MPx PROJECT WHITE PAPER

BENEFITS OF A DIRECT FIBER ROUTE BETWEEN MONTGOMERY COUNTY, MARYLAND & ASHBURN, VIRGINIA

July 2015
Montgomery County, MD
www.montgomerycountymd.gov/ultraMontgomery

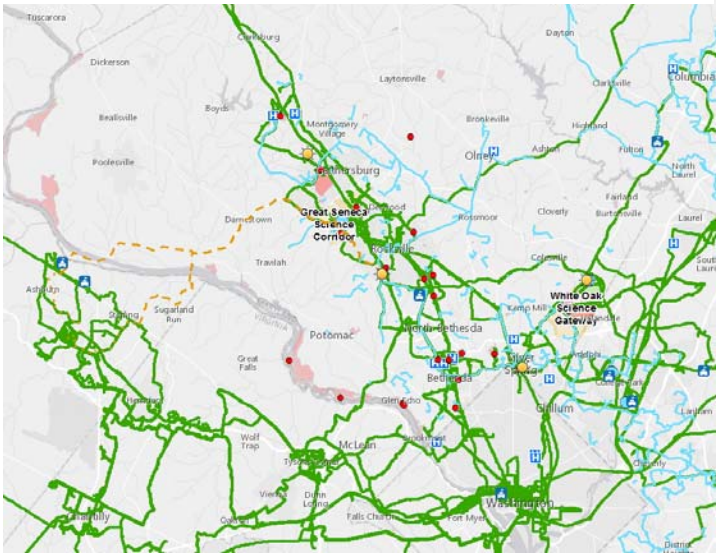
Summary

An impressive array of high tech companies and research institutions are located in Montgomery County. This knowledge-based economy is responsible for more than 8% of Maryland's economic output and is one of the fastest growing and largest sectors of the local and national economy. Montgomery County estimates that for every new 100 knowledge–based jobs, an additional $30 million is generated into the local economy.

The demand for ultra high-speed, reliable and secure broadband capacity is growing exponentially among these companies, and educational, research and governmental entities. A direct fiber route from Montgomery County's growing business hubs to the data centers in Ashburn, Virginia, is vital to the long-term growth of Maryland's knowledge-based economy. More than 90% of all Internet traffic on the East Coast travels through data centers in Ashburn. Yet fiber routes to Ashburn are artificially constrained by the lack of direct and diverse routes to Ashburn.

A shorter, direct fiber route under the Potomac River – between Montgomery County and Ashburn (**MPx Project**) – could lower the cost for public and private entities to obtain access to dark fiber and lit fiber services, improve network reliability, and enhance network performance.

Map 1: Montgomery County Regional Fiber Networks



Montgomery County is seeking financial support from public and private partners to form a consortium to build the MPx Project within the next 3 years. The estimated cost is $12 million. Our goal is to support our region's growing digital economy by facilitating access for private broadband service providers, companies, research and educational institutions, and governmental agencies, to a shorter, more direct, fiber route between Montgomery County, Maryland and Ashburn, VA.

Montgomery County hereby submits this White Paper for review and requests support for the MPx Project.

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Introduction

ultraMontgomery is a keystone of Montgomery County Executive Isiah Leggett's Six-Point Economic Plan. In introducing this plan in his Inaugural Address on December 1, 2014, Mr. Leggett stated:

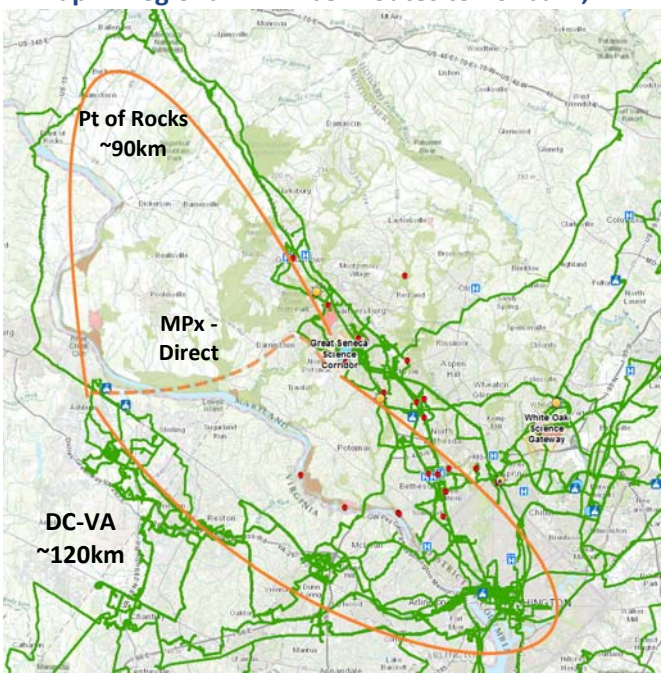
> "We live at a time when Internet connectivity and network infrastructure is just as fundamental to our economic future as are transportation systems, which requires us to have robust fiber networks to connect people with opportunities, and move our economy at the speed of our ideas. I am, therefore, launching ultraMontgomery, a high-speed fiber network that will connect our business, academic and federal institutions along major corridors and transit-oriented smart-growth communities."

A key component of ultraMontgomery is a shorter, direct fiber connection between Montgomery County, Maryland and Ashburn, Virginia.

Ashburn is a key data center hub for all Internet traffic and "cloud services" on the East Coast. More than 90 percent of all East Coast Internet routes use one of the 10,000 Internet connection points in Ashburn. Amazon Web Services, Google, Microsoft Azure, Akamai, and every telecommunications provider have fiber routes that reach Ashburn. All Maryland companies, data centers in Baltimore and Montgomery County, and Internet2 – the backbone communication network for connecting research and education institutions – must all eventually bring their Internet traffic to Ashburn.

However, because the Potomac River separates Montgomery County and all of Maryland from Virginia, there is no direct path between Montgomery County and Ashburn, and only a limited number of routes through Washington DC, or Point of Rocks, MD. As a result, the fiber distance between Montgomery County and Ashburn is two to three times what it would be if fiber directly connected companies on opposite sides of the Potomac River. Moreover, the limited number of routes artificially deprives all Maryland businesses, educational institutions, first responders and federal, state, and local governmental entities, of the benefits that competition brings.

Map 2: Regional MD Fiber Routes to Ashburn, VA



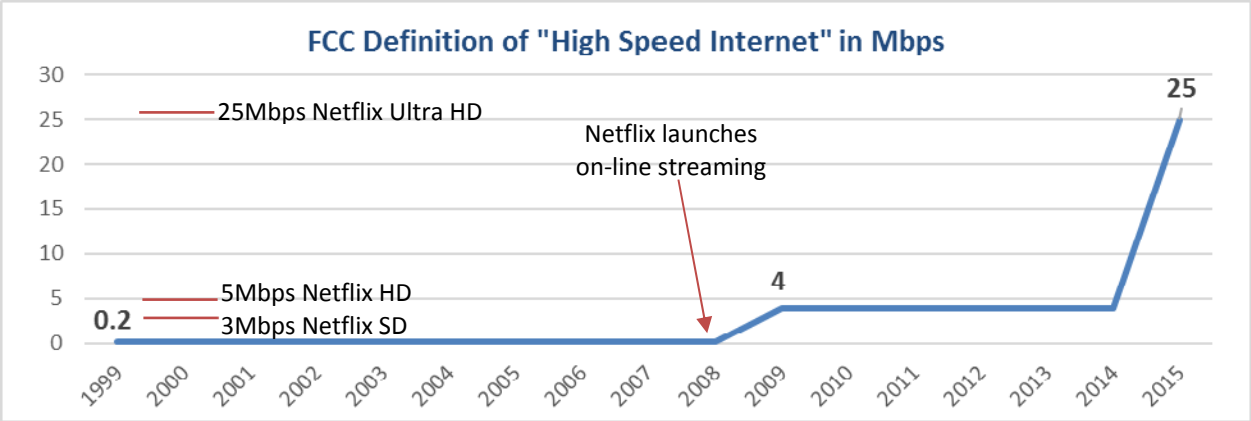
Thus, as part of County Executive Leggett's mission of stimulating additional economic development, Montgomery County is working to create a public-private consortium to construct a direct fiber route from Great Seneca/Rockville to Ashburn in the next three years andis seeking federal, state, university, and commercial financial and regulatory support for this effort.

A Vital Economic Future Requires Continued Expansion of Internet Broadband Capacity

Demand for Broadband Is Growing Exponentially

Bandwidth demand is growing *exponentially*. More and more managed IT, software and data storage services are being offered "through the cloud." In simple terms, devices connect to the Internet to access services, instead of having these programs and the associated data physically reside on a user's device or local network. Fewer and fewer companies are hosting their own e-mail and other application servers. An increasing number of companies use cloud-based file storage in place of more manual, data backup services, and the cloud is growing as a primary means of file storage. Moving resources to the "cloud" places greater demand and reliance on Internet connectivity.

In addition, the growth of wireless broadband services and the growing use of broadband mobile devices to access online services – especially mobile video – means that the each person is consuming more bandwidth, more frequently. Thus, "the cloud" and wireless broadband have led to an exponential increase in demand for bandwidth. The Maryland Research and Education Network estimates that over the past 15 years, broadband demand among its members has doubled every 18 to 24 months, and in January 2015, the FCC significantly redefined "high speed" Internet service.



The Internet-Related Economy Is Driving Economic Growth in Montgomery County and Throughout Maryland and the United States

Montgomery County continues to be a strong economic driver for the Maryland and national economy. As the chart below demonstrates:

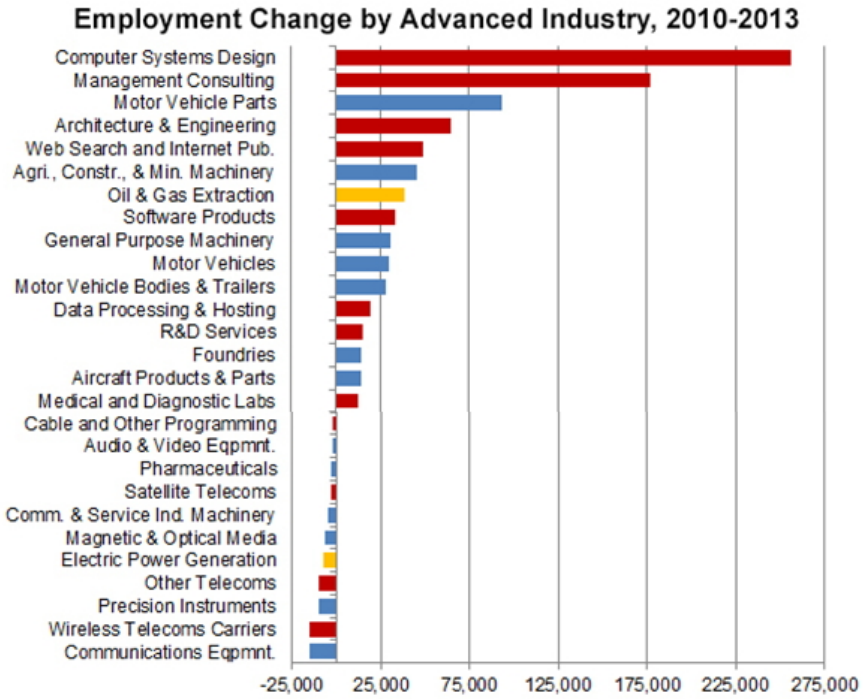
- Montgomery County is home to 20% of all Maryland businesses and generates 24% of the total annual Maryland payroll.
- 30% of the information jobs, and 40% of the information economy payroll, in Maryland are generated from Montgomery County
- 30% of professional, scientific and technical jobs, and 32% of the professional, scientific and technical payroll, in Maryland are generated from Montgomery County

2013 Census Data	Montgomery County			Maryland			Mont. County as % of MD		
	No. of Estb'mts	No. of Paid Employees	Annual Payroll	No. of Estb'mts	No. of Paid Employees	Annual Payroll	# of Ests	# of Empl	Annual Payroll
00-All Sectors	**26,739**	**419,956**	**$ 25,558,782**	**135,421**	**2,182,260**	**$ 108,758,652**	**19.7%**	**19.2%**	**23.5%**
51-Information	**643**	**16,086**	**$ 1,620,628**	**2,467**	**53,899**	**$ 4,123,482**	**26.1%**	**29.8%**	**39.3%**
52-Finance and Insurance	1,577	18,987	$ 2,350,933	7,551	99,107	$ 8,702,955	20.9%	19.2%	27.0%
54-Professional, Scientific & Technical Services	**5,713**	**79,057**	**$ 6,934,084**	**20,115**	**266,902**	**$ 21,827,583**	**28.4%**	**29.6%**	**31.8%**
61-Educational Services	554	11,044	$ 449,244	2,037	80,913	$ 3,516,590	27.2%	13.6%	12.8%
62-Heathcare & Social Assistance	3,601	62,621	$ 3,128,968	16,032	353,520	$ 16,631,815	22.5%	17.7%	18.8%
Subsector Total	**12,088**	**187,795**	**14,483,857**	**48,202**	**854,341**	**54,802,425**	**25.1%**	**22.0%**	**26.4%**
Subsector as % of All Sectors	**45.2%**	**44.7%**	**56.7%**	**35.6%**	**39.1%**	**50.4%**			

Source: 2013 Census County Business Patterns

These types of "advanced industry" jobs are having a huge impact nationally:

- A recent White House broadband paper cited studies stating that broadband Internet accounted for $28 billion in U.S. Gross Domestic Product in 2006 and the internet applications economy grew from $0 in 2007 to $20 billion in revenue in 2011.
- Strategic Networks Group collected research from 10 states and reported that 31 percent of their new jobs can be "directly attributed to broadband and the use of e-solutions."
- The Brookings Institution reports that Advanced Industries, the nation's "tech" sector, created almost 1 million jobs, or 18 percent of the nation's total job growth, between 2010 and 2013



A Shorter, Direct, Montgomery County-Ashburn Fiber Route Will Enable Business and Educational and Governmental Entities to Manage Exponential Growth in Demand for Broadband

Creating a direct fiber route between Montgomery County, Maryland and Ashburn, Virginia would benefit Montgomery County and Maryland businesses, and educational, research, and government entities by:

- **Lowering Recurring Fiber and Bandwidth Leasing Costs.** Expanding market opportunities to lease dark fiber could lower the cost for commercial, public, and homeland security agencies to operate their own networks over leased dark fiber, and could create price competition in the market for leased lit services as well.

- **Improving Network Reliability.** Increasing fiber route diversity will improve reliability by reducing single points of failure between companies in Maryland and data centers in Ashburn, and by expanding automated rerouting options.

- **Enhancing Network Performance.** Enabling dark fiber transport at distances under 80 km will enable large Montgomery County businesses and federal institutions to transport data within their own networks using dark fiber, rather than having to transport sensitive data over third-party lit service networks. A more direct route will reduce transmission latency and eliminate the need for intermediate signal regeneration within the network paths.

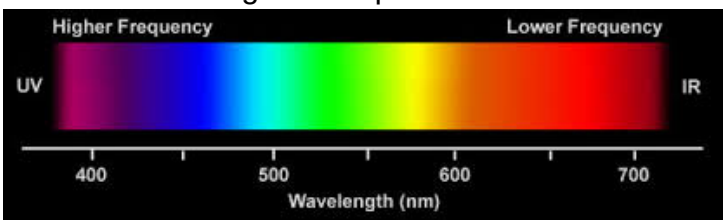
More Dark Fiber Will Lead to More Competitive Pricing of Dark Fiber and Lit Services

To understand how users manage exponential demand for bandwidth, it is helpful to understand “Dark Fiber” and “Lit Fiber” or “Lit Services.” Using a transportation analogy, “dark fiber” is like a high-tech highway where every user has an exclusive lane. The user pays for exclusive lane access, and supplies its own vehicle to move valuable cargo along the highway, and no one else can travel in the user’s exclusive lane. The user is responsible for maintaining its own equipment and supports maintenance of the highway. “Lit fiber” is like a premium-car service that uses the highway. The user pays to have the car service deliver whatever is needed to wherever it needs to go. The car service maintains the equipment, keeps the cargo packages secure, and uses technology to fit as many cars as possible into each lane. In the fiber world, if a user is a big entity that transports a lot of data, it may be cost-effective to own its own equipment and lease dark fiber. If a user is smaller, it may be more cost-effective to use someone else’s equipment and lease a lit service.

In a limited sense, both the lit service and dark fiber users pay tolls to use the high-tech highway based on distance. Thus, if there is a shorter route, the total charges are less. A shorter fiber route between Montgomery County, Maryland and Ashburn, Virginia could reduce the total costs that both dark fiber and lit service users pay. Moreover, if there are more alternative routes and the toll operator faces competition, the price to

use the high-tech highway may go down, or the operator may add amenities that the user values. In a similar way, if there are more fiber routes to reach Ashburn, or more fiber operators that offer lit services or dark fiber to reach Ashburn, users should realize the benefits of competition, both through improved services or more competitive prices.

However, when there is a shortage of high-tech highway lanes (dark fiber), the owner must typically price those lanes at higher rates compared to the premium-car service (lit service) – once a length of dark fiber is leased, the fiber owner cannot lease that fiber to anyone else, or use that capacity to offer lit services itself. However, like the lane sharing transportation analogy, in the fiber world, lit service providers divide the light that travels through fiber optic cable into different colors, like the colors in a rainbow.



The lit service provider can provide service to multiple users *at the same time*, *in the same fiber*, by having traffic travel separately in the different colors of light spectrum, all within the same fiber.

Thus, when a fiber owner establishes rates to lease dark fiber versus lit services, these rates will generally reflect the potential market value of the lit services the provider might otherwise be able to offer over those same dark fibers. While a provider can continue to increase capacity available over an individual fiber strand by upgrading electronics, dark fiber is generally a more finite resource. Thus, until an individual customer's demand reaches some relatively high level, leasing dark fiber is generally more expensive than lit service alternatives. However, as more dark fiber becomes available for lease, or as more competitors offer dark fiber for lease, competition will tend to drive down dark fiber leasing rates – the owner, or its competitors, now have a greater inventory of fiber to lease. Similarly, lower prices for dark fiber can lead to lower prices for lit services.

Leasing dark fiber and paying to operate your own network is an alternative to leasing lit services that makes fiscal sense for large entities that can support significant IT operating costs and service repair contracts. But an operator wants to make it attractive for an entity to lease lit service instead of leasing dark fiber. (The operator increases its profitability if it can use its investment in network equipment and fiber to lease lit services to more customers.) To make the value of leasing lit services more attractive, the operator may offer better lit service rates as the price of the alternative options of leasing dark fiber (especially from a competitor) and operating one's own network improves. In addition, as the lit service operator secures better dark fiber leasing rates itself, it may be able to pass those cost savings through to its customers.

Thus, constructing a direct fiber route underneath the Potomac River between Montgomery County and Ashburn is a cost-effective way to significantly add more fiber capacity for commercial, educational, and governmental purposes in the Northeast U.S.-Maryland-Washington D.C. fiber market. A direct fiber route would create significantly more capacity to Ashburn, and could lower dark and lit fiber leasing costs for all entities in Maryland, including statewide networks operated by Maryland State agencies for governmental, homeland security, and public safety purposes.

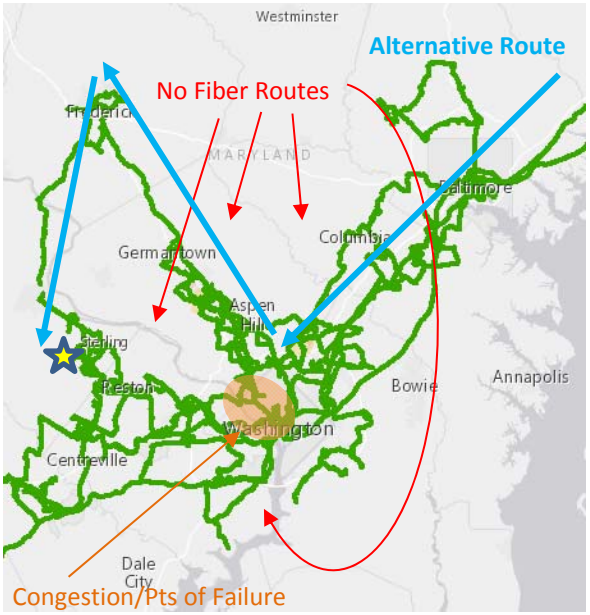
A Direct Fiber Route to Ashburn Will Improve Reliability by Increasing Route Diversity and Eliminating Single Points of Failure

Network connectivity is made more reliable and secure when there is route diversity. If diverse paths are available, networks can automatically reroute traffic in the event of a fiber break or equipment failure, and can mitigate congestion by load-balancing traffic over redundant links along a route. However, if there is only a single path, when there is a point of failure or congestion, network traffic may be impaired or completely blocked until the problem is resolved.

Using our transportation analogy, the traffic between Montgomery County and Ashburn is artificially constrained because there is no bridge between Montgomery and Loudon Counties. In the fiber world, one or two companies control the access across the American Legion Bridge and Chain Bridge, and those fiber routes can only be used by their customers at premium rates.

All the Internet traffic of users who are not customers of these bridge owners must use another bridge farther away. Now imagine that there is an incident in Washington, DC, which congests or blocks access to the Memorial and 14th Street Bridges. All of the traffic coming from New York and Baltimore becomes stuck trying to get around the congestion in D.C. However, in the fiber world, it is as if the Wilson Draw Bridge is in a permanent drawn position, with traffic unable to cross it, because there is almost no fiber available for commercial use that crosses this drawbridge. The other alternative is using the crossing at Point of Rocks in Frederick County. However, there is limited access to fiber along I-70. And regardless of which route is used, it takes longer for traffic from New York and Baltimore to be routed through Howard and Frederick Counties, or travel south to the middle of Montgomery County and back north to Frederick County to cross at Point of Rocks, or travel south through D.C. and back northwest to Ashburn, than to cross Montgomery County directly to reach the data centers in Ashburn, just across the river.

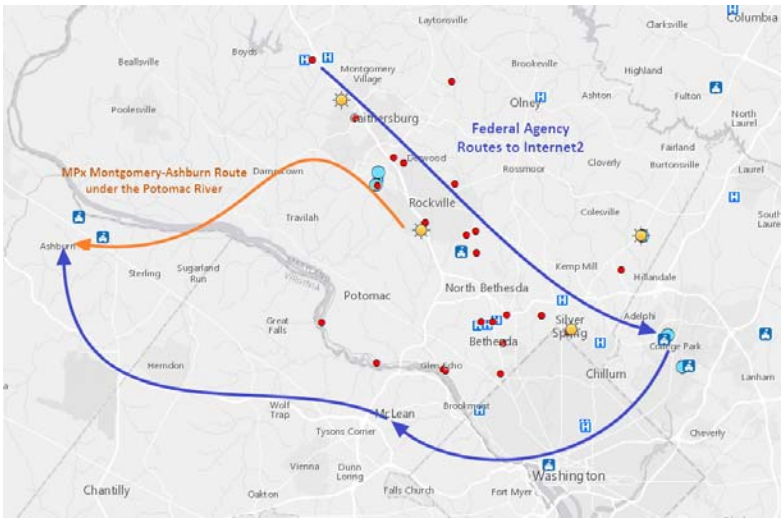
Map 3: Commonly Available Commercial Fiber



In our traffic analogy, back-up traffic may be an annoyance, missed appointments, or an ambulance that cannot make it to a hospital in time. In the fiber world, it may mean telephone and video conference call conversations become unintelligible; video services stop to allow for buffering multiple times; delays occur receiving x-ray images or genomic data sets; financial transactions miss deadlines; or critical public safety communications are disrupted. Building a major alternative route through Montgomery County to Ashburn that can be used by many operators would create a highly diverse route that could make all of the Northeast U.S. Internet traffic more reliable.

Furthermore, most federal agencies, and some state agencies, need to reach one of two Internet2 connections in Ashburn or McLean, Virginia. To get to Ashburn from Montgomery County, most federal traffic is transported to the University of Maryland in College Park, Maryland. The network traffic is then transported through Washington D.C. and Arlington, Virginia to McLean in Fairfax County, and then to Ashburn, Virginia in Loudon County. Even though there are two Internet2 connection points in Ashburn and McLean for diversity purposes, there is no diverse route to reach Ashburn – all the traffic to Ashburn has to goes through McLean. Most State traffic must use a single provider to get between McLean and Ashburn. Thus, a diverse route through Montgomery County to Ashburn that does not require going through McLean would significantly improve network reliability for *network*Maryland, Maryland's IT communications network, and all federal agencies located north of Ashburn.

Map 4: Federal Agency Fiber Routes to Internet2



A Fiber Route to Ashburn Could Improve Performance Network Security for Businesses and Government Agencies by Enabling Dark Fiber Transport

Large bandwidth users seek fiber routes that are shorter than 80 km to enable use of dark fiber instead of lit fiber. Imagining our transportation analogy, think of an electric car that can travel a maximum of 80 km on a single charge – sometimes the vehicle makes it 80 km, but sometimes not, so the operator avoids traveling more than 70 km to avoid battery failure. In the fiber world, signal degradations increase proportionately to speed (bandwidth used) and distance traveled. At speeds above 10 Gbps (gigabits per second), and certainly at 100 Gbps and higher, distance-related signal degradation affects performance of the communications network and can require use of additional equipment to mitigate the signal degradation. Ultimately, longer distances increase equipment and operational costs.

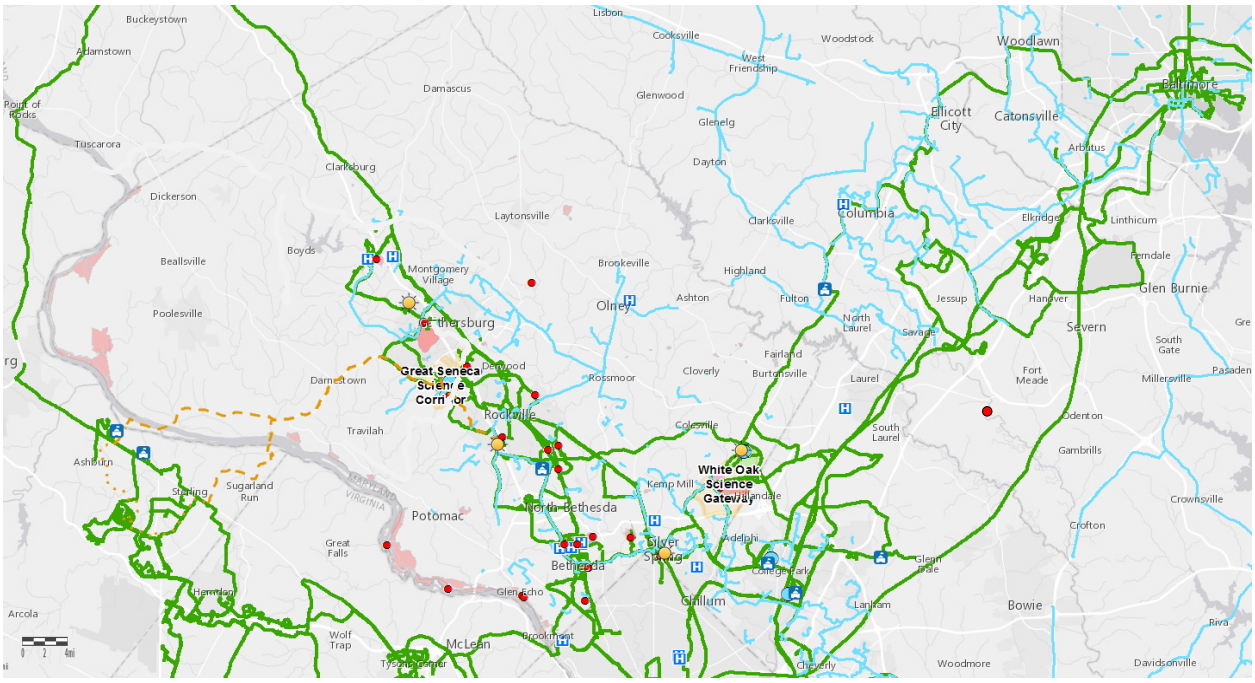
Moreover, each time a signal must be regenerated (or switched at an intermediate point within a fiber route), the total delay, or "latency," increases, as does the potential for outage due to equipment failure or fiber breaks. Minimizing latency is sometimes as important to the overall performance of a communications application as capacity and reliability. Interactive two-way communications, such as Voice-over-IP (VoIP) and videoconferencing are highly sensitive to latency, and can exhibit noticeable impairment above 50 milliseconds. Synchronous data replication between data centers for backup and disaster recovery purposes generally requires less than 5 milliseconds of total

latency, which can be difficult to achieve if a lengthy route requires a lot of additional equipment to regenerate the signal.

Using the electric car analogy, imagine that it is very expensive to own a charging station (the signal regeneration equipment), so you have to use someone else's charging station if you travel more than 80 km. If your electric car contains classified valuables, you might prefer not to have to plug anyone else's charging station into your car. So you would need a route to Ashburn that is less than 80 km. In the fiber world, if a fiber route to Ashburn existed that was less than 80 km, a federal agency or large company could send all of its network traffic without having to use third-party or its own additional equipment to regenerate its signals. This is how the use of dark fiber works. All of your valuables (your network data) could be transported by using your own car (your own network), without use of additional expensive equipment, and no one else would have access to what's in your car (the data in your network).

As discussed above, the route that most federal agencies use to reach Ashburn travels through College Park, Maryland, and is well over 80 km. A shorter route is a better option for many reasons and a direct fiber route under the Potomac River between Montgomery County and Ashburn is about 40 km. Thus, such a direct fiber route would enable large businesses, government agencies, fiber providers, and data centers in Montgomery County to offer fiber routes to the data centers in Ashburn that are more competitively priced, more diverse, and that improve network performance.

MAP 5: CURRENT AND POTENTIAL REGIONAL FIBER ROUTES



American Recovery & Reinvestment Act (ARRA) Local Government Fiber

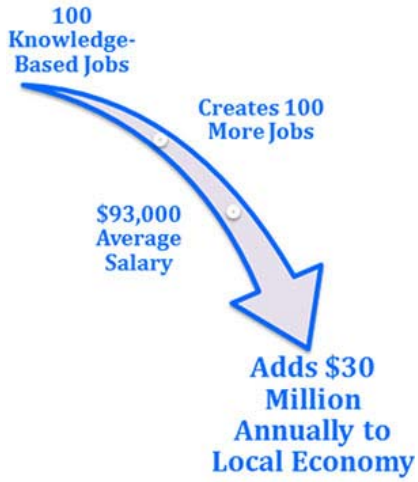
Commercial Fiber • Federal Agencies ✹ Data Centers

Proposed MPx Montgomery County-Ashburn Fiber under the Potomac River

Potential Roles of Montgomery County and the State of Maryland

Montgomery County is seeking financial support from public and private partners to form a consortium to build the MPx Project within the next 3 years. Montgomery County and the State of Maryland could perform several key roles to facilitate rapid construction of a direct fiber route.

As discussed within this paper, the Potomac River crossing through Montgomery County, or MPx Project, could further the goals of both Montgomery County and the State of Maryland to spur economic development of broadband-dependent, advanced industry jobs. For example, in the life sciences sector alone, Montgomery County's Department of Economic Development estimates that for every 100 jobs the sector creates, an additional $30 million dollars is generated into the local economy. Thus, an investment constructing the MPx route could produce significant dividends for both Montgomery County and the State of Maryland.



Private and Regulatory Agency Support

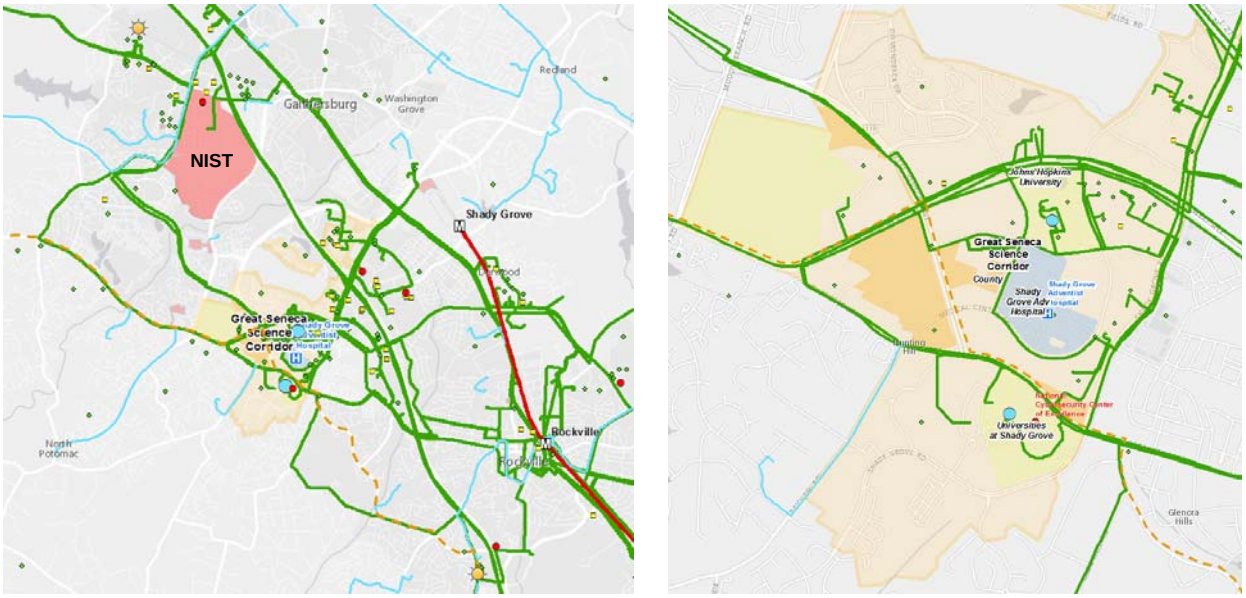
The County is actively working to form a consortium of interested commercial, educational and government partners who would be willing to provide financial support for the MPx Project. Meetings are being held to discuss engineering requirements and potential ownership and cost-sharing models. The County is also working with, or will be seeking support from, the following government and regulatory agencies:

- Maryland Department of Natural Resources, Department of Information Technology, Department of Transportation, State Highway Administration, and State Police
- U.S. Park Service and Army Corp of Engineers
- Loudon, Fairfax, and Arlington Counties, Virginia
- Fairfax County Water Authority

Potential MPx Route

Montgomery County is exploring two options for direct fiber routes between Montgomery County and Ashburn. At present, as shown in Map 5 above, and Maps 6 and 7 below, each route would start near Rockville, travel along the edge of the Great Seneca Life Sciences Center, using MD State Route 28 and Route 112, and a portion of River Road to reach the Potomac River. All construction would be underground and not visible after completion of the construction.

Maps 6 and 7: MPx Route in Great Seneca Science Corridor



Local Government Fiber | Great-Seneca Science Corridor | Educational Property
Commercial Fiber | Federal Agencies | Data Centers | County Property
Proposed MPx Route | Biotech Companies | Cybersecurity Companies | Gigapops

At present, an endpoint in Montgomery County has not yet been determined. However, this endpoint is likely to need to have several attributes that are common to a data center, and should be in a location that will not require relocation for 20 years.

Estimated Timeline

Montgomery County estimates that the fiber route could be constructed in two to five years based on the following timelines:

- Negotiation of cost sharing, route, and financing of construction budget (12-18 months)
- Engineering (2-3 months)
- Environmental impact assessment and permitting (6-12 months, but could take as long as 24 months)
- Construction (6-12 months)

However, with the coordinated support of the federal and State regulatory agencies, as well as commercial support, Montgomery County believes that the MPx Project could reasonably be constructed within 3.5 years (42 months).

Estimated Cost

Using sample endpoint locations in Montgomery County and Ashburn, the County has estimated the following potential route distances and cost.

ROUTE OPTION	DISTANCE		ESTIMATED COST
Through Lowes Island, VA	25.17 mi	40.5 km	$ 11.8 million
Through Seldon Island, VA	26.78 mi	43.1 km	$ 12.6 million

As stated above, each route assumes underground construction of two 4” conduits, with 3-cell Maxcell innerduct and two 432-strand fiber cables installed in one of the conduits, in both Maryland and Virginia. Under the Potomac River, an additional two conduits and one innerduct would be installed by boring through sediment. This construction would provide ample fiber capacity for leasing and future conduit to support future fiber installation. The cost of the project would be lower if less fiber and conduit capacity is constructed.

Conclusion

A direct dark-fiber route between Montgomery County, MD and Ashburn, VA, could have a number of benefits for companies and federal agencies in Montgomery County and across Maryland. The MPx project could lower dark fiber and lit service costs, enhance reliability, and improve security for crucial data transport. Supporting the construction of a direct fiber route to Ashburn would create another incentive for companies to look to Montgomery County and Maryland as an innovative place to do business.