ctc technology & energy

engineering & business consulting

September 15, 2021

Elizabeth Lose
Assistant Planning Director
Centre County Planning and Community Development
Via email: ealose@centrecountypa.gov

Subject: Proposal to prepare a countywide strategic broadband plan

Dear Elizabeth:

CTC Technology & Energy (CTC) is pleased to submit this proposal to develop a strategic broadband plan for Centre County. We have more than 35 years of experience delivering broadband consulting services primarily to public sector clients.

We have a long, successful history of broadband planning for counties that have both well-served population centers and unserved and underserved rural areas. For example, we are proud of our work with Multnomah County, Oregon, and King County, Washington, where we have been deeply engaged with rural broadband strategy. We also have a longstanding consulting relationship with Garrett County, Maryland—where we developed a broadband strategic plan and an award-winning public-private partnership approach that is considered one of the leading rural broadband partnerships in the country.

We specialize in making complex broadband issues accessible to policy-makers. Our expertise includes broadband strategic planning, needs assessments, business modeling, network engineering, feasibility analysis, public-private partnership planning, and the development of grant strategies and grant applications.

Our team for this proposal includes Dan Cohen and his colleagues at the Cohen Law Group (CLG), which has specialized in representing local governments in cable, wireless, and broadband matters for more than two decades. CLG assisted the City of Pittsburgh in preparing its own fiber broadband network (2021) and represented eight municipalities in Centre County in negotiating their cable franchise agreement with Comcast (2019).

Please do not hesitate to contact me if you would like to talk further. We look forward to the opportunity to work with you and your colleagues on this important initiative.

Best regards,
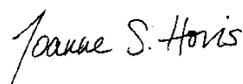
Joanne S. Hovis

Joanne S. Hovis | President | jhovis@ctcnet.us

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1. The CTC Team's Qualifications and Experience

1.1 About CTC Technology & Energy

CTC is an established, nationwide, woman-owned consulting firm that offers a unique combination of qualifications and capabilities in fiber and wireless broadband engineering, network strategic planning, financial analysis, and business planning. Founded in 1983, we deliver independent financial, strategic, and technical, guidance primarily to local governments, state governments, non-profit consortia, universities, and cooperative and municipal utilities.

We have three decades of experience assisting local and state governments throughout the United States with all aspects of the County's request, including data acquisition and analyses; public outreach and engagement; recommending broadband technologies; providing cost estimates for project design, engineering, and construction; and outlining applicable funding sources for broadband deployment.

Engaging with CTC means receiving customized analysis and the level of time, consideration, and care required to provide you with the answers you need. This level of service is complemented by our proven ability to communicate our findings and recommendations—in high-quality written reports and engaging in-person presentations—to decision-makers, elected officials, citizens, and other interested project stakeholders.

We are independent advisers. We will work solely in the County's interests. Unlike others in our industry, *we do not seek to profit from the decisions the County will make as a result of our engagement or from funding the County may make available for new networks*; to the contrary, we choose not to own networks and not to bid for grants, construction, or network operations contracts for the precise reason that we believe a consultant should be independent. We commit to you that our loyalty will be to your mission and goals.

1.2 CTC's Key Team Members

Resumes for CTC's key team members are attaches as Appendix A. Our principals are President Joanne Hovis and Chief Technology Officer Andrew Afflerbach, Ph.D., P.E.:

Joanne Hovis, *President,* is a nationally recognized authority on local broadband market forces, the rural digital divide, and innovative strategies for collaboration and partnership among the public and private sectors. Since 1997, she has directed CTC consulting services related to strategic planning, business modeling, and financial analysis for hundreds of clients nationwide—from state agencies and large cities to small rural communities.

Joanne is a nationally recognized authority on local broadband market forces, as well as innovative strategies for collaboration and partnership among the public and private sectors.

Joanne has extensive experience conducting market assessments and developing business case and business model scenarios for public sector broadband initiatives. She also guides clients on federal and state broadband grant, loan, and universal service programs such as Economic Development Administration grants, ReConnect, the Rural Digital Opportunity Fund, E-Rate, and the Healthcare Connect Fund.

Joanne leads the CTC team that advises or has advised the states of Alabama, Connecticut, Kansas, Kentucky, Massachusetts, and New Mexico, the cities of San Francisco, Seattle, and Washington, D.C., and the statewide broadband networks in Maryland and Pennsylvania.

An attorney by training, Joanne is an experienced and polished communicator who has presented project reports, facilitated work sessions, managed stakeholder outreach efforts, and provided briefings for technical and non-technical audiences—including state legislatures, city and county councils, mayors of major American cities, and state and federal agencies and commissions.

Joanne has testified before Congress on many occasions regarding rural broadband, public-private networking strategies, and infrastructure solutions for bridging digital divides. She has provided expert presentations to the Federal Communications Commission, the U.S. Conference of Mayors, the National League of Cities, and other national organizations. She has been an invited facilitator and presenter at White House events on broadband.

Joanne is a member of the boards of directors of the Benton Institute for Broadband & Society, Consumer Reports, and the Fiber Broadband Association. She is a former board president of the National Association of Telecommunications Officers and Advisors (NATOA).

Andrew Afflerbach, Ph.D., P.E., *Chief Technology Officer*, has designed fiber optic and wireless networks for states, large cities, small towns, and utilities. He led the CTC team that developed hybrid fiber and wireless strategies for King County, Wash., the City of San Francisco, and New York City—and has also designed telecommunications networks to meet the needs of rural communities.

Andrew conceived and developed the super-regional interoperable fiber optic network in the National Capital Region (including the District of Columbia, Maryland, Virginia, and 22 large local communities). He also served as technical adviser to the government of New Zealand in its nationwide fiber-to-the-premises initiative, where he developed the reference architecture for the effort and led the specification and procurement strategy.

Andrew oversees all CTC engineering and GIS work; under his leadership, our mapping team has developed extensive data collection and machine learning methodologies to understand broadband deployment patterns and services. Andrew is a licensed Professional Engineer and an experienced network planner who understands the business and financial implications of various network designs.

Andrew oversees all CTC engineering and GIS work; under his leadership, our mapping team has developed extensive data collection and machine learning methodologies to understand broadband deployment patterns and services.

A current member of the FCC's Broadband Deployment Advisory Committee (BDAC) Disaster Response and Recovery Working Group, and a former member of SAFECOM, Andrew has supported the District of Columbia and other clients on FirstNet planning. He led the CTC team that researched and wrote a "Network Resiliency and Security Playbook" on behalf of the National Institute for Hometown Security (NIHS), under a contract with the Department of Homeland Security's Office of Infrastructure Protection (DHS/IP). This Playbook was written to help local and state governments adopt best practices for preventing significant communications infrastructure failures and stopping or mitigating intrusions, hacking, and other disruptions of communications networks.

1.3   About the Cohen Law Group

For nearly 24 years, the Cohen Law Group (CLG) has specialized in representing local governments in cable, wireless, and broadband matters. CLG has worked on many local government broadband projects both inside and outside Pennsylvania. CLG's attorneys have the industry experience and expertise in these matters to vigorously address and craft effective broadband solutions. Founded by a former municipal official, CLG understands the operations and budgetary constraints of local governments as well as the integral role that broadband plays in the future of their communities.

CLG has assisted local governments in both community-led broadband projects and in projects that directly impact the speed and availability of their broadband service. Whether assisting the City of Pittsburgh in 2021 in preparing its own fiber broadband network, known as NetPGH, or representing eight municipalities in Centre County in 2019 in negotiating their cable franchise agreement with Comcast, CLG has significant experience in providing legal services pertaining to broadband deployment.

The Cohen Law Group assists local governments with the following services:

- Assisting with broadband expansion planning and broadband feasibility studies

- Drafting and negotiating indefeasible right-of-use (IRU) agreements with fiber-based companies

- Negotiating master broadband services agreements with broadband providers

- Drafting and negotiating cable franchise agreements with cable operators

- Drafting wireless facilities ordinances and design standards

- Negotiation of leases for wireless facilities in the public rights-of-way and on rooftops of local government facilities

- Drafting right-of-way ordinances and assessing right-of-way fees on telecommunications companies

- Assisting with right-of-way management and enforcement

- Drafting and negotiating pole attachment agreements with telecommunications companies

- Conducting litigation pertaining to cable, wireless and broadband disputes

1.4   CLG's Key Team Members

For the last four years, Dan Cohen, the founder of CLG, has served on the Board of the National Association of Telecommunications Officers and Advisors (NATOA), which is the national organization that assists and advocates for local governments in cable, wireless and broadband matters. Prior to providing professional counsel to local governments, Mr. Cohen served as an elected municipal official for 12 years on the Pittsburgh City Council. He served as Chair of City Council's Cable Television Committee for 10 years and also served on the Mayor's Telecommunications Committee. He led Pittsburgh's efforts to regulate cable rates, which resulted in a refund ordered by the FCC for all City of Pittsburgh cable customers. Mr. Cohen graduated from Yale University and Stanford Law School.

In addition to Mr. Cohen, CLG includes a strong team of qualified and experienced attorneys, including attorney Stacy Browdie, attorney Phil Fraga, attorney Mike Roberts, and attorney Joel Winston. Our Office Manager is Akila Iyer. Their resumes are available upon request.

2 Broadband Delivery and Telecommunications Knowledge

2.1 CTC's Demonstrated Knowledge

CTC has decades of proven experience supporting county governments and other local governments on broadband strategy, grant strategy, needs assessments, business planning, and network engineering in rural, suburban, and city environments. The sample projects we describe below illustrate our knowledge and record of success in helping local governments assess their broadband gaps and develop technical and programmatic solutions for meeting the needs of underserved and unserved residents. We have also been instrumental in developing public-private partnership strategies and leading negotiations in many of these communities.

In addition to the projects described below, CTC has performed broadband needs analyses or other broadband-related studies for the following local government clients that are home to major universities:

- Atlanta – our work was a collaboration between the city government and Georgia Tech

- Baton Rouge, La. – Louisiana State University was a key stakeholder in our work

- Bloomington, Ind. – Indiana University's IT department was a key stakeholder

- Boston (Boston University, Northeastern University)

- Boulder – the University of Colorado's telecommunications law program was a key stakeholder

- Cambridge, Mass. (Harvard, MIT)

- Lawrence, Kan. – the University of Kansas' IT department was a key stakeholder

- Madison, Wis. (University of Wisconsin)

- Newark, Del. (University of Delaware)

- New Haven, Conn. (Yale University)

- Palo Alto, Calif. (Stanford University)

- Princeton, NJ – our work was for Princeton University

- Seattle/King County (University of Washington)

- Urbana-Champaign, Ill. – our work was for a collaboration among the two cities and the University of Illinois

Carroll County, Maryland

CTC engineers and analysts developed a broadband strategic plan for rural Charles County in 2021. Drawing on a range of data sources, as well as our own extensive desk surveys, we

identified gaps in broadband availability among the County's residents and businesses. We then developed a sample fiber optic network design as potential technical solutions. The design built on the County's existing backbone fiber network, which reduced the likely fiber-to-the-premises construction costs. The analysis provided a baseline with which to evaluate potential partner cost estimates, and gave County leaders a sense of the overall costs and funding amounts that would incentivize such partners.

Charles County, Maryland

CTC engineers and analysts developed a broadband strategic plan for rural Charles County in 2019 and 2020. Drawing on a range of data sources, as well as our own extensive desk and field surveys, we identified gaps in broadband availability among the County's residents and businesses. We then developed sample fiber optic and fixed wireless designs as potential technical solutions, as well as total cost of ownership estimates. These elements demonstrated that in almost all areas of the county, fiber-to-the-premise constituted the most cost-effective and scalable solution over the long term.

The analysis also provided a baseline with which to evaluate potential partner cost estimates, and gave County leaders a sense of the overall costs and funding amounts that would incentivize such partners. With this analysis, CTC helped identify a suitable partner and a partnership model and supported the County in its partnership negotiations. We also presented recommendations for how to strategically form a partnership that would be competitive for state and federal grant applications.

We helped the County develop its successful $2.9 million grant application to the State of Maryland Office of Rural Broadband in 2020,[1] and assisted the County in term sheet development and negotiations with its private partner.

Fayette County and City of Lexington, Kentucky

CTC prepared a broadband feasibility study to help the Lexington-Fayette Urban County Government (LFUCG) understand the challenge of meeting broadband needs in the rural areas of Fayette County, and to develop cost estimates and potential strategies for meeting those needs. CTC evaluated the County's current broadband supply and demand, and potential approaches to filling that gap—through public–private partnership, middle-mile fiber, or a fiber-to-the-premises (FTTP) network.

We found that businesses in the rural areas of Fayette County had very limited broadband connectivity options, and service providers had no active plans for widespread deployment. A major reason for the lack of service was the high cost of buildout in low-population-density areas; we estimated that the cost of network construction in the County was nine times higher than the cost of construction in the City of Lexington.

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[1] https://www.charlescountymd.gov/Home/Components/News/News/2437/400

To illustrate LFUCG's options, CTC's engineers undertook two system-level design and cost estimation efforts for networks in the Fayette County area of the LFUCG: middle-mile and FTTP.

Following the County's decision to move forward with a public-private partnership approach, CTC helped the City negotiate a partnership with MetroNet, which currently is constructing a fiber network under an agreement that shifts most of the financial risk to the private company.[2]

Garrett County, Maryland

CTC developed Garrett County's successful application to the U.S. Department of Commerce's Economic Development Administration (EDA) broadband grant program in fall 2020. We currently are engaged in broadband strategic planning efforts for this long-time client.

We previously helped the local government with engineering and strategic and business planning for expansion of middle-mile fiber—then helped the County negotiate with a private partner to leverage that fiber to support the deployment of a fixed-wireless broadband network.

The private partner is matching the public investment with its own capital and will assume operating risk. The County contribution (which was matched with development funds from the Appalachian Regional Commission—following a successful grant application that CTC developed with the County) made the economics of this opportunity attractive to the private partner.

The fixed wireless "TV White Spaces" network will serve up to 3,000 currently unserved homes in the most remote parts of the County.

This innovative technical solution to the County's lack of broadband was featured in a "Motherboard" article, "Rural America Is Building Its Own Internet Because No One Else Will" (https://motherboard.vice.com/en_us/article/paax9n/rural-america-is-building-its-own-internet-because-no-one-else-will).

Greene County, Pennsylvania

CTC currently is working with Greene County to develop a data-led approach to design potential network solutions and a grant strategy to deploy infrastructure that will enable affordable, equitable broadband access and support economic development efforts. Our work in Greene County began with a methodological approach to data collection, including a comprehensive review of existing assets and a wide variety of existing data sets. We will augment this analysis with the collection of new data through statistically valid residential market research and CTC's hosted online speed test survey. These data will be used to define service gaps and determine the best technology solution for each area of Greene County, which will inform partnership and grant application strategy.

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[2] For more details, see: https://www.kentucky.com/news/local/counties/fayette-county/article217385750.html.

King County, Washington

CTC' currently is engaged in a project comprising high-level strategic design, analysis, and business case development. That effort follows on a significant year-long effort to develop detailed mapping and related analysis of unserved and underserved areas of King County.[3]

King County is home to 2.2 million people and the dense city of Seattle, but also sparsely populated mountainous regions, unincorporated rural communities, multiple bodies of water, and many populated islands.

Given the County's challenging topography, range of local governing jurisdictions, and tremendously varied population density across its 2,100 square miles, we developed an innovative approach and methodology to developing the data and map insights the County needs. We are evaluating FCC Form 477 data about broadband services available in the County, evaluating Connect America Fund (CAF II) funding areas, identifying and analyzing relevant state, federal, County, and commercial datasets for insight into where communications infrastructure exists, reviewing existing cable franchise agreements throughout the County, analyzing the County's GIS-based population density data to identify areas where cable infrastructure is required, and estimating demand based on the results of our survey work in other communities, Pew research, and other reputable data sources.

Based on these inputs, we are building a comprehensive dataset and map of where there is broadband and where there is not within the unincorporated parts of the County. This mapping exercise will be a foundational element of our analysis and recommendations related to identifying potential solutions for expanding broadband service in unserved and underserved portions of the County.

Lancaster County, Pennsylvania (Economic Development Company of Lancaster County)

Using a variety of industry-accepted evaluation methods, CTC is identifying current broadband use and needs among the County's residents and businesses—as well as a general overview of available services (and, by extension, an understanding of the locations of the County's unserved and underserved areas). We will then develop potential technical solutions that could form the basis for a strong grant or loan application (federal or state) and future public-private partnership planning. The outcome of the engagement will be a strategic plan that provides clear direction on how the EDC, a private partner, the County government, or a combination of entities could execute on a grant strategy.

City of Lancaster, Pennsylvania

CTC developed a strategic plan to enable the City to maximize the benefits of existing fiber the City received from a private ISP. We also developed a recommended plan for incremental, low-

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[3] https://www.ctcnet.us/publications/broadband-access-study/

risk expansion of that infrastructure to create revenue and other benefits. And we advised on mitigating pole attachment issues.

Multnomah County, Oregon

CTC prepared an extensive fiber-to-the-premises feasibility study for the County in 2020.[4] The report was commissioned to consider the feasibility of a publicly owned and operated fiber-to-the-premises network to serve residential and business customers throughout Multnomah County. CTC's engineers and analysts developed candidate fiber and wireless network designs and cost estimates; prepared financial analyses; conducted statistically valid market research of residents and businesses; and explore partnership models and approaches.

Pierce County, Washington

In 2020, CTC worked working with Pierce County—which includes both the city of Tacoma as well as large swaths of rural geography—to develop a strategy to secure federal and state grant funding based on rigorous data collection and the identification of well-defined service areas.

Our approach includes first developing reliable broadband availability data to give the county a better understanding of where gaps exist and to determine grant eligibility. CTC is working to map the areas of the county where broadband is deficient using several sources of data, including available FCC Form 477 data, Connect America Fund funding areas, USDA's map of existing grantees, relevant County datasets, relevant commercial datasets, existing cable franchise agreements, and desk survey data.

Together, these data will serve as a foundation to develop potential technical solutions that could form the basis for a strong grant or loan application and a future private partnership.

Summit County, Colorado

A rural county deep in the Rocky Mountains, Summit County is known for resorts that attract visitors year-round. Despite its proximity to significant communications infrastructure, and the demand created by its residents and visitors, some parts of the County lack sufficient access to reliable and robust broadband.

To identify strategies that will help the County reach its goals—improved broadband connectivity for residents, businesses, and public safety users; greater digital inclusion; the delivery of municipal services; governmental cost savings; and more efficient "connected government"— the County hired CTC to evaluate existing communications infrastructure, conduct outreach to the cellular carriers; evaluate potential solutions (including partnerships); and develop requests for information (RFI) to seek partners willing to engage on wireless or fiber-to-the-premises (FTTP) deployment in the County.

CTC and the County conducted a comprehensive needs assessment session to understand the County's goals and objectives for the project. CTC then evaluated the existing wired and wireless

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[4] https://www.ctcnet.us/publications/fiber-to-the-premises-feasibility-study/

communications infrastructure and services; spoke with the town managers/mayors, affected citizens, and other stakeholders to gather insight and information; and facilitated discussions with cellular carriers and tower companies that could potentially fill the coverage gaps.

To seek input on options for public–private partnerships, CTC developed and assessed responses to two requests for information (RFI): one for fiber-to-the-premises (FTTP) throughout the County and one for wireless broadband, primarily targeting the County's unserved areas. We also developed a high-level design and cost estimate for a County-implemented wireless broadband solution for the unserved areas.

CTC's work with the County resulted in igniting discussions with major carriers who may be able to fill the coverage gaps in the County. These conversations have been instrumental in the County establishing good relationships with private carriers that have the potential to provide additional coverage in areas of the County.

Talbot County, Maryland

In July 2020, the U.S. Department of Agriculture announced it had awarded a $13 million grant to Easton Utilities in Talbot County to deploy fiber-to-the-premises in all the unserved parts of the County. This grant is the culmination of years of work CTC did in partnership with Talbot County, which included developing strategy for addressing the County's rural broadband gaps; identifying and negotiating with Easton Utilities as the County's partner; supporting preparation of the grant application; testifying before the County Council regarding the potential and terms of the partnership; undertaking a scientific study of the market to support the grant application; and providing ongoing guidance to the County and Easton Utilities while the application was submitted and reviewed.

We previously assisted the County in evaluating its process for siting new cellular towers. We examined the areas of the County where cellular coverage existed, as well as areas where service was not available or where service was deemed to be inadequate. We assisted the County in developing a more systematic approach. Our report addressed a variety of factors that needed to be understood in order to provide for an intelligent and fair distribution of cellular communications towers within the County. The report focused on technical and engineering issues, zoning, the concerns of nearby residents, and land availability—all of which will need to be weighed to optimize voice and broadband service availability while minimizing the impact of wireless structures.

State of Pennsylvania – KINBER

CTC provided the Keystone Initiative for Network Based Education and Research (KINBER), a statewide fiber optic network in Pennsylvania and recipient of a $99.6 million federal grant, with extensive support in developing its business model and pricing schedule. Our team conducted interviews with KINBER project stakeholders to assess the statewide market for networking services. We combined this information with our in-depth knowledge of public sector networking initiatives, markets, and pricing schedules. We then presented different business model scenarios

based on varying take rates of the networking services offered. We gave preliminary marketing advice and conducted initial outreach on behalf of KINBER to potential new members. CTC also prepared engineering advice for how to cost-effectively provide networking services.

City of Bloomington, Indiana

CTC led a study and analysis of "digital equity" gaps affecting the City's low-income or otherwise disadvantaged population in their use of the broadband internet. Our goal for the study, which included a statistically valid survey, was to help the City better understand the gaps—including those related to broadband access, affordability, digital skills, and device ownership—that may be preventing some residents from making the most effective, meaningful use of broadband. Based on the research and data gathered, we developed an actionable plan of steps that could be taken by both the public and private sectors to address those challenges.

CTC has also supported the City's efforts to develop ubiquitous, Gigabit-class broadband. We collaborated with City staff and other stakeholders to facilitate a public symposium and related communications materials on the value of next-generation infrastructure. We performed in-depth analysis of the local broadband market and fostered engagement with a range of public and private stakeholders. CTC's analysts and engineers also assessed the City's existing assets, prepared a competitive assessment of broadband services, benchmarked the City's broadband availability, and developed high-level engineering and cost estimates. Additionally, our team developed and administered an RFI to gauge public-sector interest in partnering with the City to achieve its broadband goals.

City of Cambridge, Massachusetts

CTC conducted a pioneering digital equity study to develop data and strategies for closing the city's digital divide as it pertains to broadband access, broadband affordability, access to devices, and acquisition of skills necessary to effectively use broadband and computers. The study included two mail surveys, extensive stakeholder engagement, a market assessment, and preliminary engineering and cost analysis related to bringing competing high-speed internet service to certain public housing complexes. The study established a clear understanding of factors affecting residents' ability to access and use broadband, and provided a strategy roadmap that included a range of programmatic and infrastructure solutions, including pilot initiatives.

City of Dallas and Dallas Independent School District

Working with the Dallas Independent School District, the City of Dallas, and the regional "Internet for All" coalition (i.e., the Dallas ISD and City's collaboration with Dallas County, Dallas College, and other independent school districts within the Dallas region), CTC developed a comprehensive set of solutions for ensuring all students have access to high-speed home broadband service.

CTC presented our findings to the City in June 2021. We began the engagement in late summer 2020 with fast-paced efforts to gather initial data, capitalize on existing incumbent service availability, and develop potential pilot solutions for quickly serving unconnected students. We conducted research to identify, quantify, and understand the nature of the digital divide affecting

students (and Dallas residents more broadly). Then, over the course of an engagement that comprised extensive community engagement, pilot network deployments, and analysis of federal grant opportunities, we developed a longer-term strategy that encompassed infrastructure, subsidies, and programmatic solutions as means by which Dallas ISD and the City might sustainably bridge the digital divide affecting students and residents.

City of Madison, Wisconsin

CTC wrote a fiber-to-the-premises (FTTP) feasibility study for the City in mid-2016.[5] Over the course of the engagement, CTC engineers and analysts inventoried the City's key physical infrastructure, including the Metropolitan Unified Fiber Network (MUFN); conducted interviews with representatives of City departments and stakeholders; researched the region's available broadband services and costs; evaluated potential public–private partnership business models; and developed pro forma financial statements for a City-owned fiber network. In addition to those tasks, CTC conducted residential market research to supplement the report's findings, and to help gauge the community's interest in broadband.

CTC recently began a citywide audit and inventory of conduit, fiber, and splice information for the Madison Unified Fiber Network (MUFN) outside plant network.

City of Pittsburgh

CTC advised the City on a plan to expand its municipal fiber infrastructure in coordination with state and private sector efforts. As technical and strategic advisers, we developed an approach to replace the City's existing leased network services with dark fiber operated by the City.

City of Westminster, Maryland

The Westminster model that CTC pioneered is the most influential broadband public–private partnership in establishing the model of city-owned fiber and private use of that fiber. This demand-driven model was the first of its kind. (For more details, see CTC's website: http://goo.gl/h14Lqi.)

The construction of the City's FTTP network and its groundbreaking partnership are the culmination of a multi-year engagement with CTC. CTC first prepared an FTTP feasibility study, cost estimate, and business case for the City in 2012 and 2013. Our report, which focused on maximizing available backbone network connectivity, included a technical design and cost estimates for two last-mile FTTP pilot projects (one focused on residential customers, one focused on businesses).

Based on the strength of the City's commitment to its principles, and the outcome of the feasibility analysis, the City decided to move forward with the small-scale pilot projects. As that focused construction began, CTC continued to work closely with the City to establish its principles and risk tolerance, then designed a potential public–private partnership model that would

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[5] The final report is available on our website: http://www.ctcnet.us/news/city-of-madison-releases-ctc-report/

achieve a balance between those guiding forces. We established the City's preferred role in each aspect of network construction and operations, developed criteria for evaluating potential partnerships, and develop a financial analysis tool to model a range of assumptions.

We then wrote an RFP to identify a private partner that would assume operating risk in providing services to the public over the City's FTTP infrastructure. The RFP led to successful negotiations, led by CTC President Joanne Hovis, and the announcement of a first-of-a-kind partnership with Ting Internet.

2.2   CLG's Demonstrated Knowledge

Dan Cohen and his colleagues at the Cohen Law Group in Pittsburgh will provide his knowledge of the legal complexities involved in the project, including Pennsylvania Public Utility Commission rules and other State and County regulations regarding rights-of-way and public easements.

The Cohen Law Group is well versed in the laws and regulations pertaining to telecommunications matters. At the federal level, CLG has been actively involved with various FCC proceedings that are important to local governments. This includes filing many petitions and comments before the FCC in key proceedings. For example, in 2018, our law firm filed comments on behalf of Charles County, MD, Clackamas County, OR, the City of Rochester, NY and MassAccess in a proceeding pertaining to the reduction of cable franchise fees to local governments. CLG has also lobbied individual FCC Commissioners regarding public policy issues that impact local governments. Finally, in 2021, Dan Cohen has Chaired the Policy & Legal Committee for NATOA, which is a committee of local government attorneys focused on public policy issues in the telecommunications field at the federal level.

At the state level, CLG has worked closely with the Pennsylvania Municipal League (PML), the Pennsylvania State Association of Boroughs (PSAB) and the Pennsylvania State Association of Township Supervisors (PSATS) on cable, wireless and broadband issues on behalf of local governments. Our attorneys have also filed comments (and encouraged our clients to file comments) with the Pennsylvania Public Utilities Commission (PUC) on behalf of local governments. For example, in 2017-18, we represented all of the Pennsylvania municipal associations in successfully persuading the PUC to reverse its position that wireless contractors are "public utilities" under the PA Public Utility Code. Our law firm has also worked with state legislators in both chambers on telecommunications issues, most recently with respect to legislation pertaining to wireless facilities regulation by local governments.

The Cohen Law Group also has expertise in **state legislation that could affect (or at least help inform) the Centre County Strategic Broadband Plan**. Pennsylvania Act 183 conditionally prohibits local governments from providing broadband services to the public for a fee. The conditions to providing such service directly include: 1) whether such broadband service (at the

speeds desired by the local government) are already provided by the incumbent local exchange carrier (ILEC); and 2) the ILEC declines to provide such services within 14 months of a request by a local government. Act 183 requires local governments to submit an application to the company outlining its broadband plans and specifications. The company may then elect either to upgrade its network to provide such services at such specifications within 14 months or decline to upgrade its network and allow the local government project to move forward.

The following are a few selected projects performed by CLG and related to the project being considered by Centre County:

City of Pittsburgh: NetPGH

Since May of 2020, our law firm has assisted the City of Pittsburgh with the legal components of the RFP and bid award process for the deployment of a unified high-speed broadband network, known as NetPGH, connecting all 131 City facilities. These facilities currently reside on disparate institutional networks and consolidating them into a single network controlled by the City will significantly improve the delivery of core municipal services to City residents and businesses.

In addition to vastly improving communications within City Departments, NetPGH will have a direct impact on external City programs. Solely by way of example, NetPGH will enable the expansion of the City's Rec2Tech program, a multimillion dollar program that will convert aging recreation centers throughout the City into digital learning labs. It will also advance the Smart Corridors initiative to improve traffic efficiency and help prioritize public transportation, cyclists and pedestrians. It will also deploy public Wi-Fi in City parks. These are just a few of the benefits that will be realized from the creation of NetPGH.

Keystone Initiative for Network-Based Education and Research (KINBER)

CLG worked with the Pennsylvania non-profit KINBER (the Keystone Initiative for Network Based Education and Research) with respect to a key project. KINBER built and manages an 1800-mile broadband network that runs through 51 of Pennsylvania's 67 counties. The funding to build this network came from a $99 million grant that KINBER was awarded by the National Telecommunications and Information Administration (NTIA).

On behalf of KINBER, CLG negotiated an Indefeasible Right of Use (I.R.U.) agreement with Sunesys, LLC. Through this agreement, KINBER granted Sunesys an exclusive IRU with respect to certain strands of fiber across its broadband network. The agreement provides, among other requirements, for significant payments in consideration from Sunesys to KINBER and the requirement that Sunesys abide by the open access requirements of the NTIA in operating the fiber strands.

Pennsylvania Act 183 Applications

CLG assisted five counties in Pennsylvania in the filing of Act 183 submissions—Armstrong County, Cambria County, Clarion County, Indiana County and Lycoming County. Under current Pennsylvania law, local municipalities are prohibited from operating their own high-speed broadband networks unless the incumbent local exchange carrier (ILEC) is given a right of first refusal under Act 183. CLG prepared and submitted the applications in a manner that made it likely that the ILEC was unable to meet municipal demands, thereby freeing up the County to proceed with the broadband network. These projects required that CLG have an in-depth understanding of all aspects of a given municipal broadband project. All Act 183 applications submitted by the Cohen Law Group on behalf of municipal clients have been successful.

Cable Franchise Negotiations in Pennsylvania

CLG has assisted hundreds of Pennsylvania municipalities in negotiating cable franchise agreements with their cable operators. Our attorneys are well-versed in federal law and FCC regulations pertaining to cable franchising. As a result of these negotiations, CLG has been able to obtain significant benefits for its clients, including increased revenue from the cable operators in the form of franchise fees and expanded build-out of the cable system to provide cable and internet services for more resident and businesses. As required by the federal Cable Act, we have also prepared our clients for public hearings on franchise renewal or conducted public hearings on their behalf. In 2019, we represented eight municipalities in Centre County (known as the Centre Area Cable Consortium) in negotiations with Comcast.

Wireless Facilities Regulation

CLG has also assisted hundreds of Pennsylvania municipalities in drafting wireless facility management ordinances, primarily to manage wireless networks being constructed in the public rights-of-way. We have also worked with many of these municipalities in negotiating master wireless leases for these facilities. For example, since May of 2020, CLG has assisted State College Borough in preparing a wireless ordinance (and design guidelines) as well as negotiating wireless leases with wireless providers.

City of John Day, Oregon

Since 2018, CLG has assisted the City of John Day, Oregon in forging a partnership with Oregon Telephone Corporation (OTC) for a community-led high-speed broadband network in the City. Among other projects, this has included the drafting and negotiating of a Memorandum of Understanding (MOU) and an indefeasible right of use (IRU) agreement with OTC.

3 Work Plan

We understand Centre County's need for enhanced broadband infrastructure and services in its unserved and underserved areas—because that need is similar to the needs of other large jurisdictions with rural and urban communities in Pennsylvania and nationwide.

We think of broadband as a critical service like electricity and water—yet broadband often is not equitably available. At a high level, this inequity is related to affordability and availability: Lack of affordability prevents some residents from adopting broadband service even where it is available, while lack of availability prevents other residents from accessing broadband service at any price.

Availability is typically the cause of digital divides in rural areas. The private sector will not build costly wireline infrastructure to reach all homes and businesses in rural areas because the potential return on investment is insufficient to justify the investment. The same dynamics apply to virtually all areas of rural infrastructure development. In the case of broadband, the issues are starker because broadband is traditionally thought of as an area of private investment, rather than public investment.

These challenging economics, which result largely from the portions of the County that have low population density, have real consequences for the community—affecting young people's access to education (including distance learning) and economic development in general.

Our scope of work represents a methodical approach to gathering the data and insight needed to develop a long-term broadband strategy and an actionable grant strategy for the County. We will focus on:

1. Developing an understanding of the gaps in broadband service across the County, in terms of underserved and unserved residents

2. Developing a candidate design and associated cost estimates for a broadband deployment project that might fill the County's broadband availability gaps—using best-fit technologies that may vary in different parts of the County (e.g., fiber-to-the-premises, fixed wireless, hybrid)

3. Developing a strong, well-documented justification for potential grant or loan applications (federal or state)—which may also support future efforts to attract private partners—to address affordability and availability challenges

4. Preparing legal instrument templates to assist the County in engaging an internet service provider and other potential private partners

Ultimately, we will seek to identify a clear path and strategy that would enable the County, a private partner, or some combination of entities to enable affordable, equitable broadband access to the County's residents.

Task 1: Assess and prioritize geographic areas and communities unserved and underserved by broadband

Our project team will initiate the project by meeting with the County's project team to discuss project goals and objectives, review relevant maps and documents, establish project parameters, and confirm the expected project timeline. We will discuss relevant federal and state grant opportunities, and potential public-private partnership approaches.

We will collaborate with the County on definitions of "unserved" and "underserved" to guide our work throughout the engagement; similarly, we will seek the County's guidance on defining which unserved and underserved areas should be considered priorities in terms of recommending broadband deployment projects.

Given the need to maintain social distance and limit the size of in-person gatherings, we recommend conducting the meeting over videoconference using our Teams platform or another one of your selection.

Subtask A: Analyze existing broadband infrastructure

We will review any relevant maps, studies, documents, or data that the County can share with us—including the locations of communications towers and potential interconnection points, and GIS files showing known business and governmental facilities.

We will draw on a range of other, publicly available data sources, including the locations of anchor institutions, demographic data, and information about federal grant and subsidy awards (such as the Rural Digital Opportunity Fund[6]). We will also evaluate any anecdotal information about broadband deployment plans in the area (such as Atlantic Broadband's announcement that it will deploy new infrastructure).[7]

A CTC outside plant engineer will then conduct an extensive desk survey using available GIS maps, Google Earth imagery, and other relevant sources.

These data analyses will be a critical foundation for our assessment and prioritization of the unserved and underserved areas of the County. *They will also inform our recommended broadband delivery methods and technologies in Task 3.*

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[6] See CTC's interactive RDOF and CBRS auction award maps here: https://www.ctcnet.us/analytics/
[7] "Atlantic Broadband to provide internet to rural communities," StateCollege.com, Sept. 10, 2021, https://www.statecollege.com/centre-county-gazette/atlantic-broadband-to-provide-internet-to-rural-communities/

Subtask B: Assess the availability of broadband services

In this task, we will seek to determine what ISPs are active in the area, what services are available, and what residents and businesses pay for varying levels of service. We will explore not just starter and enticement pricing, but also the actual pricing for established customers. Our assessment will include developing a list of current broadband providers and their costs for services, based on publicly available information. We will also evaluate available FCC Form 477 data and other indicators of services in the County.

Ideally, we will be able to use this multi-step analysis to develop a map that visually approximates what kind of services are available in each part of the County—to supplement and confirm the results of our desk survey (see above). We approximate this inventory based on service and pricing information because the industry does not share data on its infrastructure. We will make highly educated estimates, based on our experience, of competition gaps, affordability gaps, and service gaps.

Taken together, these issues and service gaps will drive the development of a strategy and roadmap for future initiatives.

Task 2: Conduct public outreach and engagement campaign, including stakeholder meetings and survey

We will conduct stakeholder and community outreach to gather qualitative input and insight into the data we collect on broadband needs in the County.

Subtask A: Facilitate stakeholder meetings

We will facilitate two meetings with stakeholders selected by the County to gather diverse perspectives about broadband gaps facing the County and to solicit the stakeholders' ideas for solutions and potential partnerships. In our experience, these stakeholder sessions can also encourage consensus and support for County plans.

We anticipate engaging with municipal officials, school district representatives, healthcare practitioners, and representatives from civic, businesses, and nonprofit organizations who have an awareness of and involvement in broadband issues in the County.

In advance of these meetings, we will prepare and disseminate an information request and questionnaire intended to maximize the value of the discussions. We assume the County will identify and invite the participants and will be responsible for managing meeting logistics (including by providing a teleconference or videoconference platform). We may request permission from attendees to record the discussions.

Subtask B: Collect supporting evidence of residents' broadband service gaps

Because online surveys are inherently biased toward residents who have broadband service, we propose to facilitate a town hall-style meeting, similar to the stakeholder sessions, to invite residents to share information about their broadband services (including service gaps and

complaints). As with the other sessions, we will seek the County's help in identifying participants, scheduling the session, and advertising the event.

We will also seek to collect standardized speed test results from County households, with a particular focus on identifying areas where broadband service is problematic. To that end, we will host, operate, and maintain a customized, proprietary speed test website for three months. The sample screenshot below illustrates the online tool.

Figure 1: Sample Speed Test Website
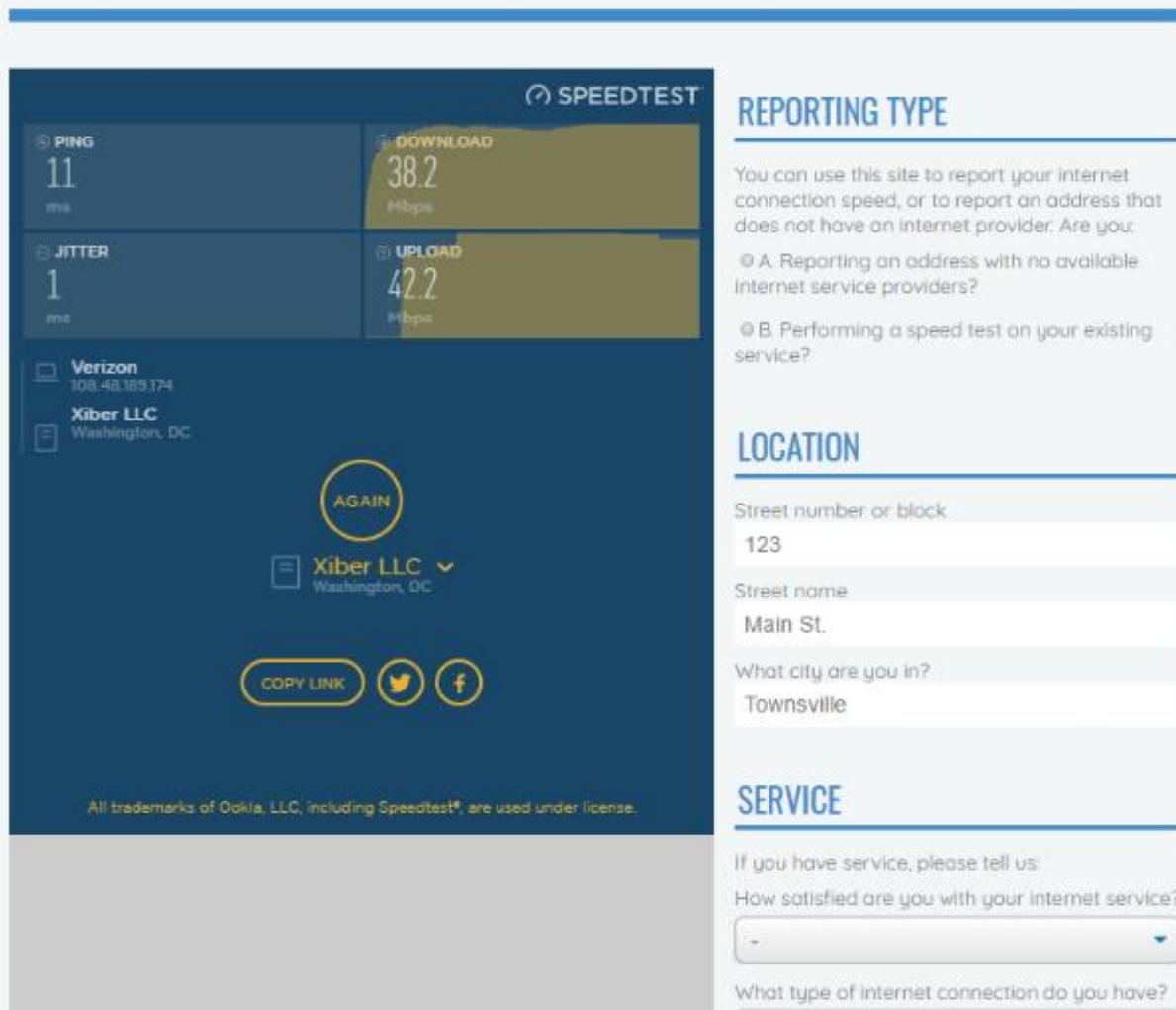
Our specific tasks will include the following:

1. Prepare draft questions to be included on the speed test website (i.e. survey); review text and layout with the County before the test goes live

2. Develop and launch the custom online speed test website (subject to our standard terms of use for our proprietary online tool)

3. Host the broadband speed test, which we assume the County will regularly publicize on its website, through social media platforms, and in other ways it communicates with the public—with a goal of encouraging high levels of participation among residents

4. Collect data submitted by respondents who run the speed test, with a focus on identifying areas where incumbent services are slow (and, by overlaying those data with demographic data, identifying where affordability may be a significant issue for residents)

5. Collect data submitted by respondents who indicate they lack broadband service

6. Prepare data reports that illustrate broadband service gaps (including graphs such as the following, which represent data collected for another client)

Figure 2: Sample Speed Test Reporting
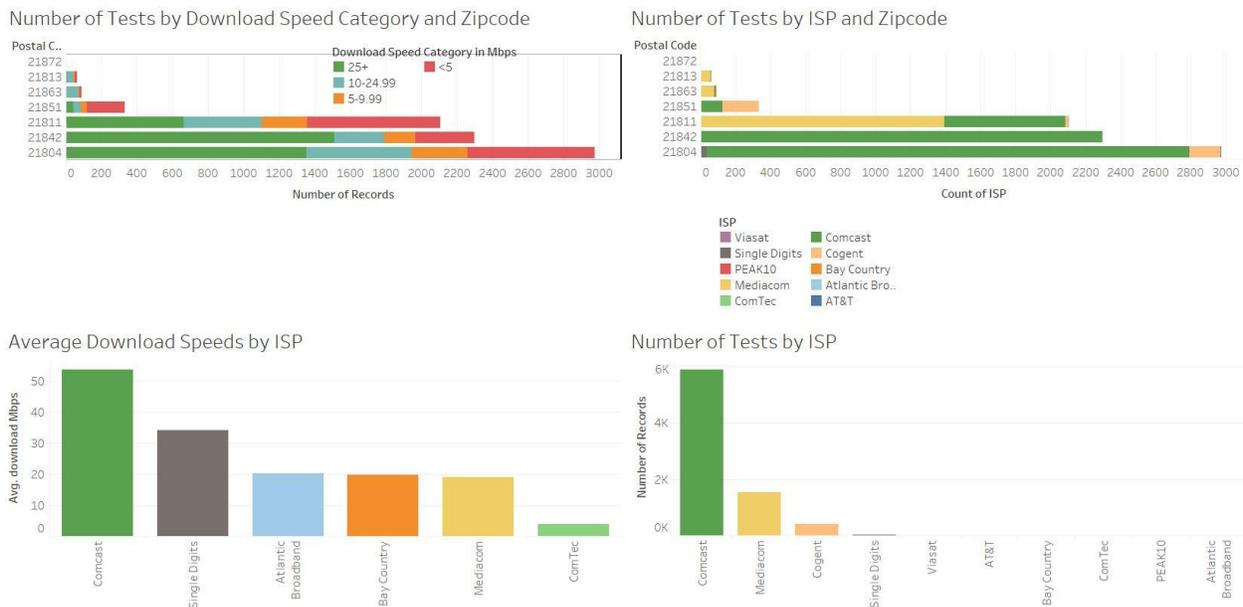
CTC will maintain a shared, cloud-based MySQL database to store the test results. CTC will host the speed test using Amazon Web Services (AWS). We will prepare maps and data analysis to support our strategic recommendations. We note that we cannot guarantee a participation level.

Subtask C: Conduct a mail-based, scientific survey (optional)

To the extent the County seeks quantitative data on broadband needs, we will perform a mail-based survey of samples of the County's population to provide a benchmark on basic questions related to internet access and usage. This robust, statistically valid survey approach can provide

a baseline for measuring changes going forward, including the impact of the County's efforts and interventions.

The mail survey will gather data on barriers to accessing and using broadband, computers and other devices, and online resources. The County's project team will have an opportunity to review and provide feedback on the survey instrument.

Recognizing the differences in broadband options between residents of rural areas and residents of urban/suburban areas—and that, statistically speaking, a survey of the County as a whole would be dominated by results from State College and other densely populated areas—we will design the survey to separately sample State College and rural regions.

We will purchase a mailing list and mail a written survey to randomly selected samples of residents from each of the geographic areas. Based on the sample sizes, we would anticipate receiving approximately 400 responses from each area—which would provide results within a confidence interval of ±3.4 percent for each of the three areas at the 95 percent probability level. That is, more than 19 times out of 20, the results from the respondents would be within those boundaries as compared to the responses from the entire population.

The survey will require an estimated 12 to 15 minutes to complete. To encourage participation, the survey will be printed as a booklet (which enhances readability) and mailed in a non-standard sized envelope (which increases the likelihood that it will be noticed and opened by the recipients). We will manage all aspects of survey distribution, return mailing, processing, and data analysis.

Survey responses will be entered into a database format and analyzed. The raw data will be reviewed and processed following our standard data-cleaning protocol. This might include coding missing responses, establishing new response categories, verifying skip logic, and other steps necessary to ensure a clean and valid dataset.

The survey data will be weighted by the age of the respondent to minimize any age bias in the survey results. Because younger residents are much less likely to respond to surveys, "weighting" the survey responses based on the actual (Census) distribution of adult population by age cohort is necessary to minimize response bias. This is especially true for surveys regarding internet technologies and uses that may be more widely adopted by younger residents than by older residents.

Data analysis will include, at minimum, development of frequency tables for all responses and selected cross-tabulations and/or comparisons of mean ratings by geographic area and key demographics.

Additionally, we will seek to identify key target segments by examining demographic, income, or other relevant drivers. The level of analysis completed will depend on the number of responses and the characteristics of the data collected.

For example, cluster analysis and/or classification trees can be used to segment and profile residents according to their needs or perceptions, and a gap analysis can help us evaluate whether and where the broadband Internet marketplace is meeting or failing to meet expectations for attributes that are important to respondents. That is, including questions about the level of importance respondents assign to various aspects of their service, along with the level of satisfaction with those service aspects, enables us to identify in what areas providers are meeting or failing to meet customers' expectations. An example of this analysis is shown in the following table.

Figure 3: Sample Survey Gap Analysis

	Mean Importance	Mean Satisfaction	GAP < -- >	Significance?
Price (n=345)	7.9	7.2	-0.7	Expectations not met
Local office (n=322)	5.0	6.4	1.4	Expectations exceeded
Connection speed (n=343)	8.3	7.6	-0.7	Expectations not met
Connection reliability (n=308)	9.0	8.6	-0.4	Not significant

Task 3: Prepare high-level design and cost estimate for broadband deployment projects specific to priority unserved and underserved areas

CTC's engineers will develop a high-level candidate design and cost estimate for a fiber, fixed wireless, or hybrid network that might fill the broadband service gaps (i.e., unserved and underserved areas) the County has identified as priorities. We will identify the most topography-appropriate and cost-effective infrastructure (reflecting, for example, the availability of vertical assets for mounting wireless equipment).

We will identify the number of premises (homes and businesses) to be served by the candidate solution. We will include in our engineering analysis existing infrastructure (including fiber, but also rights-of-way access and locations for network hubs and other necessary infrastructure) that we believe might be useable to support the deployment.

We will identify routing for potential topologies and will consider construction and design practices to minimize overall cost, including planning construction in conjunction with capital improvements in the rights-of-way (e.g., road work, sidewalk replacement programs).

Based on that analysis, our engineers will develop a high-level estimate of likely costs and timelines for construction and implementation of a baseline network. Our cost estimate will include a total estimated project cost (encompassing a material costs per mile) and key costs to

be considered, including likely permitting ad pole attachment fees, engineering fees, and other associated costs.

Our recommended network design and cost estimates will assume a phased approach to network deployment. To be clear, we will not be providing a blueprint-level network design or cost estimate. Rather, we will be providing an analysis of existing infrastructure, a conceptual design, high-level maps, and a system-level overview of the potential infrastructure—which in turn can become a roadmap for financial analysis and business modeling, and for future decisions (potentially including detailed engineering and contracting with private sector service providers).

As is typical in this phase of a fiber construction project, the cost estimates will not be based on a detailed design, environmental assessment, or geotechnical analysis of soil composition. As a result, actual costs may vary due to unknown factors, including costs of private easements and the presence of subsurface hard rock. We will incorporate suitable assumptions to address these items based on our experience.

Task 4: Identify applicable funding options for project implementation

We will provide Centre County with information about current federal and state grant and loan programs for which it might be eligible (alone or in partnership with a private entity).

Public sector broadband network deployments reflect both an ambitious vision and, often, a public commitment to financing broadband access for all citizens. Many local governments have pursued grans or loans, taken out bonds, or otherwise sought funding for construction of publicly owned fiber networks.

We will help the County develop realistic options for federal, state, or regional funding. We will draw on our hands-on knowledge of broadband funding opportunities and our ongoing research in this area[8]—particularly the many broadband funding allocations in the American Rescue Plan Act—to conduct a high-level evaluation of existing and pending state and federal grant programs that the County government, a partner, or a combination of applicants might consider. Our goal in this task is to help the County determine whether there is a path toward at least partial funding for broadband deployment to unserved and underserved residents.

Task 5: Develop legal instrument templates

The Cohen Law Group will perform the drafting and negotiation of key legal instruments with potential partners and internet service providers. Depending on the County's specific needs, such agreements might include, but not be limited to, Memoranda of Understanding (MOU), cooperation agreements with partners, an indefeasible right of use (IRU) agreement, and a master broadband services agreement (MSA). CLG has significant experience in preparing each of these agreements.

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[8] See our website for our most recent analyses: https://www.ctcnet.us/blog/

Our price proposal assumes the County will require an MOU, an IRU and an MSA—and that the expected number of hour needed to draft, obtain comments from the client, and negotiate each of these agreements is 30 hours for a total of 90 hours for all three agreements.

While it is unlikely that any aspect of the County's broadband project will result in litigation and hopefully such an outcome will not occur, CLG has a strong litigation practice that will zealously defend the County if it ever becomes necessary. Indeed, our primary goal is to ensure that the County is careful and takes the necessary steps to ensure that litigation does not ensue. Given that litigation is unlikely, we are not including a cost estimate for this task below.

Task 6: Deliver broadband strategic plan

Our final deliverable will be a broadband strategic plan that documents our data collection and analysis of the County's broadband needs; presents our candidate technical solution and cost estimate; and presents a potential grant strategy.

The report will include the data, insights, and recommendations developed in the previous tasks. Our engineering will be prepared such that our deliverable can, with relatively modest effort, be incorporated into an RFP to identify a private partner.

We will provide the County with an electronic draft of our report, which will include a concise narrative supported by tables, graphics, and maps as appropriate. We will incorporate feedback from reviewers and deliver an electronic version of the final report.

4 Cost Submittal

We propose to perform the tasks described in the scope of work above for a flat fee of $175,000, excluding the optional mail survey—which is priced separately at $64,000.

We will pass through CLG's fees with no mark-up. Legal services beyond the assumed number of hours identified for Task 5 will be billed at an hourly rate of $300.

The estimated fees per task are as follows:

Task	Flat Fee[9]
Task 1: Assess and prioritize geographic areas and communities unserved and underserved by broadband	$39,000
Task 2: Conduct public outreach and engagement campaign, including stakeholder meetings and survey	$27,000
Subtask C: Conduct a mail-based, scientific survey (optional)	*$64,000*
Task 3: Prepare high-level design and cost estimate for broadband deployment projects specific to priority unserved and underserved areas	$47,000
Task 4: Identify applicable funding options for project implementation	$20,000
Task 5: Develop legal instrument templates	$27,000
Task 6: Deliver broadband strategic plan	$15,000

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[9] We reserve the right to shift budget among tasks as long as the total project budget is not exceeded.

5   Schedule

We anticipate completing the broadband strategic plan within six months of receiving notice to proceed. If the County opts to conduct the mail-based survey, the project timeline will be on the longer end of that range (to allow time for mailing the surveys and receiving the responses). Our preliminary project timeline is as follows:

Task	Month					
	1	2	3	4	5	6
Project initiation workshop	█					
Task 1: Assess and prioritize geographic areas and communities unserved and underserved by broadband	█					
Task 2: Conduct public outreach and engagement campaign, including stakeholder meetings and survey		█	█			
Subtask C: Conduct a mail-based, scientific survey (optional)		█	█	█		
Task 3: Prepare high-level design and cost estimate for broadband deployment projects specific to priority unserved and underserved areas			█	█		
Task 4: Identify applicable funding options for project implementation				█	█	
Task 5: Develop legal instrument templates					█	█
Task 6: Deliver broadband strategic plan					█	█

Appendix A: CTC Key Personnel Resumes

Joanne S. Hovis | President

Joanne Hovis is a nationally recognized authority on broadband markets and on the evolving role of public–private partnerships in the provision of communications services to the public. For more than 20 years, she has overseen directed CTC's consulting services related to strategic planning, market analysis, business modeling, and financial analysis for localities, states, and tribal governments throughout the country.

Joanne leads the CTC teams that advise the states of Alabama, Connecticut, Nebraska, New Mexico, and New York; the cities of Atlanta, Boston, San Francisco, Seattle, and Washington, D.C.; and the statewide broadband networks in Colorado, Maryland, and Pennsylvania. She also leads CTC's advisory work regarding federal broadband funding programs such as E-Rate, ReConnect, the Connect America Fund, the Rural Digital Opportunity Fund, and the Healthcare Connect Fund.

Joanne has testified on multiple occasions before Congress on rural broadband, broadband public-private partnerships, and the digital divide, and has provided expert presentations to the Federal Communications Commission, the U.S. Conference of Mayors, the National League of Cities, and other national organizations.

Joanne is also CEO of the Coalition for Local Internet Choice (CLIC) and a member of the boards of directors of the Benton Institute for Broadband & Society, Consumer Reports, and the Fiber Broadband Association. She is a former president of the National Association of Telecommunications Officers and Advisors (NATOA).

Public–Private Partnership Planning and Negotiations

Joanne has spearheaded projects that explore a range of business models by which local and state governments can leverage their assets to build or expand fiber networks, and to incentivize private sector broadband expansion.

- Joanne has provided extensive business planning, market assessment, and strategic planning for the City and County of **San Francisco** over a dozen years. She played a key role in the project team that developed an innovative partnership strategy for deploying a ubiquitous fiber-to-the-premises network. In an earlier project that laid the groundwork for the city's current efforts, Joanne conducted an independent evaluation of the feasibility of San Francisco constructing and operating such a network.

- Joanne advises the State of **Alabama** Department of Economic and Community Affairs regarding Broadband public-private partnerships and planning. She designed the State of **New Mexico** Department of Information Technology's strategy for grant funding of public-private partnerships in rural broadband. She has developed strategy for broadband public-private partnerships for the Departments of Transportation for the state of **Delaware, Nebraska, Texas, and New Mexico**.

- Joanne has been the strategic and business planning consultant to numerous smaller cities as they have planned and negotiated broadband public-private partnerships, including the **city of Tacoma, WA**; **Westminster, MD**; and the **Urbana-Champaign Big Broadband Coalition** (University of Illinois and the cities of Champaign and Urbana). For these projects, she developed strategy to enable the communities to identify a private partner that would finance and operate fiber deployment and expansion. She evaluated potential partners' proposals, then

helped negotiate win-win partnerships that reduce risk to both parties and ensure achievement of economic development and digital inclusion goals.

Business Planning and Feasibility Analysis

Joanne is sought nationwide as an expert in municipal broadband business models and planning. Among the projects she has led are the following CTC engagements:

- Joanne advised the **City of Atlanta** on strategic and tactical approaches it can take to plan, build, and operate its own fiber network to cost-effectively serve its internal needs, promote private sector broadband investment, and enable competition in the City's residential and business broadband markets. She assisted the City in its discussions with telecommunications providers about options for joint build and partnership.

- Joanne advised the **City of Seattle** regarding business planning strategies for a citywide fiber enterprise and facilitating equitable access to wireless broadband services. In her report on citywide fiber, she analyzed the public subsidies a network would require and delivered a full assessment of opportunities and risks. The report included an internal needs analysis, statistically significant market research, an assessment of competing services and technologies, and an evaluation of the business case and financial risks. Joanne led further analysis of the benefits of FTTP beyond the traditional balance sheet, including cost avoidance.

- Joanne advises the **State of New Mexico's Department of Information Technology** on broadband planning. She developed the state's broadband strategic plan and a guidebook for New Mexico's local governments on the business, financial, and strategic planning necessary to implement city- or county-owned broadband networks. The guidebook discusses strategies for exploring public-private partnerships to facilitate broadband expansion.

- Joanne supported the **State of Kansas Department of Commerce** on a needs assessment of the state's network infrastructure. She conducted major market surveys of core sectors across the state (residents, businesses, and community anchor institutions) to evaluate the current uses and needs of broadband infrastructure. She also developed a strategy for the evolution of the state-created broadband program that serves schools, hospitals, libraries, and higher education institutions.

- Joanne has advised officials in the **District of Columbia** government on a range of telecommunications and fiber optic projects for almost a decade. She worked with the Office of the Chief Technology Officer to create a business plan and strategy for building a municipal fiber optic network with a wireless overlay in the least-served wards of the city**.** She performed a business case and technology analysis for DC-Net, a fiber optic telecommunications network that provides voice and data services for the District. She analyzed governmental, educational, and public safety uses of the network.

- Joanne devised a business strategy and wrote a business plan for **KINBER**, the statewide backbone and middle-mile fiber infrastructure focused on the higher education and healthcare sectors in Pennsylvania. One highlight of the KINBER strategy was developing an actionable plan to increase early cash flow.

- Joanne developed a broadband feasibility study for **Garrett County, Maryland**, with a focus on maximizing the benefits and use of the state's grant-funded fiber backbone. That initial analysis led to strategic planning and support for the county's successful Appalachian Regional

Commission grant funding and a pioneering public-private partnership that has deployed TV White Spaces wireless service to unserved rural parts of the county.

Federal Funding and Grant Planning

Joanne's expertise includes the funding opportunities available to local, state, and tribal governments and public-private partnerships through the federal government and other sources. She has guided clients through project planning, application writing, and fund management. Her work on behalf of clients has included successful applications for funding from a range of agencies, including the FCC/USAC, Rural Utilities Service, National Telecommunications and Information Administration, the Appalachian Regional Commission, and the Department of Homeland Security.

Speaking and Advocacy

Joanne is in wide demand as a speaker and expert source on broadband deployment and public–private partnership issues. She has testified before the U.S. Congress on matters of broadband deployment and policy; has been interviewed by publications including *Business Week*, *The Washington Post*, *The New Yorker*, and *The Baltimore Sun*; and has been featured on C-SPAN's "The Communicators."

She has provided expert presentations to the Federal Communications Commission, the U.S. Conference of Mayors, the National League of Cities, the Broadband Communities Summit, Technology Policy Summit, the University of Illinois, Case Western Reserve University, the New America Foundation, and the Congressional Internet Caucus.

EDUCATION
Juris Doctor, **with honors**, University of Chicago Law School, 1994
Bachelor of Arts, **with distinction**, University of Wisconsin, Madison, 1990

ORGANIZATIONS
- Coalition for Local Internet Choice, CEO
- Benton Institute for Broadband & Society, Director
- Fiber Broadband Association, Director
- Consumer Reports, Director
- United States Unified Community Anchor Network, Task Force on Community Anchor Network Economic Models, Charter Member
- National Association of Telecommunications Officers and Advisors, Past President

PRIOR TO COMING TO CTC IN 1997
1996–1997   Litigation/Communications Attorney
         Mintz, Levin, Cohn, Ferris, Glovsky, & Popeo P.C., Washington, D.C.
1994–1996   Litigation Attorney
         Jenner & Block, Chicago

SELECTED PUBLICATIONS
- "Public Infrastructure, Private Service: A Shared-Risk Partnership Model for 21st Century Broadband Infrastructure," published by the Benton Institute for Broadband & Society, October 2020
- "The Broadband Lifeline in a Pandemic: How Your Community Can Quickly Connect the Unconnected," CTC Technology & Energy, April 2020

- "Closing the Digital Divide: Broadband Infrastructure Solutions," Testimony Before the United States House of Representatives Committee on Energy and Commerce Subcommittee on Communications and Technology, January 2018
- "Leaping the Digital Divide: Encouraging Policies and Partnerships to Improve Broadband Access Across North Carolina," co-author, published by the North Carolina League of Municipalities, 2018
- "The Emerging World of Broadband Public–Private Partnerships: A Business Strategy and Legal Guide," co-author, published by the Benton Foundation, 2017
- "The Atomic Age of Data: Policies for the Internet of Things," contributor as participant at the Aspen Institute Conference on Communications Policy, 2015
- "The Art of the Possible: An Overview of Public Broadband Options," published by the New America Foundation, 2015
- "Better Communities through Better Broadband: A Coalition of Public and Private Interests Affirms the Need for Local Internet Choice," Benton Foundation Blog, 2015
- "The Killer App for Local Fiber Networks," *Broadband Communities* magazine, November/December 2014
- "Gigabit Communities: Technical Strategies for Facilitating Public or Private Broadband Construction in Your Community," 2014
- "How communities can facilitate fiber construction," Google Fiber Blog, 2014
- "Facilitating Broadband Construction," *Broadband Communities* magazine, January/February 2014

Andrew Afflerbach, Ph.D., P.E. | CEO and Chief Technology Officer

Dr. Andrew Afflerbach specializes in the planning, designing, and implementation oversight of broadband communications networks, smart cities strategies, and public safety networks. His expertise includes state-of-the-art fiber and wireless technologies, the unique requirements of public safety networks, and the ways in which communications infrastructure enables smart and connected applications and programs for cities, states, and regions.

Andrew has planned and designed robust and resilient network strategies for dozens of clients, including state and local governments and public safety users. He has delivered strategic technical guidance on wired and wireless communications issues to cities, states, and national governments over more than 20 years. He has advised numerous cities and states, including New York City, San Francisco, Seattle, Atlanta, Washington, D.C., and Boston, and served as a senior adviser to Crown Fibre Holdings, the public entity directing New Zealand's national fiber-to-the-home project.

In addition to designing networks, Andrew testifies as an expert witness on broadband communications issues. And he is frequently consulted on critical communications policy issues through technical analyses submitted to the Federal Communications Commission (FCC) and policymakers. He has prepared white papers on:

- Streamlining deployment of small cell infrastructure by improving wireless facilities siting policies
- Limiting interference from LTE-U networks in unlicensed spectrum
- Developing technical frameworks for wireless network neutrality
- Estimating the cost to expand fiber to underserved schools and libraries nationwide
- Conducting due diligence for the IP transition of the country's telecommunications infrastructure

As CTC's Chief Technology Officer, Andrew oversees all technical analysis and engineering work performed by the firm. He has a Ph.D. and is a licensed Professional Engineer.

Wireless Network Planning and Engineering

Applying the current state of the art—and considering the attributes of anticipated future technological advancements such as "5G"—Andrew has developed candidate wireless network designs to meet the requirements of clients including the cities of Atlanta, San Francisco, and Seattle. In a major American city, Andrew led the team that evaluated wireless broadband solutions, including a wireless spectrum roadmap, to complement potential wired solutions.

In rural, mountainous Garrett County, Maryland, Andrew designed and oversaw the deployment of an innovative wireless broadband network that used TV white space spectrum to reach previously unserved residents. To enhance public internet connectivity, Andrew provides technical oversight on CTC's Wi-Fi-related projects, including the design and deployment of Wi-Fi networks in several parks in Montgomery County, Maryland.

Andrew also advises local and state government agencies on issues related to wireless attachments in the public rights-of-way; he leads the CTC team that supports the Texas Department of Transportation (TxDOT) and many large counties on wireless attachment policies and procedures.

Public Safety Networking

Andrew leads the CTC team providing strategic and tactical guidance on FirstNet (including agency adoption and other critical decision-making) for the State of Delaware and Onondaga County, New York. In the District of Columbia, he and his team evaluated the financial, technical, and operational impact of building the District's own public safety broadband network, including the design of an LTE system that provided public-safety-level coverage and capacity citywide. This due diligence allowed the District to make an informed decision regarding opting in or out of the National Public Safety Broadband Network.

Andrew currently is working with the State of Delaware to evaluate LTE coverage gaps throughout the state to assist agencies in their choice of public safety broadband networks. On the state's behalf, he and his team are also conducting outreach to AT&T and other carriers to evaluate their public safety offerings. He is performing similar work as part of CTC's engagement with El Paso County, Colorado.

Earlier, Andrew led the CTC team that identified communications gaps and evaluated potential technical solutions for the Baltimore Urban Area Security Initiative (UASI), a regional emergency preparedness planning effort funded by the U.S. Department of Homeland Security (DHS).

He previously served as lead engineer and technical architect for planning and development of NCRnet, a regional fiber optic and microwave network that links public safety and emergency support users throughout the 19 jurisdictions of the National Capital Region (Washington, D.C. and surrounding jurisdictions), under a DHS grant. He wrote the initial feasibility studies that led to this project for regional network interconnection.

Fiber Network Planning and Engineering

Andrew has architected and designed middle- and last-mile fiber broadband networks for the District of Columbia (Washington, D.C.); the city of San Francisco; the Delaware Department of Transportation; the Maryland Transportation Authority; and many large counties.

He oversaw the development of system-level broadband designs and construction cost estimates for the cities of Atlanta, Boston, Boulder, Palo Alto, Madison, and Seattle; the states of Connecticut and Kentucky; and many municipal electric providers and rural communities. He is overseeing the detailed design of the city-built fiber-to-the-premises (FTTP) networks in Westminster, Maryland; Alford, Massachusetts; and Holly Springs and Wake Forest, North Carolina.

In Boston, Andrew led the CTC team that developed a detailed RFP, evaluated responses, and participated in negotiations to acquire an Indefeasible Right of Use (IRU) agreement with a fiber vendor to connect schools, libraries, public housing, and public safety throughout the City. This approach was designed to allow the City to oversee and control access and content among these facilities.

Smart Grid

Andrew and the CTC team provided expert testimony and advisory services to the Public Service Commission of Maryland regarding Advanced Metering Infrastructure (AMI). CTC provided objective guidance to the staff as it evaluated AMI applications submitted by three of the state's investor-owned utilities (IOUs). This contract represented the first time the PSC staff had asked a consultant to advise them on technology—a reflection of the lack of standards in the Smart Grid arena.

Broadband Communications Policy Advisory Services

Andrew advises public sector clients and a range of policy think tanks, U.S. federal agencies, and non-profits regarding the engineering issues underlying key communications issues. For example, he:

- Provided expert testimony to the FCC in the matter of the preparation of the **national broadband plan** as a representative of the National Association of Counties (NACo) and the National Association of Telecommunications Officers & Advisors (NATOA).
- Served as expert advisor regarding broadband deployment to the U.S. Conference of Mayors, NACo, National League of Cities, Public Knowledge, New America Foundation Open Technology Institute, and NATOA in those organizations' filings before the FCC in the matter of determination of the deployment of a **national, interoperable wireless network in the 700 MHz spectrum**.
- In connection with the FCC's ongoing **Open Internet proceeding**, advised the New America Foundation regarding the technical pathways by which "any device" and "any application" regimes could be achieved in the wireless broadband arena as they have been in the wireline area.
- Provided expert technical advice on the **700 MHz broadband and AWS-3 proceedings** at the FCC for the Public Interest Spectrum Coalition (including Free Press, the New America Foundation, Consumers Union, and the Media Access Project).
- Served as technical advisor to the **U.S. Naval Exchange** in its evaluation of vendors' broadband communications services on U.S. Navy bases worldwide.
- Advised the **U.S. Internal Revenue Service** regarding the history of broadband and cable deployment and related technical issues in that agency's evaluation of appropriate regulations for those industries.
- Advised the Stanford Law School Center for Internet and Society on the technical issues for their briefs in the *Brand X* **Supreme Court appeal** regarding cable broadband.

Broadband Communications Instruction

Andrew has served as an instructor for the U.S. Federal Highway Association/National Highway Institute, the George Washington University Continuing Education Program, the University of Maryland Instructional TV Program, ITS America, Law Seminars International, and the COMNET Exposition. He developed curricula for the United States Department of Transportation.

He taught and helped develop an online graduate-level course for the University of Maryland. He developed and taught communications courses and curricula for ITS America, COMNET, and the University of Maryland. His analysis of cable open access is used in the curriculum of the International Training Program on Utility Regulation and Strategy at the University of Florida.

Andrew has also prepared client tutorials and presented papers on emerging telecommunications technologies to the National Fire Protection Association (NFPA), NATOA, the National League of Cities (NLC), the International City/County Management Association (ICMA), and the American Association of Community Colleges (AACC). He taught college-level astrophysics at the University of Wisconsin.

EMPLOYMENT HISTORY

1995–Present	CEO/Chief Technology Officer, CTC
	Previous positions: Director of Engineering, Principal Engineer, Senior Scientist
1990–1996	Astronomer/Instructor/Researcher
	University of Wisconsin–Madison, NASA, and Swarthmore College

EDUCATION

Ph.D., Astronomy, University of Wisconsin–Madison, 1996
- NASA Graduate Fellow, 1993–1996. Research fellowship in astrophysics
- Elected Member, Sigma Xi Scientific Research Honor Society

Master of Science, Astronomy, University of Wisconsin–Madison, 1993
Bachelor of Arts, Physics, Swarthmore College, 1991
- Eugene M. Lang Scholar, 1987–1991

PROFESSIONAL CERTIFICATIONS/LICENSES

Professional Engineer, states of California, Delaware, Georgia, Illinois, Maryland, and Virginia

HONORS/ORGANIZATIONS
- Disaster Response and Recovery Working Group, FCC's Broadband Deployment Advisory Committee (BDAC)
- Association of Public-Safety Communications Officials (APCO)
- Board of Visitors, University of Wisconsin Department of Astronomy
- National Association of Telecommunications Officers and Advisors (NATOA) Technology and Public Safety Committees
- Armed Forces Communications and Electronics Association (AFCEA)
- Society of Cable and Telecommunications Engineers (SCTE)
- Institute of Electrical and Electronic Engineers (IEEE)
- Charleston Defense Contractors Association (CDCA)

SELECTED PUBLICATIONS, PRESENTATIONS, and COURSES
- "The Broadband Lifeline in a Pandemic: Strategies for Provisioning Fast Internet Service to the Most Remote Rural Areas," March 2020
- "The Broadband Lifeline in a Pandemic: Strategies for Provisioning Broadband to Temporary Emergency Sites," March 2020
- "The Broadband Lifeline in a Pandemic: How Your Community Can Quickly Deploy Free Wi-Fi to Meet Urgent Needs at Public Housing and Other Locations," March 2020
- "Small Cell Standards and Processes: Protecting Community Assets, Interests, and Public Safety," prepared for NATOA, Feb. 2019
- "SB 937: Wireless Facilities – Installation and Regulation," Testimony before the State of Maryland Senate, Feb. 2019
- "HB 654: Wireless Facilities – Installation and Regulation," Testimony before the State of Maryland General Assembly, Feb. 2019
- "The Three "Ps" of Managing Small Cell Applications: Process, Process, Process," Dec. 2018

- Declaration in Response to FCC's Order, "Accelerating Wireless Broadband Deployment by Removing Barriers to Infrastructure Investment," prepared for the Smart Communities and Special Districts Coalition, filed with the FCC, Sept. 2018
- Declaration in Response to the Proposed T-Mobile/Sprint Merger, prepared for the Communications Workers of America, filed with the FCC, Aug. 2018
- "A Model for Understanding the Cost to Connect Anchor Institutions with Fiber Optics" (co-author), prepared for the Schools, Health & Libraries Broadband Coalition, Feb. 2018
- "How Localities Can Prepare for—and Capitalize on—the Coming Wave of Public Safety Network Construction," Feb. 2018
- "Network Resiliency and Security Playbook" (co-author), prepared for the National Institute of Hometown Security, Nov. 2017
- "Mobile Broadband Service Is Not an Adequate Substitute for Wirelines" (co-author; addressing the limitations of 5G), prepared for the Communications Workers of America, Oct. 2017
- "Technical Guide to Dig Once Policies," April 2017
- "Streamlining Deployment of Small Cell Infrastructure by Improving Wireless Facilities Siting Policies," prepared for the Smart Communities Siting Coalition, filed with the FCC, March 2017
- "How Localities Can Improve Wireless Service for the Public While Addressing Citizen Concerns," Nov. 2016
- "LTE-U Interference in Unlicensed Spectrum: The Impact on Local Communities and Recommended Solutions," prepared for WifiForward, Feb. 2016
- "Mobile Broadband Networks Can Manage Congestion While Abiding by Open Internet Principles," prepared for the New America Foundation's Open Technology Institute – Wireless Future Project, filed with the FCC, Nov. 2014
- "The State of the Art and Evolution of Cable Television and Broadband Technology," prepared for Public Knowledge, filed with the FCC, Nov. 2014
- "A Model for Understanding the Cost to Connect Schools and Libraries with Fiber," prepared for Schools, Health & Libraries Broadband Coalition, filed with FCC, Oct. 2014
- "The Art of the Possible: An Overview of Public Broadband Options," prepared jointly with the New America Foundation's Open Technology Institute, May 2014
- "Understanding Broadband Performance Factors," with Tom Asp, *Broadband Communities* magazine, March/April 2014
- "Engineering Analysis of Technical Issues Raised in the FCC's Proceeding on Wireless Facilities Siting," filed with the FCC (http://apps.fcc.gov/ecfs/document/view?id=7521070994), Feb. 2014
- "A Brief Assessment of Engineering Issues Related to Trial Testing for IP Transition," prepared for Public Knowledge and sent to the FCC as part of its proceedings on Advancing Technology Transitions While Protecting Network Values, Jan. 2014
- "Gigabit Communities: Technical Strategies for Facilitating Public or Private Broadband Construction in Your Community," prepared as a guide for local government leaders and planners (sponsored by Google), Jan. 2014
- "Critical Partners in Data Driven Science: Homeland Security and Public Safety," submitted to the *Workshop on Advanced Regional & State Networks (ARNs): Envisioning the Future as Critical Partners in Data-Driven Science*, Internet2 workshop chaired by Mark Johnson, CTO of MCNC, Washington, D.C., April 2013
- "Connected Communities: How a City Can Plan and Implement Public Safety & Public Wireless," submitted to the International Wireless Communications Exposition, Las Vegas, March 2013
- "Cost Estimate for Building Fiber Optics to Key Anchor Institutions," prepared for submittal to the FCC by NATOA and SHLB, Sept. 2009

Matthew DeHaven | V.P., Fiber & Infrastructure

Matthew DeHaven specializes in wired and wireless communications and broadband telecommunications technology for public safety and other local government and institutional needs. He has 20 years of engineering experience designing, developing, installing, and overseeing construction and integration of middle-mile and fiber-to-the-premises (FTTP) networks. His work focuses on local and wide area networks for institutional, public safety, and Intelligent Transportation System (ITS) applications.

Matt has experience at many levels of wired and wireless network design, procurement, and implementation for high-capacity metropolitan-area networks. He leads network designs and the preparation of specifications for competitive bid processes and serves as project manager overseeing implementation and testing for a wide range of CTC's local and state government clients.

Matt also prepares designs and cost models to support decision-makers in the deployment of a range of wireless and wireline data network technologies. He serves as CTC's lead engineer on numerous wide area network projects. Among many other projects, he served as a primary technical architect for the 19-jurisdiction fiber optic/microwave network deployed in the National Capital Region (NCRnet) to support public safety interoperable communications.

Wireless Communications

Applying the current state of the art—and considering the attributes of anticipated future technological advancements such as "5G"—Matt has developed candidate wireless network designs to meet the requirements of clients including the cities of Atlanta, San Francisco, and Seattle. In a major American city, he supported the CTC team that evaluated wireless broadband solutions, including a wireless spectrum roadmap, to complement potential wired solutions.

Matt assesses clients' existing and projected communications needs and recommends potential strategies for using established and emerging wireless technologies to enhance and improve network operations and services. Some select examples of his ongoing and past projects include:

- Overseeing the Delaware Department of Transportation's (DelDOT) deployment of a 4.9 GHz point-to-multipoint wireless network for traffic device interconnection and public safety communications. That high-speed, high-capacity wireless deployment connects DelDOT's fiber network to critical and high-bandwidth devices located in remote areas unserved by fiber.

- Developing the wireless engineering elements of broadband deployment feasibility analyses for the City of Baltimore and other major American cities.

- Developing a strategic plan for a wireless data network to meet public safety and local government needs in Seattle, WA. CTC previously conducted a feasibility study that identified these needs.

- Providing engineering support for the deployment of a citywide 4.9 GHz public safety radio mesh network for the City of Port Angeles, WA. CTC conducted a needs assessment of the city's network and reviewed public safety mobile data communications considerations, which led to the development of network specifications and overseeing the procurement for the expansion of the city's fiber network and a citywide wireless network serving both public safety and public access needs.

- Assessing the city of Cincinnati's networks and recommending updates to the city's long-term strategic plan. This project involved assessing and identifying new department and network application needs, assessing the current networks to meet identified needs, assessing emerging fiber and wireless technologies, recommending wireless strategies, and providing recommendations and strategies for meeting foreseeable needs.

- Designing a broadband wireless network for Annapolis, MD, that provides connectivity for a citywide video surveillance system. The network was designed to provide high-degrees of security and has substantial reserve capacity to support the addition of new video requirements, expand toll-quality IP-based voice and data services, and, potentially, provide backhaul for a future mobile wireless solution.

- Overseeing the development of an infrastructure plan to support the implementation of Wi-Fi services throughout a downtown area targeted for economic development in Rockville, MD. The plan focuses on deploying a flexible architecture of physical support infrastructure to enable a wide range of wireless connectivity options for visitors, residents, and business tenants while maintaining the aesthetics of the development.

- Researching current and future wireless technologies and evaluating the feasibility of implementing a secure public safety wireless network in Prince George's County, MD. Designed and implemented a pilot project to test the feasibility of a public safety network. A successful solution was deployed to enable Mobile Data Computers in emergency response vehicles to securely roam from a carrier CDMA network to private, County-operated Wi-Fi hotspots.

Public Safety Networking

In addition to supporting the design and deployment of NCRnet, Matt is the lead engineer responsible for one of the key applications leveraging this regional network. Matt is responsible for the design, implementation, and ongoing operations of a regional videoconferencing network supporting Emergency Management among the 21 jurisdictions in the National Capital Region (DC, MD, VA). CTC developed the systems' designs and oversaw implementation under a grant from the Department of Homeland Security Urban Areas Security Initiative (UASI). This network now serves thousands of end users, integrated tightly with the ever-growing videoconferencing and VoIP systems leveraged by these jurisdictions.

In Anne Arundel County, MD, Matt assisted with the deployment of traffic surveillance cameras. He provided analysis of candidate technical solutions for cameras using the County's high-speed fiber-optic I-Net to transport video and control signals, developed system specifications, and oversaw the implementation of the County's video surveillance capabilities.

Matt was also involved in the planning and implementation of a statewide network in Delaware that provides traffic information and traffic control capabilities to transportation management facilities. Such a network allows remote control of traffic signal systems and variable message displays, while providing real-time traffic surveillance in the form of video images and microwave sensor data. He has developed expertise in the numerous forms of technology used in this type of project, ranging from fiber optics to wireless digital spread-spectrum communications.

Matt served as CTC's lead engineer for the Delaware Department of Transportation's Advanced Traffic Advisory Radio System, the first Advanced TARS system in the country. He trained on-site staff, specified and installed new equipment, and monitored system performance.

Fiber-to-the Premises
Matt has assisted in the planning and deployment of dozens of FTTP networks for public sector clients, providing expertise in varying roles from the development of system-level designs and cost estimates to detailed engineering and construction oversight. He led the engineering team responsible for the design of a rural FTTP network in southern Anne Arundel County, Maryland, to serve more than 600 homes within a previously unserved neighborhood. He is currently managing the engineering designs and overseeing construction for an FTTP network in Westminster, Maryland, comprised of approximately 80 route miles of fiber plant to serve more than 6,000 residential and business passings.

Inter-County Broadband Network
Originally serving as part of the grant application development team that successfully led the State of Maryland to a $115 million Broadband Technology Opportunities Program (BTOP) administered by the National Telecommunications and Information Administration (NTIA), Matt served as the Portfolio Manager for the One Maryland Inter-County Broadband Network (ICBN) BTOP grant project.

The ICBN is a nine-jurisdiction consortium in central Maryland led by Howard County, Maryland, and was a key sub-recipient of the State's grant award. Matt served as the lead technical consultant overseeing the use of approximately $72 million in grant funds to build over 800 miles of fiber optics and directly connect approximately 650 community anchor institutions, including schools, libraries, government buildings, community colleges, and public safety agencies. Matt was tasked with overseeing numerous engineering and construction contractors, as well as playing a key role in overall network design during this aggressive three-year endeavor.

Video and Unified Communications Engineering
Matt's experience includes the management, design, and procurement of video, voice, and data networks. Some select examples of his recent project work include:

- System-level design and procurement support for the deployment of a multi-tenant unified communications network for Harford County, MD. The network supports approximately 3,000 users across all County agencies, Libraries, and Schools.

- Development, implementation, and continued support of videoconferencing and unified communications tools for the 21 jurisdictions in the National Capital Region (DC, MD, VA) Emergency Operations Centers (EOCs) and Emergency Communications Centers (ECCs) over a state-of-the-art fiber-optic and microwave network.

- Preparation of system-level design recommendations and cost estimates for an extensive, countywide system to support interactive and on-demand video training communications for the Anne Arundel (MD) County Fire Department. CTC also developed the design for a video display system for the Fire Department's new dispatch center, intended to allow key sources of information to be prominently displayed throughout the facility.

- Preparation of system-level design recommendations and cost estimates for an extensive, citywide system to support interactive and on-demand video communications for training, emergency collaboration, and routine meetings between Mesa, AZ Fire Department personnel. CTC also integrated a pilot videoconferencing system to demonstrate certain capabilities of the system design.

- Development of a videoconferencing system for homeland security applications on behalf of Arlington County, VA—the site of the September 11th Pentagon attack. The system links numerous public safety and other government users and aims to ensure uninterrupted emergency communications in the event of a terrorist attack or natural disaster.

Instruction/Expertise

Matt led the CTC research team that prepared Web-based Intelligent Transportation System (ITS)-Communications courses on behalf of the University of Maryland Center for Advanced Transportation Technology. He served as an online instructor for these courses for more than six years.

Matt has also provided expert technical witness reports and testimony in connection with litigation related to a large commercial carrier's failure to complete construction of a citywide fiber network in a major North American city.

EDUCATION

The Johns Hopkins University, 1996 – 2000

Heather Mills | V.P., Grant & Funding Strategies

Heather Mills has more than a decade of experience in project management and data analysis. She has exceptional skills in long-term strategic planning for broadband funding; execution of complex tactical funding plans; and grant administration, budgeting, and financial reporting. Heather leads the CTC team the develops grant funding strategies and delivers tactical application and post-award support to our public sector clients. She has authored guidance on new and emerging federal broadband funding programs that is highly regarded by industry colleagues.

At CTC, Heather guides clients on strategic funding for network planning, as well as applying for and complying with the requirements of major federal broadband and communications grant programs, including ARC/EDA POWER grants, USDA RUS grants (such as ReConnect and Community Connect), and New Market Tax Credits. She has particular expertise in the Federal Communications Commission's E-Rate program, Lifeline program, and Healthcare Connect Fund.

Heather and her team supported several clients in the past year with applications to the U.S. Department of Commerce's EDA Public Works and Economic Adjustment Assistance program for funding related to COVID relief; she guided clients in many parts of the country through the consultation process with EDA regional representatives. Under Heather's management, the CTC team supported clients with strategy and navigation of the USDA ReConnect application process through Round 1 and Round 2, which required detailed understanding of the application and applied strategy.

Heather currently is advising clients on new federal funding programs such as the FCC's Emergency Broadband Benefit and the NTIA's COVID stimulus programs, while keeping a close eye on and providing singular analysis for clients around funding programs created by the 2021 Consolidated Appropriations Act and the American Rescue Plan Act.

Heather has provided strategic guidance and prepared ARC/EDA POWER grant pre-applications for CTC's public sector clients. She also prepared a FirstNet grant application for the District of Columbia's Office of the Chief Technology Officer; following the award, she provided ongoing grant management services to help the District maximize the benefits of the funding.

Over the past few years, Heather wrote an E-Rate program guidebook, prepared client responses to E-Rate RFPs, oversaw and advised on the strategy and development of RFPs for library and school clients applying for E-Rate, and helped a hospital association develop a consortium-based approach to the Healthcare Connect Fund.

Heather previously led the CTC team that researched and wrote a successful federal Environmental Assessment (EA) and addenda for the $115 million One Maryland Broadband Network (OMBN) project—a Broadband Technology Opportunities Program (BTOP) grantee. Following submission of the EA, she coordinated required consultations for the EA and addenda over a period of several months. Similarly, she wrote and coordinated consultations for an EA on behalf of the State of Maryland's Department of Natural Resources when that agency sought to construct a radar support tower on state land.

EDUCATION
Master of Science, Management, University of Maryland University College, 2012
Master of Arts, Political Science, Washington State University, 2002
Bachelor of Arts, English Literature/Pre-law, Washington State University, 2000

Ziggy Rivkin-Fish, CGEIT | V.P., Broadband Strategy

Ziggy Rivkin-Fish has been an analyst and project manager with CTC since 2005. Mr. Rivkin-Fish has managed multiple federal-grant-funded interoperability projects that interconnect jurisdictional communication networks. He has also applied his management, technical, and governance expertise to the implementation of large-scale network infrastructures, as well as developing governance frameworks to manage both small and large public broadband networks. His background in organizational sociology and certification in Governance of Enterprise IT has enabled him to advise multiple clients on structuring themselves to manage IT departments and fiber optic network services.

In addition to his work on government network interconnections and governance consulting, Mr. Rivkin-Fish has played key roles in other large-scale projects, such as by overseeing the preparation of successful Environmental Assessments (EA) for major BTOP-funded networks including the One Maryland Broadband Network (OMBN) and the Urbana-Champaign Big Broadband (UC2B) fiber optic network, enabling the projects to proceed to the construction phase. Mr. Rivkin-Fish then oversaw the preparation of required addenda to the OMBN and UC2B EAs to address project revisions during the construction phase. In addition, Mr. Rivkin-Fish advised on the preparation of an EA for the State of Maryland Department of Natural Resources to enable construction of a radar support tower on state land.

Notably, Mr. Rivkin-Fish has served as the lead manager for all phases of deployment of NCRnet, the interoperable public safety communications network that interconnects 20 jurisdictions in the National Capital Region around Washington, D.C. Mr. Rivkin-Fish's role with NCRnet includes oversight of fiber optic design, procurement, and implementation to network design, governance development, construction oversight, network operations, and long-term sustainment. Mr. Rivkin-Fish has also ensured project compliance with grant regulations, including environmental and procurement requirements. Currently, Mr. Rivkin-Fish is focused on facilitating public safety applications rollouts on NCRnet, as well as engineering feasibility studies and oversight roles for fiber optic and wireless extensions to new client.

Mr. Rivkin-Fish's accomplishments include a full fiber optic network feasibility study, including a governance roadmap for the city of Highland Park, Illinois, which enabled the city to decide between ownership models and methods of operational governance. Most recently, he conducted a large organizational governance study for Montgomery County FiberNet to advise the County both on executive governance and on operational organization and business process improvement. He has consulted on governance frameworks for Commonwealth of Kentucky, Harford County IT Department, and City of Vancouver. For Vancouver and for City of Vallejo, he also consulted on joint trenching policies and business process improvement. Alongside his work on NCRnet, Mr. Rivkin-Fish also continues to advise public interest oriented networks on governance at all phases of deployment and operation.

Mr. Rivkin-Fish is currently following up the FiberNet organizational governance study with a project facilitating the development and implementation of key performance indicators aligned to the report's recommendations and guidance by the governing board. He is also managing outside plant and network engineering support projects in Montgomery County, overseeing fiber optic and application projects for NCRnet, and consulting for municipal and regional interconnection networks.

EDUCATION
Master of Arts, Sociology, Princeton University, 2000
Bachelor of Arts, Individualized Major in Social Theory, Rutgers University (4.0 GPA)

RELEVANT PUBLICATIONS
"FCC's Rural Digital Opportunity Fund Auction Was Supposed to Significantly Reduce America's Rural Broadband Gap" *Benton Institute for Broadband & Society.* 2020. https://www.benton.org/blog/fccs-rural-digital-opportunity-fund-auction-was-supposed-significantly-reduce-americas-rural

"NCRnet: How the National Capital Region is Building a 21st Century Regional Public Safety Communications Network" *NATOA Journal* 15(4):16-18. 2007.

CERTIFICATIONS
Certified in the Governance of Enterprise IT (CGEIT) certification, 2015

Marc Schulhof | Principal Analyst and Director of Editorial Services

Marc Schulhof has more than 25 years of experience in technical writing, financial journalism, and public and corporate communications. As an analyst and editor, he plays an integral role in developing CTC's client deliverables, including:

- Strategic and master plans (business and engineering)
- Needs assessments
- Feasibility studies
- Requests for proposal (RFP) and requests for information (RFI)
- Survey instruments
- Expert witness testimony
- Federal and regional grant applications
- Wireless facility siting reports
- E-rate RFPs and bids
- Research reports
- White papers

Over the course of his nine years as CTC's senior technical writer, Marc has supported dozens of CTC clients—including the District of Columbia, the states of Connecticut, Delaware, Kentucky, Maryland, and New Mexico, and the cities of Atlanta, Boston, New York, Palo Alto, San Francisco, and Seattle. He has collaborated on white papers on topics related to fiber optic and wireless technologies, including technical reports filed with the Federal Communications Commission. He is the co-author, with CTC President Joanne Hovis, of "The Emerging World of Broadband Public–Private Partnerships: A Business Strategy and Legal Guide."

Prior to joining CTC, Marc was the worldwide editor-in-chief of CIO program websites at IBM, where he established editorial direction for 36 country-specific CIO websites and worked with local editors to update each site's mix of multimedia content. He also wrote and edited feature articles and white papers on information technology and business topics.

Earlier, as a global editor at PricewaterhouseCoopers Consulting, Marc wrote and edited reports on a variety of technology and business topics. He served as daily editor of the PwC-sponsored *BusinessWeek Online Handheld Edition,* a news summary service for mobile device users in the pre-smartphone era. Marc began his career at *Kiplinger's Personal Finance Magazine, where* he researched, analyzed, and wrote about a range of complex financial issues, first as a reporter and later as an associate editor.

EDUCATION
Master of Science, Journalism, Northwestern University
Bachelor of Science, Journalism, Northwestern University

David Talbot | Director of Research Services

David Talbot joined CTC from the Berkman Klein Center for Internet & Society at Harvard University, where, as a fellow researching community networks, he convened local leaders and wrote case studies about municipal fiber business models, paybacks, and pricing.

Dave currently is serving as CTC's project manager for an I-Net replacement feasibility study for the Town of Milton, Mass., and as CTC's local point of contact for fiber strategic planning for Norwich Public Utilities and Hingham Municipal Lighting Plant. He is also supporting other CTC clients around the country on policy studies and other reports.

A resident of Reading, Massachusetts, he is currently **chairman of the Reading Municipal Light Department Board of Commissioners**, giving him practical experience in local government and municipal utility governance and management.

Previously, as chief correspondent at *MIT Technology Review*, the magazine and website owned by MIT, he frequently wrote about internet policy topics, emerging communications technologies, and digital divide issues.

David's research projects at the Berkman Klein Center included the following:

- *Community-Owned Fiber Networks: Value Leaders in America* documented that most U.S. municipal FTTH networks offer lower and clearer prices than do incumbents when considering basic broadband service.

- *Enabling Competition & Innovation on a City Network* profiled Ammon, Idaho's open-access business model, which uses a lit fiber network and virtualization and is expanding based on neighborhood demand.

- *Smart Grid Paybacks: The Chattanooga Example* concluded that the well-known Chattanooga, Tennessee, network was sustainable thanks to utility savings and revenue even without the $111 million federal stimulus it received.

- *Citizens Take Charge: Concord, Massachusetts Builds a Fiber Network* profiled the long-running effort of a Boston suburb to build a smart grid and FTTH network and overcome industry resistance.

- *Holyoke: A Massachusetts Municipal Light Plan Seizes Internet Access Business Opportunities* profiled the long-running effort of a western Massachusetts mill city to build a city network and then expand into serving and consulting for other municipalities.

David's earlier background is in newspaper and magazine journalism, covering stories at the nexus of government and technology and a wide range of energy technologies and climate science. His past projects include:

- *The Unacceptable Persistence of the Digital Divide,* profiling efforts to end the digital divide in Cleveland, Ohio, through a variety of emerging technologies and programs.

- *The Great German Energy Experiment,* a deep dive on Germany's Energiewende, the national effort to greatly ramp up renewable power and smart grid technologies

- *How Obama Really Did It*, a look at the social networking technologies and startup companies that played a role in the 2008 election of Barack Obama

- *The Internet is Broken*, a review of fundamental internet architecture research sponsored by the National Science to address issues of security, privacy and resilience.

- *China's Internet Paradox*, an examination of China's censorship regime and development of China-centric e-commerce and other internet technology companies.

- *Saving Holland,* a feature on the urban planning and modeling efforts and communication technologies aimed at protecting the Netherlands from rising sea levels and floods related to climate change.

Previously, as chief correspondent at *MIT Technology Review*, the magazine and website owned by the Massachusetts Institute of Technology, he frequently wrote about internet policy topics and emerging communications technologies.

EDUCATION
Knight Science Journalism Fellow, Massachusetts Institute of Technology

BA, English, Colgate University, Hamilton, NY

Shawn Thompson | V.P., Analytics

Shawn Thompson is a recognized expert in wireless engineering, radio propagation, and issues related to wireless siting in the public rights-of-way and on private property. He has overseen the design and implementation of more than 1,000 distributed antenna systems nationwide, and has advised wireless carriers such as Sprint, Verizon, and AT&T in solving their indoor coverage and capacity needs.

Shawn manages the CTC teams that provide ongoing wireless facility siting application review services to Montgomery and Prince George's counites in Maryland, and Fauquier and Louisa counties in Virginia. He is also supporting the State of Texas Department of Transportation (TxDOT) on strategic planning and the development of standards for its wireless facility siting program. Shawn's expertise includes strategic approaches that local governments can take to address the FCC's 2018 preemption Order.

Among his recent client engagements, Shawn led the CTC team that designed a neutral-host distributed antenna system (DAS) network to enable the government of the **District of Columbia** to use its citywide fiber to distribute wireless signals. He then worked with the District to develop a program for installing commercial, public safety, and Wi-Fi wireless systems in its key facilities. This $10 million, five-year program will improve wireless communications in as many as 60 city-owned buildings.

Additionally, Shawn assisted the District in developing a strategy for the use of small-cell technology, in which cellular carriers use poles and rooftops owned by municipalities to increase the density of their high-speed 4G LTE networks and deliver better service. This sector promises to be a growth area, as more and more carriers approach municipalities to negotiate terms of usage. Shawn helped the District move to the forefront of cellular deployment technology by developing a plan for standardizing equipment and space utilization for hundreds of proposed wireless facility sites. Shawn's plan will allow the city to maximize profits, reuse sites efficiently, and maintain sites more easily. His work will also benefit the area's cellular carriers and citizens by paving the way for streamlined cooperation between the municipal government and the carriers to maximize wireless facility deployments and create denser coverage.

Shawn helped the **cities of Boulder, Colorado,** and **Newark, Delaware,** evaluate technical and operational options for deploying an outdoor Wi-Fi network in the downtown area and parks.

Technical Background
Indoor Propagation Theory
Shawn was an early pioneer (2003–2005) in educating the industry against the use of coffee cup design (i.e., the idea that RF travels a uniform distance from a radiating point). Rather the partitions within buildings greatly affect the propagation patterns, and therefore RF power levels, antenna types, and intended density need to be considered in each building.

He collected data from multiple types of indoor environments to improve the published equations for indoor RF propagation. Specifically, he has made improvements to modeling RF propagation in environments such as industrial, retail, hospital, and airport venues.

Shawn has also furthered the understanding of antenna density and types within different types of environments. He has shown that the typical omni-directional antenna may not be appropriate for many newer high-capacity wireless systems. Shawn has demonstrated through various stadium designs that

precisely controlling the antenna beam-width patterns can have dramatic impact on throughput because of the antennas' sensitivity to noise and unwanted signals.

High-Capacity Design
Shawn has developed solutions for the ever-growing capacity needs in public venues such as stadiums, arenas, and airports. Working with manufacturers and carriers, he has participated in developing solutions that deliver high-speed data to users in these ultra-dense environments. In particular, Shawn's innovative sector-driven design approach using distributed antenna systems is driving a complete revamping of the existing systems in stadiums across the country. Among the stadiums on which Shawn worked are First Energy Stadium and Progressive Field in Cleveland; PNC Park in Pittsburgh; the Verizon Center in Washington, D.C.; and stadiums at the University of Montana and the University of Wyoming.

Program/Project Management
As an early leader in distributed antenna system design, Shawn collaborated with industry groups, wireless carriers, and manufacturers to develop several industry best practices. He assisted industry manufacturers in developing a grounding methodology that could be used as a template for the installation of DAS systems. The solution needed to be vetted and agreed upon by installation contractors, manufacturers, and carriers.

In 2012, working with Verizon Wireless on LTE DAS upgrades, Shawn developed a system through which Verizon could easily collect information across a region (usually several states) at existing sites, to determine a rough order of magnitude to upgrade these sites with 4G LTE service. This was executed in blocks of 100 projects. Also in 2012, he developed methodologies to use "The Last Planner" project management system across large DAS deployments.

Shawn also contributed to the understanding and practicality of passive intermodulation (PIM) testing within low-power RF antenna systems. He successfully negotiated compromise between construction-side concerns and carrier-demanded closeout policies by assembling leaders across various disciplines and developing a policy white paper.

EMPLOYMENT HISTORY
Henkels & McCoy   2011 – 2013
Associate Director, Wireless Solutions
Manager, Engineering and Design

In-Building-Wireless, *Co-Founder and CEO*   2004 – 2011

Applied Communications Technology, Inc., *Founder and President*   1999–2004

EDUCATION
Bachelor of Science, Computer and Information Science, University of Maryland University College, 2016
Master of Science, Data Analytics, University of Maryland University College, 2018

Karen J. White | V.P., Client Solutions

Karen White has more than 25 years of experience in municipal, commercial, and public safety telecommunications. Her background includes the planning, design, procurement, and implementation of wireless and wired broadband systems and small cells; public safety land mobile radio (LMR) communications systems; FirstNet systems and business case analysis; project management; and engineering management in the wired and wireless LMR, public safety wireless broadband, and municipal broadband markets. She also has extensive experience in communications software engineering management, requirements analysis, design, and development.

Karen has served as project manager, technical and policy advisor, and business analyst for many high-profile, multi-million-dollar communications systems projects for states, municipalities, and large transit clients including the States of Georgia, New Mexico, Texas, and Delaware, and the District of Columbia. These projects included technology assessments, client requirements discovery, alternatives analysis, system design, system procurement, and implementation tasks. Karen is very familiar with federal, state, and local policy and funding affecting broadband communications, including FCC orders and broadband support programs, and USDA, NTIA, EDA, CISA, and other federal and state funding programs.

As a member of SAFECOM, under the Department of Homeland Security's Cybersecurity and Infrastructure Security Agency (CISA), Karen represents the National Association of Telecommunications Officers and Advisors. She supports SAFECOM's mission to collaborate with emergency responders and elected officials to improve emergency communications interoperability. Karen has contributed to numerous SAFECOM products and has supported the direction of the committee. Karen is also an executive member of the National Public Safety Telecommunications Council as the Council's Technology and Broadband Committee's chair.

AREAS OF SPECIALIZATION
- Wireless and fiber networks
- Voice and data network design
- Strategic planning
- Needs assessment
- Solution development
- Technology evaluations (LTE, LMR)
- Small cells
- Fiber and wireless facility policy, design standards, and permit application processing
- Public safety voice and broadband networks including FirstNet
- Systems and software project management
- Radio system subscriber software design and development

CTC Technology & Energy   2016 – present
Project Manager and Principal Analyst
State of Georgia – Georgia Technology Authority and Department of (DOE) – K-12 Connectivity - Project Manager
- Primary point of contact for client throughout engagement; coordinate technical team to develop deliverables

- Develop and oversee execution of location identification program to find viable commercial carrier outdoor hotspots to support service to students throughout the state
- Issue tracking and resolution support for problems arising during the DOE's commercial carrier hotspot (WiFiRanger) deployment working with the school districts, carriers, and hotspot access program provider
- Oversee development of and contribute to fixed wireless network study
- In-depth research of potential spectrum, including CBRS, EBS, TV white space, and other unlicensed spectrum for fixed LTE wireless network use throughout the state and in particular counties
- Develop high-level data dashboard illustrating project status

State of New Mexico Department of Transportation – NMDOT Broadband Technical and Business Analysis - Project Manager and Principal Analyst/Engineer
- Primary point of contact for client throughout engagement; coordinate technical team to develop deliverables
- Oversee and contribute to development of a high-level statewide broadband network design to serve NMDOT operational needs
- Work closely with NMDOT to review broadband infrastructure provider proposals and develop negotiations points to potential engagement
- Develop process for NMDOT right-of-way (ROW) access permitting/agreements
- Develop ROW access permitting documentation including application form, design standards, and support for terms and conditions
- Develop mapping tools to capture existing assets and future desired assets to be connected by an NMDOT-owned operational network
- Participate in discussions with tribal representatives to outline tribe and pueblo broadband infrastructure needs

State of New Mexico Department of Information Technology (DoIT) – Statewide Strategic Broadband Plan - Project Manager and Principal Analyst
- Primary point of contact for client throughout engagement; coordinate technical team to develop deliverables
- Oversee and contribute to development of a high-level statewide broadband network models that would serve unserved locations throughout the state
- Oversee and contribute to the development of New Mexico's statewide strategic broadband plan
- In close concert with DoIT, develop successful $1.5 million federal Economic Development Administration grant application for technical assistance

Texas Department of Transportation (TxDOT) Small Wireless Facility Implementation – Project Manager and Principal Analyst
- Primary point of contact for client throughout engagement; coordinate legal/engineering/policy team to develop numerous deliverables and attend industry interface and other meetings with the client
- Conduct existing process and systems analysis and develop gap analysis between current state and desired future state
- Conduct interviews with carriers regarding needs, processes; collect and analyze attachment forecasts

- Advise client extensively on impact of FCC orders and other laws/regulations regarding small cells
- Research municipal and other state DOT processes including the relationship between municipalities and DOTs when DOT ROW is within municipal boundaries
- Support the development of design standards for wireless siting/small cell attachments on poles and other structures
- Develop revamped wireless siting lease/permit application processes for TxDOT internally and for applicants
- Support overhaul of Master Lease Agreement and Individual Site lease Agreements
- Cost analysis of application process and oversight requirements to establish a justifiable ROW rental fee basis
- Develop master plan

City of Boston Fiber Network Procurement and Implementation – Project Manager and Principal Analyst
- Primary point of contact for City, responsible for managing project resources and accountable for budget
- Manage collection of outside plant and inside plant site information for close to 200 sites
- Dark fiber IRU agreement review and contract negotiations support
- Design and oversee the development of a site information repository database documenting OSP and ISP data enabling the City to run quick reports on close to 200 sites
- Manage the procurement of a conduit construction vendor
- Support the implementation of a 30-year dark fiber IRU deployment for close to 200 sites
- Analyze City's fiber management operations and fiber resource management tools

District of Columbia Public Safety LTE Network/FirstNet Support – Project Manager and Principal Analyst
- Prepare report in close conjunction with the District to inform the Mayor's decision to opt in or opt out of the National Public Safety Broadband Network
- Oversee the conceptual design of a District-wide LTE radio access network (RAN) considering coverage, capacity and backhaul requirements
- Develop a financial model including both capital and operating expenses to determine the financial feasibility of the District owning, building and/or managing a District RAN
- Develop a Request for Information and Request for Proposals for an Alternative District Alternative RAN. Evaluate responses to inform the Mayor's decision
- Develop a FirstNet State Plan Portal evaluation matrix and evaluation plan/process
- Participate as a primary State Plan Portal evaluator and trusted adviser during FirstNet/AT&T consultations

State of Delaware Public Safety LTE Network/FirstNet Support – Principal Analyst
- Work closely with state public safety stakeholders to evaluate the FirstNet State Plan Portal
- Participate as a primary State Plan Portal evaluator and trusted adviser during FirstNet/AT&T consultations including several meetings with FirstNet and AT&T to discuss site deployment, policy, services, and costs
- Complete State and Local Grant Implementation Program (SLIGP) 2.0 grant application which required FirstNet-related program planning for 2 years including detailed budget breakdown and investment justifications

- Developed commercial carrier outdoor and in-building performance evaluation plan for assessing and comparing carriers that provide public safety services within the state
- Research current data sharing, interoperability, and other related policy processes; advise on and document new processes and policies

State of Kansas Statewide Interoperable Communications System Valuation Study – Principal Analyst
- Develop book value and commercial value of the 80+-site public safety network
- Work with team to develop long-term sustainable funding options and identify alternative management options
- Research and analyze state and federal statutory and regulatory constraints to sell, lease or transfer the management of the system in part or in whole
- Prepare in-depth report and support the presentation of findings and recommendations to the client

City of Atlanta Fiber Broadband Buildout Support – Project Manager and Principal Analyst
- Primary point of contact for City, responsible for managing project resources and accountable for budget
- Review current status of Citywide fiber buildout and begin strategic planning
- Review existing franchise agreements and assess potential modifications

City of Boulder, Colorado, Fiber Backbone and FTTP Engineering and Financial Studies – Project Manager
- Primary point of contact for City, responsible for managing project resources and accountable for budget
- Oversee the development of a system-level, optimized backbone and fiber-to-the-premises (FTTP) design including the selection of candidate hub and core locations, determination aerial vs. underground builds, consideration of the location of smart city and underserved locations, and the assessment of environmental impacts such as rock in the ground
- Oversee the cost analysis based on the engineering studies including updating unit pricing based on the expected prevalence of subsurface hard rock and on available data from recent bids and construction in the region
- Facilitate the analysis of the financial and policy aspects to support City decision making regarding next steps including laying out the benefits and challenges from both a financial standpoint and in light of the City's key policy goals of ubiquity, competition, equity, and control
- The City, based on our work on this project, continues to engage CTC in further financial analysis of different broadband deployment and operation options

Summit County, Colorado, Public Safety Land Mobile Radio (LMR) Upgrade – Project Manager and Business Analyst
- Primary point of contact for Summit County responsible for schedule, tasks, project costs and team
- Oversee coverage analysis comparing existing analog coverage with upgrading to P25 or joining the statewide Colorado Digital Trunked Radio System (DTRS)
- Business analyst responsible for collecting and evaluating pricing data for system upgrade
- The County will use this information to determine next steps for upgrading to a digital LMR network

Summit County, Colorado, Broadband Feasibility Study – Project Manager and Technical Lead
- Primary point of contact for Summit County responsible for schedule, tasks, project costs, and team
- Technical lead responsible for collecting, inventorying, and analyzing broadband and cellular carrier data
- Responsible for interviewing Summit County Town representatives and other County communications stakeholders
- Outreach to cellular carriers on behalf of the County to pursue a solution for major cellular coverage gaps within the County
- Prepared and reviewed responses to Requests for Information for FTTP and wireless solutions for the underserved areas
- Responsible for final report and presentations to Board of County Commissioners
- As a result of this project, the County is fully engaged with a commercial carrier to deploy additional sites within the County; in addition, this work has coordinated the Towns with respect to implementing fiber within the County and spring boarded other efforts

Onondaga County, New York, Public Safety Mobile Data System Upgrade – CTC Project Manager and Technical Lead
- Point of contact for prime contractor responsible for CTC schedule, tasks, project costs, and team
- Participated in stakeholder needs assessment and existing system evaluation
- Develop reports providing an analysis of public safety needs, documented data system and application requirements, and potential future options
- Provided FirstNet information valuable to the County and pertinent for future mobile data decisions based on extensive knowledge of FirstNet technical, operational, and financial components
- Engaged to develop a Request for Proposals and support the procurement and implementation of a replacement mobile data solution

El Paso County, Colorado, Broadband Strategic Plan – Principal Analyst
- Engaged to conduct a market assessment of the current availability of wireless services intended to identify deficit coverage areas and identify regions in which coverage does not meet acceptable levels of price or service reliability and identify current and planned efforts by incumbent carriers to address those issues
- Assessed public safety fiber communications needs through interviews with stakeholders

Universal Service Administrative Company (USAC) E-rate program – Principal Analyst
- Supporting the Knight Foundation and other library systems across the country, worked closely with libraries to define current and future broadband requirements
- Developed Requests for Proposals and supported the procurement or broadband services through the Universal Service Administrative Company (USAC) E-rate program

Additional responsibilities include:
- Engineering operations management for CTC's team of technical personnel
- Business development support for numerous proposals and sole source statements of work including pricing, level of effort, terms and conditions review, and interviews

PRIOR TO JOINING CTC IN 2016

Federal Engineering, Inc.   2007 – 2016
Executive Director
Chief Consultant/Business Development and Marketing Strategist
Senior Consultant/Project Manager

Major projects included the following—all of which were completed on time and within budget:

New York City Transit (NYCT) Bus Radio System – Project Manager
- Responsible for managing a large land mobile radio system project for the New York City Transit bus radio system replacement
- Managed a team of consultants in the design of a 20+-site voice and data radio system
- Participated in the engineering design of the voice and data system, as well as the generation of technical specifications for competitive system procurement

State of Minnesota Wireless Data Feasibility Study – Project Manager
- Led team to research and report on currently available mobile data system technologies; developed agency specification requirements for use in a future RFP
- Collected manufacturer specifications to accurately assess various mobile data solutions to include data throughput, capacity, bandwidth, and spectrum availability
- Evaluated several public safety and commercial mobile data technologies and characteristics
- Analyzed and developed specification criteria for use in future RFP requirements

State of Oregon Interoperability Showing – Technical Member
- Technical member of team that generated the required Interoperability Showing submitted to the FCC's Emergency Response Interoperability Center to justify Oregon's use of the 700 MHz broadband spectrum as a waiver recipient
- Participated in activities to develop the system architecture, list of applications, performance specifications, radio access network, interference coordination, testing, deployment, operations, administration, and maintenance of a statewide broadband LTE network

Routt County, Colorado, Radio Engineering Study – Project Manager and Engineer
- Managed radio engineering study to assess coverage needs for the County, which was a member of a shared statewide Digital Trunked Radio (DTR) network and was responsible for providing coverage needed beyond what statewide system provides
- Conducted project initiation, existing system data collection, and needs assessment meetings with system stakeholders
- Evaluated existing coverage; gap analysis of existing and needed coverage
- Developed recommendations and costs for coverage solutions including developing of an additional site, bi-directional amplifier(s), and a digital vehicular repeater system
- Provided written and oral report to the County

Additional responsibilities included:
- Management of high-performance location-diverse strategy and business development team responding to federal, state, local, and private sector solicitations. Responsible for the evaluation of government compliance requirements for projects.

- Intricately familiar with GSA, state, and local government bid processes, compliance requirements, and contracting that requires cross-functional coordination between government clients and consultants.
- Responsible for maintaining relationships with clients to ensure positive references and maintain client satisfaction throughout projects.
- Responsible for understanding unique structural, civil, and environmental requirements for communications site development on federal, state, local, and privately owned land. Work closely with environmental consulting firms to develop scopes of work and pricing to execute environmental compliance activities.

Motorola, Inc. (now Motorola Solutions)   1987 – 1999
Systems Engineering Manager
Systems Engineer
Software Engineering Manager/Project and Product Manager
Software Engineer

- Managed personnel, contract, revenue, expenditures, client interface, design, and implementation of multi-million-dollar land mobile radio and data systems. All projects completed on time and under budget. Major projects included the following:

New York City Fire Department
- Managed the implementation of the software for a $1M pilot for an AVL/GIS application for the New York City Fire Department
- Participated on-site with the pilot performing tests and customer demonstrations

State of New Hampshire
- Participated in field Beta testing of the statewide P25 system
- Analyzed results to feed back to development teams

Township of East Brunswick, New Jersey
- Managed the procurement and implementation of the township's new CAD and driver's license look-up applications for both the field and the fixed end
- Managed all third-party application vendors involved with the project, including the oversight of system testing

Montgomery County, Pennsylvania
- Managed the design and implementation of the county's new CAD and driver's license look-up applications for both the field and the fixed end
- Managed all third-party application vendors involved with the project including the oversight of system testing

Additional responsibilities included:
- Managed profitable Wireless Communications Systems Engineering Team for Motorola's Eastern Division encompassing the entire East Coast; responsible for systems designs, proposal development, department budget, and performance assessments

- Key member of partner/Motorola system software integration team; negotiated contracts with partners, designed systems that included their products, and technically and fiscally managed the product integration into Motorola wireless data systems
- Responsible for teaming agreements and proposal response development with third-party public safety mobile data software developers
- Responsible for responding to mobile data portions of large and small system RFPs and sole-source statements of work
- Designed, developed, and tested software for next-generation wireless voice and data communications devices implementing over-the-air protocols, ergonomic controls, and internal processing
- Received patent on innovative approach to a wireless communications device operating system
- Designed automated software test environment for next-generation wireless device that saved Motorola hundreds of hours of hands-on repetitive testing
- Guided business development and engineering departments in process and quality metrics collection
- Responsible for reporting and improving quarterly quality metrics
- Developed award-wining systems design review and software testing processes
- Chosen as the Eastern Division's Systems Technology Champion by peers for engineering efforts and for the creation of a system design review process

EDUCATION
Bachelor of Science, Electrical and Computer Engineering
University of Miami, 1986, Cum Laude

Bachelor of Music, Music Engineering Technology
University of Miami, 1985

PATENT
- Patent #5,363,315 – "Method of Communications Between and Within Virtual Radio Interface Standard Layers"

ORGANIZATIONS
- SAFECOM – Department of Homeland Security's Cybersecurity and Infrastructure Security Agency (CISA)
- National Association of Telecommunications Officers and Advisors
- National Public Safety Telecommunications Council (NPSTC)
  - Member, Executive Board
  - Chair, Technology and Broadband Committee
  - Co-chair, Broadband Emerging Technologies Working Group
- Brain Tumor Association – Local Committee Member