ctc technology & energy

engineering & business consulting

Fiber-to-the-Premises (FTTP) Implementation Plan

Prepared for City of Madison
September 2018

Columbia Telecommunications Corporation

10613 Concord Street • Kensington, MD 20895 • Tel: 301-933-1488 • Fax: 301-933-3340 • www.ctcnet.us

Contents

Figures

Tables

Executive Summary

In November 2015, the City of Madison's Common Council tasked the Digital Technology Committee (DTC) with determining feasibility of the City pursuing deployment of a citywide high-speed fiber-based broadband network. In December 2015, the DTC engaged CTC Technology & Energy (CTC) to prepare a fiber-to-the-premises (FTTP) feasibility analysis. The Common Council passed a resolution in 2016 to accept the resulting report and directed the DTC to develop an implementation plan for the fiber network.

This report provides that implementation plan. It was prepared in early 2018 by CTC with input from City staff as part of the City's ongoing effort to address the digital divide—or gaps related to broadband access, affordability, and digital skills—that may prevent the City's citizens from making the most effective, meaningful use of broadband. This report:

- Summarizes research findings about the potential benefits that may result from increased broadband competition, including benefits to low-income residents
- Summarizes the City's efforts thus far, to bring ubiquitous and equitable internet access to City residents
- Provides an overview of the City's request for proposals (RFP) for deployment of an FTTP network
- Discusses financial implications of constructing a ubiquitous FTTP network using information gained from the RFP process
- Outlines the City's potential next steps to implement an FTTP network

Based on information in this report, the DTC and Common Council may decide to proceed with the project as outlined in the RFP, pursue an alternative approach to bringing a high-speed fiber network to Madison, or defer the project.

1 Potential Benefits of a Citywide FTTP Network

Building an FTTP network would be a major financial and operational undertaking. Before discussing implementation plans, associated financing options, and potential revenue, it is worth considering potential qualitative benefits not found in financial statements.[1]

In the past several years, a broad consensus has emerged that robust broadband connections—along with access to computing devices and skills to use them—are a prerequisite for participating in the modern information economy. Competition in broadband markets frequently spurs incumbent providers to improve speeds and service offerings, and low-income groups may experience particularly significant benefits.

Four reports produced by different federal entities provide research findings relevant to this major policy question:

- "Community-Based Broadband Solutions: The Benefits of Competition and Choice for Community Development and High-Speed Internet Access,"[2] published January 2015 by the Executive Office of the President
- "The Digital Divide and the Economic Benefits of Broadband Access,"[3] a March 2016 issue brief produced by the President's Council of Economic Advisers (CEA)
- "National Broadband Research Agenda,"[4] published January 2017 by the National Telecommunications and Information Administration (NTIA) and the National Science Foundation
- "Closing the Digital Divide: A Framework for Meeting CRA [Community Reinvestment Act] Obligations,"[5] published July 2016 by the Federal Reserve Bank of Dallas

[1] CTC prepared a briefing for the City in early 2018 titled "Benefits of Broadband Competition in Terms of Service and Opportunities for Low-Income Communities," which addressed in detail the effects of municipal competition in broadband markets on services offered by providers and on low-income citizens who have access to these services.
[2] "Community-Based Broadband Solutions: The Benefits of Competition and Choice for Community Development and High-Speed Internet Access," The White House, President Barack Obama, January 2015, https://obamawhitehouse.archives.gov/sites/default/files/docs/community-based_broadband_report_by_executive_office_of_the_president.pdf (accessed July 2018).
[3] "The Digital Divide and Economic Benefits of Broadband Access," Issue Brief, Council of Economic Advisers, March 2016, https://obamawhitehouse.archives.gov/sites/default/files/page/files/20160308_broadband_cea_issue_brief.pdf (accessed March 2018).
[4] "National Broadband Research Agenda," U.S. Department of Commerce, National Science Foundation & National Telecommunications and Information Administration, January 2017, https://www.ntia.doc.gov/files/ntia/publications/nationalbroadbandresearchagenda-jan2017.pdf (accessed July 2018).
[5] Federal Reserve Bank of Dallas. "Closing the Digital Divide: A Framework for Meeting CRA Obligations." https://www.dallasfed.org/assets/documents/cd/pubs/digitaldivide.pdf, (accessed July 26, 2018).

These reports address three concerns of the City.

1. **Competition has powerful effects.** As the White House report on community broadband noted: "While increased competition will not necessarily solve all broadband access challenges, basic economics suggest increased competition leads to a better deal for consumers." It pointed to the example of the municipal network in Chattanooga, Tennessee (built by the city utility, called EPB). "EPB's efforts have encouraged other telecom firms to improve their own service. In 2008, for example, Comcast responded to the threat of EPB's entrance into the market by investing $15 million in the area to launch the Xfinity service – offering the service in Chattanooga before it was available in Atlanta, GA. More recently, Comcast has started offering low-cost introductory offers and gift cards to consumers to incentivize service switching. Despite these improvements, on an equivalent service basis, EPB's costs remain significantly lower."

2. **Competition does not just improve service, but also may *lead to greater adoption*.** The CEA report found that even after controlling for potentially relevant demographic variables such as income, age, race, education, and population density, there exists "a statistically significant relationship between the number of wireline choices and the share of households using internet at home. This result suggests that as the number of wireline choices increase, so too does the probability of internet use."[6] This is good news for low-income families given that just under half of households in the bottom income quintile use the internet at home, compared to 95 percent of households in the top quintile at the time the report was produced. Given these numbers, any forces that increase residential broadband adoption will disproportionately benefit low-income households.

3. **"Digital inclusion represents economic inclusion."** [7] Banking and many other basic services are now more conveniently available online than in physical spaces. While residential broadband is merely a tool that must be used properly to be helpful, internet access may lead to improved participation in labor markets. In fact, most job listings are now found online, and some research shows a correlation—and perhaps causation—between residential broadband access and shorter stints of unemployment. The CEA report states, "The basic relationship—where those households who use the internet exhibit better employment outcomes—remains even after controlling for a number of

[6] "The Digital Divide and Economic Benefits of Broadband Access," Issue Brief, Council of Economic Advisers, March 2016, https://obamawhitehouse.archives.gov/sites/default/files/page/files/20160308_broadband_cea_issue_brief.pdf (accessed March 2018).

[7] "Closing the Digital Divide: A Framework for Meeting CRA Obligations," https://www.dallasfed.org/assets/documents/cd/pubs/digitaldivide.pdf, (accessed July 2018).

> demographic variables such as age, education, race, and family income, as well as the number of weeks that the individuals were previously unemployed." It also cites other research suggesting that "at least part of these correlations may be causal relationships."

A more robust market environment may lead to competitive pricing benefiting low-income consumers. When competition is present, some private companies tend to become more motivated to offer lower-cost digital inclusion products and actively participate in the Federal Communications Commission's (FCC) Lifeline program, which offers broadband subsidies to low-income Americans.[8]

We recognize the research community lacks access to a great deal of important primary data relevant to fully understanding the interplay between broadband, competition in broadband markets, and various measures of productivity and community well-being. The FCC does not comprehensively collect data on broadband availability by address, adoption by address, or speeds available by address. The FCC also collects and releases very little data on broadband prices. Without complete data, it will remain difficult to fully understand precise connections between broadband access, prices, and benefits to low-income residents. See Appendix A for more information on available FCC data regarding broadband adoption in Madison.

1.1 Aiding Small and Medium-Sized Businesses

Many markets lack high-end broadband services for small and medium-sized businesses. While larger businesses and institutions may be relatively well-served by incumbents and competitive providers already present in the market, small and medium-sized businesses outside major fiber corridors are not as lucky.

Home-based businesses and teleworkers may also experience gaps when consumer-based broadband connections from phone and cable companies that currently offer service in Madison periodically prove unreliable or slow. Such gaps represent a real problem in the City and present a business opportunity for private sector retail service providers competing on service quality.

Robust internet connections provide entrepreneurs, freelancers, and small-business owners with a variety of tools allowing them to more effectively compete. A growing number of U.S. workers can do much of their work from wherever they find a robust internet connection. While a basic broadband connection is sufficient for certain tasks, gigabit speeds enable richer collaboration tools, such as higher-resolution telepresence applications.[9] As bandwidth-hungry collaboration

[8] See Appendix C and Appendix D for case studies about the impact of competition on the marketplace, and the potential benefits of increased broadband availability to low-income communities.

[9] "Killer Apps in the Gigabit Age," Pew Research Center, October 9, 2014, http://www.pewinternet.org/2014/10/09/killer-apps-in-the-gigabit-age/ (accessed November 2017).

tools continue to improve, the physical location of people becomes less important.[10] Many entrepreneurs with a desire to create new services based on high-capacity connections moved to the first few cities with gigabit service—often called Gig cities—to build and test their products.[11] And there are a number of emerging fields, such as virtual reality and precise 3D modeling, that are entirely dependent on extremely high-speed and low-latency connections made possible by fiber.

[10] According to the New Jersey Institute of Technology, 45 percent of U.S. employees already work from home at least part of the time. *See:* http://betanews.com/2015/09/11/the-rise-of-telecommuting-45-percent-of-us-employees-work-from-home/ (accessed November 2017).

[11] "Innovation Districts Report," National League of Cities, https://www.nlc.org/Documents/Find%20City%20Solutions/City-Solutions-and-Applied-Research/Innovation%20Districts%20Report.pdf (accessed May 2018).
Megan Bannister, "Three Years After Announcement, Kansas City is Still Figuring Out Fiber," Silicon Prairies News, http://siliconprairienews.com/2014/04/three-years-after-announcement-kansas-city-is-still-figuring-out-fiber/ (accessed May 2018).

2 Madison's Efforts at Achieving its Broadband Goals

The City has taken several steps toward achieving its broadband goals: It commissioned a digital divide pilot program, commissioned an FTTP feasibility study, and issued an RFP seeking partners for an FTTP deployment.

2.1 Digital Divide Pilot Program

In October 2015, the City awarded a contract to ResTech Services, LLC (ResTech) for a two-year pilot program aimed at addressing the digital divide by bringing broadband service to residential customers in four low-income areas in the City.[12] This program, "Connecting Madison," was designed to serve customers in multi-dwelling unit (MDU) buildings ranging from two to more than 100 units. The pilot was an effort to connect residents who may have never had access to broadband service—either because no service was available in their areas, or because they could not afford it. The pilot was also intended to provide the City with real-world data that could inform future broadband deployment efforts.

The City terminated the contract with ResTech in January 2018. At that time, the pilot network had only 19 active customers. Despite the low adoption rate, the pilot project gave the City valuable insight into the challenges of both deploying broadband and encouraging adoption. In particular, the City learned that the MDU broadband market is difficult to enter and that the availability of a high-speed service by itself is not enough to drive adoption. The pilot project and lessons learned are discussed further in Appendix B.

2.2 FTTP Feasibility Study

In late 2015, the City hired CTC to research and prepare an FTTP feasibility analysis. CTC developed a high-level network design and projected the potential costs and benefits associated with deploying a ubiquitous FTTP network throughout Madison. The CTC cost estimates and financial analysis used a range of assumptions to illustrate various FTTP deployment scenarios. This feasibility analysis helped the City define goals for a fiber-based broadband network:

- *Racial equity:* Align the network with the City's Racial Equity and Social Justice (RESJ) Initiative[13] and digital divide goals
- *Ubiquity:* Deploy the network across the entire City
- *Competition in the marketplace:* Enable competition among multiple providers

[12] "City of Madison - File #40237," *City of Madison* https://madison.legistar.com/LegislationDetail.aspx?ID=2473855&GUID=356DEBE5-18B0-44BC-835A-381CCED09BFE (accessed April 2018).
[13] "Racial Equity & Social Justice Initiative," City of Madison, https://www.cityofmadison.com/mayor/programs/racial-equity-social-justice-initiative (accessed July 2018).

- *Consumer choice:* Enable citizens to purchase service from different providers
- *Control:* Ensure the City's long-term stake in the fiber asset

The feasibility analysis recommended a "shared investment and risk" model in which the City and a private partner(s) find creative ways to share the capital, operating, and maintenance costs of a broadband network.

In this "Dark FTTP Partnership" model,[14] the City would deploy citywide fiber infrastructure for lease to one or more private partners.[15] This infrastructure would include a fiber backbone spanning all major parts of the City, and distribution fiber that would be built past (but would not connect to) every home and business in Madison. A private partner would be responsible for constructing fiber drop cables that physically connect distribution fiber to each customer's premises and for providing network electronics and customer premises equipment (CPE) to "light" the network and deliver retail broadband services. Because this model is based on the type of agreement first established between Huntsville (Alabama) Utilities and its private partner, Google Fiber, we refer to this as the Huntsville Model.

2.2.1 Network Cost Estimates

The feasibility study estimated that the City's portion of the capital costs required to build the network would be approximately $150 million, spread over three to five years. This estimate is based on a high-level FTTP network design that would meet the City's goals and support 1 gigabit per second (Gbps) data service. The estimate further assumes the network would be constructed entirely underground for reliability reasons and that it would leverage existing City fiber and conduit assets to reduce construction costs. CTC engineers created sample designs for the distribution portion of the FTTP network (connecting the backbone to customer premises) in representative areas of the City to estimate costs for the rest of the network.

2.2.2 The Metropolitan Unified Fiber Network (MUFN)

The Metropolitan Unified Fiber Network (MUFN)[16] provides an important starting point and would significantly reduce the cost and complexity of deploying an FTTP network. Existing fiber and conduit extend to all areas of the City, providing a way to connect distribution hubs back to the network backbone. MUFN could also provide space for network core and distribution

[14] "Dark" fiber refers to fiber that has been installed and is ready to be operated but is not yet "lit" by network electronics.

[15] See Appendix F for more information about open access and competition.

[16] Per the MUFN website: "MUFN is a collaborative metro fiber-optic network serving education, health, government, Non-Profit-Organization anchor institutions in the Madison, Middleton, and Monona, WI area. It unifies and augments existing telecom resources to facilitate enhanced internet, point-to-point connectivity, and application sharing. This effort improves broadband access, economic development, public safety, education, and community support programs." (Accessed August 2018.)

electronics at existing City facilities, as well as provide access to multiple internet points of presence (PoPs) for connectivity to the internet. We estimate that leveraging MUFN may reduce the total cost of outside plant (OSP) construction by approximately 10 percent,[17] as reflected in our projections. A map of MUFN, illustrating its suitability as a backbone network, is shown in Appendix E.

2.2.3 Aerial and Underground Construction Costs

CTC estimated that building the network with a combination of aerial and underground construction would cost approximately $144 million (see Table 1, below). Where available, aerial installation can reduce costs of fiber construction but comes with the tradeoff of exposing fiber to more potential hazards. Weather, traffic, wildlife, and other hazards can break aerial fiber, causing outages and requiring emergency repair. Variables such as pole attachment fees, pole replacements, and make-ready costs (the cost of preparing utility poles for new attachments) can significantly increase the total cost of aerial construction.

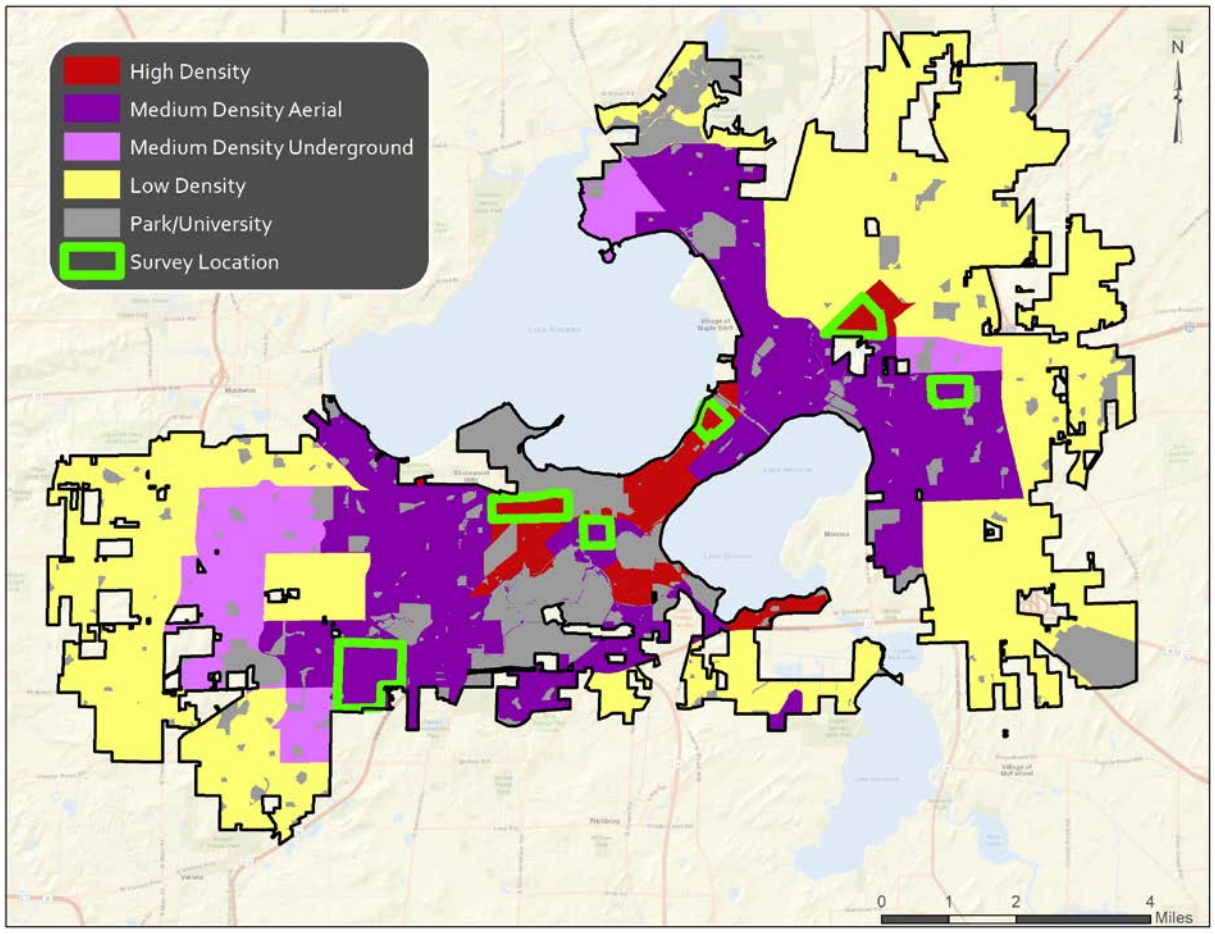
Table 1: Projected Cost Estimates Summary

FTTP Cost Estimates	
	Dark FTTP (No Electronics, Service Drops, or CPE)
Aerial & Underground Construction	$144 million
All Underground Construction	$150 million

Approximately 38 percent of the network could be constructed aerially. Figure 1 shows areas surveyed by CTC. Aerial infrastructure is available for approximately 70 percent of the network in areas closer to the City center (shown in red and dark purple), with almost no aerial infrastructure available in areas further from the City center (shown in light purple and yellow).

[17] While MUFN reduces the need for new backbone fiber, the distribution fiber that passes every home and business in Madison represents a much larger percentage of the total construction and cost.

Figure 1: Map of Field Survey Areas



2.3 Request for Proposals

After the conclusion of the feasibility study, the City opted to initiate a request for proposals (RFP) to gauge the interest of potential private partners to work with the City to bring ubiquitous broadband to Madison. The RFP was issued in August 2017 (responses were due in late October) and specified the City's goals and preferred business model for the network. (The RFP process is discussed in Section 3, below.)

3 The City's Request for Proposals: Process and Outcomes

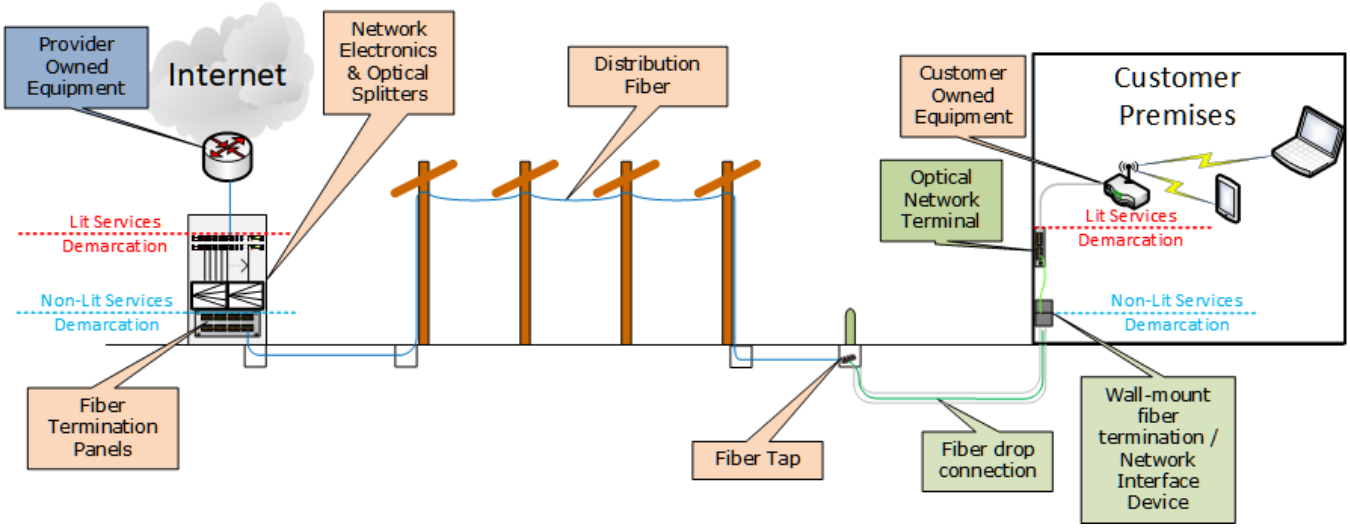
On August 30, 2017, the City issued an RFP for a partnership to bring gigabit-class broadband to the entire City of Madison. The RFP explicitly stated certain goals the City sought to achieve through a partnership and requested detailed information on how each respondent would help the City meet those goals.

3.1 The City Required a Shared-Risk Business Model

The City opted to require a shared-risk business model like the agreement between Huntsville Utilities and Google Fiber. In this agreement, Huntsville Utilities will construct and maintain ubiquitous FTTP infrastructure that passes every residence and business and will lease the fiber backbone and distribution fiber to a private partner that will construct the service drop cable into each subscriber's home or business. This demarcation is illustrated in Figure 2.

The private partner in this type of partnership is also responsible for all network electronics and CPE—as well as network sales, marketing, and operations. Because the service drop cable that connects the customer's premises to the overall network is funded by the private partner, fiber lease payments to the City under this model are based on the number of connected passings in the network.

Figure 2: Demarcation Between Madison and Partner Network Elements (Huntsville Model)



3.2 The RFP Presented Clear City Goals and Objectives

The purpose of the City's RFP was to seek a long-term, creative partnership that would meet the City's current connectivity needs and anticipate potential future needs for fast, affordable broadband services. As noted above, proposals assume a City-owned and -operated fiber infrastructure that would pass every home, business, and anchor institution.

The City specified its preferred business model was one similar to the Huntsville Model in which the City would construct and own the dark FTTP infrastructure. The City's partner would lease this infrastructure, install necessary network electronics and fiber drop cables, and provide lit services over the network. The City also allowed respondents to propose alternative business models.

The RFP outlined the following principles guiding the City's initiative:

1. **Equity:** Make fast, affordable broadband connectivity available to every resident and business in Madison with priority on providing service to traditionally underserved populations

2. **Jobs, Innovation, Growth:** Invest in new infrastructure to encourage increased local employment and provide economic development advantages for the entire City

3. **Investing in the Future:** Offer affordable choices with stable rates for high-quality connectivity at speeds faster than currently available broadband services, with the aim of sustaining and continuing to grow educational, economic and cultural opportunities

4. **Furthering the City's Racial Equity & Social Justice (RESJ) Objectives:** Provide all residents with truly equitable and affordable access to service—regardless of race, ethnicity, gender, sexual orientation, disability, age, income, place of birth, place of residence, or other group status

5. **Promoting a Competitive Local Broadband Marketplace:** Facilitate a local broadband marketplace as competitive as reasonably possible

6. **Supporting Unfettered Access:** Provide internet service that does not impose caps or usage limits on one use of data over another

RESJ objectives are among the City's key priorities. The RFP required respondents to provide service throughout the City with no selective targeting, so all members of the community have access to robust, affordable broadband service. A partner cannot build only to the most affluent areas of the community where there is a higher likelihood of obtaining subscribers willing to pay for service (and, thus, a quicker return on capital investment).

The City also asked respondents to be willing to work with the City to develop creative solutions for supporting all members of the community with equitable services. For the network to have the intended economic and quality-of-life impacts, the City considers both cost and availability of service to be important.

3.3 The City's "Short List" of Potential Partners

The City received four responses to the RFP prior to the October 20, 2017, deadline. Proposals were submitted in two separate parts—one that addressed the respondent's proposed business plan and the other that included pricing information. City procurement rules required the RFP evaluation committee to evaluate the business plan proposals before reviewing the financial details; during the response review process, evaluation of the pricing proposals was conducted by separate CTC staff members who did not exchange information with members of the evaluation committee until after initial evaluations were complete. At that time, CTC presented an overview of the pricing proposals to the committee.

Each proposal was evaluated by the RFP evaluation committee based on the proposal's compliance with the RFP requirements and how well the proposed partnership model fit with the City's stated objectives.

To guide the review process, CTC created an evaluation matrix assigning numeric scores to elements outlined in the RFP to establish the validity of each response. The evaluation matrix was designed to quantify strengths and weaknesses, and drive discussion between the City and CTC, and aid in a side-by-side comparison of respondents. Each area was assigned a maximum number of points based on its relative importance to the overall response:

1. Adherence to high level project goals
2. Adherence to market goals
3. Furtherance of the City's RESJ objectives
4. Market experience
5. Proposal structure
6. Proposed Business model
7. Respondent's experience and track record
8. Respondent's local presence
9. References
10. Schedule and timeline for completing project
11. Technical experience

CTC also summarized each proposal and presented synopses to City staff, to ensure all reviewers had a shared understanding of each respondent's proposed business model.

The RFP evaluation committee members reviewed each proposal and assigned a preliminary score based on the evaluation matrix. One response was deemed incompatible with the City's goals and requirements, and that respondent was eliminated from consideration.

The RFP evaluation committee then held interviews with the three remaining respondents to discuss their proposals in detail. Incorporating the information gained during the interviews, the committee scored each qualifying response based on the requirements in the RFP.

Through this process, the RFP evaluation committee narrowed its search to two respondents that committee members believed were well positioned to execute a successful FTTP program in Madison. The committee then selected a lead respondent based on its proposal score. Due to legal requirements of the RFP process, the identity of respondents cannot be revealed until a proposal has been officially rewarded.

4 Financial Implications of Building the FTTP Network

This section examines the financial implications of the City constructing a ubiquitous FTTP network infrastructure to every residence and business and leasing the backbone and distribution fiber to a private partner. Our analysis includes a 20-year projection covering the potential lifetime of fiber assets and extends beyond the project's initial "ramping up" phase. This financial analysis assumes that the City will:

- Deploy network assets over the course of four years for a total of $150 million;
- Pursue bond financing totaling $173.2 million to cover the deployment and necessary startup capital;
- Charge the partner a $20 monthly per-customer fee; and
- Assess a monthly special assessment of $15.33 through year 16 on every location the network infrastructure passes.[18]

4.1 The City Will Need to Pursue Two Bonds Totaling $173.2 Million to Construct and Operate the Network

To cover the $150 million in construction expenses and additional startup capital necessary in the initial years of the network, the City will need to pursue **two separate 20-year general obligation (GO) bonds, totaling $173.2 million, or some other revenue funding strategy**.[19] The amount of each bond must be determined at the outset of the bonding process. GO bonds are directly tied to the City's credit rating and ability to tax its citizens. This type of bond is not tied to revenue from any specific project but is connected instead to communitywide taxes and revenues that can be used to repay this debt.

Both bonds will affect the City's bonding capacity, and the City is ultimately responsible for payment in full. The key difference between the two GO bonds the City will need to pursue is the source of the funds the City will use to make debt service payments on them:

- **Bond A** is a $52 million GO bond borrowed at 6 percent interest with a debt service coverage ratio (DSCR) of 1.0.[20] The City will charge the partner $20 per subscriber per month, which will be applied to the debt service payments on this bond. The City will be responsible for the entirety of these payments, independent of the total amount paid by

[18] The special assessment will be discontinued once the GO bond that requires a special monthly assessment, which we refer to here as "Bond B," has been repaid.

[19] The City and CTC conferred with Springsted, the City's financial consultants, regarding terms the City might be able to obtain for bonds; these assumptions are applied to the financial model.

[20] The debt service coverage ratio is operating income divided by total debt service. A DSCR of 1.0 is considered "breakeven," or indicates that there is enough cash flow to service the debt—or make the principal and interest payments.

the partner. That means that even if the partner is unable to secure enough subscribers at a monthly $20 per subscriber fee to cover the cost to service the bond, the City will be responsible for any shortfall. Our model assumes this bond will be repaid by the end of year 20.

- **Bond B** is a GO bond in the amount of $121.2 million at 8 percent interest with a DSCR of 1.4.[21] The City will use income generated by a monthly special assessment of $15.33 assessed on each household and business passed by the network infrastructure to make debt service payments on this bond. Our model assumes that the assessment will be collected at the same rate that the network is deployed.[22] Further, we assume that this bond will be repaid by the end of year 16, due to the City's requirements for repayment on financing secured by special assessment.

On both bonds, we project bond issuance costs will be equal to 1 percent of the principal borrowed. We assume a 10 percent debt service reserve will need to be maintained for the lifetime of each bond.

Table 2: Comparison of Bond Attributes

	Principal	Rate	DSCR	Issuance Costs	Debt Service Reserve	Source of Funds
Bond A	$52 million	6%	1.0	1% of principal	10%	Per-subscriber fee from partner
Bond B	$121.2 million	8%	1.4	1% of principal	10%	Special assessment on all network passings

4.2 Take-Rate Will Drive Partner Payments to the City and Influence the Amounts the City Will Need to Borrow

The partner will pay the City a monthly per-subscriber fee of $20 to use the City's network, which we anticipate the City will apply to its debt service payments on Bond A. In this analysis, we estimate that the partner will be able to obtain and maintain a 30 percent take-rate. In other words, 30 percent of the potential customers passed by the network infrastructure will subscribe to the partner's service. This monthly per-subscriber fee would generate roughly $7.08 million annually by the end of year five. A portion of this would be used to pay debt service on Bond A.[23]

[21] Our model used DSCR of 1.4 in this model based on guidance from Springsted, the City's financial consultants.
[22] Our financial analysis assumes the City will deploy infrastructure to 22.5 percent of the total potential passings by the end of year two, 57.5 percent by the end of year three, 85 percent by the end of year four, and 100 percent by the end of year five. This means that the 22.5 percent of the total potential amount of the special assessment will be collected in year two, 57.5 percent will be collected in year three, etc.
[23] The City will use this income to cover both its operating and maintenance expenses (roughly $2.07 million annually) and debt service payments.

If the partner could obtain and maintain a higher take-rate, and thus pay the City additional monthly per-subscriber fees, the City would be able to increase the total amount pursued for Bond A and reduce the amount pursued for Bond B. As an example, if the partner obtained a 40 percent take-rate, the City could pursue a total of $84.61 million for Bond A, and $88.59 million for Bond B. A take-rate of 40 percent is less likely in a market like the City's, where multiple voice, video, and data providers already have captured significant portions of the market.

4.3 A Special Assessment May Present Challenges to the City

CTC and the City discussed several options for raising necessary project funds. We assume the City will use a special assessment to raise funds for this project, however, a special assessment may present some challenges.

A special assessment is usually done in small areas of the City, generally covering only two or three blocks. The City has never issued a special assessment for a citywide project. City staff estimate that the City would need to create ten to 20 assessment areas matching construction phases, because assessments can only be performed after an improvement has been made to homes and businesses in the area. A special assessment of this scale would also require the commitment of significant administration staff time and costs, which would stretch current staffing resources.

A citywide special assessment may also prove challenging because the assessment would be applied to all households and businesses passed by the network regardless of whether they acquire service. The impact of such an assessment should be considered alongside costs of service to subscribers. In addition, the City would need to show the value provided by the project to each household and business assessed. The assessment would require a public hearing and public notice and may require a referendum because bonds would be issued. Finally, the determination of when the City will begin to collect the special assessment (i.e., once construction has begun in the neighborhood, once fiber is deployed immediately in front of the household, or once assets pass every household in the area) will complicate the matter.

Alternatives to a special assessment may include funding raised through property tax increases or other fees assessed by the City. The committee also considered applying for grants to fund construction of the network, but recent changes in the political climate and current FCC leadership have made the availability of such grants less likely.

4.4 Although the City's Net Income Would Vary Annually, the City Would Finish Year 20 With a Cash Surplus of $27.74 Million if the Partner Take-Rate was 30 Percent

Table 3 provides a financial summary for this base case model, using assumptions above with a 30 percent take-rate.

Table 3: FTTP Network Financial Summary Using a 30 Percent Take-Rate

Income Statement	Year 1	Year 5	Year 10	Year 15	Year 20
Per-Customer Fee	$-	$7,084,320	$7,084,320	$7,084,320	$7,084,320
Special Assessment	-	18,099,640	18,099,640	18,099,640	-
Total Cash Expenses	(626,930)	(2,068,620)	(2,068,620)	(2,068,620)	(2,068,620)
Depreciation	(1,528,600)	(7,494,600)	(7,494,600)	(7,494,600)	(7,494,600)
Interest Expense	(3,120,000)	(12,478,440)	(8,487,750)	(2,415,210)	(257,740)
Taxes	-	-	-	-	-
Net Income	$(5,275,530)	$3,142,300	$7,132,990	$13,205,530	$(2,736,640)
Cash Flow Statement	**Year 1**	**Year 5**	**Year 10**	**Year 15**	**Year 20**
Unrestricted Cash Balance	$12,522,070	$6,188,960	$6,364,410	$16,157,770	$27,739,340
Depreciation Reserve	-	119,920	226,720	333,520	440,320
Interest Reserve	-	-	-	-	-
Debt Service Reserve	5,200,000	17,320,000	17,320,000	17,320,000	5,200,000
Total Cash Balance	$17,722,070	$23,628,880	$23,911,130	$33,811,290	$33,379,660

As shown, the City's net income will be negative in year one, but by year five, the income from per-customer and special assessment fees will generate a net income of $3.14 million. The City's net income will remain positive through year 16, at which point net income would turn negative because the special assessment will be discontinued. That is, the City would stop its monthly $15.33 assessment on each household and business passed by the network infrastructure.

This model will operate cash-positive, generating a cumulative unrestricted cash balance (or cash surplus) of $12.52 million by the end of year one. This total surplus will vary annually, totaling roughly $6 million in years five through 10, and growing to $16.16 million by the end of year 15, and $27.74 million by the end of year 20.

5 Options for Implementation

There are four potential paths the Mayor and Common Council could take upon reviewing this implementation plan:

5.1 Proceed with a Public-Private Partnership as Outlined In the RFP

The Common Council could approve moving forward with the proposal submitted by the preferred respondent. In this scenario, the City would need to complete a public hearing process before executing a contract with the vendor and deploying the FTTP network. The City would also need to define details of its plan to finance the FTTP deployment.

This scenario would require negotiations with the City's private partner to finalize terms of the agreement between the two parties. This would include fees paid by the partner to the City for use of the City-built network, a construction schedule including prioritization of areas to be built, and the partner's participation in the City's RESJ initiatives. To see its RESJ goals addressed in a meaningful way, it is critical that the City establish concrete objectives and requirements during negotiations with the private partner. These objectives and requirements should be an enforceable component of the agreement between the City and its preferred respondent, with clearly stated responsibilities, metrics, and milestones.

5.2 Engage in a Targeted FTTP Build

The City could enter discussions with the preferred respondent to develop a variation of the proposed model, an approach in which the City would first build fiber infrastructure only to selected areas, then expand the network over time. As in the ubiquitous fiber model, the City would be responsible for constructing a fiber network that would pass each home and business in the designated build areas, while the private partner would be responsible for building service drops and providing service over the network. However, in this targeted FTTP model, only certain areas of the City would receive service.

A targeted FTTP build involves building in certain neighborhoods, generally those where the market will provide an adequate return on investment or where the City steps in to subsidize construction. A fully ubiquitous buildout is not guaranteed or even likely in such an approach; rather than attempting to provide universal service throughout Madison, a targeted FTTP build focuses on filling gaps in service availability.

This business model may allow the City to mitigate some risks of a ubiquitous FTTP deployment while still meeting some of the City's goals. Although the City would have some influence over which areas are deployed, this approach would not ensure a ubiquitous availability of FTTP nor would it ensure low-income and underserved neighborhoods receive service.

A targeted build requires the City to identify areas of higher priority, such as low-income neighborhoods or other underserved areas, and negotiate with the private partner to prioritize these areas. The private partner would likely prioritize areas of the City where it would see greatest profit margins, which would likely conflict with the City's priorities. As the fiber network in this scenario would not pass all residences and businesses in Madison at first, these negotiations would be critical in determining the City's success in meeting its RESJ goals.

With a smaller available market, the provider may be less willing to take on financial risk of building to lower-income customers. As the City learned during its Connecting Madison Pilot Project (see Appendix B), the mere availability of affordable, high-speed internet service does not guarantee that a significant number of households will subscribe. The City would need to find ways to incent the partner to build to neighborhoods by mitigating these risks. For example, the City may increase its share of the financial burden in some areas by requiring reduced fees from the partner or by funding construction of drop cables in these areas. The City may also require that a certain proportion of new fiber construction each year be within prioritized areas.

In discussions with the City's preferred respondent, CTC learned that the respondent has an interest in exploring a targeted build scenario. However, these discussions were preliminary and did not define details necessary to predict potential costs.

5.3 Lease Backbone Fiber to Interested Providers

The City could enter discussions with various providers (potentially including entities that did not respond to the City's RFP) about a "middle-mile" approach, in which providers lease strands on the City's backbone fiber infrastructure and MUFN and invest in the FTTP distribution fiber themselves. This approach may be as simple as developing dark fiber lease rates and managing ongoing customer relationships with one or more providers. This would greatly reduce the City's risk and its required investment.

The partner, in this case, would bear most of the costs and responsibilities it would have if entering the market alone, but would have the advantage of the fiber footprint provided by MUFN. Under this model, the City would see advantages of another competitor entering the Madison market, but the City would have no influence on which neighborhoods receive service, nor when.

CTC had informal discussions with three potential providers that have shown an interest in this approach. These providers prefer not to be named at this time, but none currently have a local presence in Madison. One provider was a respondent to the City's RFP, another is based in the Midwest, and a third is based in Europe. This does not represent a complete list of providers that

may be interested in this approach, but it does indicate a potential for the City to incent new providers without making a significant investment in network infrastructure.

This approach also has the potential to enable non-traditional ISPs, such as nonprofits and community cooperative groups, to offer services in Madison. It may further be appropriate for the City to consider leasing its infrastructure not only to traditional service providers, but also to other competent organizations that are willing (and provide proof of capability) to offer service.

This will potentially allow even nontraditional groups like homeowner or neighborhood associations and other similar collections of citizens to be active participants in solving their connectivity challenges. While this is a new concept, the technology and business models to support it are being explored and executed worldwide. While such community-based service providers have their limits, anecdotal evidence suggest that with adequate demand, they can successfully serve niche market segments which remain underserved by larger providers.

5.4 Defer Action

The DTC and the Common Council may decide not to move forward with either the FTTP implementation plan or the fiber lease plan at this time and could opt to put these plans on hold for a later review.

Appendix A: Broadband Adoption in Madison

Twice a year, internet service providers (ISP) nationwide submit data to the Federal Communications Commission (FCC) via Form 477, reporting where their wireline broadband services are available and the percentage of households subscribing to their services. This information is aggregated by the FCC and released to the public roughly one year after collection. The data illustrate the percentage of homes with minimum internet speeds within a given census tract.

Census tracts are defined by geographical boundaries (rather than population) and can contain from 1,200 to 8,000 people.[24] Thus, it is impossible to obtain from Form 477 data, a definitive number of households that are internet subscribers. Rather, the most recent available data (from June 30, 2016) show the percentage of households receiving a service of at least 200 Kbps one-way, and at least 10 Mbps/1 Mbps (downstream/upstream) within 75 census tracts in the City.

Table 4 provides a breakdown of Madison's subscription rates by census tracts.[25]

Table 4: Broadband Subscription Rates by Census Tract in Madison in 2016

Percent of Households	Census Tracts with at Least 200 Kbps (One Way)	Census Tracts with at Least 10 Mbps Downstream/1 Mbps Upstream
0	1	1
1 to 20 percent	1	1
21 to 40 percent	1	2
41 to 60 percent	4	6
61 to 80 percent	13	40
81 + percent	55	25

The majority of census tracts have a subscription rate of 80 percent or above for 200 Kbps service, and a 60 to 80 percent subscription rate for 10 Mbps/1 Mbps service. While these adoption rates are slightly higher than the nationwide average,[26] neither of these speeds meet the current FCC definition of broadband, which is 25 Mbps/3 Mbps.[27] It is important to note that the data provided to the FCC is self-reported, and if even one passing in a census tract receives or is eligible to receive a service, that tract is considered "served." That is, if one household in a census tract

[24] "Geographic Terms and Concepts – Census Tract," United States Census Bureau: https://www.census.gov/geo/reference/gtc/gtc_ct.html (accessed April 2018).
[25] "Residential Fixed Internet Access Service Connections per 1000 Households by Census Tract," Federal Communications Commission: https://www.fcc.gov/maps/residential-fixed-internet-access-service-connections-per-1000-households-by-census-tract/ (accessed April 2018).
[26] "Internet Access Services Reports," Federal Communications Commission: https://www.fcc.gov/file/12343/download (accessed April 2018).
[27] "2015 Broadband Progress Report," Federal Communications Commission: https://www.fcc.gov/reports-research/reports/broadband-progress-reports/2015-broadband-progress-report (accessed April 2018).

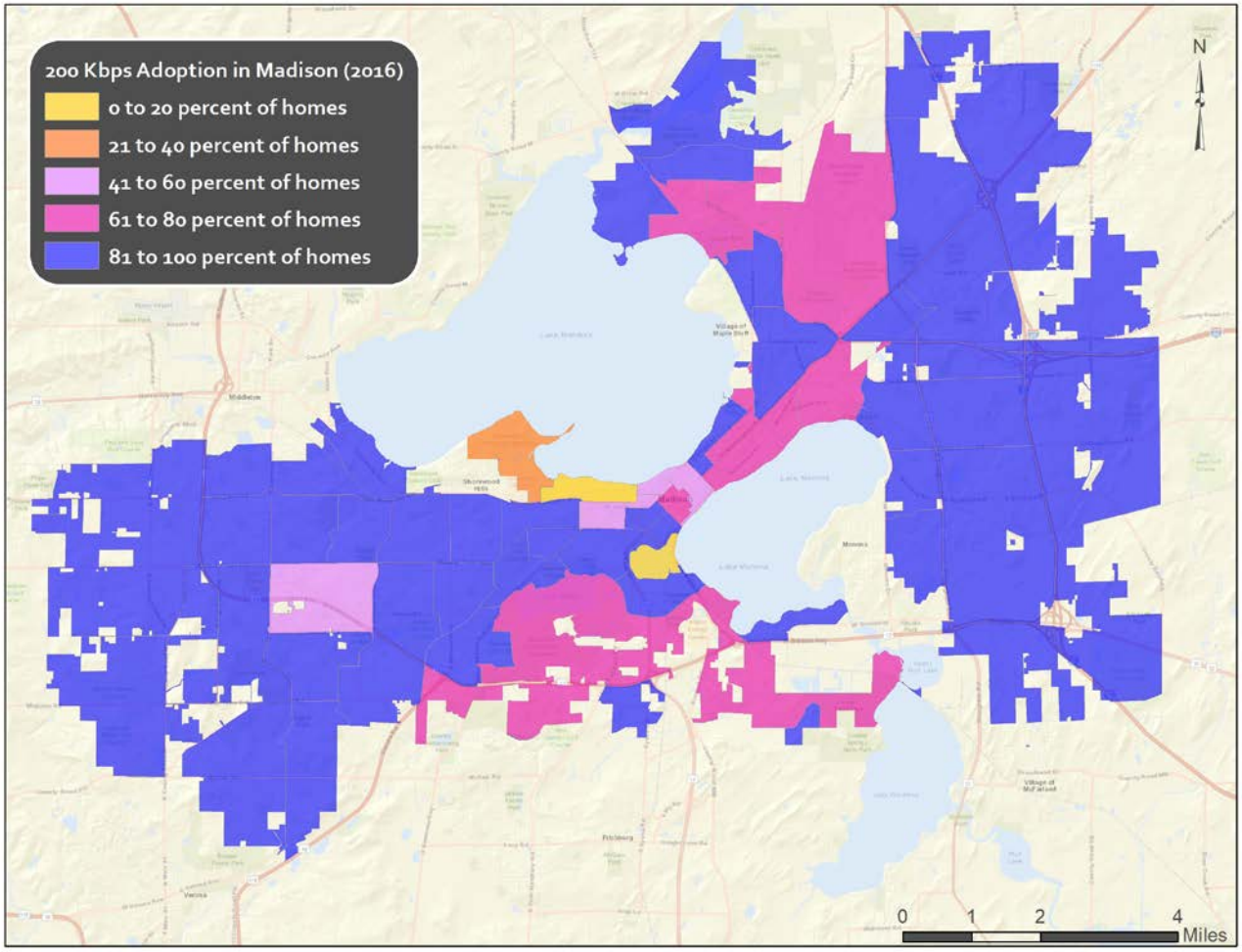
has access to a service that is capable of providing speeds of 25 Mbps upload and 3 Mbps download, the entire census tract is considered served.

Figure 3 shows 200 Kbps adoption rates by census tract. Figure 4 shows 10 Mbps/1 Mbps adoption rates by census tract. Figure 5 shows yearly household income by census tract, with dark purple representing higher average household income.[28] This map illustrates a correlation between average household income and broadband adoption in Madison—particularly at speeds over 10 Mbps/1 Mbps.

The data shows areas of the City with lower household income also have lower broadband subscription rates.

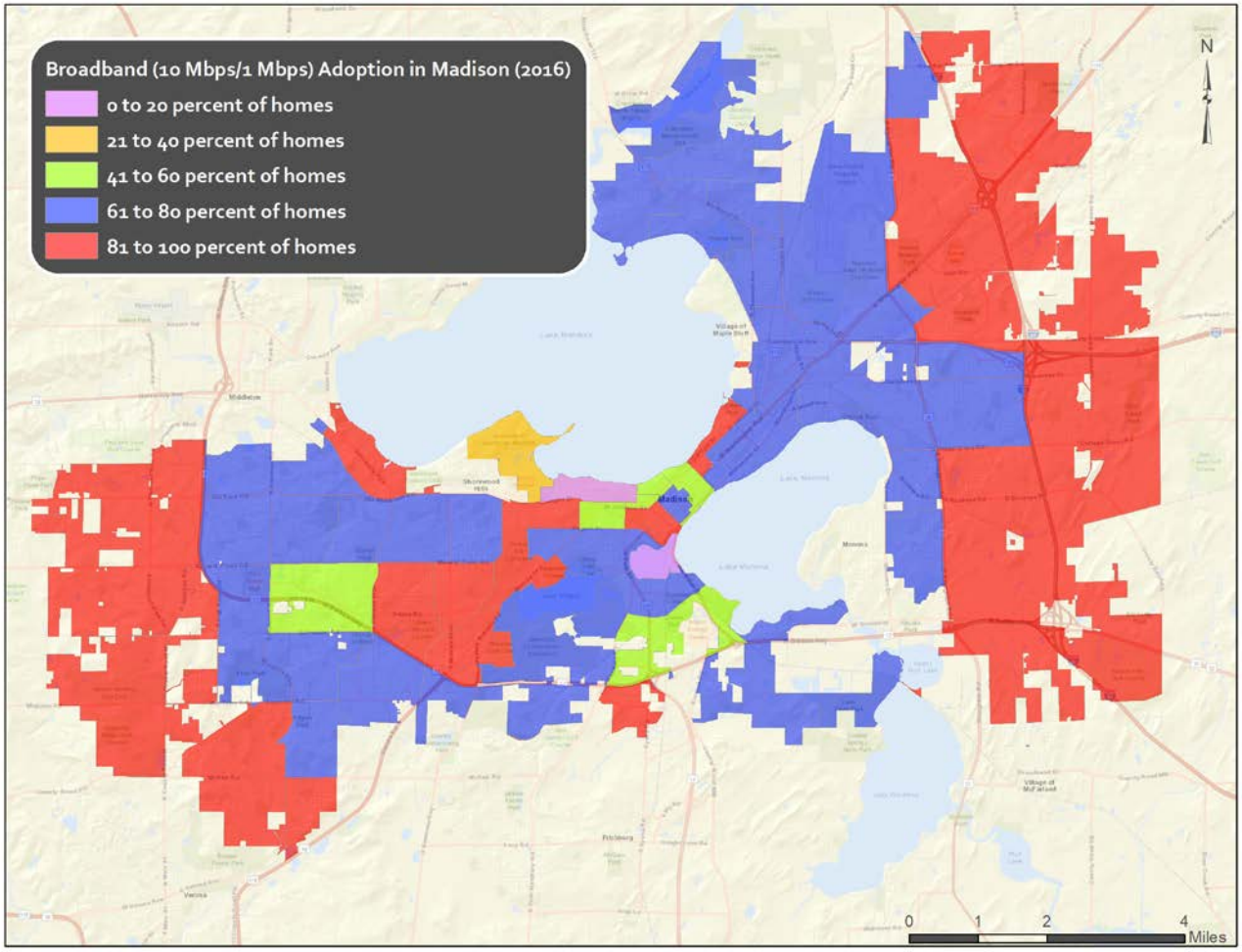
[28] "2016 Planning Database Data and Documentation," United States Census Bureau, https://www.census.gov/research/data/planning_database/2016/ (accessed April 2018).

Figure 3: Percent of Households with at Least 200 Kbps Service[29]



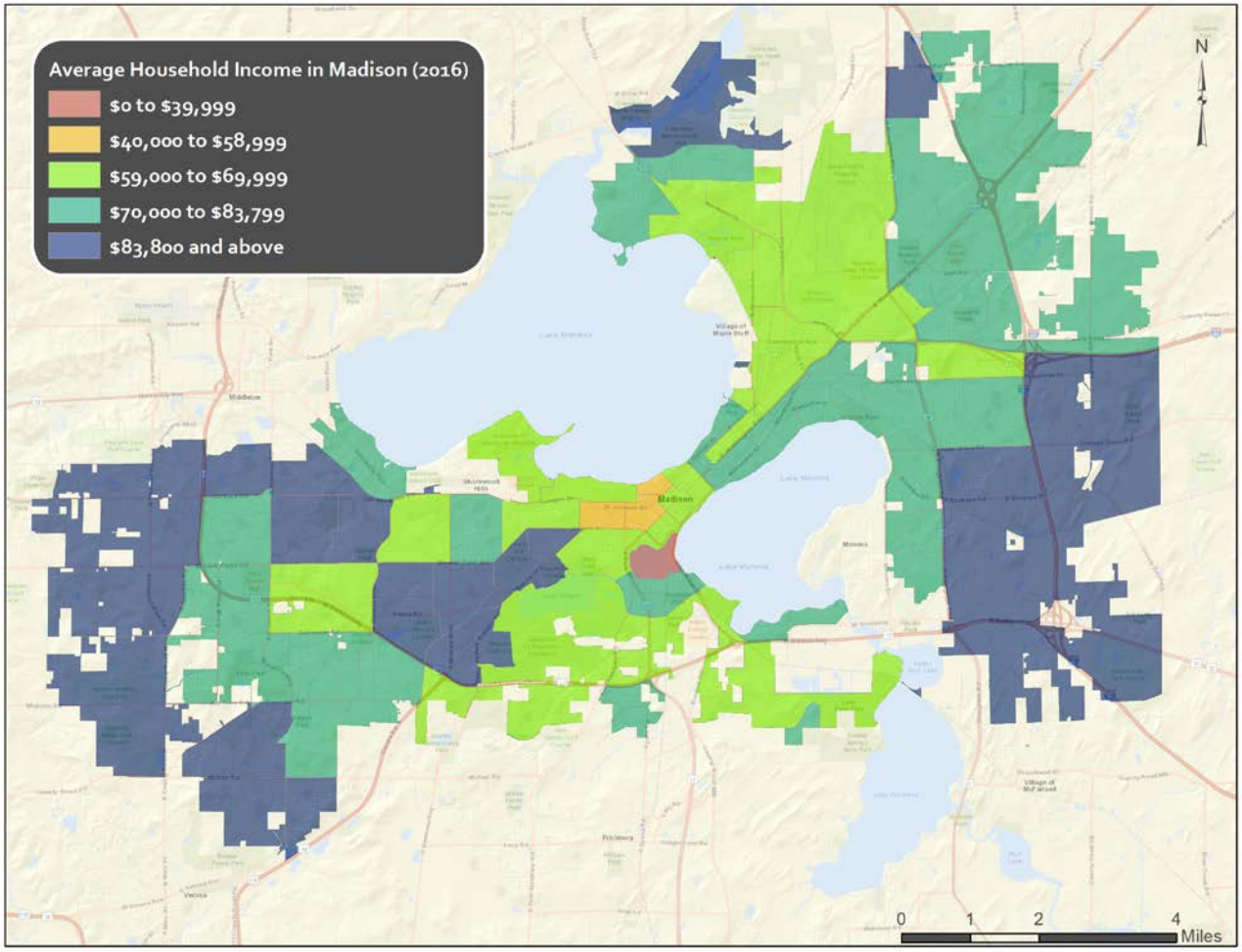
[29] "Residential Fixed Internet Access Service Connections per 1000 Households by Census Tract," Federal Communications Commission, https://www.fcc.gov/maps/residential-fixed-internet-access-service-connections-per-1000-households-by-census-tract/ (accessed April 2018).

Figure 4: Percent of Households with at Least 10 Mbps/1 Mbps Service[30]



[30] "Residential Fixed Internet Access Service Connections per 1000 Households by Census Tract," Federal Communications Commission, https://www.fcc.gov/maps/residential-fixed-internet-access-service-connections-per-1000-households-by-census-tract/ (accessed April 2018).

Figure 5: Yearly Household Income by Census Tract[31]



[31] "2016 Planning Database Data and Documentation," United States Census Bureau, https://www.census.gov/research/data/planning_database/2016/ (accessed April 2018).

Appendix B: Lessons Learned from the Connecting Madison Pilot Project

The Connecting Madison pilot project was designed to make affordable internet access available to vulnerable populations who may never previously have had access to broadband service—either because no service was available in their area, or because they could not afford it. The pilot was also intended to provide real-world data that would inform any future broadband deployment efforts by the City.

The City released an RFP in June 2015 for a two-year pilot program that would provide low-cost internet service to residents in the Allied Drive, Brentwood, Darbo-Worthington, and Kennedy Heights neighborhoods. In October 2015, the City awarded a contract to ResTech, a local ISP. The company proposed an FTTP network to serve customers in multi-dwelling units (MDUs) in the pilot areas. MDUs ranged from two to more than 100 units, totaling over 1,000 units in 161 buildings.

ResTech offered various levels of internet service starting at $9.99 per month for 10 Mbps speed and to $44.99 per month for 100 Mbps. ResTech also offered phone and television services.[32] The resulting product was called "Connecting Madison." When the contract was terminated in January 2018, the pilot program had made service available in 86 buildings but had only 19 active customers, or an average of less than one customer for every four buildings.

Large MDUs Present a Challenge for New Service Providers

During the pilot program, ResTech and the City encountered unanticipated barriers to providing access to many apartment buildings. These largely centered around obtaining rights-of-access required for ResTech to construct connections to individual units within apartments buildings. In some cases, ResTech was unable to obtain permission because landlords had granted exclusive access to their buildings to other ISPs. In other cases, landlords were not responsive to communications from ResTech or the City. These issues consumed a significant amount of time and resulted in a lower than anticipated number of potential customers.

Factors Beyond Availability and Affordability Are Affecting the Digital Divide

While access issues limited the number of potential customers for the pilot program, the percentage of potential customers who signed up to receive service was still extremely low. Although there are likely many reasons for the low number of subscribers, this indicates a lack of access to affordable internet services is not the sole driving factor in the digital divide in Madison. Residents who have access to a low-cost service may still lack knowledge of how to use internet

[32] "Low-Cost Internet Service," City of Madison, https://www.cityofmadison.com/information-technology/initiatives/low-cost-internet-service (accessed April 2018).

services, may not know what benefits home broadband service can provide, or may lack basic equipment required to use broadband services (such as a home computer).

Residents in areas targeted by the pilot may also have little interest in paying for a home broadband connection despite its availability and low cost. Residents who have never had home internet access before, or who have grown accustomed to accessing the internet through smartphones, may not see the value or relevancy of a home internet connection.

These issues illustrate the importance of a multi-faceted approach to addressing the digital divide and the City's RESJ objectives. In addition to making services available, the City may need to adopt more proactive approaches to tackling the digital divide, including a robust and expensive marketing effort designed to advertise the City's broadband service in a targeted way and to demonstrate what broadband might enable residents to do.

Madison Residents May Have New Options for Affordable Internet Access

Since the City's digital divide program began, some providers have launched new services aimed at providing internet service to qualifying residents in Madison.

In 2015, Spectrum began offering the "Spectrum Internet Assist" program[33] providing 30 Megabits per second (Mbps) internet service for $14.99 per month when a member of the household is a recipient of the National School Lunch Program (NSLP), the Community Eligibility Provision (CEP), or Supplemental Security Income. Neither program was available in Madison until 2017.

The AT&T Access program,[34] launched in 2016, is also available in Madison. Households with at least one member in the Supplemental Nutrition Assistance Program (SNAP) may qualify for a connection for either $5 or $10 per month. Speeds range from 768 Kilobits per second to 10 Mbps. Speeds and pricing are dependent on services available at that location.

Though availability is dependent on the presence of existing network infrastructure, providers offering these services appear to have fairly extensive service coverage within the City and may be able to connect much of the population the City seeks to serve. While there may be areas of the City without access to these services, the presence of these programs may further reduce the number of low-income households that would take advantage of a City-built FTTP network.

[33] "Spectrum Internet Assist," https://www.spectrum.com/browse/content/spectrum-internet-assist.html, (accessed July 2018).
[34] "Access from AT&T," https://www.att.com/shop/internet/access/index.html, (accessed July 2018).

Appendix C: Two Case Studies on the Effects of Competition

In 2012, two major broadband market disruptions unfolded in midwestern cities. In the first, Google Fiber announced that Kansas City, Kansas (and, a short time later, its Missouri twin) would be the first location of its fiber-to-the-home service. In the second, a consortium of the University of Illinois and the cities of Urbana and Champaign, Illinois completed construction of a regional fiber network and began making residential connections.

Both events led to sharp competitive reactions that benefited citizens. (The Urbana/Champaign competitive reaction has not been previously documented and included some remarkable benefits to poor neighborhoods and Spanish-speaking citizens. Since this occurred in a city with a major research university, this case study may be particularly relevant to Madison.)

The Google Fiber Case

In 2010, Google launched its "Fiber for Communities" initiative and sought city applicants who would help facilitate deployment of a fiber network. Kansas City, Kansas was chosen in early 2012; Kansas City, Missouri was soon added to the project. Google later added other cities. The company ceased expanding to new markets in 2016 but continues to expand and operate its existing networks in nine metropolitan areas.

In the spring of 2012, Google Fiber announced that it would start rolling out gigabit internet service—nearly 100 times faster than the U.S. average—for $70 per month, or $120 with television service, a Nexus 7 tablet remote, and generous DVR and cloud storage. Installations began in late 2012 and continued over the next few years across a growing number of "fiberhoods."

On the same day in August of 2014, both Comcast and Time Warner Cable (purchased by Charter in 2016) announced they would significantly increase speeds in Kansas City and other locations without raising prices. Comcast carried out the increases swiftly. Customers with 25 Mbps service were upgraded to 50 Mbps; customers with 50 Mbps were upgraded to 105 Mbps; and customers paying for 105 Mbps got bumped to 150 Mbps.[35] Since then, there have been additional announcements of this kind.

In 2015, AT&T, which had previously offered only slow DSL services, announced it would launch "U-verse," (which was then its name for enhanced broadband speeds over its copper telephone network), in parts of Kansas City, Missouri and the metro area. John Sondag, president of AT&T Missouri, declared in a press release: "We've moved quickly to bring more competition to the Kansas City area for blazing-fast internet speeds and best-in-class television service. But this is

[35] "Comcast is boosting Internet speeds for Olathe, Independence and other KC suburbs," *The Kansas City Star*, August 1, 2014, www.kansascity.com/news/business/technology/article845967.html (accessed March 2018).

just our initial launch. We look forward to continuing to expand our AT&T GigaPower network in the Kansas City area where there are strong investment cases and receptive customers."[36]

Speed improvements in Kansas occurred in the months following Google's announcement. Akamai, which is involved in delivering substantial portions of all Web traffic and can measure speeds at which the content is delivered, noticed that in the fourth quarter of 2012, the state of Kansas experienced the largest one-year jump in average internet connection speeds of all U.S. states. ISPs in Kansas started providing speeds in the fourth-quarter of 2012 which were 86 percent faster than fourth-quarter speeds in 2011.

David Belson, who authored Akamai's "State of the Internet" report, explained at the time that no cause was known to Akamai, but that incumbent network improvements were a plausible source of the change. "It could be the case that the other incumbent providers were going, 'Oh, crap, we stand to potentially lose subscribers to this deal with Google (fiber) if we don't provide competitive service.'"[37]

The Urbana/Champaign Case

Similar incumbent responses have played out in other cities with lesser-known networks. This section describes anecdotally what occurred in Urbana and Champaign, Illinois when a regional fiber network began serving residences. Because the public fiber-to-the-premises (FTTP) network was initially intended for "underserved" lower-income neighborhoods, benefits may have accrued particularly to those areas.

The University of Illinois and the two cities established "Urbana-Champaign Big Broadband" (UC2B) as an intergovernmental consortium to address a local broadband deficit. UC2B established a goal of constructing seven primary fiber rings totaling 125 miles in length and connecting 256 broadly defined Community Anchor Institutions (CAIs). The network would also provide the backbone for a FTTP deployment in 11 neighborhoods comprising roughly 10 percent of premises in Urbana and Champaign. The network was built with enough fiber strands to eventually provide FTTP service to every premises in the two cities.[38]

In 2009, UC2B was awarded $22.5 million from the U.S. Department of Commerce's Broadband Technology Opportunities Program (BTOP) and $3.5 million from the State of Illinois. Another

[36] "U-verse® with AT&T GigaPower Launches Today in Cities Across the Kansas City Area," News Release, AT&T, February 16, 2015, http://about.att.com/story/uverse_gigapower_launches_in_cities_across_kansas_city_area.html (accessed March 2018).
[37] David Talbot, "Google Fiber's Ripple Effect: The threat of superfast Google Fiber is causing other Internet providers to crank up their own offerings.," *MIT Technology Review*, April 26, 2013, https://www.technologyreview.com/s/514176/google-fibers-ripple-effect/ (accessed March 2018).
[38] "Welcome to UC2B," Urbana-Champaign Big Broadband Not-for-Profit, http://www.uc2b.net/uc2b2016/ (accessed March 2018).

$3.4 million in local matching funds were raised through the pre-sales of long-term leases of fiber strands on UC2B's backbone rings to local public and private entities. UC2B planned construction of FTTP connections to about 5,000 homes and businesses in areas deemed underserved with broadband, most of them tending to be low-income neighborhoods.

Construction was completed by August of 2013, and the following year UC2B evolved into a not-for-profit entity. It contracted with service provider iTV-3 to manage the network and the services to more than 1,000 existing customers, and to expand the FTTP service. In 2017 iTV-3 was acquired by i3 Broadband, which manages the network and customers today. i3 Broadband built FTTP facilities past more than 3,000 homes in 2017 and is working toward another 3,000 passings this year.

The two main local incumbents, AT&T and Comcast, appear to have spent the first several years ignoring the UC2B effort. But things began to change in 2012, when UC2B began connecting customers. Before recounting what happened next, it is important to restate that there is no official data kept by the FCC or other regulators on the competitive behavior of incumbent cable and telephone companies. Anecdotal reports can help fill this gap and paint a picture of what occurred.

According to Michael K. Smeltzer, who led the development of the UC2B network and is the retired Director of Networking at the University of Illinois, the normal practice of both Comcast and AT&T through 2012 was to impose annual internet service price increases. But around the time UC2B connected its first FTTP customer in late 2012, annual increases stopped and never resumed. Mr. Smeltzer also recounts that Comcast began offering higher levels of service at the same prices.

In the past two years, Mr. Smeltzer says, both Comcast and AT&T dispatched salespeople to go door to door and market cut-rate long-term contracts. In late 2017, an AT&T representative arrived at the Smeltzer residence to offer a service plan. Mr. Smeltzer recalled that the AT&T representative promised to beat Comcast's pricing. Mr. Smeltzer asked the rep about the status of UC2B and recalls that the representative "… said he had been told that there were problems with the UC2B fiber and iTV-3's rights to use it, and that the fiber would all belong to AT&T very soon." These statements were not true. Mr. Smeltzer says he asked whether AT&T would be providing fiber to his home and recalls getting this response: "He said he would need to check, but that he was pretty sure that I would have fiber to my home. When he checked, lo and behold, fiber to my home was not an option." Indeed, unless a consumer is willing to pay for costly construction, it is not an option from AT&T anywhere in Champaign or Urbana. Mr. Smeltzer noted that the salesman did not provide anything in writing about contract offers, other than a verbal assurance that the pricing would beat Comcast's pricing.

According to another anecdotal report (gathered for this study), in late 2017 a Comcast representative offered a Champaign customer a TV/internet bundle for $115, and then explained to the customer that he could get the same bundle plus Spanish-language channels for $90, a $25 discount. This episode was recounted by Mike Hosier, a Champaign resident (and, coincidentally, the former owner of Champaign Telephone Company).

Mr. Hosier reports that he had been negotiating with Comcast for a TV bundle after his family became dissatisfied with "over-the-top" video services. After days of back and forth, the Comcast representative told Mr. Hosier that $115 was the lowest price Comcast could offer for the bundle Mr. Hosier had in mind. But if Mr. Hosier took a package called "X1 Starter Latino Double" which included "Starter Latino, Streampix and Blast! Internet" he would get everything in the $115 bundle, plus Spanish-language channels, and the price would only be $89.99. Mr. Hosier accepted the deal.

It is not clear whether this offer was in any way related to competition from UC2B, but it does point to the fact that Comcast varies its pricing for similar services to different people. Further evidence of these varying Comcast pricing practices emerged in the recent study from Harvard's Berkman Klein Center. The study found, in part, that Comcast "varies its teaser rates and other pricing strategies substantially from region to region." The study reached no conclusions about the effects of these practices on low-income or other demographic groups.[39]

[39] "Community-Owned Fiber Networks: Value Leaders in America."

Appendix D: Benefits of Broadband for Low-Income Communities

A robust internet connection is a basic precondition for participation in the modern information economy. Many basic services are migrating online: job listings, government information and services, and access to e-commerce and resulting lower prices. Children in many cases need internet access to do homework. Some home-based jobs require the applicant to have broadband speeds as a precondition of employment. And other forms of digital work promise to make up increasing segments of the labor market. Fiber is the platform on which the technologies underpinning our economy will depend.

Full-time Jobs Are Available Online

The U.S. Bureau of Labor Statistics estimates that 500,000 computer and information technology jobs will be created between 2016 and 2026.[40] Among these will be full-time work-from-home jobs and other opportunities available to those with home broadband. For example, Apple recently posted a full-time job for a Spanish-speaking "at home advisor" to help customers.[41] The listing includes a requirement for "high-speed Internet service (5 megabits download and 1 megabit upload) from a reliable provider." This speed would exceed what can be provided by DSL service, the only service available in parts of some cities. Other similar listings require home broadband speeds of 12 Mbps or more and require applicants to perform speed tests and submit proof. Aside from such jobs, internet access enables home-based businesses to flourish. Any home-based businesses that sends photos or videos would need symmetrical high-speed connections enabled by fiber.

New Categories of Piecemeal Digital Work Are Emerging

In addition, new technologies are creating temporary labor markets for new types of online tasks, like labeling photos and moderating content. One driver of this trend is artificial intelligence, which will eliminate some jobs while creating new tasks that are well suited to humans. According to one research paper, by 2033, 30 percent of today's full-time occupations could morph into augmented services completed "on demand" through a mix of automation and human work performed online.[42]

---

[40] "Computer and Information Technology Occupations," Occupational Outlook Handbook, Bureau of Labor Statistics, U.S. Department of Labor, https://www.bls.gov/ooh/computer-and-information-technology/home.htm (accessed March 2018).

[41] "Jobs at Apple: At Home Advisor," Apple, https://jobs.apple.com/us/search?searchString=At%20Home%20Advisor#&ss=At%20Home%20Advisor&t=0&lo=0*USA&pN=0&openJobId=113474828 (accessed March 2018).

[42] Carl Benedikt Frey and Michael A. Osborne, "The Future of Employment: How Susceptible Are Jobs to Computerisation?" September 17, 2013, https://www.oxfordmartin.ox.ac.uk/downloads/academic/The_Future_of_Employment.pdf (accessed March 2018).

Educators Identify a "Homework Gap"

According to the Consortium for School Networking, a nonprofit research and advocacy group, seven in 10 teachers assign students homework that requires access to broadband.[43] Some students can complete this homework after school or at libraries. However, it would be difficult for many of them to complete this work at home, given that almost one in three households do not subscribe to broadband services, in many cases because they say they cannot afford it. This problem is often called the "homework gap."

Social Service Agencies Move Services Online

Many government agencies are moving services online. For example, Cuyahoga County, Ohio, which includes Cleveland, is increasingly attempting to reduce costs and improve efficiency by moving toward online service delivery.[44] One goal is to reduce the need for low-income recipients of country services to make personal visits to offices in central locations, an inefficient process for both county employees and aid recipients.

According to Scot Rourke, chief transformation officer for the county, the goal is to reduce the size of the county's social services bureaucracy and reinvest those savings in more broadband and job training for residents.[45] But this will require home broadband, computers, and tutoring on how to use software. A nonprofit group called DigitalC is working to ensure residents of the county's housing projects will gain these resources and skills.[46] DigitalC's training will help members of the city's low-income population gain basic skills and perhaps obtain degrees through online schools such as Career Online High School.

Municipal Engagement and Broadband Infrastructure

Robust broadband connections, access to computing devices, and computing skills are all important prerequisites for participation in the modern information economy. Madison is considering how municipally enabled competition enhances broadband service and whether low-income residents benefit from broadband and from the presence of competition in the broadband marketplace. A large body of research suggests the answer is yes. And the case studies of Kansas City and UC2B clearly illustrate how this can unfold.

It is also important to recognize how little data is available to fully explore many of these questions. According to the NTIA, approximately 33 million U.S. households, 27 percent, had not adopted residential broadband internet service as of July 2015; 20 percent of all U.S. households

[43] "Advancing Digital Equity and Closing the Homework Gap: The Need to Connect Students at Home," Alliance for Excellent Education and Consortium for School Networking, May 2017, http://cosn.org/sites/default/files/Digital_Equity_Homework_Gap_5.11.17.pdf (accessed March 2018).
[44] "Online Services," Cuyahoga County, Ohio, https://www.cuyahogacounty.us/online-services (accessed March 2018).
[45] Interview with David Talbot, October 2016
[46] "We are DigitalC," DigitalC, https://www.digitalc.org/about-us/ (accessed March 2018).

were offline. The NTIA said Americans with family incomes between $25,000 and $49,999 per year had an internet adoption rate of 70 percent, compared to 83 percent for those with family incomes of $75,000 to $99,999.[47] But these data come from surveys by the U.S. Census Bureau, and are inherently imprecise.[48] The NTIA research agenda, published in the waning days of the Obama administration, made clear cities need more data on topics including:

1. Adoption and usage data for population segments such as households, businesses, and vulnerable populations
2. Privacy and security challenges to adoption and meaningful usage
3. Impact of pricing on adoption and usage
4. Impediments and opportunities to foster meaningful usage and digital inclusion
5. Enterprise and small business access and adoption, and resulting socioeconomic impact
6. Expansion of broadband to select prison populations
7. Vulnerable population segments, especially individuals with disabilities and seniors[49]

As Madison continues its broadband planning efforts, it is important to recognize part of the problem in understanding the most efficient steps to address the digital divide is the lack of hard data. But experiences of local initiatives offer a great deal of anecdotal evidence of the benefits. As CTC's president recently testified before a House subcommittee about how local efforts spur better service and prompt incumbent reactions: "The data are clear: The areas of the country with the best infrastructure and the liveliest competition are areas where localities have been able to engage in addressing their broadband needs based on local strategies and local needs."[50]

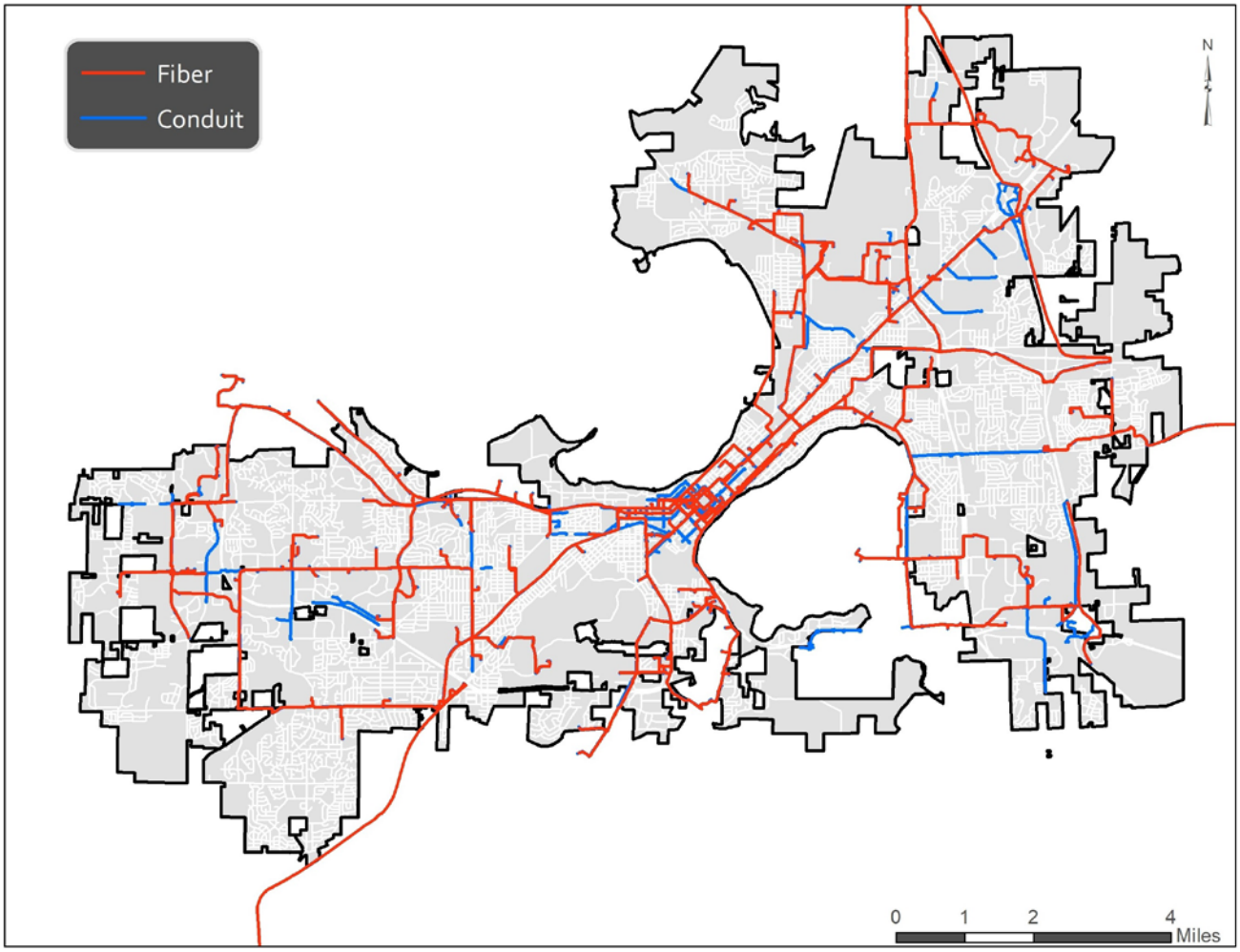
[47] "The National Broadband Research Agenda: Key Priorities for Broadband Research and Data," National Telecommunications and Information Administration and National Science Foundation, January 2017, https://www.ntia.doc.gov/files/ntia/publications/nationalbroadbandresearchagenda-jan2017.pdf (accessed March 2018).

[48] "American Community Survey: Why We Ask Questions About Computer and Internet Use," U.S. Census Bureau, https://www.census.gov/acs/www/about/why-we-ask-each-question/computer/ (accessed March 2018).

[49] https://www.ntia.doc.gov/files/ntia/publications/nationalbroadbandresearchagenda-jan2017.pdf (accessed March 2018).

[50] Joanne S. Hovis, "Closing the Digital Divide: Broadband Infrastructure Solutions," Testimony before the U.S. House of Representatives Committee on Energy and Commerce, Subcommittee on Communications and Technology, January 30, 2018, http://docs.house.gov/meetings/IF/IF16/20180130/106810/HHRG-115-IF16-Bio-HovisJ-20180130-U5002.pdf (accessed March 2018).

Appendix E: Map of the Metropolitan Unified Fiber Network (MUFN)



Appendix F: Understanding Competition and Open Access

One potential means for increasing competition in the broadband marketplace is through an "open access" network. Open access networks are meant to enable numerous providers to deliver service over the network fostering greater competition, and to give consumers greater choice and flexibility in picking a provider.

In a traditional, facilities-based competition scenario, competition is achieved when multiple separate entities develop their own separate networks and physical pathways to reach the customer. Most private providers are usually not interested in granting access to their expensive infrastructure for companies that will then compete with them over it, so each of these networks is likely to host only one Internet Service Provider—the network owner.

This approach is less efficient because it requires a large capital expenditure by each network owner and robust competition over separate facilities has not emerged for the most part in the United States. For cities that have had the benefit of an additional provider in the market (public or private), facilities-based competition has begun to work, particularly as incumbents have started to react to competition by investing, upgrading, and improving services and prices.

Open access competition is most easily achieved if a community builds and owns its own network, because it is then in a position to set terms for private lessees of its fiber that could include open access. However, some forms of open access may be possible even under the pure private investment model.

While open access may reduce the barrier to entry for providers, there is no guarantee that many new competitors will emerge in the near-term. Indeed, it may not make sense for smaller ISPs to operate in a market where there are several other competitors and where customer acquisition and retention costs are correspondingly high, and many providers may be averse to relying on shared infrastructure to provide service to their customers.

This section summarizes methods for competing over open access infrastructure. More detail can be found in CTC's 2016 Feasibility Analysis.[51]

Competition at the Dark Fiber Level

Dark fiber open access enables providers to offer services without having to construct their own infrastructure. Instead, ISPs can enter into dark fiber lease or indefeasible right of use (IRU) agreements with the network owner, and the ISPs can then offer retail data, video, and voice services over the network.

[51] "City of Madison Fiber-to-the-Premises Feasibility Analysis," http://www.ctcnet.us/wp-content/uploads/2016/08/Madison-FTTP-Feasibility-Study-Final-20160808.pdf (accessed July 2018).

In a dark fiber model, there is one fiber network infrastructure, and one or more ISPs pay the network owner for access to dedicated fiber strands that the ISPs can use at their discretion

This model requires each ISP to "light" the dark fiber by investing in network electronics to provide service over the network. The ISP may also be required to pay some portion of the cost to install a fiber drop from the dark fiber network at the curb to the home or business of a potential customer it wishes to serve.

Competition at the "Lit" Services Level

Another option to enable competition is to allow ISPs to compete over a "lit" fiber network—this lowers the barriers to market entry by removing the cost of fiber, electronics, and maintenance, thus allowing more ISPs to compete in the marketplace. In this scenario, the network owner lights the fiber and ISPs compete at the virtual network layer instead of at the physical layer.