sector to bid. Ultimately, the PTC realized that the project would not be accomplished by solely leveraging existing ROW and we speculate that the additional public capital investment needed would place high financial risk onto the public sector.
Appendix E

Broadband Visual Aid

VDOT Broadband Expansion

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<th>Problem Statement</th>
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<td>Many in the commonwealth live and work in communities with no access or limited access to broadband. Having access to broadband is a necessity that contributes to education, quality of life, and economic competitiveness. In many communities, broadband connectivity is essential for the delivery of health care services, the digital infrastructure that powers businesses, and the educational resources that can make a difference for students. While the state of Virginia has made significant progress in expanding broadband throughout the Commonwealth, there remains a need for continued investment. As a result, the Federal State Technology Transfer Program (FSTTP) is working with the state of Virginia to identify potential opportunities to leverage Broadcom connectivity across Virginia by aligning interests of different stakeholders, leveraging the existing assets and resources to provide the necessary tools to reach the unconnected. The approach includes the development of a broadband connectivity plan, implementation strategies, and identification of potential funding sources. This initiative is aligned with the statewide broadband strategy to ensure that all communities have access to reliable, affordable, and fast broadband services.</td>
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Broadband Basics

- Underdeveloped populations
- Limited knowledge of broadband capabilities
- Many communities lack access to broadband infrastructure
- Adequate broadband services are essential for education, health, and economic development

Legislation, Policy, Organizational Ownership

- Relevant Codes and Policy
- Dividing Fiber-View Statement
- Asset Utilization
- Access/Utilization
- Include Fiber-in-every-Project
- Maintenance
- Construction
- Development
- Organizational Accountability Matrix
- Governor Broadband Objectives

Inventory of Current Activities

- Inventory Broadband Assets
- High-speed Network
- Local Area Network
- Wireless Connectors
- Inventory of RWA's
- Inventory of Funding
- Future
- Inventory of Projects
- Planned
- Future

Needs and Opportunities

- Transition to broadband
- Transition to fiber
- Transition to 5G
- Transition to 6G
- Transition to 7G
- Transition to 8G

Case Study Comparison

Georgia Broadband Project

- Overview
  - Attempted to solicit a P3 agreement to install broadband using existing roads
  - Removed ROA, private sector funding, maintenance, and operations
  - Wide broadband network for public Use

- Benefits
  - Limited to use of VDOT
  - Expand broadband network
  - Expand VDOT's footprint Infrastructure statewide

- Challenges
  - No successful P3 contracts to date
  - Private sector interest may not align with VDOT goals

Pennsylvania (PA) Tanktop Broadband Project

- Overview
  - Attempted a DEBRW P3
  - Extended network cost of $232M/58M
  - Project was cancelled and proceeded with a new approach

- Benefits
  - Upgrade existing revenue stream to fiber
  - Private sector interest in revenue stream for operations without providing a large investment

- Challenges
  - Lack of commercial appeal to the private sector
  - Non-responsive bids

Kentucky Broadband Project

- Overview
  - Engaged a DEBRW P3 Proposal
  - Collaborative State Initiative
  - Open access network
  - $5 million dollar settlement with private sector for project delays

- Benefits
  - Directly benefits underserved population
  - Unique fiber connection to government facilities
  - 30 percent of the fiber would be available for commercial use to generate revenue

- Challenges
  - Project Delay
  - Issues with budget

Virginia Broadband Project

- Overview
  - Utilizes Resource Sharing Agreements with the Private Sector
  - Program has successfully installed 1,000 miles of broadband
  - Directs to expand network along all interstates and primary roads

- Benefits
  - Links to no roads to VDOT
  - Expands broadband network
  - Connects VDOT operational centers
  - Challenges
  - No 5G/6G/7G/8G network
  - Limited access to backbone service providers

Resource Sharing Fiber Network

3,708 miles

Source: Resource Sharing Location Data from VDOT Operations Division

Case Study Successes

- Broadband Infrastructure
- Broadband Infrastructure
- Broadband Infrastructure
- Broadband Infrastructure

Maintain the current RSA Agreement

Virginia has successfully installed fiber optic cable in the rights-of-way of roadways at no cost to the Department by exchanging ROW for road work. Virginia has installed 3,700 miles of fiber optic cable through these Resource Sharing Agreements (RSA). The option of continuing with the current policy has been a success and may still succeed in the future. Although, may not fully meet the goal of reaching rural areas due to lack of commercial attractiveness.

Solicited RSA Approach

P3 process could be successful in Virginia if they model them off of current RSA's. VDOT could further its Resource Sharing program by soliciting specific routes to current agreement holders or new internet service providers; VDOT should identify which segments might have enough value to justify a new RSA approach; identify and account for potential contingent liabilities that could cause public costs to increase.

Holistic Government Cooperation

Create a board made up of state agency stakeholders that are currently pursuing or have interest in pursuing fiber optic initiatives. This approach would help the state better leverage resources and costs required to expand a fiber network.

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