EXPANDING COMMUNITY NETWORKS IN MICHIGAN

THE MICHIGAN MOONSHOT GUIDE TO BUILDING HIGH-SPEED INTERNET SERVICE

SUMMER 2022

THE MICHIGAN MOONSHOT℠

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ABOUT THE MICHIGAN MOONSHOT

The Michigan Moonshot is a collective call to action which aims to bridge the digital divide in Michigan. Stakeholders include Merit Network, the nation's longest-running research and education network, the Quello Center at Michigan State University and M-Lab, the largest open internet measurement platform in the world. Learn more about the Michigan Moonshot at MichiganMoonshot.org.

ABOUT MERIT

Merit Network, Inc. is an independent nonprofit corporation governed by Michigan's public universities. Founded in 1966, Merit owns and operates America's longest-running regional research and education network. We now manage more than 4,000 miles of fiber-optic infrastructure. With more than 55 years of innovation behind us, Merit continues to provide high-performance services to the educational communities in Michigan and beyond. Merit pulls from its past experience managing NSFNET, the precursor to the modern internet, to catapult Michigan into the forefront of networking technologies. Through Merit, organizations have access to leading-edge network research, state and national collaborative initiatives, and international peering.

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LETTER FROM THE PRESIDENT

Michigan Moonshot's Upper Peninsula Origins

Merit's Michigan Moonshot broadband initiative is certainly not a typical activity for a Research & Education (R&E) network. In fact, Merit was the only R&E network in the nation working on such a statewide program in 2018, years before the pandemic significantly amplified the need for residential broadband connectivity. Now, every state in the nation and many sister R&E networks are endeavoring to find ways to improve internet service to their residents. Homes are the new classrooms, offices and medical consultation rooms of the 21st century.

Merit is the nation's longest-running R&E network, having been started in 1966 by the University of Michigan, Michigan State University and Wayne State University, when researchers at those schools conceived of a new method of sharing digital information between their campuses. In the 1980s and 1990s, Merit operated the National Science Foundation Network (NSFNET) — the precursor to the modern internet. Merit's mission is to connect organizations and build community, and today we serve about 400 anchor institutions across Michigan — universities, colleges, K-12 schools, libraries and governmental entities, among others — providing high performance internet service regardless of locale.

Given our mission, Merit will never be a residential internet service provider. Why, then, did Merit begin to think about helping improve connectivity to peoples' homes? There were two events in my tenure at Merit that convinced me we needed to help our great state. The first happened in 2017 as I was driving around the Upper Peninsula meeting our members. At the end of one of my long daily trips as the sun was setting on a very cold, clear winter day, I was leaving a small rural library. I noticed the parking lot was full of running cars despite the library being closed. I asked someone what this was all about, and they told me that townspeople were using the library's Wi-Fi so their children could finish their homework because they didn't have internet service in their homes. This stunned me, and I had a hard time believing this was possible in America in the 21st century. My mother and father grew up near this place, and I thought about people like them today who must have an incredibly difficult time with educational

and work-related activities, given the need to use the internet for these things in the modern age. Lack of access to information could have life-changing consequences for many, I thought.

The second event involved my participation in 2018 on then-Governor Rick Snyder's broadband taskforce, the Michigan Consortium of Advanced Networks. I worked alongside policymakers, local community leaders, business leaders, educators and residents to help develop Michigan's first long-term broadband plan. During local community outreach events, I heard moving stories about the real plight of people who did not have internet access. It was this civic work that compelled me to ask my capable team at Merit how we could get involved to help communities. The result was our Michigan Moonshot initiative.

Today, through this program, we're helping educate communities on how to tackle the broadband problem. We're working with policymakers and funding agencies; we're providing accurate broadband maps and sentiment surveys through crowdsourced citizen science; we're working with university researchers on gauging the impact of broadband on residents and students; and we're finding novel ways to use our advanced network to help local communities and internet providers connect more people.

Our goal is to have no student or resident left behind in the 21st century, with people in places like Newberry, Ironwood and Bellaire having the same high-speed connectivity as those in Ann Arbor, Grand Rapids and Ferndale. I hope you'll join us on our quest to make Michigan the best connected state in the nation.

Joseph Sawasky

Joe Sawasky

President & CEO, Merit Network, Inc.

INTRODUCTION

As the quarter-way point of the 21st century approaches, it's clear that high-speed internet service is a necessity of life in the United States, in rural areas as well as cities. And yet, well into the century's third decade 17% of rural Americans lack access to high-speed internet service, according to the U.S. Federal Communications Commission.[1]

On the bright side, the rural-urban digital divide continues to narrow. The FCC notes that the 17% figure, derived from data at the end of 2019, is a 46% improvement from 2016. The gap between urban and rural Americans fell to 16 percentage points, from 30 in 2016. However, as will be shown shortly, FCC data paints a rosy picture (even by the FCC's own admission) by sometimes overstating high-speed internet coverage in the United States.

Yet, even according to these more optimistic figures, the divide still exists. About 11 million rural Americans did not have fixed broadband[2] coverage as of the end of 2019.

Michigan is no exception.

BROADLY SPEAKING

"A 10-percentage-point increase in broadband access in 2014 would have resulted in more than 875,000 additional U.S. jobs and $186 billion more in economic output in 2019. That is an average of 175,000 jobs and $37.2 billion in output per year."

Deloitte, Broadband for All: Charting a Path to Economic Growth, April 2021.

The state ranked 32nd in the nation for broadband availability in a 2021 report from the Michigan High-Speed Internet Office, which gathered data from the U.S. Census.[3] Some 1.24 million households (31.5%) lacked a permanent, fixed internet connection at home, the report said. According to U.S. Census estimates, 549,000 Michigan households, or 13.8% of the total, did not have any internet subscription at all as of 2019.[4]

Given that most of Michigan is rural, the numbers skew heavily toward these areas. More than 90% of Michigan's land area is rural, with a quarter of the state's population, or 2.5 million people, living in these areas.

[1] Federal Communications Commission, Fourteenth Broadband Deployment Report, January 2021.

[2] "Fixed" is industry terminology referring to hard-wired service delivered by fiber, coaxial or copper cables, as opposed to wireless and cellular services. "Broadband" is the standard industry term for high-speed internet service.

[3] Michigan Office of High-Speed Internet, 2021 Update to the Michigan Broadband Roadmap, November 2021.

[4] U.S. Census Bureau, American Community Survey, 2019. Michigan data can be found here.

The urban population that makes up the other three quarters live on just 6% of the land.[5]

Currently-available figures still largely reflect a pre-pandemic world, when remote working finally came into its own. That trend should bode well for less-populated areas of Michigan, which tend to be quiet and beautiful — ideal surroundings in which to work. But they'll need quality internet service if they want to take advantage of the trend.

More broadly, the pandemic left a permanent digital mark on all areas of practical life, from working from home and e-commerce to telehealth and education. And it accelerated a trend already well underway. Any disparities amount to a competitive advantage for areas that have high-speed internet and a disadvantage for those that don't.

With this in mind, and as part of Merit Network's Michigan Moonshot initiative, which aims to bridge the digital divide in the state, we put together this report as an update on where things stand with high-speed internet service in Michigan. Working with the Quello Center at Michigan State University, our partner in the initiative, we completed a landmark study on the impact of broadband service to Michigan K-12 students. (See page 9 for more.) We've also been conducting broadband access and availability surveys in counties throughout the state to get a more accurate picture of Michigan's rural broadband gap. The results of a

BROADLY SPEAKING

"Connecting currently disconnected Michigan households is estimated to produce $1.8 billion to $2.7 billion in annual economic opportunity."

Michigan Office of High-Speed Internet, _2021 Update to the Michigan Broadband Roadmap_, November 2021.

[5] Citizens Research Council of Michigan, _Exploring Michigan's Urban/Rural Divide_, April 2018.

sampling of these surveys, which can be seen beginning on page 19, are eye-opening when compared with existing FCC data.

We also took this opportunity to share pointers on setting up a community broadband network, and so the bulk of the report serves as a starting guide for communities that want to close their broadband gap. We'll run through the types of technologies used to access the internet, how to plan your network, what's involved in building and running a network, funding programs available to you, ownership models, legal considerations, resources for help and other practical information. While the guide was made with rural Michigan areas in mind, much of it can be applied to cities, as well as communities outside Michigan.

Merit has been deeply involved in digital networking since 1966 — well before the term "internet" was coined. Merit Network Inc. is what's known as a Research & Education (R&E) network. R&E networks operate at the state or regional level, providing internet access and related services to universities, K-12 schools, municipalities, police and fire departments, libraries and other community anchor institutions. Merit operates in Michigan and has about 400 members in its network, including 12 public universities that are its governing members. We were the first R&E network to come into existence and our network continues to be the longest-operating regional computer network in the United States. We managed NSFNET, the forerunner to the internet, on behalf of the National Science Foundation from NSFNET's beginning in 1988 through its end in 1995.

BROADLY SPEAKING

In a 2021 poll of prospective homebuyers, 90% indicated they prioritize fast, reliable home internet. Two-thirds of realtors said their clients more frequently sought information about access to broadband home internet over the previous year than before the pandemic.

Morning Consult and Verizon, *Homebuyers' 5G & Connectivity Needs*, May 2021.

In 2014, we completed a 4,000-mile fiber-optic network, which we continue to manage. We understand what it takes to plan, build and operate fiber networks, right down to the maintenance crews.

Working with the Michigan Broadband Alliance, we organized this report to help more communities close their broadband gap. It's hard to imagine a 21st century life without broadband, just as it's hard to imagine a 20th century life without electricity. Communicating with friends and family, streaming video services, e-commerce and smart-home features are some of the conveniences of broadband that come to mind. There are plenty more. High-speed internet service is now central to business, employment, entrepreneurship, job creation, education, health care, government and public safety, as technology delivers more efficiencies.

Background

A similar situation did indeed exist 100 years ago as the 20th century took shape. Electricity was common in cities but not in the countryside — less than 10% of rural U.S. households had electricity. The Rural Electrification Act of 1936 changed that, by providing a national strategy as well as funding to build rural electric infrastructure.

We can see the same pattern developing for broadband. Few today would debate whether rural areas need electricity. Broadband similarly ensures that rural areas are able to participate in today's digital life and enjoy the same benefits of technology that their urban counterparts do.

There's much more at stake than watching Netflix. With the benefit of several decades of internet service now behind us, researchers are able to show the positive impact that broadband has on the economy, education, health care, jobs, small business, agriculture and real estate values.

BROADLY SPEAKING

Michigan students with fast home internet access see overall grade point averages (GPA) of 3.18, while students with no access see averages of 2.81. Students without home internet access perform lower on a range of metrics regardless of gender, race and ethnicity, or parental income and education.

K.N. Hampton, L. Fernandez, C.T. Robertson, and J.M. Bauer, *Broadband and Student Performance Gaps* (James H. and Mary B. Quello Center, Michigan State University, March 2020).

So what's the holdup? One impediment has been the economics of building network infrastructure. Putting up cables and poles in areas where everyone is far apart tends not to be profitable. The low population density means the return on investment for bringing connections to each location would only come far in the future, if at all. Rough terrain, such as forests or rocky ground, further hinders things.

Complicating matters is the lack of clarity over broadband access. The confusion stems from the widely-used main source of information, the FCC "Form 477", which measures fixed broadband access according to census block. But it has a major drawback: If one home within a block has broadband access, the entire block is counted as having access.[6]

As the FCC itself says in its most recent broadband progress report, reliance on Form 477 data "could overstate the coverage experienced by some consumers, especially in large or irregularly-shaped census blocks." [7]

The result is the misleading impression that broadband is available nearly everywhere even though it isn't. This in turn affects everything from applying for funding to identifying the problem in the first place.

[6] Specifically, the FCC's "Fourteenth Broadband Deployment Report" says: "A census block is classified as served if the FCC Form 477 data indicate that service is available in the census block, even if not to every location. Therefore, it is not necessarily the case that every household, housing unit or person will have coverage from a given service provider in a census block that this analysis indicates is served."

[7] Federal Communications Commission, *Fourteenth Broadband Deployment Report*, January 2021.

MICHIGAN COMMUNITIES ARE ALREADY SEIZING THE INITIATIVE AND SETTING UP THEIR OWN NETWORKS.

SEE PAGE 51 TO READ THE EXPERIENCES OF FOUR OF THEM.

THE HOMEWORK GAP

quello center
MEDIA & INFORMATION POLICY

QUELLO CENTER STUDY SHOWS HOME BROADBAND SERVICE LEADS TO STARK DIFFERENCES IN STUDENT PERFORMANCE

The digital divide hits K-12 students particularly hard, creating what's known as the "homework gap". In Michigan, we have a very clear picture of this homework gap, thanks to work done by Michigan Moonshot partner the Quello Center for Media and Information Policy at Michigan State University.

In that time, we've seen how the lack of home broadband connectivity leads to some creative workarounds. Students report completing homework on their phones on the sides of roads near cell towers where they can get a good signal. Schools provide 24-hour Wi-Fi access in their parking lots so parents can drive their children back to school at night to complete homework from the car. Some teachers report preparing two lesson plans, one for those with connectivity and one for those without, while others report foregoing the inclusion of online resources at all to avoid disparities for their unconnected students.

In 2019, the Quello Center for Media and Information Policy at Michigan State University, Merit's Moonshot partner, undertook a study of students in grades 8-11 from 15 mostly rural Michigan school districts. The study, titled "Broadband and Student Performance Gaps", involved a paper survey, standardized test scores and home internet speed tests, all of which yielded a trove of data on how broadband service affects student performance:

Students with fast home internet access reported an overall grade point average (GPA) of 3.18 on the standard 4.0 scale. Students with no access reported an average 2.81 GPA, and those with only cell phone access reported a 2.75 average.

Students who had only cell phone internet access at home performed lower on standardized tests, while students who had higher digital skills performed significantly better on standardized tests such as the SAT.

Students without home internet access performed lower on a range of metrics regardless of gender, race and ethnicity, or parental income and education. Students who accessed the internet only through their phones performed similarly to those who couldn't access the internet from home at all.

Students with no home internet score approximately three points lower on the 64-point digital skills scale; those who have only a cell phone to access the internet score four points lower than those with fast or slow internet at home.

Students with slower home internet access were 21% less likely to say they planned to complete college or university.

82% of students reported that they sometimes or often received homework that requires internet access.

On average, those who had no internet access at all spent 30 minutes more on homework than their peers who had high-speed access.

Those with no home access were 29% less likely to intend to finish a post-secondary education.

A student with even moderately lower digital skills was 26% less likely to intend to attend college the year after high school.

MICHIGAN'S STUDENTS: IN THEIR OWN WORDS

"At home, I have no access to the internet."

"If my YouTube video is five minutes, it will take out our Wi-Fi access for three days."

"I miss out on a lot of schoolwork."

"I couldn't come in to town to do my homework because the roads were dangerous. My grade suffered."

"It takes 15 minutes to load one page."

"I turn on my computer, then go get dinner. By the time I finish eating, my computer is loaded and I can log in."

"I'm still stuck in the 20th century. It's a curve and it's not really fair to us."

Hear directly from students in our video at the Michigan Moonshot homepage.

64% of students with no home internet access often or sometimes left homework unfinished because they lacked internet access or a computer. This compared to 49% of those who relied on cell phones, 39% with slow home connections, and 17% of students with high-speed home internet access.

82% of students with high-speed internet at home did science homework on a typical school night, compared with 76% of students with no, slower or cell phone-based home access.

Those with home internet access were more likely to say that they wanted a career in a STEM (science, technology, engineering and mathematics) field, and the same was true for STEAM (science, technology, engineering, arts and mathematics) professions.

The full report on these survey results, "Broadband and Student Performance Gaps", can be found at BroadbandGap.net.

ACCESS TECHNOLOGIES

A number of technologies have come along over the years to provide access to the internet. For the purposes of this guide, we assume your network will use fiber-optic technology, as it's faster and more reliable than old copper or coaxial technologies. And while wireless can be a less expensive solution, fiber doesn't put your network at risk of being obsolete in a few years.

First, a little bit of history on how we got here and the array of access technologies currently on offer.

BROADLY SPEAKING

"Municipal networks tend to offer the fastest, most affordable options," said the authors of a 2020 study of 760 internet service plans in 28 cities in Asia, Europe and North America. The study emphasized U.S. service, covering 296 plans in 14 U.S. cities. "A growing body of evidence indicates that these locally-owned networks yield significant cost savings for consumers, yet at least 20 states restrict or outright prohibit these networks from existing."

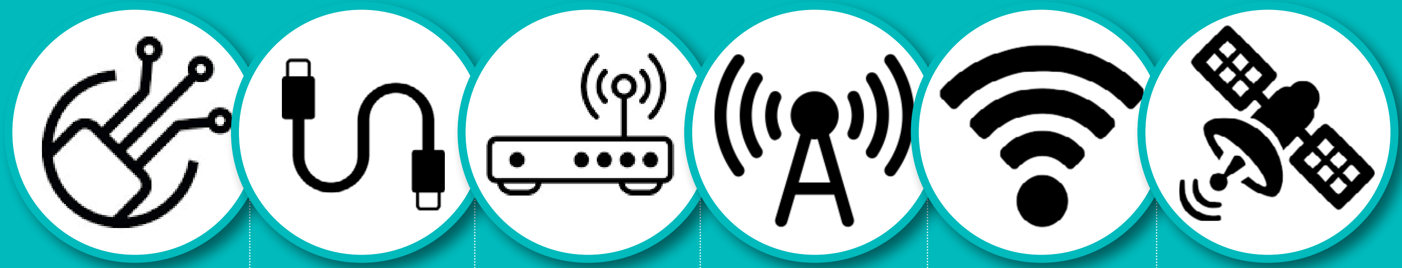
Becky Chao, Claire Park, and Joshua Stager, *The Cost of Connectivity 2020* (Open Technology Institute, New America, July 2020).

History

Dial-up modems were the first widely-used home internet access technology. Deployed in the early 1980s, they connected over standard telephone lines and operated at speeds of about 1200 bits per second. Nearly every U.S. household could get dial-up service if it chose to, thanks to the success of universal telephone service efforts and the ubiquity of analog phone lines.

The 1980s also saw the popularization of cable television services. While cable TV had existed since the 1950s, adoption grew in the 1970s and 1980s, and became a major force in providing high-quality

COMMON INTERNET ACCESS TECHNOLOGIES



Fiber
Service provided using light wavelengths transmitted through glass cables

Cable
Service provided through coaxial cables originally designed for delivering television service

DSL
Service provided through copper lines originally designed for delivering telephone service

Cellular
Service provided through mobile devices

Fixed Wireless
Service provided through radio waves transmitted between towers and buildings

Satellite
Service provided using satellites in Earth orbit

> The digital divide has grown in step with internet technology, from modems through fiber optics.

video entertainment and information to consumers. By the end of the ‘80s, nearly 53 million households subscribed to cable. The 1980s also brought the introduction of satellite dishes as a better way to access television programming, especially in rural areas without access to a cable network.

In the 1990s, analog modems gave way to digital subscriber lines (DSL) that use the same telephone wires, introducing significant speed increases compared to dial-up modems. Cable TV companies began providing internet access over their systems, offering the first competition to telephone lines. Satellite TV companies began to offer internet access service via satellite dishes. Some providers also began to experiment with the delivery of internet access through wireless technologies.

It was in this period that the broadband gap began to take shape. While almost all households had access to a phone line, many people in rural areas were not close enough to DSL infrastructure to access speeds as fast as their urban neighbors — or any DSL at all. Cable internet was only available to the 65 million Americans with access to cable infrastructure. Wireless internet was still uncommon. And, while satellite grew as an option for those with no other choice, it offered a comparatively poor quality of service.

At this time, many users were unaware of the service gap. Websites were still new and had simple content.

BROADLY SPEAKING

A 2015 study looked at the impact of broadband on the prices of homes. The authors estimated that just having the ability to upgrade to a 1 gigabit-per-second connection in a single-family home led to sale prices 1.8% higher than in similar homes where only a 100 megabit-per-second connection was available. They also said homes where fiber was available had a price about 1.3% higher than similar homes without fiber. “When evaluated at the sample median house price, the combined effect of 3.1 percent suggests that access to fiber may be associated with about a $5,437 increase in the typical home’s value. This is roughly equivalent to a fireplace or just under half the value of a bathroom,” the study said.

Gabor Molnar, Scott J. Savage, and Douglas C. Sicker, *Reevaluating the Broadband Bonus: Evidence from Neighborhood Access to Fiber and United States Housing Prices* (Fiber To The Home Council Americas, June 2015).

BROADLY SPEAKING

The authors of a 2014 study sought to measure how broadband had affected rural economic growth in the U.S. and said that rural counties with high broadband adoption rates showed faster growth in household income and lower growth in joblessness, while rural counties with low adoption rates saw lower growth in the number of firms and employment. For low-adoption counties, the growth rates in the number of businesses and employment were about three percentage points lower than in high-adoption counties. Poverty levels were 2.6 percentage points lower in counties with high download speeds.

Brian Whitacre, Roberto Gallardo, and Sharon Strover, "Broadband's Contribution to Economic Growth in Rural Areas," Telecommunications Policy 38, no. 11 (December 2014): 1011–23.

> By deploying fiber all the way to the home, you're building a network with the fastest speeds possible.

So those without high-speed access were not significantly disadvantaged.

That began to change in the 2000s, when greater differences in levels of service became more apparent. Those with access to cable or DSL took advantage of new experiences, while those with slow technologies were left out.

This decade also brought the first fiber-to-the-home (FTTH) deployments. While fiber-optic cables had long been used for the "backbone" of the internet, it was not until the 2000s that this nearly limitless transmission technology began seeing deployment for home use.

By the 2010s, the gap between cable and DSL technologies had widened such that only households with access to the fastest DSL services could get similar speeds as cable. This meant that only households with access to cable or fiber-optic sources, or those close to DSL or wireless sources, had access to broadband speeds. The many other access technologies — satellite, cellular, rural wireless and rural DSL — offered internet access services that were better than no access, but fell short of meeting modern needs.

Access Technologies in Wide Use Today

FTTH is the gold standard: The network runs fiber-optic strands directly to homes and businesses.

Internet "backbone" links — the primary lines that make up the core infrastructure of the internet — already use fiber. So by deploying fiber all the way to the home, you're building a complete fiber network with the fastest speeds possible. Every other access technology, such as cable and DSL, also taps into the fiber internet backbone. They just don't bring it to your doorstep.

In nearly all cases at this point, wireline internet providers are no longer building new networks using anything but fiber. Fiber is considered "future proof". That is to say, it won't become obsolete a few years down the road. Fiber-optic cables use light instead of electromagnetic signals to transmit data. This is what makes fiber faster, and it also means the signal doesn't degrade as it's moving over long distances — 1 Gbps, 10 Gbps and 100 Gbps links are common for fiber-optic backbone networks, at distances of many miles without degradation. The coaxial lines used by cable internet service providers and the copper wires used by DSL providers, on the other hand, require special boxes to be placed every so often to reinforce their

FIXED WIRELINE ACCESS TECHNOLOGIES

	FIBER	CABLE	DSL
Speed	Up to 10 Gb (1 Gb more common)	Up to 10 Gb (1 Gb more common)	Up to 100 Mb (<10 Mb more common for rural)
Cost to Build	$10,000 - 100,000/mile	$10,000 - 100,000/mile	$10,000 - 100,000/mile
Signal Degradation	20 km - 10,000 km	Up to 160 km	Up to 3.5 km
Latency	Very Low	Relatively Low	Relatively Low

Table provided by the Michigan Broadband Alliance using data from the National Telecommunications and Information Administration

Fiber technology is capable of delivering exponentially increasing speeds for decades to come. Other technologies struggle to keep up.

BROADLY SPEAKING

"As of the end of 2019, approximately 17% of Americans in rural areas and 21% of Americans in tribal lands lack coverage from fixed terrestrial 25/3 Mbps broadband, as compared to only 1% of Americans in urban areas."

Federal Communications Commission, *Fourteenth Broadband Deployment Report*, January 2021.

signals and prevent degradation. Costly repairs and replacements are common.

But most importantly, fiber technology is capable of delivering exponentially increasing speeds for decades to come, while other technologies will struggle to keep up over time. For these reasons, fiber offers a higher return on investment.

FTTH networks with speeds of 1 Gb are generally deployed using either gigabit-passive optical network (GPON) technology or “active Ethernet” technology. Both have their advantages. GPON does not require a dedicated fiber for each customer and is more economical to deploy over a large area. Active Ethernet does provide a fiber for each customer, offering the fastest speeds and dedicated connections. In practice, many communities deploy GPON with a few extra fibers to provide the capability to have dedicated fibers for a few heavy customers if they emerge. For GPON, the bandwidth of the single connection is 2.4 Gb down, 1.2 Gb up, shared between up to 128 customers. NGPON2 and XGSPON are relatively new standards that allow up to 10 Gb symmetric connections for each customer connected to the PON.

Be aware that fiber broadband providers often describe themselves as “100% fiber networks”. That may be misleading. Several tiers of fiber broadband service are recognized by the FCC, and some switch to another technology, like coaxial cable or even copper telephone lines, at some point between the office of the internet service provider and home modem jacks. Only FTTH is truly 100% fiber.

> Few providers are installing coaxial cables anymore, as fiber has significantly more capacity.

BROADLY SPEAKING

"The estimates indicate that increased access to high-speed internet leads to about 6 percent growth in farm revenue and about 3 percent growth in production expenditure, which results in about 3 percent growth in farm profits."

Amy M.G. Kandilov, Ivan T. Kandilov, Xiangping Liu, and Mitch Renkow, "The Impact of Broadband on U.S. Agriculture: An Evaluation of the USDA Broadband Loan Program," Applied Economic Perspectives and Policy 39, no. 4 (March 2017): 635–61.

Here's a rundown of today's other access technologies:

Cable internet services are delivered over the same coaxial cables that were originally installed for the purpose of delivering analog video to television sets. Most cable internet providers use a standard called DOCSIS (Data Over Cable Service Interface Specification), which is an international telecommunications standard that allows for the addition of high-bandwidth data transfer to an existing coaxial cable TV system. The DOCSIS 3.1 standard is widely deployed and supports speeds of 10 Gbps down and 2 Gbps up on a single line. Yet, few providers are installing coaxial cables anymore, as fiber has significantly more capacity. If you're starting from scratch, coax cable is not a prudent option. But if you have an existing coax system, it may be possible to extend that network using more coax.

DSL, or digital subscriber line, service is a family of technologies used to provide internet connectivity over lines originally built for traditional telephone service. DSL can be delivered alongside phone service, on the same line, because DSL uses higher frequency bands for data. However, DSL signals degrade as they travel over the unshielded wires. Speeds depend heavily on the distance from regularly-placed distribution points.

DSL is already considered an obsolete technology. On top of that, fiber is generally cheaper than copper.

Fixed wireless is a popular way to provide coverage in areas of low population density. Fixed wireless uses wireless communication devices or systems used to connect two fixed locations, such as between a tower and a building. These have the advantage of low cost and relatively easy deployment. Non-cellular fixed wireless can use a variety of technologies and frequencies, but the frequencies typically used struggle to travel through areas of rough terrain or significant tree cover — not ideal for rural Michigan.

Though less expensive, fixed wireless systems struggle to achieve 100% coverage for a given community, and their speeds are generally low. They can deliver up to 1 Gbps, but speeds of less than 10 Mbps are more common in rural areas. An FTTH network could reach 100% of your community with speeds well above that for decades to come. A compromise is to build a hybrid fiber/wireless network that serves part of the community with fiber and part of the community with wireless, as long as the model supports eventually expanding the fiber to all the wireless customers.

Multiple fixed-wireless providers currently serve Michigan, but many do not provide broadband speeds. Those that do can only do so for a subset of subscribers who are near a tower with few or no obstructions. Most fixed-wireless providers have expressed a desire, but not necessarily tangible plans, to replace their wireless network with fiber-optic cable over time, as they recognize that consumer demands for broadband have outpaced the ability of wireless to keep up. Wireless may be a useful steppingstone for some unserved areas, as part of a plan to build long-term wireline service.

Cellular service providers also offer plans that, combined with "tethering" of other devices, give customers home internet service through their mobile phone. All the major providers offer "unlimited data" plans for cellular phones, but the data can still be limited when used by any device other than a phone (such as when tethering a laptop to a hotspot). Some major providers have begun to offer truly "unlimited data" plans for household connectivity in certain areas, but it's difficult to know where as these companies don't publish detailed maps. Generally these plans

Cellular services can deliver speeds of up to 1 Gbps, but speeds of under 25 Mbps are more common in rural areas.

work better in denser areas where more infrastructure investment has been made. Time will tell how widespread this technology will become and at what speeds and quality. Cellular services can deliver speeds of 1 Gbps or higher, but speeds of under 25 Mbps are more common in rural areas. Like other wireless technologies, cellular internet service is vulnerable to interference from foliage and weather.

Satellite access technology is widely available but with limited data capacity and high latency. Traditional communications satellites are launched into geosynchronous orbit at an altitude of 22,236 miles, which entails a round-trip latency of about a half a second for data flowing through the satellite. This makes satellite service problematic for real-time applications such as voice or video chat and gaming. In recent years, some companies have begun launching large numbers of low-earth orbit satellites that are less prone to these issues. One well-known such company is Elon Musk's Starlink, aided by Musk's rocket technology outfit SpaceX. However, it's still early for these offerings, which limits their reach at the moment. And the equipment needed to become a customer is costly — $499 for a satellite dish and router, according to a 2021 MIT Technology Review article.[1] "For much of the rural world, in America and elsewhere, the price is simply too high," the article noted. (The price has since gone up further.)

Geosynchronous satellite systems deliver speeds of up to 100 Mbps. Low-earth orbit satellites deliver speeds of up to 1 Gbps, though speeds of 100 Mbps are more common. Both are vulnerable to interference from foliage and weather, as well as capacity limitations that can cause slowdowns during peak usage periods.

WHAT ABOUT 5G?

Many providers are rolling out 5G service, but while 5G will provide improvements for rural cellular phone service, it's unlikely to be useful for rural broadband. It's important to understand that 5G actually encompasses two main technologies: 1) Improvements to traditional cellular service, and 2) high-speed "millimeter wave" service. Millimeter-wave spectrums promise to deliver much higher speeds (up to 1 Gbps) but have a much shorter range than cellular signals. That means devices need to be much closer to cell towers to receive signals, and these towers in turn need to be connected to fiber "backhaul".

While this technology will be helpful in urban environments, in rural areas millimeter-wave 5G is not significantly less expensive than "fiber to the curb" and doesn't change the financial model for rural deployments. For the former, two of the main improvements to traditional cellular service that 5G will bring is the ability for a single cell site to have many more individual connections and the ability to increase speeds on a single device by having it connect to multiple cell sites.

Since rural cell sites are in low-density areas, connecting to more individual devices isn't a big need, and the likelihood that a single device will be in range of multiple cell sites is low. As such, while 5G is likely to greatly improve cellular service in urban areas, it is unlikely to solve the rural broadband gap.

[1] Neel Patel, "Who Is Starlink Really For?" MIT Technology Review, September 6, 2021.

WHAT IS **BROADBAND?**

“Broadband” and “high-speed internet” are the same thing: a connection that is sufficient to support modern networked applications, such as streaming video, real-time communications and transferring large files. Three main attributes define broadband: 1) bandwidth, 2) latency and 3) data caps.

Bandwidth is what most people focus on when measuring the quality of an internet connection, and for good reason: The amount of bandwidth largely determines the quality of the video and audio you can send and receive, how long it will take to transfer files, and how many users and devices can use your connection at the same time. When visualizing bandwidth, or broadband speed, it helps to think of an internet connection as a system of roads. If there is only one lane and a lot of traffic, it will take a long time for cars to reach their destinations. But if more lanes are available, the cars will reach their destinations faster.

The amount of bandwidth required to be considered broadband is currently defined by the FCC as 25 megabits per second (Mbps) download and 3 Mbps upload, though this threshold was established in 2015 and has become outdated. (The FCC updates this definition every so often; it started out at 200 kilobits per second in 1996, for both downloads and uploads.) A more realistic standard today should be 100 Mbps symmetrical download and upload speed. While previous broadband standards prioritized download speeds, users are no longer solely consumers of data. Today, users are just as likely to be producers. From uploading large data files for work, to cloud backups of home computers, to cloud-based home security cameras, upload speeds are just as important as download speeds. As such, modern broadband standards should be symmetric for both downloads and uploads. A broadband connection should have bandwidth of at least 100 Mbps download and upload.

HOW LONG DOES IT TAKE TO DOWNLOAD?

It’s not uncommon for a digitally-delivered video game to exceed 100 gigabytes (GB) in size. Here’s how long that would take to download on different connection speeds:

- **1 Gbps (1,000 Mbps):** 13.3 minutes
- **100 Mbps:** 2.2 hours
- **25 Mbps:** 8.9 hours
- **10 Mbps:** 22.2 hours
- **1 Mbps:** 9.3 days

Latency is a different kind of speed. Sticking with the road metaphor, this is the amount of time it takes a single car — or piece of data — to travel from one end of the road to the other. This is critical for real-time applications like voice or video calls: If there is a significant delay between when one party speaks and the other party hears them, it can make two-way conversations difficult and frustrating. Generally, a latency of less than 100 milliseconds (ms) is sufficient for natural two-way conversation, though some applications such as online gaming, remote musical performance and interactive virtual reality benefit from or require latencies of 50 ms, or less. In short, a broadband connection should have a latency of less than 100 ms.

For **data caps**, an analogy can be drawn to the business model of leasing a vehicle: If you exceed the miles you are contractually limited to, you are penalized. However, it should be noted that the vehicle analogy is a loose one: Although driving long distances does reduce the useful life of a car, using data on an internet connection does not deplete a consumable resource. (This is true even for electricity — there is virtually no difference in power consumption when a home internet connection is idle vs. when it is operating at full speed). Broadband connections should not have data caps. Any data caps, even relatively high ones, artificially limit the applications for which an internet connection can be used. And while some service providers use data caps to limit how much users can use their connections in the name of "fairness", this generally means that sufficient infrastructure investments aren't being made to keep up with demand. A properly resourced broadband system should have no issue accommodating households that make full use of their connections.

Quality, Durable Connections

A modern broadband connection should allow for 100 Mbps download and upload speeds, have a latency of less than 100 ms, and no data caps. Remember, "broadband" is a moving target: Streaming video and video chat were niche services 10 years ago, but network equipment maker Cisco predicts video will reach 82 percent as a proportion of global consumer internet traffic this year, up from 73% in 2017[1].

The concept of "future-proofing" is something you'll likely hear on your path to a community network. It refers to how long an access technology will hold up in the face of rising demand. "Nielsen's Law of Internet Bandwidth"[2] says available bandwidth for well-connected users grows by 50% each year. As speed requirements grow exponentially, so does the gap between well-connected and poorly connected populations. While in some cases it may be expedient to deploy less expensive solutions in the near term, it is important to consider future growth so your community doesn't face the same problem in a few years.

HOW MUCH DATA DOES IT TAKE?

Different applications take different amounts of data per month. Some figures on monthly data usage for the average household:

- **Streaming music:** 3 GB/month
- **Playing video games:** 6 GB/month
- **Zoom meetings (work from home):** 192 GB/month
- **Cloud security camera:** 400 GB/month
- **Downloading video games:** 400 GB/month
- **Streaming video (HD):** 450 GB/month
- **Cloud backup for computer:** 500 GB/month
- **Streaming video (UHD):** 1050 GB/month

A 25 Mbps download connection becomes saturated with a single ultra-HD video stream from Netflix. A 3 Mbps upload connection becomes saturated by a single home-security camera streaming to the cloud. And these examples only account for single devices. The average U.S. household now has 25 connected devices, according to Deloitte[3].

Communities should plan their networks with this in mind.

[1] Cisco, *VNI Complete Forecast Highlights*, 2018.

[2] Jakob Nielsen, "Nielsen's Law of Internet Bandwidth," Nielsen Norman Group, September 27, 2019.

[3] Deloitte, *How the Pandemic has Stress-Tested the Crowded Digital Home*, 2021.

MICHIGAN MOONSHOT SURVEYS

As part of Merit's Michigan Moonshot initiative, we've been collecting broadband coverage data from Michigan counties. This is done through surveys sent to residents asking what kind of broadband coverage they have and at what speeds. Residents also are asked to take a speed test by visiting a website that tests their internet connections.

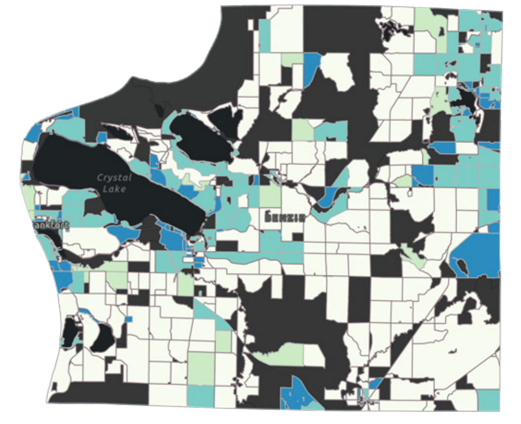
The goal is to improve on the existing data in wide use today, that provided through the FCC's Form 477. Filled out by broadband providers, the form counts an entire U.S. Census block as having fixed broadband coverage if just one household has service. "This analysis could overstate the coverage experienced by some consumers, especially in large or irregularly-shaped census blocks. However, these data nonetheless remain the best and most granular data available for our analysis at this point in time," said the FCC in its 2021 broadband deployment progress report.

Seeking more granular data, Merit set out to survey residents in individual households across counties that work with the Moonshot initiative. A sampling of the counties surveyed so far is shown here. Maps on the left show results from our surveys. Maps on the right reflect FCC Form 477 data. The results are striking. For each county, a large gap in coverage can be seen between the two.

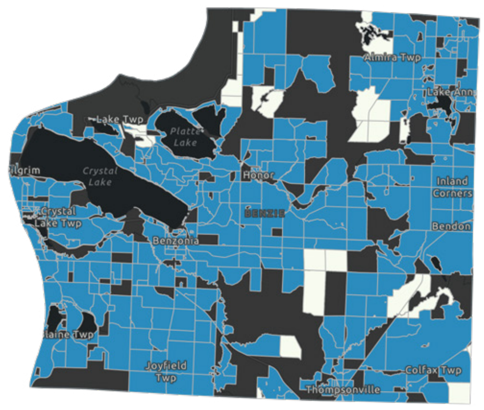
PROJECT: BENZIE

BROADBAND DENSITY PER CENSUS BLOCK
25/3 THRESHOLD

BASED ON SURVEY RESPONSES



FCC BREAKDOWN



Esri, HERE, Garmin, SafeGraph, METI/NASA, USGS, EPA, NPS, USDA, Esri, HERE, Garmin, SafeGraph, FAO, METI/NASA, USGS, EPA, NPS

BROADBAND DENSITY
OF SURVEYED HOUSEHOLDS

- 0 - 10% have broadband
- 11 - 25% have broadband
- 26 - 75% have broadband
- 76 - 100% have broadband
- No Survey Data Collected

FCC FORM 477

- Served
- Unserved
- No Survey Data Collected

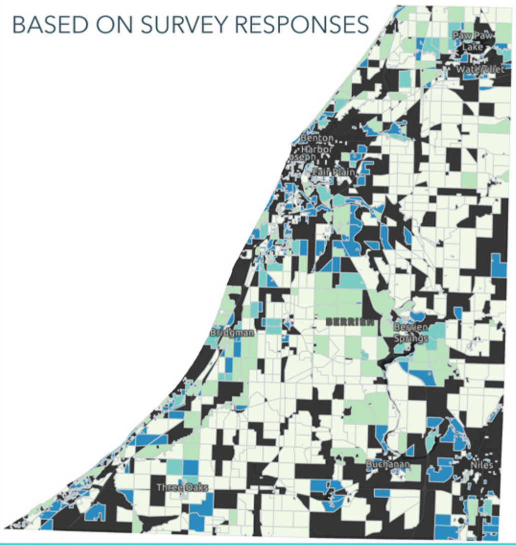
merit

The FCC counts an entire census block as being served if one household has access to broadband, leading to a binary served-unserved measurement. Merit surveys are conducted at the individual-household level, leading to a range of densities, as indicated by the different-colored percentages.

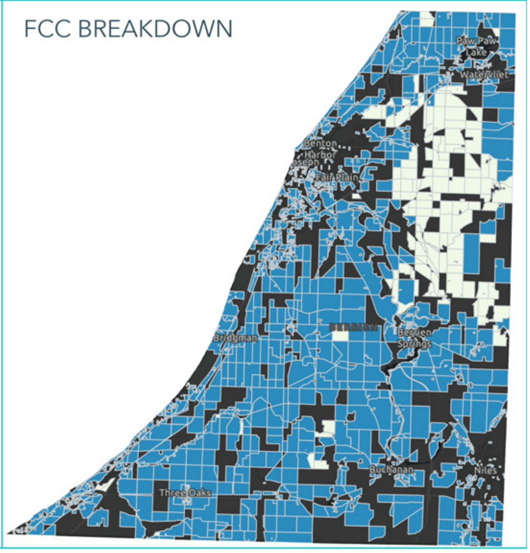
PROJECT: BERRIEN

BROADBAND DENSITY PER CENSUS BLOCK
25/3 THRESHOLD

BASED ON SURVEY RESPONSES



FCC BREAKDOWN



Esri Canada, Esri, HERE, Garmin, SafeGraph, FAO, METI/NASA, USGS, EPA, NPS

BROADBAND DENSITY OF SURVEYED HOUSEHOLDS

- 0 - 10% has broadband
- 11 - 50% has broadband
- 51 - 75% has broadband
- 76 - 100% has broadband
- No Survey Data Collected

FCC FORM 477

- Served
- Unserved
- No Survey Data Collected

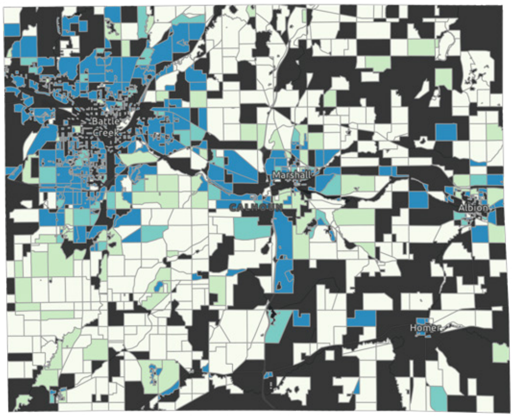
merit

The FCC counts an entire census block as being served if one household has access to broadband, leading to a binary served-unserved measurement. Merit surveys are conducted at the individual-household level, leading to a range of densities, as indicated by the different-colored percentages.

PROJECT: CALHOUN

BROADBAND DENSITY PER CENSUS BLOCK
25/3 THRESHOLD

BASED ON SURVEY RESPONSES



FCC BREAKDOWN

Province of Ontario, Esri Canada, Esri, HERE, Garmin, SafeGraph, FAO, METI/NASA, USGS, EPA, NPS

PER CENSUS BLOCK
- 0 - 10% has broadband
- 11 - 25% has broadband
- 51 - 75% has broadband
- 75 - 100% has broadband
- No Survey Data Collected

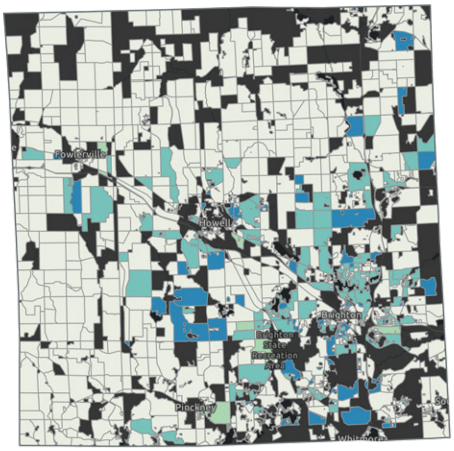
FCC FORM 477
- Served
- Unserved
- No Survey Data Collected

The FCC counts an entire census block as being served if one household has access to broadband, leading to a binary served-unserved measurement. Merit surveys are conducted at the individual-household level, leading to a range of densities, as indicated by the different-colored percentages.

PROJECT: LIVINGSTON

BROADBAND DENSITY PER CENSUS BLOCK
25/3 THRESHOLD

BASED ON SURVEY RESPONSES



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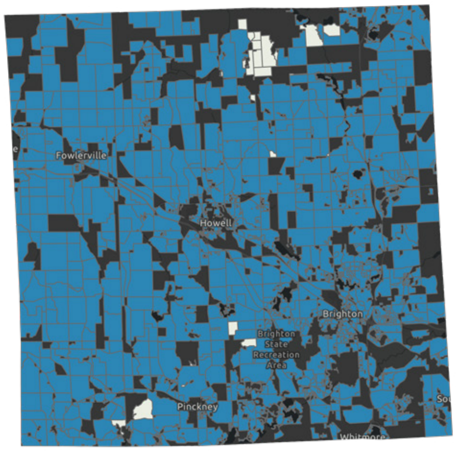

Province of Ontario, Esri Canada, Esri, HERE, Garmin, SafeGraph, FAO, METI/NASA, USGS, EPA, NPS

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- Unserved
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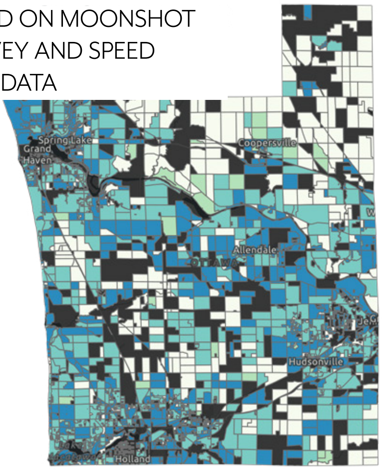
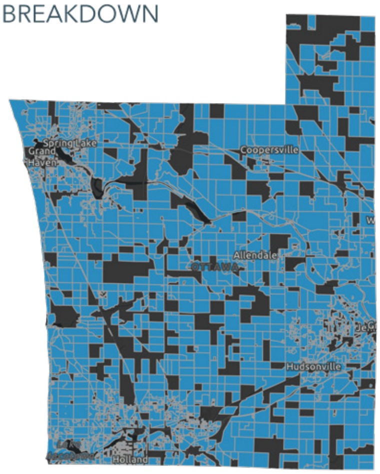
PROJECT: OTTAWA

BROADBAND DENSITY PER CENSUS BLOCK
25/3 THRESHOLD

BASED ON MOONSHOT SURVEY AND SPEED TEST DATA



FCC BREAKDOWN



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- No Survey Data Collected

FCC FORM 477
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- No Survey Data Collected

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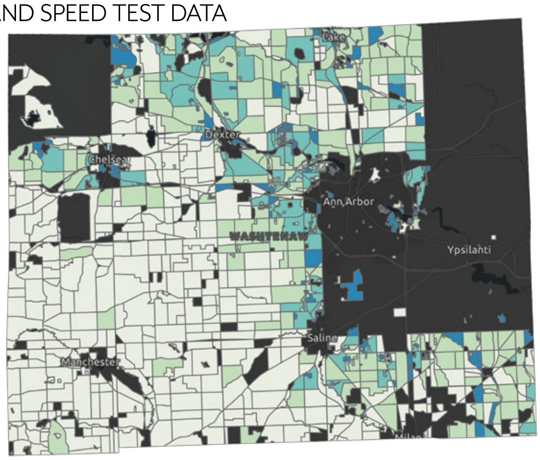
The FCC counts an entire census block as being served if one household has access to broadband, leading to a binary served-unserved measurement. Merit surveys are conducted at the individual-household level, leading to a range of densities, as indicated by the different-colored percentages.

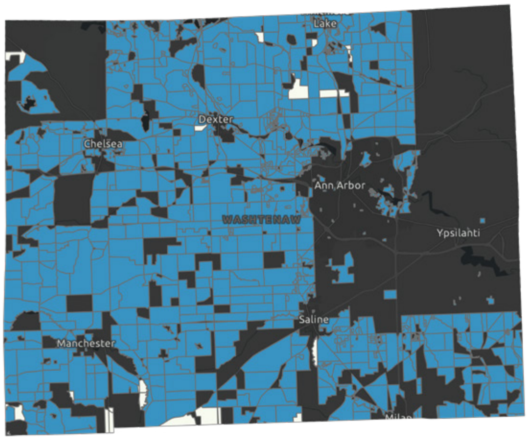
PROJECT: WASHTENAW

BROADBAND DENSITY PER CENSUS BLOCK
25/3 THRESHOLD

BASED ON MOONSHOT SURVEY AND SPEED TEST DATA



FCC BREAKDOWN



Province of Ontario, Esri, HERE, Garmin, SafeGraph, FAO, METI/NASA, USGS, EPA, NPS

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The FCC counts an entire census block as being served if one household has access to broadband, leading to a binary served-unserved measurement. Merit surveys are conducted at the individual-household level, leading to a range of densities, as indicated by the different-colored percentages.

PLANNING A NETWORK

Building a broadband network is no light undertaking. As you begin planning, some fundamental questions to ask are: Are any efforts to expand broadband already underway? What level of service do residents already have? Is it the same level across the area? Do commercial providers have any plans to expand coverage in this area?

Ultimately, we're talking about installing miles and miles of fiber-optic cable infrastructure and equipment. An organization will administer the service, including interacting directly with customers. Duties run the full gamut of an enterprise: project management, network engineering, public relations, marketing, contract administration, environmental engineering, permit management, billing, cybersecurity, customer service reps, maintenance technicians and so on.

There also will be a network operations center, though this is not as intimidating as it may sound — it probably won't call for constructing a building. The equipment may be as small as a cabinet, with the staff who monitor and operate the network spread across different offices.

Of course, not all of this needs to be done by a big, brand new (and expensive) utility department. Communities that already have a public works department or run their own power utility probably can fold the network operations into those teams. Otherwise, communities will have to decide whether to create a new team to handle all the work in-house, or farm it out to a single or multiple vendors. Much of the work can be accomplished by outside vendors and consultants. Most projects will be a combination of internal and external resources, depending on needs and available resources.

Here are key steps to consider taking as you plan your community network, followed by information and further points of consideration regarding communications with existing service providers, legal and regulatory issues, and possible resistance you may encounter.

KEY PLANNING STEPS

Seek out Existing Efforts

One of the first steps is to explore whether any broadband efforts are already underway in your community. Begin by reaching out to local groups, anchor institutions (the library, school district) and government offices. Then move up to your county board of commissioners, regional planning commission, state representative or state senator. Even if no community team is in place, these groups or Merit may be able to connect you with like-minded individuals from your area who have made inquiries. If no local initiative has been started, contact local anchor institutions to gauge interest and start the conversation. Community anchor institutions include municipal government offices, school districts, state representative offices, local libraries and public safety departments.

Establish Governance

A governance body should be established for this crucial early planning stage and then later to oversee the project. An ideal group structure is one that's officially sanctioned by the local government, such as a township or county. This group can be a committee, subcommittee, task force or similar body. If the local government is not interested in being involved, a residents' group can fulfill the same role. In either case, the group should have a leader — a chair or president — and if possible a second-in-command to share responsibilities. A formal group structure and leadership roles will smooth operations and provide an additional sense of legitimacy to the effort.

Build Your Team

This is a marathon rather than a sprint, and it's essential to have help along the way. You may be surprised how many of your neighbors are not only in the same boat, but are willing to help and have skills suited to the challenge.

At this early stage, building a team largely consists of gathering volunteers and identifying possible leaders.

Interested residents with a local commitment should emerge from your search. The only hard requirements of a team member are desire and time. The best way to kick off a volunteer effort will be to host a community broadband meeting. You can also reach out to people through social media groups, local news outlets, flyers and mailings.

Likely members for your group include local elected officials and policymakers, community leaders, technical and nontechnical local activists, any existing internet service providers in your area, representatives from community anchor institutions such as schools and libraries, area chambers of commerce or economic development groups, regional planning groups and volunteers.

It will also be helpful to find others to help you lead the project. Here are two points to keep in mind:

- Delegate and ask for volunteer leaders. It's important to recognize that you cannot be successful by doing everything yourself, so find tasks or groups of tasks that can be delegated, and ask for volunteers to lead those tasks. If successful, those individuals can be cultivated to provide additional leadership to your effort.
- Targeted recruitment of promising individuals. During the process, it's likely that individuals may rise to the top in terms of efficacy, enthusiasm and leadership potential. Sometimes people don't want to raise their own hands and need a nudge to get started, so don't be afraid to approach these people and ask them to lead or help lead parts of the effort.

Identify Your Target Area

When considering the target area, it's important to cast your net widely enough to have critical mass but not so widely as to make the goal unachievable. Often, municipal or school district boundaries are an easy way to focus efforts. But broadband challenges do not cleanly follow boundaries, so your focus area can be whatever makes the most sense for your community.

Assess Current Broadband Coverage

Earlier, we noted the problems with the commonly-used coverage data provided by the FCC. But coverage data is needed — organizations that award broadband grant money and subsidies expect it. Unfortunately, this is an area where there aren't many good options. It touches again on issues with the available data. Some companies may offer survey services, but they too rely on FCC data and data from existing internet service providers, leaving you still at risk of overbuilding or underbuilding your network. If your community has in-house data analysts and geographic information system experts, you can probably do a thorough survey on your own. But most small communities won't have such specialists.

This gets back to why Moonshot was formed to begin with: We wanted to give communities a better way to get granular broadband coverage data in their areas. Michigan Moonshot teams conduct surveys to assess coverage and internet connection speeds. Accurate data helps you build a stronger case when seeking private and public funding, while also helping to define the needs of your community. For more information, email us at moonshot@merit.edu or visit michiganmoonshot.org.

SEE **PAGE 19** FOR MORE ON HOW MOONSHOT COLLECTS DATA, AND **PAGE 57** FOR MORE ON THE MICHIGAN MOONSHOT INITIATIVE.

Talk to Residents

Be sure to ask residents what they want so wrong assumptions don't lead to wasted efforts. Doing this well before any construction begins makes sure you don't end up with a service that goes unused. The central question is whether residents would subscribe to the type of broadband service you're proposing and at the price you're planning to offer. Then you can estimate the "take rate", or the number of households and businesses that would sign up for service. Take-rate surveys can be conducted by a task force, municipality or outside consultant.

Conduct a Feasibility Study

To get a more specific idea of how much it would cost to build broadband infrastructure in your community, some amount of pre-engineering and financial analysis is necessary — generally referred to as a feasibility study. Feasibility studies can cost anywhere from $3,000 to more than $100,000, depending on the scope. A reasonably comprehensive study for smaller communities ranges closer to between $15,000 and $50,000.

The most critical part of a feasibility study is the pre-engineering work required to estimate the total cost of a project. An experienced consulting firm will base the estimate on the requirements of your project, combined with the specifics of your geographic area. This estimate is necessary when seeking funding.

Begin Your Marketing and Communications Early

Public communications and marketing are critical for building awareness of community network projects. This could be done by your organization, your network operator or a third-party firm. The communications work should begin early in order to gauge interest, inform residents and get people involved. This early work also will seed the necessary customer communications and advertising that come later.

APPROACHING INCUMBENT PROVIDERS

In almost all cases, if building broadband in a given area would yield a rapid enough return on investment to support a private provider, service would already exist. However, it is important to check in with any "incumbent" providers, as they are known in the industry, in your area and build relationships with them. This is both to understand their current plans as well as future opportunities for partnerships. Resources like Broadband Now and Connect Michigan can provide a list of providers in your area. (But take note: Even if a company is listed, it doesn't necessarily mean the company provides coverage throughout your area at this time.)

HERE ARE SOME KEY QUESTIONS TO ASK INCUMBENT PROVIDERS:

Are you planning to expand coverage in our area, and if so, when and with what level of service?

If a provider is planning significant investment in your area, any additional work may be redundant. However, this is uncommon. If a provider does communicate an intention to expand in the future, try to get specifics on these plans. In some cases, providers may promise future expansion to dissuade competition when such expansion is not actually forthcoming or not at a level that will meet the goals of the community.

Can you provide an accurate coverage map for your service in our area, or a list of serviceable addresses?

Service providers, especially wireline providers, generally have a good understanding of which addresses in a community are "serviceable" — that is, can receive service without substantial additional investment. Many providers are unwilling to share this information for competitive reasons. For providers that are interested in partnering with a community, they will sometimes share this information under a nondisclosure agreement.

Are you interested in working together to explore opportunities for public-private partnerships?

When asking about interest in future partnerships, the answer will almost always be "yes" when no specific action is required of the service provider. Gauging whether a provider is actually a good candidate for public-private partnership will require cultivating a longer-term conversation and relationship, but this is the starting point toward that goal.

Can you provide an estimate on what it would cost for you to provide service to all currently-unserved households in our area?

An estimate like this can be useful when exploring public-private partnerships. One option for such a partnership is helping an incumbent provider fund expansion of its own infrastructure.

LEGAL AND REGULATORY CONSIDERATIONS

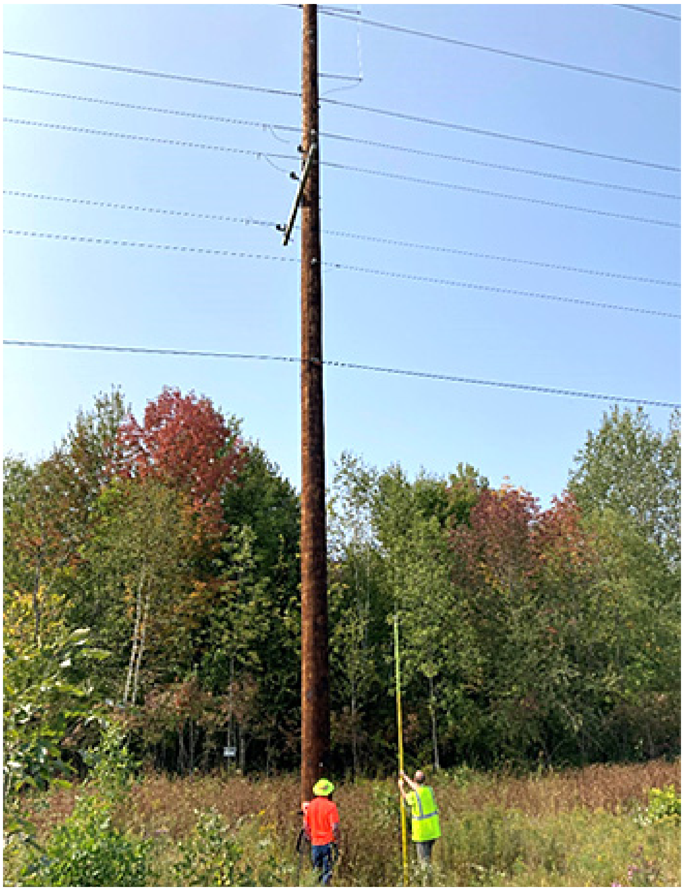
As with any major endeavor, special rules and practices apply. Here are some of the legal and regulatory points to be aware of as you plan your network.

METRO Act and the Michigan Telecommunications Act

In 2002, the Michigan legislature passed several laws to stimulate the availability of affordable high-speed internet connections. The Metropolitan Extension Telecommunications Rights-of-Way Oversight (METRO) Act created a telecommunication rights-of-way oversight authority and prescribed the powers and duties of municipalities to bring broadband to their communities. The act was amended in 2005 to allow public entities to provide telecommunication services within their boundaries. This led to the amending of an already-existing state law, the Michigan Telecommunications Act, that also concerns communities seeking to build a network.

With certain exceptions, the changes led to the following requirements for municipalities that wish to build their own broadband infrastructure:

- A public entity must issue a request for competitive, sealed bids before it can provide telecommunication services within its boundaries. If the entity receives less than three qualified bids from private providers, it can provide its own services.
- A municipality must conduct a cost-benefit analysis that covers three years before it adopts an ordinance or resolution authorizing the municipality to construct broadband facilities.
- The municipality must conduct at least one public hearing before it adopts an ordinance or resolution authorizing the municipality to construct broadband facilities.
- After the public hearing, the public body may adopt a broadband ordinance. This is not required by law but is recommended.



Environmental Permitting

Michigan has a rich and diverse ecosystem as well as a robust process for protecting that ecosystem. It may be necessary to obtain a permit to cross wetlands, streams, rivers or other water bodies from the Michigan Department of Environment, Great Lakes and Energy. It is recommended that you contact your local district office to discuss your project and review any permit requirements. A permit to cross streams and wetlands can take 60-90 days to receive. Some municipalities also may have local wetland permit requirements. Contact your local zoning officer to identify any permit requirements.

Rights of Way and Easements

When considering any buried infrastructure, there are two options: a public right of way or a private easement.

When placing infrastructure on, above or below private property without an existing public right of way, private easement must be granted from the property owner. (An easement is a legal right to use someone else's land for a particular purpose.) Often property owners will ask for compensation in exchange for granting easement. In some cases, property owners will grant easement at no cost for public projects that are helping the community. Any specific private easement situations should be confirmed by an attorney.

It is more common to use existing public rights of way that are controlled by local road commissions. The requirements and costs to access these rights of way can vary significantly based on the permit requirements of the road commission. Although some standardization has been applied to these requirements, it is prudent to consult your road commission early in the process if you are considering underground cable.

Pole Attachments

When constructing any cables that hang in the air on existing utility poles, permission is needed from the pole owner, such as a power utility, and various fees will be incurred. Generally, permission to attach to the poles cannot be unreasonably withheld, but it is up to the attacher to pay any associated costs. Any fiber placed on utility poles with electrical wires must adhere to the National Electric Safety Code (NESC). One of the most fundamental safety recommendations by the NESC is the separation of supply space (power distribution) and communications space on utility poles. Other requirements include minimum space between lines, minimum height of the cable above the ground and engineering analysis to ensure poles are strong enough to withstand the weight of additional cables. If a pole doesn't have room or strength for another cable, and a new pole would be needed to accommodate an additional cable, the attacher would need to pay for that new pole.

Utility poles are most commonly installed in public road rights of way, in which case permitting is handled through the local county road commission and is minimal for existing pole infrastructure. However, utility poles can also be installed on private easements. In these instances, case law in Michigan suggests that third parties can install telecommunications cables on existing utility poles without obtaining additional private easement.

Adjacent Municipality Consent

If your infrastructure for whatever reason needs to cross into adjacent municipalities, you will need to get the adjacent municipality's consent, probably through a resolution passed by its officials. It's also possible that the adjacent community will want to connect to your broadband infrastructure.

According to Lansing-based law firm Foster Swift Collins & Smith PC, which prepared an extensive legal report and toolkit[1] for the Michigan Broadband Cooperative: "The (Michigan Telecommunications Act) provides that 'a public entity shall not provide telecommunication services outside its boundaries', unless two or more public entities jointly request bids. However, this prohibition against providing service outside of municipal boundaries may be preempted by Section 706 of the Federal Telecommunications Act of 1996, which directs the Federal Communications Commission to take action to remove barriers to broadband investment and competition."

Municipalities commonly follow one of two legal paths for these deals. In an interlocal agreement, the "originating broadband local unit maintains ownership and responsibility for the infrastructure and provides broadband services to the adjacent municipality for a fee and under certain terms."

Or, they can form a separate authority. In this case, "the adjacent municipality buys into the broadband system and the two local units jointly form a new authority to maintain and be responsible for the system and provision of services to both jurisdictions. This would likely require resolutions of both municipalities and other agreements/documents to form and govern the joint authority."

1 Foster Swift Collins and Smith PC, *Community Broadband Access Framework* (Michigan Broadband Cooperative, July 2018).

FOR FURTHER READING ON THIS, SEE THE "COMMUNITY BROADBAND ACCESS FRAMEWORK" FROM THE MICHIGAN BROADBAND COOPERATIVE.

CLAIMS AND RESPONSES

Many false claims are targeted at municipal and community broadband networks, often from private entities that consider these networks a threat. Here are some of the common claims made and ways to refute them.

> CLAIM

Municipal broadband discourages private-sector investment.

> RESPONSE

Municipal broadband is only undertaken in areas where current private-sector solutions are not meeting the needs of residents. In Michigan, this is ensured by the Michigan Telecommunications Act, which requires a municipality to seek public bids from companies before executing a broadband project and can only proceed if the municipality does not receive at least three qualified responses. In some instances, such as in the city of Holland (see page 51), municipal broadband service has led to increased private-sector investment and better broadband service overall for the community. Plus, municipal projects often follow the open-access network model, which encourages private competition.

> CLAIM

Broadband, like the telephone networks, is better off left to the private sector, where market competition yields lower costs and unprecedented innovation for customers.

> RESPONSE

Private-sector unregulated monopolies do not yield lower customer fees. In fact, they strategically limit choices, resulting in artificially high prices because no serious competition exists. This is why the Bell System and AT&T monopolies were broken up in 1982. Telephone lines were wired successfully throughout rural America thanks to a robust program of federal subsidies.

> CLAIM

Providing broadband can be a high-risk endeavor, and if the network fails, taxpayers face significant potential financial liability.

> RESPONSE

In Michigan, the Michigan Telecommunications Act addresses this concern by requiring municipalities to prove the financial viability of any municipal broadband project before execution.

> CLAIM

Public funds used for broadband take funding from higher-priority projects, including roads, the electric grid and water system.

> RESPONSE

When public projects are undertaken in rural areas, they are often funded by residents who are already spending significant amounts on internet services that do not meet their needs. Municipal projects can actually save residents money. In urban areas where the municipality operates broadband services, the services are often a separate division within the utility company and are self-sustaining, not funded by tax dollars.

> CLAIM

Municipal broadband projects don't have to abide by the same rules and regulations as the private sector.

> RESPONSE

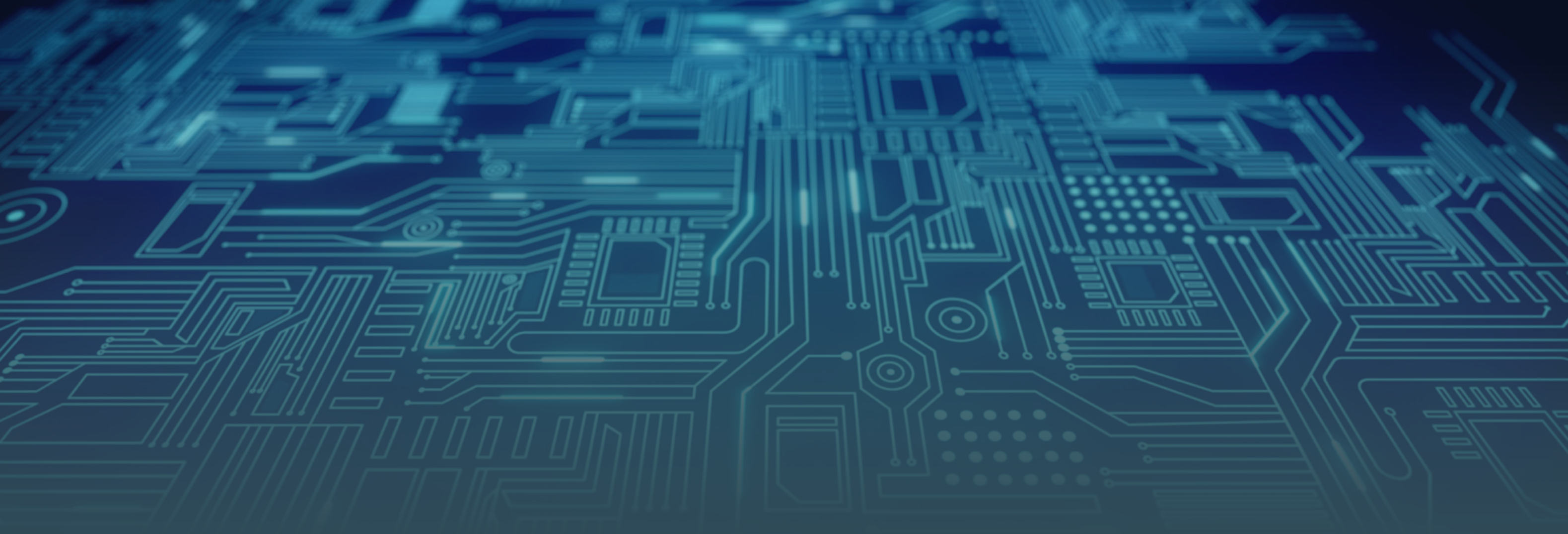
Fiscal accountability and transparency are ensured by the annual reporting requirements of GASB 34 (Governmental Accounting Standards Board Statement No. 34, Basic Financial Statements and Management's Discussion and Analysis for State and Local Governments). Engineering and siting requirements for infrastructure projects are uniformly enforced to safeguard the health, safety and welfare of the public.

> CLAIM

Municipal broadband projects draw on the public treasury and result in higher taxes.

> RESPONSE

While municipal broadband can be paid for with taxes, many municipal broadband projects are self-sustaining and do not use tax dollars at all. Alternative sources of funding are available through state and federal grants, foundations, private partnerships and subsidies.



DIGITAL **INCLUSION**

It may seem redundant to raise digital inclusion as an issue when talking about building a rural community broadband network. After all, the whole point is to close a local digital divide. But it's one thing to see that your residents have broadband service available to them; it's another to make sure they can use it.

A 2021 Deloitte report[1] on the digital divide looks at Alger County, Michigan, and notes the importance of helping residents adopt broadband: "The decline of homes in Alger County meeting the FCC broadband threshold in tandem with the county receiving substantial funding highlights that **money to address broadband availability is not the sole answer to closing the digital divide**. Additional factors for consideration include addressing affordability issues in terms of both broadband service and devices (PCs, smartphones, Wi-Fi access points and gateways) and attaining meaningful competition between providers to achieve the lowest reasonable price to maximize both investment and adoption." (Emphasis added.)

Studies on the economic impact of broadband in communities reveal that adoption is a crucial follow-through to get the desired boost. "In general, thresholds for broadband *adoption* are shown to be more important to economic growth measures than those for *availability*," said the authors of one 2014 study[2]. (Emphasis in original.)

The FCC estimated that as of the end of 2019, 64.5% of Americans in "non-urban core" areas had adopted broadband service[3]. The estimate was based on the agency's Form 477 deployment data (covering availability of service) and the number of residential subscriptions in a given area (to estimate adoption). For urban areas, the figure was 73.3%.

The time to start thinking about inclusion is at the beginning, not after the network is built. Some questions to ponder as you plan your community network:

Will the monthly charge for this service be affordable? This fundamental question speaks to the economics of the project and influences what ownership model you will choose. It may be that your community will offer service to lower-income households at lower rates, or that the investment horizon envisioned for the project will intentionally allow for affordable rates.

[1] Deloitte, *Broadband for All: Charting a Path to Economic Growth*, April 2021.

[2] Brian Whitacre, Roberto Gallardo, and Sharon Strover, "Broadband's Contribution to Economic Growth in Rural Areas," Telecommunications Policy 38, no. 11 (December 2014): 1011–23.

[3] "Federal Communications Commission, *Fourteenth Broadband Deployment Report*, January 2021.

Can a training program be set up to help people learn digital skills? Setting up a program could be as simple as getting local volunteers to offer training sessions at anchor institutions such as the library. This would at minimum cover the basics of how to use a computer or smartphone, pay bills and take courses online, use computer applications and so on. But it could go all the way to formal computer coding courses for more ambitious communities.

How can digital devices be made available to residents who can't afford them? Communities have created computer-refurbishing programs where people get together to repair and upgrade old computers, and make then cheaply or freely available. Such programs help cover the training component of digital inclusion by bringing in local people, such as high school students, to learn and do the work of computer hardware maintenance.

Will residents need tech support? Such support extends beyond the usual customer support that a broadband service would have to help users with devices and applications. A tech support program could be wrapped into or closely associated with a local digital training program.

Each community is different, and yours will chart its own course to suit its needs. But many others have been down this road and can offer valuable insight and innovative solutions to how they overcame their obstacles.

The Columbus, Ohio-based National Digital Inclusion Alliance offers help, as does Washington, D.C.-based Next Century Cities, Wilmette, Illinois-based Benton Institute for Broadband and Society and the Minneapolis-based Institute for Local Self-Reliance. And our Michigan Moonshot initiative also has resources online.

DEFINING DIGITAL INCLUSION

> The National Digital Inclusion Alliance defines[4] the concept as: "The activities necessary to ensure that all individuals and communities, including the most disadvantaged, have access to and use of [information and communications technologies]. This includes five elements: 1) affordable, robust broadband internet service; 2) internet-enabled devices that meet the needs of the user; 3) access to digital literacy training; 4) quality technical support; and 5) applications and online content designed to enable and encourage self-sufficiency, participation and collaboration."

> The NDIA also offers the following definition for "digital equity: "A condition in which all individuals and communities have the information technology capacity needed for **full participation in our society, democracy and economy**. Digital equity is necessary for civic and cultural participation, employment, lifelong learning and access to essential services." (Emphasis added.)

> For "digital literacy", the NDIA goes with the American Library Association, whose Digital Literacy Task Force defines it as "the ability to use information and communication technologies to find, evaluate, create and communicate information, requiring both cognitive and technical skills."

[4] "Definitions," National Digital Inclusion Alliance, accessed March 14, 2022.

COSTS, FUNDING & OWNERSHIP

COSTS

Solving the lack of broadband infrastructure is a costly proposition. After all, if it were cheap and easy, the problem would already have been solved by a private entity.

With public projects, the equation changes in two fundamental ways. First, the acceptable period for return on investment becomes much longer, taking some of the pressure off to see profits. Second, value is measured not just in cash flow but also by the value provided to the community. In some cases, community value can be quantified by cost avoidance (the savings that residents realize on the community broadband network versus previously available private offerings). Other significant but hard-to-quantify value comes from improvements to education, economic development, increased property values, cost savings and general improvements to quality of life.

Here is a rundown of some of the major costs associated with building a community network. (Note that inflation pressures may add further variance to these estimates.)

Coverage data gathering: $0-$50,000

As discussed previously, the FCC already provides some coverage data, but it lacks granularity and tends to overestimate coverage. Other entities can provide the tools to gather better data, but there may be associated costs such as for printing and mailing.

Pre-engineering/feasibility: $10,000-$50,000

To engage effectively in community conversations and decisions regarding how to proceed, it is very helpful to understand projected costs for a network project, and whether those costs are feasible based on likely business models.

Engineering/design: $500-$5,000 per mile

The significant cost variance here represents the difference not only in projects and engineering firms but also in aerial versus underground projects. Underground projects can have significantly more engineering costs compared with aerial projects.

Mainline construction: $25,000-$100,000 per mile

Again, the significant cost variance represents the difference between aerial and underground construction. Underground is more robust and protects cable from storm damage, cars striking utility poles and chewing squirrels, but it is significantly more costly. On the flip side, aerial projects can have significant costs to access the poles and make them ready to receive the fiber. See page 46 for more.

While most of this funding goes to the construction company for labor, other costs including materials and construction management, permits, rights-of-way acquisition and pole access can be included.

Drop construction and installation: $500-$1,500 per home

Cable must be run from the mainline fiber to individual homes, either underground or on utility poles. Then an installer must come into the home to install and activate the customer equipment.

Legal: $0-$100,000-plus

Legal costs are highly variable, but plan for not only contract assistance but also compliance with Michigan telecommunication laws, municipal financing and general guidance and advice.

Financial: $0-$100,000-plus

Like legal costs, financial costs are highly variable. Activities range from conducting a cost-benefit analysis both to ensure a successful project and to comply with Michigan law, to the significant costs that can come along with a bond issuance.

Project management and administration: $0-$100,000+

While every project requires management and administration, in some cases these tasks can be undertaken by existing staff resources for no additional hard costs. In other projects, outside firms are hired to complete necessary management. Whenever possible, it is recommended you use project management resources from within the community.

Funding

Now, here are some of the funding options available for covering these costs.

Municipal Options

General fund: If a municipality or utility has sufficient funds in the general fund, the money can be used to build broadband infrastructure. Generally, it's desirable to have a business model where this initial investment is repaid out of future revenue from the broadband service. But a decision can also be made to treat the initial investment as a sunk cost. If repayment is expected, significant due diligence is required to quantify take rates and revenue prospects.

Public revenue bond: A municipality or utility can issue a bond that is secured by the future revenue from the broadband buildout. Revenue bonds carry additional risk because their repayment depends on the success of the broadband service, so significant due diligence is required. Public bonds are sold to investors, which can include residents, and can be sold in small increments to encourage community investment.

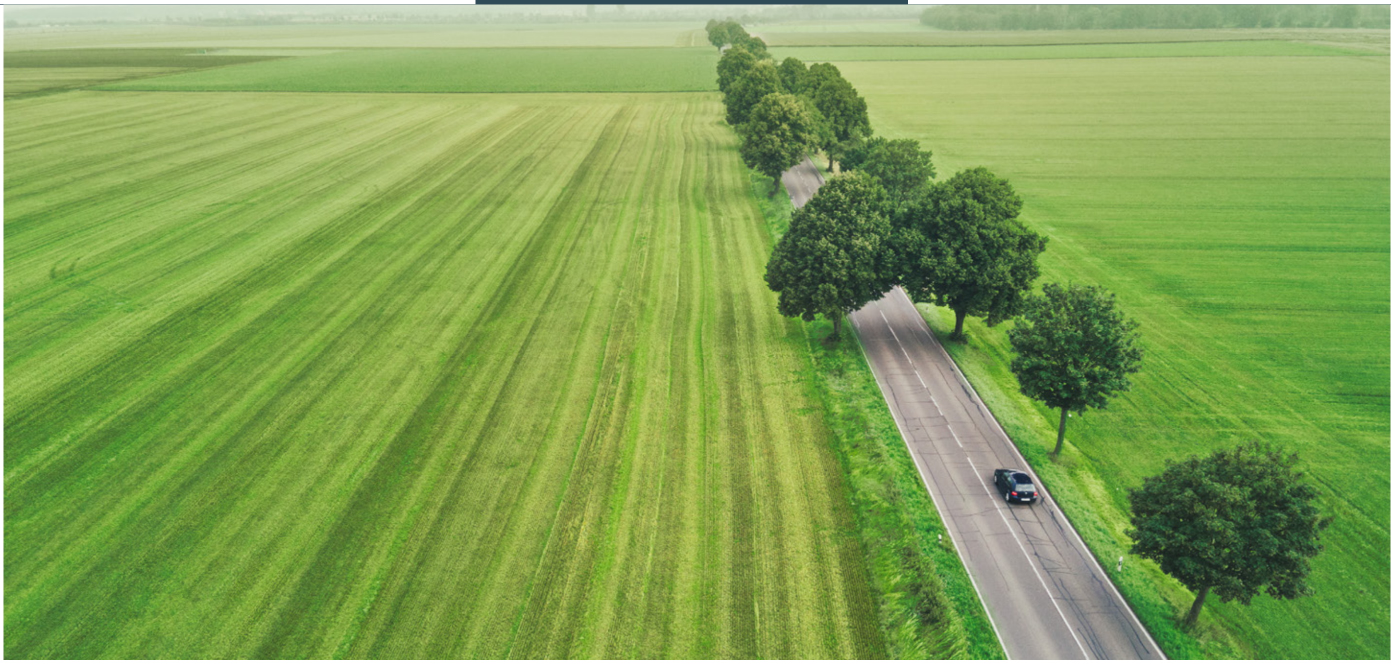
General obligation bond: A municipality or utility can issue a general obligation bond, which is backed by the credit and taxing power of the issuing jurisdiction rather than the revenue from a given project. Often the municipality would vote on a new tax, such as a property tax, to fund the bond repayment.

Cost avoidance: A municipality can redirect existing funding used to pay for private network services to build and operate its own network. Longer paybacks may require bonds to be issued and repaid using this funding. This approach is more common for smaller networks that provide municipal services only to start.

THE GRANT TRAINING INSTITUTE

SUGGESTS THESE INTRODUCTORY CONSIDERATIONS:

- What is your idea, problem or question?
- Why is your idea significant, important or needed?
- Who will fund your project?
- What is the match between your project and the donor?
- Who will benefit from the grant?
- What is the ultimate purpose or outcome of your project?
- How will the goal be achieved?
- How will the objectives be achieved?
- Who will implement your project?
- How will you know the project succeeded?
- What is the timeline for your grant?
- How much time do you need to distribute the grant funds?
- Where will the funds be directed?
- How will your project results be disseminated?
- How will you sustain the project once the funding ceases?



Private Options

Direct/private loan (debt financing): This model involves a bank or similar private entity providing a short-term loan to launch the network, with the money repaid out of revenue from the network. As with the previously discussed models, due diligence is required to ensure successful future repayment. This model generally has a significant equity requirement — in the range of 20% of the loan amount — which can be a barrier for many projects.

Private equity: If a third-party investor can be found, this entity or individual can provide the startup capital for the network and own some or all of the network for an agreed-upon period before giving the community a buyback option.

Loan guarantees: These programs provide a guarantee of repayment on a loan, making loans more accessible in some cases. The challenge with this is that the project must be able to support repayment of the loan out of revenue, in addition to significant equity requirements. Various national programs provide loan guarantees. These include:

- Rural Utility Service
- Department of Housing and Urban Development 108 Program
- Small Business Administration 504 Loan Program
- New Markets Tax Credits

Grants

A number of state and national grant options are available. These broadband grant programs often have been small compared with the amount of funding needed to solve the broadband gap in the areas they cover. However, new state and federal grant programs are expected to provide significant funding that are projected to be very impactful in this space.

But different grants cover different aspects of the community network process, including general purpose, planning, feasibility, buildout, operations, technology/device procurement, consumer education and technical assistance.

Don't forget to look into grants possibly offered by local foundations and corporations.

Developing a narrative that answers foundational information about your project and goals will help guide your exploration of potential grant sources, in addition to providing a compass for your broadband initiative as a whole.

AVAILABLE **FUNDING PROGRAMS**

Broadband infrastructure became a hot topic during the pandemic, as state and federal leaders saw the renewed urgency in providing robust connectivity for all.

Here are some of the major government-led initiatives to support broadband infrastructure investment.

Public Works and Economic Adjustment Assistance

This program comes by way of the American Rescue Plan Act of 2021, a $1.9 trillion coronavirus relief measure, and is managed by the U.S. Economic Development Administration. The program provides grants and cooperative agreements to support economic development and job creation, and attract private investment in economically distressed areas of the United States. Proposal applicants are encouraged to use existing regional assets to address recovery and resilience, fund critical infrastructure, foster workforce development, promote manufacturing or increase exports and foreign direct investment. Broadband infrastructure is among the program's priority areas.

Community Development Block Grants

Individual states make these grants, funded by the Department of Housing and Urban Development, to local governments for neighborhood revitalization, economic development and improved community facilities and services. Eligible activities include providing decent housing and a suitable living environment, expanding economic opportunities that benefit low- and moderate-income people and prevention or elimination of slums and blight. Funds can also be used to finance broadband services such as infrastructure development and digital literacy.

Broadband Equity, Access, and Deployment Program

The largest allocation for broadband in the Infrastructure Investment and Jobs Act (IIJA), the Broadband Equity, Access, and Deployment Program (BEAD) is a $42.5 billion grant program designed to bridge the digital divide in rural areas and in states that consistently rank below others in broadband access. Department of Commerce funds will be granted to states to make subgrants across the broadband lifecycle of plan, build, run and adopt. Primary importance is given to "unserved" areas, defined as lacking access to reliable internet service that provides download speeds of 25 Mbps and upload speeds of 3 Mbps. However, "underserved" areas (with download speeds of less than 100 Mbps and upload speeds of less than 20 Mbps) and community anchor institutions (schools, libraries and hospitals) also can qualify. Specific uses identified include data collection and broadband mapping, installing internet and Wi-Fi infrastructure, and projects that address affordability, including purchases of internet-capable devices.

ARPA: Coronavirus State and Local Fiscal Recovery Funds

The American Rescue Plan Act's Coronavirus State Fiscal Recovery Fund, Coronavirus Local Fiscal Recovery Fund and Coronavirus Capital Projects Fund provides a great deal of local flexibility in addressing the impact of COVID-19. States and municipalities can use funds for COVID-19 mitigation, to offset related government revenue losses or provide aid to affected industries such as tourism, travel and hospitality. Funds may also be used to provide premium pay to essential workers, for the provision of government services to the extent of the reduction in revenue or to make necessary investments in water, sewer or broadband infrastructure.

Digital Equity Act of 2021 Programs

This act set aside $2.75 billion to help communities close the digital divide. This is done through three programs: a $60 million state planning grant program, a $1.44 billion state capacity grant program and a $1.25 billion competitive grant program. More information can be found at the National Telecommunications and Information Administration.

Rural eConnectivity (ReConnect) Program

Loans, grants and loan/grant combinations are available from the Department of Agriculture's ReConnect Program for broadband deployment in rural areas. Eligible expenses include costs of construction, improvements and purchases to support deployment of internet service with a minimum download speed of 100 Mbps and upload speed of 20 Mbps. At least 90% of the households in the recipient's service area must lack sufficient broadband access. Key priorities include helping rural communities recover economically from the effects of COVID-19, ensuring residents have equitable access to rural development programs and benefits, and addressing climate change.

Connecting Michigan Communities

The Michigan Department of Technology, Management and Budget's Connecting Michigan Communities program offers grants for projects that extend retail terrestrial internet service with a minimum download speed of 10 Mbps and upload speed of 1 Mbps into unserved areas. Priority is given to proposals that promote collaboration in meeting community investment and economic development goals. Eligibility is limited to internet service providers in Michigan, who must prove they have the ability to build and manage a broadband network.

GRANT OPPORTUNITIES

Stay current with quarterly reports available through Merit's partnership with Grants Office: Funding programs are fluid. They come and go, as do their deadlines for applying. Grants Office LLC puts together a detailed report on current and upcoming state and federal grants that can be applied towards broadband projects. The report is updated quarterly and can be downloaded for free by completing the form at this page: **https://www.merit.edu/community/moonshot/grants/opportunities/**.

GRANT FUND

Merit also offers a funding program of its own, through its **Moonshot Community Grant Fund**. Merit Members may be eligible for funding for their community network projects, particularly for data collection, feasibility and pre-engineering, grant consultations and consulting over Michigan's METRO Act. Learn more at **http://merit.edu/grants**.

Ownership Models

Quite a few ownership arrangements have arisen over the years for organizing a community network. They break down into the following four main categories, according to public and private participation:

> PUBLICLY OWNED, PUBLICLY OPERATED

> Advantages

No private parties involved; entire focus is on delivering best service for residents.

> Disadvantages

Unless a municipality has its own utility department, it is difficult to build the staff and expertise required to operate a broadband service.

> PUBLICLY OWNED, PRIVATELY OPERATED

> Advantages

Maintains community control while allowing an experienced operator to deliver service.

> Disadvantages

Some funds will go to the private operator in the form of their profits, and a private operator must be carefully selected to ensure their interests align with those of the community.

> PRIVATELY OWNED, PRIVATELY OPERATED

> Advantages

Minimizes risk for the community.

> Disadvantages

Community has little control over the network and service; it can be difficult to find a private provider willing to fund the network.

> PUBLICLY OWNED, OPEN ACCESS

> Advantages

Enables competition between multiple service providers to the maximum benefit of residents.

> Disadvantages

Especially for smaller communities, it can be difficult to attract more than one service provider to an open-access network.

COMMUNITY NETWORK OWNERSHIP AND OPERATING MODELS

BENEFITS AND CHALLENGES

OWNER	OPERATOR	MODEL	PROS	CONS
Public	Public	Municipal ISP	> Serve the unserved > Fair pricing for all > Focus on service, not profits > Local accountability	> Requires operational resources > Competitive labor market > Upfront costs > Potential financial risks
Public	Multiple	Open Access	> Build once for all > Lower prices > More choice > Pro-business	> Upfront costs > Long term ROI > Attracting multiple ISPs can be hard
Public	Private	Public-Private Partnership	> Serve the unserved > Prices may be lower > Less effort	> Upfront costs > No competition > Less local control
Private	Private	Incentivization Strategy	> Low upfront costs > Minimal effort > No financial risk	> Will not necessarily serve all > No control over prices or service quality > No choice or competition > Minimal or no accountability

WHAT ARE **OPEN-ACCESS NETWORKS?**

The concept of "open access" is simple: The organization that owns the physical cable connecting to your home opens up access to any provider that wishes to provide service over the same cable. The result is true competition and a robust open-access network, where providers are differentiated by the quality and cost of their services. You can compare open-access networks to roads — it wouldn't make sense for UPS, FedEx and USPS to all build separate roads to your house to deliver packages. It makes more sense for the roads to be publicly owned so anyone can use them to provide competitive services.

This sounds great. Why don't we already have open-access networks everywhere?

The main challenge with open-access networks is that there needs to be an entity willing to pay for them and whose primary goal is not profit. This is because the best way for a business to maximize the amount of money it can make from an investment in cable infrastructure is to be the sole service provider on those cables. So the kinds of organizations that are best suited to own open-access networks are public entities or nonprofits that can prioritize the value provided to their constituents over maximizing profits.

How does an open-access network work?

There are two main ways to run an open-access network: two-layer and three-layer. The three-layer model is the simplest for a municipality. In this model, the municipality owns the network, but aside from oversight, that's where its role ends. The operation of the network, including infrastructure maintenance and administration, is outsourced to another firm. Once all this is established, multiple service providers can then offer services over the network.

In a two-layer model, the municipality takes a more active role and operates the network in-house. This model is most appropriate for municipalities that have existing utility or public works departments. Once again, multiple service providers then offer services over the network.

TYPICAL 3-LAYER OPEN-ACCESS NETWORK

Owner (Municipality)

Owns and pays for construction of the network, while paying an outside vendor to manage and operate the network

Operations Vendor

Provides wholesale network service to internet service providers (ISPs)

ISPs

Businesses that compete with each other to deliver retail internet service to end-user customers on the owner's network infrastructure

End Users

The customer base of residences and small businesses

What are the different kinds of open-access networks?

The open-access model most helpful for residential broadband is a "last mile" open-access network, where multiple service providers compete to provide residential services. There are two other main kinds of open-access networks to note. 1) A "middle mile" open-access network connects the last mile (local) segments to the broader internet. Service providers can use them to get bandwidth to a last-mile network that they own. While many large providers refuse to participate in last-mile open-access networks, they are more willing to consider middle-mile open access. 2) A "dark fiber" open-access network is one where the fiber-optic cable infrastructure is built but not yet "lit", or in use. Any dark fiber is inherently open access — a private provider can lease one or more fibers, generally for middle-mile services.

PROS AND CONS OF OPEN-ACCESS NETWORKS

PROS:

Open-access networks have the potential to provide the best possible results for consumers. Removing the natural monopoly of cable infrastructure from the equation and allowing multiple providers to use the infrastructure promotes competition not only of broadband, but other "over the top" services, such as voice, video, home security and smart home features. Providers compete based on the price, quality and diversity of their services, rather than just by which one is willing to make the capital investment to build the infrastructure. Many communities with open access have experienced a "race to the bottom" for broadband pricing, with gigabit service offered for $10/month or less. Service providers then focus on differentiating their offerings with additional service offerings and bundles. Finally, a big benefit of publicly-owned open-access infrastructure, as with any public owner model, is that "profits" generated from providing access to the infrastructure accrue to the community as opposed to private companies.

CONS:

One of the biggest challenges with open access especially for small communities can be attracting enough providers to enable competition. Providers may not be willing to try to compete in a market that only has a small number of households. Second, open access can shift some financial risk to communities — care must be taken to design a financial model with realistic pricing and take rates, so that maintenance and depreciation for the infrastructure is self-sustaining over the long term. Finally, as with any public ownership model, municipalities will likely face political pushback from large "incumbent" providers. These arguments can be somewhat mitigated by the fact that the incumbents would be welcome to participate as providers on the open-access network.

BUILDING A NETWORK

For the buildout, designs will be made, permits obtained and a construction company selected.

Given that the construction of a fiber network involves engineers, inspectors, work crews, lift trucks, bulldozers, plows and more, most communities will opt to contract out the work. This guide assumes that will be the case, but much of it also applies to municipalities that choose to build the network on their own.

TERMINOLOGY

First, here is some terminology you will need to know as you make decisions about building your network.

Backhaul: The connection from a local network (such as a community network) to the global internet. An outside company provides backhaul internet service by connecting the smaller network to the internet backbone.

Middle mile: The connection between the last mile and the greater internet. In a rural area, the middle mile would likely connect the town's network to a larger metropolitan area, where it interconnects with major service providers. While there are some technical differences between "backhaul" and "middle mile", in practice they often refer to the same infrastructure.

Backbone: Backbones are network connections that interconnect different networks. They can be as small as a corporate connection in an individual data center or as large as a global transoceanic cable. They also can be seen as a collection of network links that connect internet peering points. Where these peering points then branch off into more local routes is called middle mile. Backbones are like large freeways or highways — the core connection that ultimately provides services to customers.

Peering point: This is the point at which one backbone network connects to another. These connections are made according to agreements made by the administrators of the individual networks involved. Also called an exchange point.

Mainline fiber: The connection lines that come down streets, before the final link to each home.

Last mile: The final leg of a connection between a service provider and the customer.

Drop: The connection from the mainline fiber to the individual residence or business. The drop can be buried underground or run aerially on utility poles. This is an example of a last mile connection.

Aerial infrastructure: The equipment used to place cables, such as those used in electricity and telecommunications services, in the air, usually through the use of utility poles. Communications cables usually need to occupy a specific place on the poles, and there are specific requirements to be allowed to attach to poles owned by other parties.

Underground infrastructure: Cable that is buried. Plowing or directional boring is usually used to place conduit into which the cables are then pulled. Cable can also be directly buried with no conduit.

ENGINEERING

This phase determines the details of the network design. The key task here is the issuing of a request for proposals.

Requests for Proposals (RFPs)

Engineering and design of the network can cost $100,000 to $1,000,000, or more. A request for proposals (RFP) should be issued to solicit formal competitive bids. Here are some elements an engineering RFP should include.

Project management
The respondents detail how they plan to handle project management, including key personnel working on the project, expectations regarding meetings with stakeholders and how the engineering firm plans to ensure a high-quality result.

Project schedule
The respondents should provide a detailed timeline for how quickly the project will be completed. Timelines always include variables beyond the control of respondents, but the apparent accuracy of estimates that involve outside variables are an important evaluation criteria. A timeline that is too optimistic is worse than one that is too conservative.

Subcontractors
If the respondent is planning to subcontract any of the work, this should be detailed in the response.

Mapping and design
One of the main deliverables will be construction drawings to be used by the contractor to build the project. A description of the company's systems to produce these drawings should be part of the response.

SEE GLOSSARY, BEGINNING ON P. 60 FOR MORE TERMINOLOGY.

Design benchmarks
Include any specific details the respondent should address. Examples include whether active Ethernet or a passive optical network is desired, whether all homes and businesses in the community should receive service or just certain areas, and desired levels of future-proofing.

Engineering proposal
Respondents should explain expected deliverables and reasonable information about their ability to design the requested infrastructure.

Permit acquisition
The engineering firm will play a critical role in acquiring public permits and private easements, and should describe its ability to do this in its response. An ongoing relationship with the local road commission is necessary to ensure the project remains compliant with road permits.

Construction management
Engineering firms often also supply construction management, as an option. This could be included in the engineering RFP.

Standards and code references
The RFP should include expectations on standards and codes that the project should follow. Examples include the National Electric Safety Code, ANSI/TIA/EIA standards and fiber-optic testing standards.

CONSTRUCTION

Next comes the building of the network design from the engineering phase. Construction costs for a fiber-optic network of any significant size will quickly reach millions of dollars, so it's best to have another solid RFP.

Here are the major aspects of the construction phase.

Construction RFPs
There are multiple ways to approach construction RFPs. A quick one is to use the Rural Utilities Service Form 515 and its related forms (515 a-d). These forms were designed for the Rural Utility Service and have since become a standard across the networking industry.

Project management
Any project of this scale requires effective project management. If possible, find a local consulting firm or similar resource for project management. Someone from the community will be more invested in the project.

Construction management
The firm that did the initial design and engineering work can be tapped to oversee the construction, but local resources can also be found or trained for this.

Selecting a backhaul provider
This is how your network will connect to the rest of the global internet. Start by asking for quotes from wholesale providers.

Drop-construction contractor selection
Drops can be installed underground or overhead and are generally held to different engineering and construction standards compared to mainline fiber. For this reason, the drop contractor may be a different entity than the construction contractor. Some mainline construction companies also handle drop construction. But it generally is not recommended to include both in the same RFP. Depending on the construction company your organization selects, you may need to conduct a separate RFP or RFQ (request for quotation) for drop construction.

Building the drops
Homeowner participation is necessary during drop construction. Drops can be constructed via aerial or underground approaches. Aerial drops are less expensive and time-consuming, while underground drops are more aesthetically pleasing. Underground drop construction involves plowing earth and disturbing homeowners' lawns. If driveways, sidewalks or landscaping are within the fiber's path, a deeper

trench must be laid via boring techniques to allow the fiber to travel more deeply.

Homeowners often have their own underground infrastructure — such as wells, electric service to outbuildings, sprinkler systems and invisible fences. Because these are not registered in Michigan's "MISS DIG" system, homeowners generally must bear the responsibility of marking the underground barriers themselves.

Construction Speeds

Underground boring is the slowest method of fiber construction. Boring typically can be completed at a maximum of 500 feet per day per crew. After boring, fiber must be pulled through the conduit, which can be completed at about one mile per day per crew.

Plowing can be done more quickly, but only in open areas without obstructions like trees and driveways. Additionally, plowing should not occur too close to any trees because severing a tree's root system can kill it.

Once conduit is in the ground, fiber is placed either by "pulling" or "blowing" it through the conduit. This step of the project goes relatively quickly.

Note that early in the process you may not know what vendors are out there, what they offer, the scope of their capabilities and their prices. In this case, an RFI, request for information, might be the way to go. It's similar to but less final than an RFP and allows for flexibility as the conversations progress. It's a way to get the lay of the land.

HIRE INSPECTORS

Don't rely on the word of contractors or even third-party inspectors. Hire your own inspectors who will ensure quality standards are being met, so you don't run into problems like accidental cuts to your fiber cables, dangerous conditions for the cables, permit violations and other issues that could lead to disruptions to your network's internet service later on. Look for engineers with experience in "outside plant", as outdoor networking equipment is called in the industry. In-house inspectors also will be there to safeguard the lines you put up on poles. Inspectors' documentation can be a life-saver if another party moves your cable without your permission. Your inspector will have the photos and measurements to make your case. The same holds true for underground cables, which may end up being moved during construction of buildings and driveways.

AERIAL VS BURIED

Underground is Better Than Aerial in the Long Run

The first instinct many network builders have is to put all the cable in the air, connected to utility poles. That's because it's cheaper. When Merit embarked on its massive project to build 2,500 miles of fiber-optic network in Michigan, we found that it cost at the time (more than 10 years ago) about $22,000 per mile for an above-ground, or aerial, cable, while to go underground cost $40,000 per mile.

But that was the upfront cost. Such estimates don't take into account other costs that crop up.

"Don't just look at that initial so much per mile. You have to look at the whole cost of ownership over time, 15 or 20 years or so, and ask: What's in your best interest?" said Bob Stovall, Merit's vice president of infrastructure strategy and research.

In the end, we put about 60% of our fiber underground. We advise others to carefully consider the long-term costs when weighing the benefits of "aerial vs buried" for their fiber-optic cables.

In some places, poles can't take more weight without costly modifications. This is part of what's called the "make ready" process: preparing a pole to accept another cable, or even replacing it altogether. "Make ready" is the responsibility of the newcomer to the pole, and the costs can be more expensive than the construction itself.

The owner of the pole, typically a power utility company, may have to reposition a power line or a transformer to make way for your new fiber cable. Not only can this happen at the outset, but also later on as conditions change and other parties want to add lines to the pole. Then you have to send inspectors out to make sure the new party did everything correctly. And they may not have. Sometimes the other parties don't ask or notify the pole owner or other attachers, such as your organization, of changes they made to the arrangements on the pole — including of your fiber cable.

The pole owner also may decide to replace the pole at some point. That cost is borne by the owner, but the cost to move the cable is not.

"Make ready is the gift that keeps on giving," Stovall said.

Going underground is no guarantee that later costs will be avoided entirely. The widening of a road, for example, may force you to move your underground cable. And new construction can lead to one of your cables getting accidentally cut. To fix a cut cable, the cost ranges between $10,000 and $50,000 for underground cables, and from $10,000 to $20,000 for aerial cables. However, aerial lines are more likely to need repairs, as they are susceptible to more risks, from squirrels and falling trees to vehicle accidents. And the common risk to an underground cable — being cut by construction equipment — is covered by reimbursement from the construction company at fault.

Two Forward-Thinking Policies to Consider

Rural municipalities that have a bit more population density, such as small towns, may want to consider two policies others have used to lower the costs of both underground and aerial infrastructure work.

One is the practice known as "dig once". This has to do with making the most out of times when digging is done to access infrastructure, such as when roads and sidewalks are dug up to get at water and sewer lines. "Dig once" boils down to making sure you lay conduit for fiber cable any time such digging is done.

Similarly, the practice of OTMR — "One Touch Make Ready" — has to do with simplifying the attachment of cables to utility poles. Poles usually already have attached to them multiple lines belonging to several parties. An OTMR policy designates one pre-approved contractor to handle the work of attaching new lines (which may also include moving existing ones). While you'll still need to get approval from the existing lines' owners, you won't have to wait for those owners to send work crews. You can just go to the approved contractor.

RUNNING A NETWORK

As with previous steps, you'll face a choice in whether to manage your network within your organization or to outsource it to a vendor. Choosing a vendor to operate your network, particularly one that offers a full "turnkey" menu of services, makes this a much less daunting task, especially for communities that don't have existing public works and utility operations. Having a single point of contact to be responsible for customer sign-ups — which includes home installation, network administration, billing, customer support and more — helps to ensure a seamless experience. A piecemeal approach split between multiple vendors or an insource/outsource model too often leads to hidden costs and high manpower requirements.

The network operator will have a relationship with your community for years or even decades. As with any critical decision, a formal solicitation and evaluation should be performed.

Considerations when choosing a network operator:

- Does the firm have experience scaling a network at the size you're planning?
- Can the network operator provide strong referrals for similar deployments and ongoing operations?

- Is this vendor currently involved in litigation? Have there been any past judgments against the company? Are there any current liens?
- How have provider and partner agreements been crafted and vetted?
- Where is the operator's support located? Strong local support is recommended. Support channels that operate in a different time zone can present challenges. Does the organization offer 24/7 services from a network operations center to monitor traffic, outages, alarms and performance issues?
- Is this vendor well-versed and experienced in the technology solutions you plan to deploy on your network?
- Will this network operator provide ongoing management services, such as billing and home installation?
- Will the network operator provide ongoing GIS maps of your network infrastructure?
- How is the network monitored for issues and remediation needs? What are the vendor's remediation processes?
- What minimum service levels will you negotiate with the provider in regard to latency, packet loss, jitter and other network performance matters?

Further Considerations

Here are some of the major categories of activity when it comes to running your own community network, and for which an outside vendor may prove helpful:

Network Management

Many network operators also provide management services such as billing, home installations, troubleshooting, help desk support and communications. These services again could fall under one vendor, be individually outsourced to other vendors or controlled within your organization.

Help Desk

The following are some of the considerations that should be explored with any potential help desk arrangement:

- Does the network operator offer 24/7 customer service?
- Is the help desk locally operated?
- Is the network constantly monitored?
- Can the contractor provide and issue escalation matrix and contact lists?
- Can this operator provide references and recommendations regarding their customer service relationships?

Billing and Financial Management

This is one area where the in-house option is popular among municipalities and public utility networks. But if you choose to outsource, here some questions to ask:

- Does the vendor follow generally accepted accounting principles (GAAP)?
- Does the company have an annual independent audit performed by an external auditor?
- Has the company filed all required federal and state tax returns?
- Does the company use outside legal counsel for guidance when necessary?
- Does the company maintain internal controls such as:
    - Separation of duties
    - Authorization/approvals
    - Documentation
    - Regular reconciliation
    - Physical and cyber security of assets and systems
- Does the company track asset installation in the field?

- Does the company track asset relocations and/or retirements?
- Does the company create customer invoices on uniquely numbered invoices?
- Is the company's financial system able to track outstanding customer receivables?
- Does the company regularly collect on unpaid receivables, whether in-house or by use of a third party?
- Does the company have a way to give customer credits in the event of a missed deadline or service outage?

Marketing and Communications

As mentioned earlier, marketing and communications of the project should begin early to build residents' interest. When the network becomes operational, you'll already have the groundwork laid for maintaining the permanent operation that'll be needed to communicate with customers and advertise the services.

This probably will extend to creating a website, an email communications system, social media accounts and so on. Once again, it'll be up to you whether to do this work in-house or farm it out to a firm. If you hire an outside company to operate the network, that vendor also may be able to perform the communications and advertising end of things, as well.

Network Security

Cybersecurity is a requirement for any network provider, and community networks may be especially vulnerable because of their smaller size and fewer dedicated IT security staff. The security of your network is the responsibility of all parties involved: your local broadband group, your contractors and vendors, and your end-users. Here are some best practices that will bolster the security posture of your operation.

- Equipment selection: When you or your vendors select equipment, perform due diligence to ensure the manufacturer has a trusted history and a commitment to security and privacy.
- Secure your infrastructure: Community networks can be an easy target for attackers, as the potential reward on attacking the network or its subscribers is substantial — especially because there may not be a large budget for security. Ensure that all in-field electronics are properly protected with an access control list (ACL) that permits communication to your internal network only. You or your network operators should deploy complex passwords and centralized logging to further bolster security, and configure a firewall for your network's headquarters to dramatically reduce your threat profile.
- Perform regular security updates: Vulnerabilities will be discovered regarding your network electronics, and so you need to ensure they are kept up to date. Although this may mean a small outage while a reboot takes place, this is better than risking the security and privacy of your networks and data.
- Ensure payment systems are PCI compliant: Taking credit cards for payment necessitates the use of Payment Card Industry (PCI) certified products and processes. This certification ensures that the highest level of security is given to the storage, transmission and processing of financial data.
- Keep business and customer data securely stored: Both business and customer records are vital to your operation and contain sensitive and private data. Names, addresses, payment histories and call logs could be considered personally identifiable and should be viewed only by those with a legitimate business need. Company financial data and strategic plans are also prime targets for attack and should be stored centrally with appropriate controls to ensure no data loss.
- Encrypt passwords appropriately: If you or your network operator are assigning out user names and passwords to your customers, ensure that passwords are encrypted. These encrypted passwords should be treated as confidential data.
- Have an incident response plan: It is inevitable that at some point you will be the victim of an attack.

Creating a plan beforehand — identifying the people and roles they play during an incident — makes the difference between recovering from an attack or being devastated by it.

- Create an acceptable use policy: Have a clear document for your customers that states the kinds of activity that is not accepted, as well as the consequences for performing that activity.
- Know how to address abuse complaints: You will receive notifications that customers on your network are either willingly or unknowingly performing malicious activities such as spamming or copyright infringements or are launching full-fledged network attacks. Create a process that is clear on how you communicate these complaints and when to disconnect improper customers from your network.
- Have a security assessment performed: A second set of eyes is a great thing to make sure that all your cybersecurity bases are as covered as they can be. Before you begin accepting customers, conduct a comprehensive review of your network posture and security controls so you can be best positioned for success.

All this may seem intimidating, but remember, most communities will engage one or more professional firms to conduct the ongoing operation of the network. Additionally, the Michigan Moonshot coalition provides resources and networking opportunities for groups across Michigan to learn, share best practices and build relationships.

Wikipedia.org

Fiber Roots: Holland Grows its Network over 3 Decades

Holland, Michigan, can trace its power utility to before the turn of the 20th century. In 1892, the town voted to form a municipal electrical service, already then being enjoyed by residents. More recently, Holland retired its coal plant and replaced it with a $240 million natural gas plant.

All of which is to say, the city of 34,000 on Lake Michigan is well-prepared to offer its residents broadband service.

“Providing public utilities is the kind of thing we understand and know how to do here,” said Pete Hoffswell, superintendent of broadband services for the Holland Board of Public Works.

In August 2022, Holland residents voted in favor of a $30 million millage proposal to fund construction of a fiber broadband network for the whole city. The endeavor wouldn’t be starting from scratch: The network would expand upon a smaller pilot version made available to downtown businesses and residents in 2018, serving 120 customers as of spring 2022.

The story doesn’t begin there, though. Holland’s fiber roots stretch back to 1992. That’s when the town built

> "We were basically forced to become an ISP."
>
> **PETE HOFFSWELL**, SUPERINTENDENT OF BROADBAND SERVICES FOR THE HOLLAND BOARD OF PUBLIC WORKS.

fiber infrastructure to support its electric, water and wastewater treatment services, so substations, breakers and other infrastructure could be wired for better control and efficiency.

The network then had excess capacity, so Holland opened the network to industrial companies, internet service providers and anchor institutions such as the city library system. The Board of Public Works does this by providing Dark Fiber and Active Ethernet services using an open-access model.

A third variety of broadband service, called Shared Gigabit, is the one that caters to downtown customers. The proposed expansion is projected to cost $24 million, with a project return on investment in three years.

Holland's network is fully owned by the city and sits within the Board of Public Works alongside electric, water and wastewater treatment services. A vendor was used for the construction of the downtown network, but otherwise the Board of Public Works operates it in-house with its own staff and equipment. The network functions like an independent carrier, even paying pole attachment and "make ready" fees to its sister electric utility when it comes time to put cables on the utility's poles. The City of Holland is a customer, alongside anchor institutions, ISPs and industrial companies.

Holland's overall network is a mix of direct and open service. Under an open-access model, the entity that built the network (in this case, Holland), does not provide internet service to customers. Others do, and they pay a fee to use the network. This encourages multiple providers to jump on board and compete for customers. (See page 40 for more on open-access networks.) Six such providers use the city's Dark Fiber or Active Ethernet services.

But when it came time to launch the Shared Gigabit service downtown, no providers were interested. Holland issued a request for information, as required under Michigan law, but the small size of the project attracted no takers.

"We were basically forced to become an ISP," Hoffswell said.

Under the Shared Gigabit program, customers pay $85 a month for symmetrical speeds of 1 Gbps. They also can opt for "enhanced" service of $220 a month that comes with priority service during outages. This has been more popular than expected, Hoffswell said, as even small retail shops depend more and more on internet service. Customers of either plan also appreciate the local customer service, as representatives can be contacted quickly and dispatch technicians just as quickly.

Hoffswell advises other municipalities to work very closely with their community when jumping into network projects. Holland has been sure, whether in the early 1990s or now, to bring in people from all constituent groups — such as business, low-income, health care, diversity and education, to name a few — when considering and planning its network.

"Don't just sit in your tower, making decisions from the top floor of city hall," he said.

Marshall FiberNet: 100% City-Owned Broadband Service

Community leaders in Marshall, a city of about 7,000 people in south-central lower Michigan, began looking at the issue of poor internet access in 2015. While some neighborhoods received service from cable operator WideOpenWest, much of the city had access only to DSL from AT&T that did not meet the definition of broadband. Other residents lacked access entirely.

Today, all of the city has access to high-speed internet service through Marshall FiberNet, launched in late 2017. FiberNet offers the following levels of service: $44 for 50 Mbps, $66 for 150 Mbps, $99 for $250 Mbps and $200 for 1 Gbps (all symmetric).

The total cost to launch FiberNet came to $4.2 million, funded through loans from city funds such as the general fund and the Local Development Financing Authority. The network was planned to be self-sustaining, with capital investment estimated to be repaid in five years. This will require a 38% take rate, which the network is on track to meet. The service has 1,700 subscribers.

"We have blown away projections on residential subscriptions," said Marshall Director of Community Services Eric Zuzga.

Subscriptions to businesses took longer to pick up steam. To meet requirements of state law as well as to conduct due diligence, the city issued a request for proposals from providers that could improve the city's broadband infrastructure. When no responses resulted, the city proceeded to build its own. One unfortunate consequence of issuing the RFP, however, is that it made commercial internet providers aware of the plans. Those providers then went out and pushed to lock local businesses into long-term contracts, Zuzga said.

"Once they knew what our intentions were, they went to customers and said, 'If you want coverage, we can give you a good deal right now,'" he said.

Now that those contracts are beginning to come to their end of their terms, Marshall is seeing more businesses sign up to FiberNet.

www.strongtowns.org

FiberNet is 100% city-owned, and is operated by staff directly employed by the city as well as vendors that the city keeps on hand as backup when extra help is needed. (Marshall had experience in providing a service like this — the city also runs an electrical utility.)

Because it's a smaller service compared to large commercial providers, customers get to a real person quickly when calling in with questions. "We have (an automated phone) system where the caller selects billing or technical help, but then they get to a person right away, and it's a person here in Marshall unless it's after hours. That's something we take pride in," Zuzga said.

The city's small size also means that the callers often know the other person on the line, not to mention the technicians who visit homes. "We have two techs: Richard and Josh. People know them," he said.

Marshall has one tip for other communities that decide to build their own networks: Break up the work using multiple vendors. Marshall had one company help with the RFP and that company went on to win the job of building the network. In hindsight, it would have made more sense to have different vendors for the steps of design, cost-benefit analysis and construction.

Wikipedia.org

Lyndon Township Bridges the Digital Divide

With a population of only about 3,000, Lyndon Township never drew much enthusiasm from commercial high-speed internet providers.

Until a few years ago, about a dozen homes around the edges of the township, located northwest of Ann Arbor in Washtenaw County, were served through cable providers. But, otherwise, residents were left with satellite, slow DSL or their cell phone service.

"Ninety-nine percent of homes didn't have anything that can be considered broadband," said Ben Fineman, president of the Michigan Broadband Alliance and a township resident.

Fineman helped to spearhead an effort to fill the gap, beginning with a feasibility study in 2016. The initiative also included the issuing of a request for proposals to gauge interest from commercial providers, as required by Michigan regulations. (See page 27 for more.) No responses came in.

In 2017, residents were asked if they'd be willing to pay a 20-year property tax of 2.9 mils (an average of $23 a month for property owners) to support a new $7 million fiber broadband network, paid for upfront with a township-issued bond. Voters approved the measure by a two-to-one margin.

The Lyndon Township broadband network began serving its first residents in June 2019 and was completed in December 2020. The network passes by every home in the township, making true broadband service available to 100% of residents. As of spring 2022, 961 households — or about 80% of the total — had signed up, far exceeding the 38% take rate needed to hit to make the endeavor financially feasible. It couldn't have come at a more timely

> "Ninety-nine percent of homes didn't have anything that can be considered broadband."
>
> **BEN FINEMAN**, PRESIDENT OF THE MICHIGAN BROADBAND ALLIANCE AND A TOWNSHIP RESIDENT

moment, in the middle of a pandemic that suddenly made broadband service all the more urgent.

The network consists of 68 miles of mainline fiber optic cable buried along roads, plus 79 miles of cable buried for drops (from the road to the house) for a total of 147 miles. Revenue from customers' monthly fees pays for operations and maintenance. The fiber itself has a long shelf life — 40 to 80 years, according to varying estimates — but the supporting equipment depreciates in the range of five to eight years. The township plans to save money for the first round of replacement and may then consider lowering the monthly rates to customers.

But the strong revenue flow also means the township will be ready to upgrade to even faster speeds as technology improves. "We're already talking about upgrading. When it launched, 1 Gbps was the best. Now, multi-gig is more feasible," Fineman said, with speeds of between 2 Gbps and possibly even 10 Gbps on the horizon.

Given the strong take rate among residents, the township has had enough money to already increase speeds once without raising rates. The monthly plans offered at launch were $35/month for 25 Mbps, $45/month for 100 Mbps and $70/month for 1 Gbps. Now, the $35 plan delivers speeds of 50 Mbps, and the $45 plan delivers 250 Mbps.

The network falls under a public-private partnership model. Lyndon Township owns the network, while a vendor, Midwest Energy and Communications, operates it. Midwest Energy, based in Cassopolis, Michigan, is a nonprofit cooperative under a five-year contract with Lyndon. The township's Broadband Oversight Committee oversees the overall management.

Lyndon also hired separate vendors for each of the engineering, project management and construction phases of the project. By outsourcing, the township avoided having to build a new department from scratch. Midwest Energy runs the network operations center, handles customer service and operates a 24/7 call center. A couple of small utility boxes in Lyndon houses some key equipment, but other than that and the cable infrastructure itself, the township didn't have to build anything further — no new municipal utility department needed.

Midwest goes "above and beyond" in its customer service, to the point of helping residents with issues beyond the network equipment and connections that are in its main purview, Fineman said. If residents need help connecting a specific device, Midwest walks them through the process.

"One reason we selected Midwest was that as a nonprofit cooperative, they have a customer service focus. They're in business not to make a profit but to provide a quality service to their cooperative. We're not members of the cooperative, but they treat us equally. They come from that service focus, and we found they do a better job," Fineman said.

GATHERING DATA

Gathering data is one of the recommended steps for launching into a community broadband project. (See page 19.) For Lyndon, this was simple enough. The township asked residents to self-report their internet coverage. But not much more information was needed that wasn't already obvious: If a provider only has service on one road, it's not hard to identify that road. "We had an easy time figuring out coverage because there wasn't any," Fineman said.

Wikipedia.org

Washtenaw County Takes Private Path

Washtenaw County residents are set to soon have 100% broadband coverage.

Home to the city of Ann Arbor, the Southeast Michigan county in September 2021 approved a plan to spend up to $15.5 million to close its digital divide, bringing high-speed internet service to 3,300 currently unserved households.

Ben Fineman, vice chair of the Washtenaw County Broadband Task Force, said the plan follows a private incentivization model, whereby existing commercial providers are paid to build new infrastructure. (Fineman also led the effort in Washtenaw's Lyndon Township to build a community network. See page 54.) Rather than building and owning a network itself, the county will pay private broadband providers to build out more of their networks. (See page 38 for more on the types of community network models.)

The funding is a mix of county money plus $13.7 million in American Rescue Plan Act (ARPA) funds. The county has set aside $800,000 of the money for internet affordability, literacy and access efforts.

The work is expected to be complete by 2026, the deadline to spend the federal ARPA money. Some providers anticipate that their buildouts will be complete as early as this year, Fineman said. Commercial providers such as Comcast and Charter are splitting the work mostly according to the townships where they already have the greatest presence.

The county has been studying its digital divide issue in earnest since 2017, when it formed a special subcommittee to look into the matter. Most areas of Washtenaw, a mix of urban and rural areas, have a provider, but certain pockets throughout the county do not. Although public ownership models were considered, the county was "too far along" in its existing broadband deployment to consider building a separate, and costly, public network, Fineman said.

It's simpler to pay those providers to build more. "I view it pragmatically," he said.

Although it comes at the expense of competition, residents at least will no longer have to drive to Wi-Fi hotspots to attend virtual meetings from their cars.

THE MICHIGAN MOONSHOT

EXPANDING COMMUNITY NETWORKS IN MICHIGAN

THE MICHIGAN MOONSHOT

Merit Network Inc. is an independent nonprofit Research & Education (R&E) organization, owned and governed by 12 of 13 Michigan's public universities. We launched the Michigan Moonshot initiative in 2018 as a collective call to action to bridge the digital divide in Michigan. The goal is to expand broadband access by informing policymakers, fostering public-private partnerships, encouraging collaboration and narrowing the homework gap, so everyone can benefit from the advantages that high-speed internet service brings.

Merit is one of more than 40 R&E networks in the country. Like Merit, these organizations serve as ISPs to public higher education institutions and contribute to the ecosystem of organizations, partnerships and approaches aimed at solving broadband issues. Besides delivering connectivity, R&Es offer network and cybersecurity services, provide training and educational materials, and serve as centers of collaboration. Merit's history of educational, technological and governmental partnerships provides a trusted foundation for the Moonshot initiative. Founded in 1966, Merit was the first R&E network in the U.S., and our network still stands as the longest-running R&E network in the country. Merit's name stems from its original moniker, the Michigan Educational Research Information Triad. It was created by Michigan State University, the University of Michigan and Wayne State University to share resources by connecting the universities' mainframe computers. This ongoing partnership, which continues to expand, paved the way for the commercial internet as it is known today. We managed NSFNET, the forerunner to the internet, on behalf of the National Science Foundation from NSFNET's beginning in 1988 through its end in 1995.

Merit provides network, security and community services to about 400 member organizations, which include Michigan's public universities, colleges, K-12 organizations, libraries, state governments, health care organizations and other nonprofits. With a fiber-optic network spanning more than 4,000 miles in Michigan, Merit is ideally situated to bring together partners in statewide broadband accessibility under the Moonshot initiative.

The Moonshot initiative rests on three pillars:

- Data Mapping Analysis
- Education, Resources and Funding
- Infrastructure

This approach has been designed to be applicable to any region that is unserved or underserved by broadband access.

Data Mapping Analysis

Provide communities with expert GIS and broadband support to assist with data collection and mapping, analysis, grant storytelling and infrastructure planning

Leverage user-driven data and open source tools to provide accurate, granular, household-level outputs and visualizations

Education, Resources and Funding

Share educational materials, host community events and offer technical assistance to support and empower local leaders and communities to demonstrate tangible progress toward broadband expansion

Infrastructure

As a statewide network operator, Merit is positioned to assist communities with our infrastructure expertise. We approach this from an agnostic perspective in support of all ownership models, technologies and collaborator arrangements

Activities include:

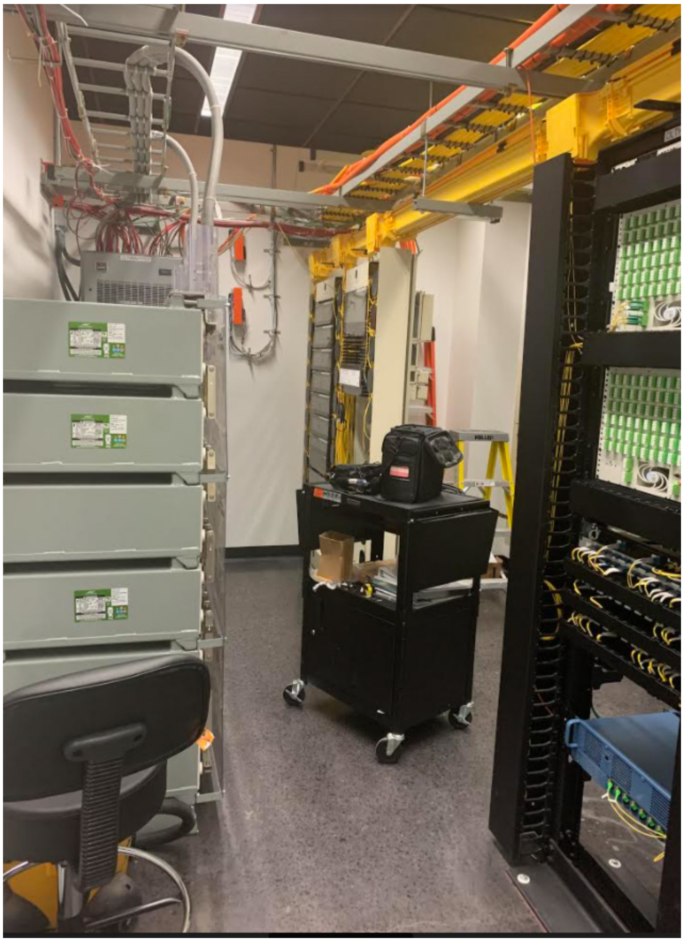
- Developing a citizen science/crowdsourcing approach to assessing the homework gap.
- Sharing information statewide.
- Fostering public-private partnerships.
- Develop educational materials on planning, building and running a network.
- Establishing unbiased community connectivity teams to provide expertise in data analysis, broadband technologies, financing, sustainability, grant writing, project management and network construction.
- Helping communities understand and access funding and one-time construction subsidies.
- Working with partners on research and policy recommendations.
- Organizing Communities of Practice — opportunities for networking, sharing industry best practices and professional development. These groups meet quarterly, with options for remote participation. (Limited to professional staff at Merit Member organizations.)
- Helping communities gather granular data and create maps showing the types and speeds of internet connections so they can make plans for improving their infrastructure. This includes a study conducted with our Moonshot partner the Quello Center at Michigan State University to assess the homework gap in Michigan (see page 9), and conducting surveys on behalf of counties (see page 19).
- Managing the Moonshot Marketplace: Here Michigan Moonshot members and Merit Members can purchase goods and services needed to plan, build and run their networks from trusted partners. We pre-negotiate rates for discounts and deals with vendors and contractors for every aspect of planning, building and running a network, including equipment.

Merit also regularly holds Moonshot educational events and webinars, where subject matter experts:

- Provide overviews of nationally available frameworks and resources to help communities jump-start their networks.
- Share updates on crowdsourced connectivity data.
- Explain the financial models, funding sources and feasibility cases for community networks.
- Explore wired and wireless solutions for connectivity.
- Provide overviews of current and future broadband policy.
- Create next steps for communities and anchor institutions.

"To go fast, go alone. To go far, go together."
— Vint Cerf, a "father" of the internet

We're in this together. Go to MichiganMoonshot.org to see how we can help you build a more equitable and inclusive network for your community.



PATHFINDER PROGRAM

The Pathfinder program offers step-by-step consultations on setting up a network. We have on hand subject matter experts plus local leaders who have already walked this path before. They will help you:

- **Assess conditions and set goals**
- **Collect data and resident sentiment**
- **Select an ownership and operations model**
- **Perform feasibility, inspection and pre-engineering work**
- **Navigate legislative and legal requirements**
- **Secure funding**
- **Engineer, build and operate the network**

See details at **https://www.merit.edu/community/moonshot/pathfinder/.**

Participation in this program can be funded through a Michigan Moonshot Community Grant. **Learn more here**.

GLOSSARY

WITH HELP AND PERMISSION FROM NEXT CENTURY CITIES AND THE INSTITUTE FOR LOCAL SELF RELIANCE

5G: Fifth-generation cell phone networks. 5G service will be faster and have lower latency than 4G and will include densely deployed "small cells" rather than the macro cell towers commonly used for 4G. Because many 5G small cells must be deployed closely together to create the network, the technology is best suited to densely populated cities.

Aerial infrastructure: The equipment used to place cables, such as those used in electricity and telecommunications services, in the air, usually through the use of utility poles. Communications cables usually need to occupy a specific place on the poles, and there are specific requirements to be allowed to attach to poles owned by other parties. See also **underground infrastructure**.

Anchor institutions: Flagship community institutions — including but not limited to schools, health care centers and libraries. Anchor institutions are sometimes connected to fiber even when fiber service is not commercially available in the community. Because of this, they can act as a connection to the internet backbone.

Asymmetrical: Internet connections have two components — downstream and upstream. When the two speeds are not comparable, the connection is termed asymmetric. Typically, phone and cable companies offer much slower upload speeds than download, in part because the internet tended to be a download-centric system in the 1990s and early 2000s. However, users increasingly need faster upstream connections to take full advantage of modern applications.

Backbone: Backbones are network connections that interconnect different networks. They can be as small as a corporate connection in an individual data center or as large as a global transoceanic cable. They also can be seen as a collection of network links that connect internet **peering points**. Where these peering points then branch off into more local routes is called **middle mile**. Backbones are like large freeways or highways — the core connection that ultimately provides services to customers.

Backhaul: The connection from a local network (such as a community network) to the global internet. An outside company provides backhaul internet service by connecting the smaller network to the internet backbone.

Bandwidth: The rate at which the network can transmit information across it. Generally, higher bandwidth is desirable. The amount of bandwidth available to you can determine whether you download a photo in two seconds or two minutes.

Bit: The base unit of information in computing. For our purposes, also the base unit of measuring network speeds. One bit is a single piece of information. Network speeds tend to be measured by bits per second – using kilo (1,000), mega (1 million) and giga (1 billion). A bit is part of **byte** — they are not synonyms. Bit is generally abbreviated with a lowercase "b".

Broadband: A speed benchmark set and updated by the Federal Communications Commission. The benchmark was last updated in 2015 to define broadband as 25 Mbps download speeds and 3 Mbps upload speeds. "Broadband" is generally shorthand for high-quality internet service. Merit's position is that broadband for the modern household should be defined at 100 Mbps for both download and upload speeds — networks should be built with a "capacity planning" and future-proofing mindset.

Byte: The base unit for file storage, consisting of 8 **bits**. A 1 MB (megabyte, or 1 million bytes) file is made of 8 million bits. Bytes generally refer to the size of storage, whereas bits are used when discussing how rapidly files can be moved. Byte is generally abbreviated with a capital "B".

Cable modem system: Cable television companies have long offered internet access through their cable systems. The network architecture uses a loop that connects each subscriber in a given neighborhood, meaning they all share one big connection to the internet. Over time, needs have increased faster than capacity on these networks. Because the cable network shares the last-mile connection with hundreds of subscribers, a few bandwidth hogs can slow everyone's experience.

Cooperative (co-op): A member-owned organization that provides a service. Members pay a small fee to join and have voting rights within the organization.

CPE: Customer Premises Equipment, typically describing the box on the side of a house that receives and sends the signal from the network, connecting the subscriber.

Dark fiber: Unused fiber infrastructure that has not been "lit" with internet service. When someone is building a fiber network, the cost of adding more fiber than immediately required is negligible, and the cost of having to add more fiber later is high. Therefore, many include dark fiber in projects — fibers that can be leased to others or held in reserve for a future need. See also **lit fiber**.

Data center: A large group of networked computer servers typically used by organizations for the remote storage, processing or distribution of large amounts of data.

Digital equity: According to the National Digital Inclusion Alliance: "A condition in which all individuals and communities have the information technology capacity needed for full participation in our society, democracy and economy."

Digital inclusion: The actions required to achieve **digital equity**.

DOCSIS: Data Over Cable Service Interface Specification, a technical specification that allows modern cable networks to offer two-way data transmissions. Every few years, the standards are improved to offer higher speeds.

Drop: The connection from the mainline fiber to the individual residence or business. The drop can be buried underground or run aerially on utility poles. This is an example of a **last-mile** connection.

DSL: Digital Subscriber Line, or internet access offered over phone lines. DSL allows consumers to use the internet at speeds greater than dial-up while also using the phone line for telephone conversations. DSL uses frequencies not used by human voices. Unfortunately, these frequencies degrade quickly over distance, meaning customers must live within a mile or less to the central office to get the fastest speeds. Even then, upstream speeds tend to top out at 5 Mbps.

Duopoly: A situation in which two companies own all or nearly all of the market for a given type of product or service.

Easement: An easement is a legal right to use someone else's land for a particular purpose. Public and private utility easements may need to be sought before network construction.

Fiber optic: A system that uses glass or plastic to carry light used to transmit information. Typically, each side of the fiber is attached to a laser that sends the light signals. When the connection reaches capacity, the lasers may be upgraded to send much more information along the same strand of fiber. This technology has been used for decades and will remain the dominant method of transmitting information for the foreseeable future.

Fixed wireless: A connectivity model that uses stationary wireless technology to bridge the "last mile" between the internet backbone and the subscriber.

Franchise: Historically, a cable company wishing to provide television services in a community signed a franchise agreement with the municipal government. The agreement would specify what the community would receive from the cable company in return for access to rights of way (such as telephone poles). However, this arrangement has changed in many states, which have pre-empted local control. In Michigan, franchise agreements are standardized at the state level, such that local communities have no control over the terms of these agreements. For example, they cannot require providers to build service in rural areas in exchange for giving them access to dense areas.

FTTH: Fiber to the home. As most telecommunications networks use fiber in some part of it, FTTH is used to specify those that use fiber to connect the subscriber. FTTP (fiber to the premise) and FTTU (fiber to the user) are similar terms used somewhat interchangeably with FTTH to describe full fiber networks.

Gbps: Gigabits per second, or 1 billion bits per second, a measure of speed. 8 Gbps means that 8 billion bits are transferred each second. Using an 8 Gbps connection, it would take one second to transfer a 1 GB (gigabyte) file — a video file, for instance. 1 Kbps (Kilobits) is less than 1 Mbps (Megabits) is less than 1 Gbps. See also **Kbps** and **Mbps**.

Gig: Shorthand for 1 **Gbps** (1,000 Mbps) download speeds. More colloquially, a speed fast enough that any number of applications can use the network without creating congestion.

GPON: Gigabit Passive Optical Network. A passive optical network implements a point-to-multipoint architecture in which unpowered fiber-optic splitters are used to enable a single fiber to serve multiple endpoints. GPON is a standard for passive optical networks that is capable of delivering gigabit service to each endpoint and is commonly used to provide last-mile service to the home.

HFC: Hybrid fiber-coax — a network that combines some fiber-optic elements (typically from the head end to a node in the field) and coaxial cable (typically the loop that connects the node to subscribers).

I-Net: Short for institutional network, which is the network a municipal government requires to carry out its duties. I-Net frequently refers specifically to a network built for city uses (connecting schools, for instance) by the cable company as part of the franchise agreement with the city. Cities are increasingly seeing the value of owning their own network.

Internet of things/IoT: Reference to internet-connected devices — anything from laptops and smartphones to "smart" streetlights or thermostats.

Kbps: Kilobits per second, a measure of speed. For example, 8 Kbps means that 8,000 bits are transferred each second. Using an 8 Kbps connection, it would take 1 second to transfer a 1 KB (kilobyte) file — a text file, for instance. 1 Kbps is less than 1 Mbps (Megabits) is less than 1 Gbps (Gigabits). See also **Mbps** and **Gbps**.

Last mile: The final leg of a connection between a service provider and the customer.

Latency: The amount of time it takes for a bit to move from point A to point B. In the words of noted engineer Dr. Stuart Cheshire: "If you want to transfer a large file over your modem, it might take several seconds, or even minutes. The less data you send, the less time it takes, but there's a limit. No matter how small the amount of data, for any particular network device, there's always a minimum time that you can never beat. That's called the latency of the device."

Lit fiber: Fiber-optic infrastructure that is actively being used to provide internet service (through the use of light signals that transmit information). See also **dark fiber**.

Macrocell: A cell used to provide cell network coverage to a large area — compared to **small cells**, which cover a smaller area. Often mounted on towers.

Mainline fiber: The connection lines that come down streets, before the final link to each home.

Mbps: Megabits per second, a measure of speed. A speed of 8 Mbps means 8 million bits are transferred each second. Using an 8 Mbps connection, it would take 1 second to transfer a 1 MB (Megabyte) file — a photo, for instance. See also **Kbps** and **Gbps**.

MDU: Multiple-dwelling unit — most often apartment buildings. MDUs can offer a challenge when building an FTTH network because of the need to negotiate with building owners and because rewiring may be necessary to bring fast speeds to each unit.

Middle mile: The connection between the last mile and the greater internet. In a rural area, the middle mile would likely connect the town's network to a larger metropolitan area, where it interconnects with major service providers. While there are some technical differences between **backhaul** and middle mile, in practice they often refer to the same infrastructure.

MISS DIG: Michigan's utility safety notification system. This system tracks all buried utility lines and notifies utility owners when a locate request is made, so that those lines can be marked to avoid disruption by new construction. Any buried utilities in the public right of way must be registered with MISS DIG.

Municipal network: A broadband network owned by a local government. These networks take many forms, from modest networks serving a few businesses to networks available at every address across a community. Some are run by the municipality, and others are managed by an ISP under contract.

NATOA: The National Association of Telecommunications Officers and Advisers. NATOA comprises local government officials and employees who work on cable and broadband issues, from public- access television to managing the community's rights of way.

NTIA: National Telecommunications and Information Administration, a division of the U.S. Department of Commerce in Washington.

Open access: An arrangement in which the network is open to independent service providers. In many cases, the network owner only sells wholesale access to the service providers, who in turn offer retail services (internet, phone, TV). Open access encourages competition.

Passed: Residences or businesses that have access to the network. As an FTTH network is constructed, it will generally be built through a neighborhood before individual houses or businesses are connected through a drop cable, which is also a fiber-optic cable. When a house or business is "passed", it means it is eligible to sign up for services, which may still require a technician to hook up the drop cable.

Peering point: This is the point at which one backbone network connects to another. These connections are made according to agreements made by the administrators of the individual networks involved. Also called an exchange point.

Peer to peer: This is a type of network that allows computers to connect directly to each other rather than organizing them via hierarchical connections. This term is most often used to describe a type of file sharing that has greatly increased bandwidth use and allowed faster downloading of the same file from multiple computers. Surveillance of these networks is more difficult because traffic does not reliably pass through bottlenecks. Synonym: p2p

PoP: Point of presence, an access point that provides a connection from one location to the rest of the internet. Internet service providers have multiple PoPs within their networks.

PPP: A public-private partnership divides risks and responsibilities of an infrastructure project between public and private entities.

RUS: Rural Utilities Service, a branch of the U.S. Department of Agriculture. RUS offers loans and grants to entities deploying broadband in rural areas in addition to supporting other utilities in rural regions.

Satellite internet: Internet access provided by using communications satellites. Traditional communications satellites are launched into geosynchronous orbit at an altitude of 22,236 miles, which entails a high round-trip latency. New types of satellites in low-earth orbit may enable satellite internet connections with latency similar to terrestrial connections.

Small cell: Small cells provide wireless service through a connection to fiber-optic networks. These units are much smaller and exist closer to the user — often attached to telephone poles and light posts — than macro cells (cell towers). Small cells already exist in many cities to provide 4G service.

Symmetrical: Internet connections have two components: a downstream and an upstream. When the two speeds are comparable, the connection is termed symmetric. Fiber-optic networks offer symmetrical connections more readily than DSL and cable, which are inherently asymmetrical.

Take rate: The number of subscribers to a service, typically expressed in a percentage of those taking the service divided by the total number of people who could take the service. If a community fiber network passes 10,000 people and 6,000 people subscribe, it has a take rate of 60%. When planning the network, it will be built to be profitable at or above a certain take rate as defined in the business plan. Generally, networks require a few years to achieve take rates because of the long time it takes to connect each customer.

Telehealth/telemedicine: Health care initiatives supported by a broadband connection. Telehealth applications are especially reliant on high-capacity, low-latency service.

Underground infrastructure: Cable that is buried. Plowing or directional boring is usually used to place conduit into which the cables are then pulled. Cable can also be directly buried with no conduit. See also **aerial infrastructure**.