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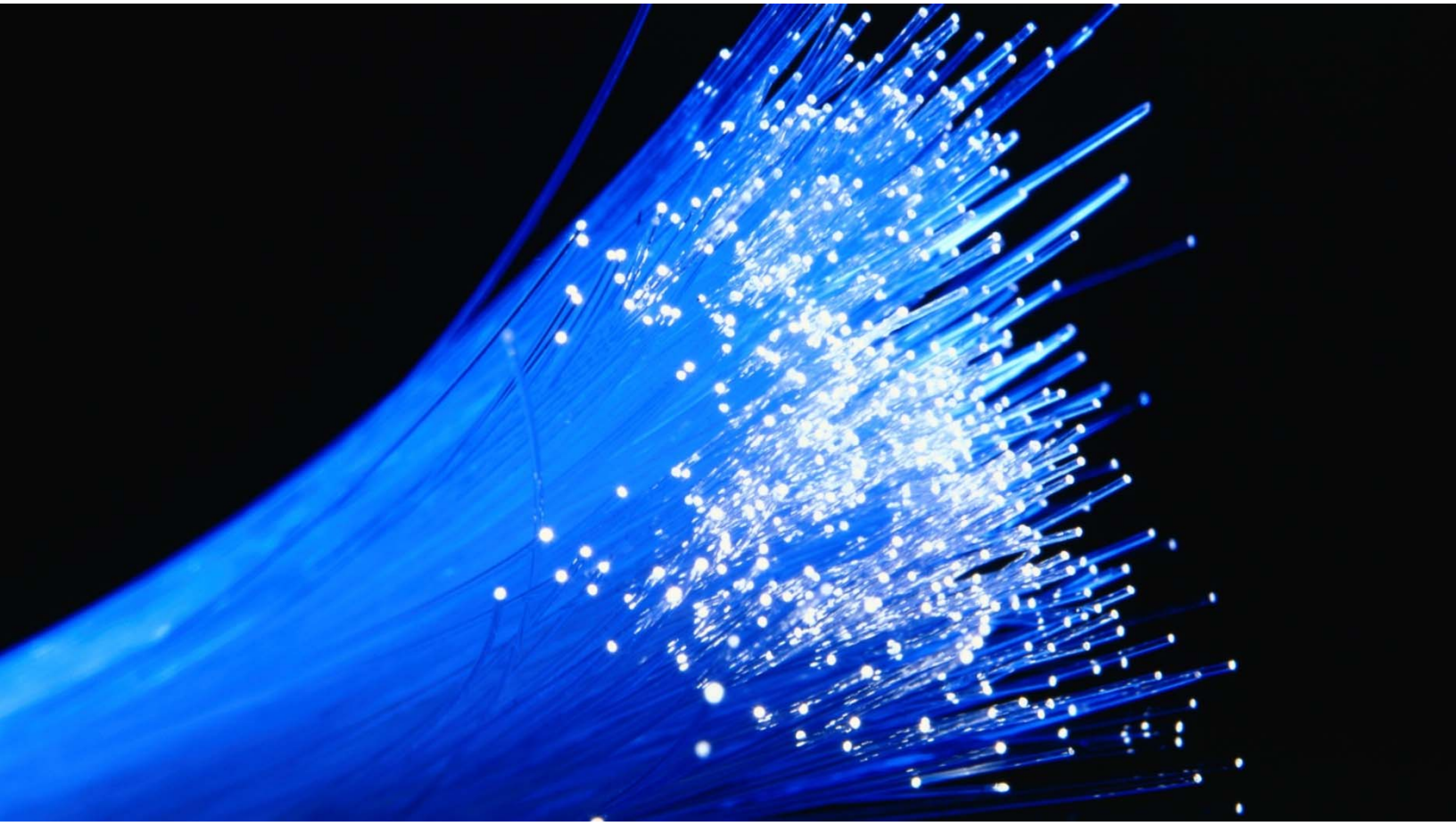

Preliminary Policy Considerations
New Mexico Broadband for Business (BB4B) Study

Prepared for
The Office of Broadband and Geospatial Initiatives
New Mexico Department of Information Technology
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1 Executive Summary

This is the first of a series of deliverables that CTC is preparing for the New Mexico Department of Information Technology as part of its Broadband for Business (BB4B) study. This deliverable suggests policy strategies for consideration as the State of New Mexico seeks to maximize the investment environment for broadband.

1.1 Overview

Advanced communications networks rank among the most important infrastructure assets of our time—for purposes of economic development and competitiveness, innovation, workforce preparedness, healthcare, education, and environmental sustainability. In the brief two decades since the advent of the commercial Internet, broadband access has become a necessity in the daily lives of Americans and fundamental to the American economy.

The New Mexico Office of Broadband and Geospatial Initiatives (OBGI, part of the Department of Information Technology) and the New Mexico Legislative Jobs Council (Jobs Council), as well as other stakeholders, are considering how to facilitate development of the advanced networks that will enable the next generation of broadband services in the State. Since its formation, the OBGI has worked alongside local communities and other key stakeholders to better understand the broadband challenges that communities face and to identify opportunities to ameliorate those challenges.

This preliminary report discusses opportunities for New Mexico to gain a competitive edge in broadband deployment by simulating and facilitating next-generation broadband investment, including tools and recommendations for both State and local government policymakers regarding how to expand and enable networks capable of gigabit (1 Gbps, or "Gig") speeds and beyond—with a particular goal of expanding gigabit broadband facilities to businesses.

Our focus is on increasing deployment of optical fiber to increase the availability of ultra-high-speed, gigabit or higher broadband services. Fiber all the way to the home and business is not yet available anywhere in the country on a comprehensive, statewide basis, but is unevenly emerging in major metropolitan areas where Google Fiber, AT&T, or CenturyLink are active—just as fiber-to-the-home emerged in many major Verizon markets a decade ago. Fiber is increasingly recognized as the ultimate platform for communications networks because it is a highly scalable (in theory, infinitely scalable) and adaptable medium that enables development and use of the communications applications of today and the future.

Fiber networks to the business market in particular have the potential to advance access to the digital economy because fiber enables high speed, reliable services, including multi-Gig and 100

Gig+ services that currently are in demand by sectors such as the oil and gas, health care, and film industries in New Mexico. This demand is only growing.

This preliminary report was prepared by CTC Technology & Energy in late 2016 in its capacity as the OBGI's independent broadband consultant. This report will be followed by further deliverables that expand on the insights and recommendations herein on the basis of engineering work, cost analysis, field review, and stakeholder engagement.

The analysis and recommendation in this document are submitted for consideration by key stakeholders in the State and should not be construed as final policy recommendations for the administration, the Jobs Council, or OBGI.

1.2 Summary of Recommendations

We recommend consideration of policy strategies that would seek to enhance the opportunities for construction of advanced infrastructure in New Mexico. Specifically, the report recommends levers for enabling and incenting investment—including low- and modest-cost strategies that are focused on creating an environment in which private capital is attracted to broadband deployment opportunities in the State.

State leaders could consider funding programs, tax incentives, or other legislative proposals to support innovative last-mile projects to provide New Mexico communities with access to advanced broadband and help make rural areas more competitive.

For example, the prospects for public–private partnerships in the broadband market have never been greater; as of this writing, there is private capital looking for opportunities to invest in new models for broadband deployment.

Legislative action and regulatory moves can also help attract capital by facilitating coordination and collaboration among localities to develop innovative partnerships. This approach would improve the State's potential to capture private investment—and even more so if the State were to provide matching grants and financial support for projects seeking to enhance high-speed broadband services.

These recommendations are made independently of budget and staffing considerations, and should be evaluated as options in that light. Each recommendations is discussed in detail in Section 3, below, and summarized briefly here.

1.3 Short-Term Recommendations

1.3.1 Consider Staffing and Funding Requirements for Any New Program or Mandate

The strategic and tactical considerations below were developed as a reflection of best practices and innovative approaches in State-level broadband planning—independent of financial

considerations such as budget or staffing requirements. Pursuing any or all of these strategies, even the relatively modest and low-cost approaches, will require adequate funding and staff allocations for OBGI.

1.3.2 Consider "Dig Once" Requirements to Place Conduit and Fiber Optics During Construction Projects

One means for the State to improve broadband deployment and access is to facilitate the expansion of public and private sector broadband infrastructure by reducing the cost of network construction. To accomplish this, the State could develop a robust "dig once" policy that prioritizes coordination among broadband providers and the deployment of conduit and fiber during all capital improvement projects.[1] Dig once policies are considered an international best practice not only for reducing disruptions in the public right-of-way such as roads and highways, but also for facilitating competition in the broadband marketplace.

1.3.3 Consider Creating a Certification Program to Identify Office Buildings with Robust Broadband

In our observation, even in the most sophisticated markets across the country, it can be difficult for businesses to determine what broadband services are available in a given area. This challenge applies both to businesses already located in a given market and those that are considering relocating to that market.

A potential enhancement in New Mexico would be a program to identify and certify buildings connected with the fastest, most reliable broadband connections. It could mirror the WiredScore initiative in New York City—a program launched in 2013 under Mayor Bloomberg in partnership with the New York City Economic Development Corp.[2]

A similar tool in New Mexico could help prospective tenants identify buildings with sufficient broadband access and could encourage owners to take greater steps to enhance broadband in commercial buildings. These steps could include paying the upfront costs to wire buildings to enable more than one provider to serve a tenant,[3] or allowing competitive providers to install infrastructure in buildings. (In some cases, building owners only allow a few providers to install the necessary equipment and serve tenants.) In addition, building owners may have a greater

[1] *See* "Brief Engineering Assessment: Efficiencies available through simultaneous construction and co-location of communications conduit and fiber," White Paper, CTC, 2009, http://www.ctcnet.us/CoordinatedConduitConstruction.pdf (accessed October 2016).
[2] "WiredScore, First Ever Connectivity Certification Service, Expands Nationally," PR Newswire, http://www.prnewswire.com/news-releases/wiredscore-first-ever-connectivity-certification-service-expands-nationally-300072080.html (accessed October 2016).
[3] This could potentially include conduit, as well as in-building or campus fiber or cable pathways, which would be available to a provider that passes the building—enabling the provider to connect without constructing from the curb.

incentive to pay for the construction costs to connect their buildings to additional network providers.

1.3.4 Consider Enabling New Investment by Providing Competitively Awarded Funding

A State program to support innovative last-mile projects would complement OBGI's planning and coordination activities. There are several examples nationwide of state governments funding last-mile projects to develop fiber infrastructure in underserved areas.

A grant or loan program would be a means of maintaining the momentum that has been created by the OBGI over the past few years. It could catalyze new efforts at the local level, in both urban and rural communities. A grant or loan program would also enable New Mexico to compete for private broadband investment that might otherwise flow to other states.

As of this writing, there is significant discussion in Washington about the potential for a substantial infrastructure funding bill in the early days of the Trump administration that might focus on tax benefits or other mechanisms for increasing private investment. Such investment, if broadband is included in the infrastructure bill, will be aggressively sought by every state and city in the country that is interested in broadband. New Mexico will need to find means by which to attract that potential increased flow of private capital and a support program such as this could help to differentiate New Mexico as an investment target.

If, as is currently expected, the new administration in Washington provides new tax and other incentive mechanisms for infrastructure (potentially including broadband), New Mexico would also benefit from having mechanisms and funding to partner with the for-profit private sector under the new infrastructure funding mechanisms. Indeed, it will be critical for states such as New Mexico to have in place strategies to make private investment even more attractive than would be the case purely with the federal incentives that may arise through the President-elect's infrastructure bill. The key benefit of such preparation would be to attract private capital to areas of the State where private investors may be less likely to directly invest absent State efforts.

We provide parameters for such a program in Section 5 and provide detailed case studies in Appendix C.

1.3.5 Consider Enabling Public-Private Partnerships in Broadband through a Range of Business Models

There exists great promise for local and state government to work with the private sector to deploy broadband networks that serve the needs and interests of both sectors. P3 legislation and support can enable such efforts as the following:

Local construction of fiber to serve internal government needs and enable service to key commercial and economic development areas

With State support, localities can build fiber optics or conduit to government users and key community anchor institutions, but not reaching all the way to the home or business. This is a proven best practice with two decades of empirical data that demonstrates its viability, albeit with a limited goal and purpose. This is a relatively low-risk strategy with narrow (but important) rewards.

At the same time, the community can route its fiber optics to reach key economic or community development targets, such as business parks, historic downtowns, or revitalization areas. Local governments are increasingly considering this low-risk, modest-impact opportunity to attract new businesses and retain existing employers.

In one variation of this model, a town or city can partner with a private company to share the cost of deploying fiber that will provide connectivity to public institutions while at the same time enabling the private entity to use fiber in a parallel conduit or sheath to market to private sector competitors.

Public Funding with Private Execution: The traditional "P3" model

With P3 enabling legislation and support, localities can negotiate formal public–private partnerships that resemble transit and toll-road construction projects, with public funding and private execution. The rewards of such an effort can be very high, and it outsources many of the headaches to a private partner, but this model entails significant public cost and risk.

Shared Risk: Both public and private sectors invest

In this model, localities create hybrid models in which a locality and private partner find a creative way to share some mix of the capital, operating, and maintenance costs of a broadband network. This approach holds particular promise for communities that are willing to take some risk in order to attract private investment. The most prominent variation on this approach has been one in which the locality builds ubiquitous fiber throughout a community and then leases it to a private partner that will pay for use of the fiber and bear all operating risk (and potentially share some capital risk). The City of Westminster, Maryland, partnered with Ting Internet in the first example of this approach. Huntsville, Alabama announced that it has an agreement with Google Fiber for lease of substantial city-owned fiber to serve the residential and small business markets.

While rural communities have fewer options and less market power than do their metro-area counterparts, modest strategies are emerging for rural broadband projects in which the community shares some risk with a private partner. Most shared-risk projects to date have been in metro areas, but those projects may be more challenging to replicate in rural communities, where the cost of fiber deployment, even in a shared-investment scenario, may still be

prohibitive due to a variety of factors, including the distance between homes and businesses. The shared-investment and shared-risk strategy, however, is still applicable to rural communities—perhaps using other technologies that secure the benefits of broadband even if they do not result in the kinds of speeds that fiber enables.

1.4 Areas for Long-Term Consideration

The concepts identified here have been successfully implemented in other states, and may prove beneficial to New Mexico. We list them here as potential areas for long-term consideration by OBGI.

1.4.1 Consider Facilitating Greater Efficiency in the "Make-Ready" Portion of Fiber Deployment

One of the most critical, unpredictable, and high-cost elements of fiber outside plant construction is the "make-ready" process. At times, that process requires three or more companies to dispatch crews with specialized equipment and bucket trucks to move their physical attachments on the communications portion of utility poles, causing slowdowns and duplicate expense for deployments. This recommendation suggests that there is a way for the State to enable and encourage all of this work to be done by one company rather than by many, thus realizing the efficiencies of "climb once" or "one touch," rather than three, four, five, or more truck rolls.

1.4.2 Consider an Infrastructure Bank

New Mexico could leverage limited public funds to spur private investment in broadband infrastructure deployment. Making lower-cost financing available for investment in telecommunications infrastructure would allow both private and public entities to increase their investments in broadband networks. Low-cost financing options may also allow private companies to invest in infrastructure in regions where the potential return on investment is relatively low, such as rural and low-income areas. By using innovative financing tools, New Mexico could enable new investment in the critically important, next-generation broadband infrastructure the State needs to compete in the 21st century.

As one option, the State could empower OBGI or an economic development agency to subsidize the interest portion of a deployer's debt service during the first two to three years of network deployment; from a financial perspective, this low-cost subsidy would reduce the deployer's cash flow requirements during the early phases of the deployment, before revenue develops.

1.4.3 Consider Applying Economic Development Mechanisms to Broadband

Another potential approach to maximizing the effects of minimal funding would be to apply key economic development mechanisms to broadband. This would be a novel approach using

established tools. For example, the State might consider the value of extending the Labor and Economic Development Act (LEDA), or creating a broadband version of the LEDA, as a means of stimulating job creation and community development.

In another example, tax benefits traditionally offered to attract investment in other sectors could be extended to broadband. Some states for example utilize tax increment funding for broadband programs.

1.4.4 Consider Creating a Non-Profit Entity to Further the Digital Inclusion Approach

New Mexico may also be able to further its goals in a less direct way by participating in the creation of a 501(c)(3) non-profit dedicated to expansion of broadband interests within the State.

A non-profit will serve as a private entity with which the public sector can partner to work together to accomplish the State's goals. The public-private partnership strategy has been adopted with impressive results by many jurisdictions, including the states of California, Minnesota, and North Carolina.

Creation of a non-profit affords the cause of digital inclusion numerous benefits. Primarily, 501(c)(3) status opens the cause to external funding resources not previously available. The non-profit can access funding sources (such as foundations and certain grants) in a way that no current government entity is able. Further, a non-profit Board of Directors and Advisory Board can retain State and agency (DoIT, OBGI) input without requiring the State to assume any of the burden of maintaining related programs. A non-profit can also act as an intermediary to support adoption and inclusion efforts for the time being, as a temporary entity that may later be incorporated by the State if and when appropriate.

2 Why New Mexico and Its Localities Should Address Broadband Needs

2.1 Next-Generation Broadband Represents a Critical, Necessary Element of Competitiveness for Which Business Demand Is Present and Increasing

Advanced broadband capabilities are at the core of many technological advances. As a result, the common perception of robust broadband capabilities has shifted from a luxury to an essential service. Today, the average single-family home no longer has one or two connected devices but six or seven;[4] companies are increasingly relying on bandwidth-rich applications to conduct business; and most industries have already been disrupted by technological innovations—and those that have not are ripe for disruption. This does not even account for the trillions of dollars that high-technology industries are predicted to add to the global economy in the next 10 years.[5] As a result, economic competitiveness, both now and especially in the future, will increasingly be dependent on access to robust, affordable, high-speed Internet connections.

High-speed communications are not only an engine for commerce, but also for integration of the many, diverse areas of the U.S. into an increasingly global economy. High-bandwidth broadband is widely recognized as a key driver of a state's future economic competitiveness because it:

- Enables small business creation and growth.
- Enables job creation and the enhanced, multiplied economic activity that accompanies it.
- Supports businesses with very high bandwidth needs, such as digital media and software.
- Attracts and helps retains businesses of all sizes.
- Enables workforce education.
- Enables telework and distributed work.
- Promotes major development initiatives such as revitalization zones or event bids.

There is a sound economic basis for states and regions to continue to upgrade their broadband capabilities. For example, small and medium businesses are dependent on affordable, high-speed

[4] See "2015 Broadband Progress Report and Notice of Inquiry on Immediate Action to Accelerate Deployment" GN Docket No. 14-126, FCC, ¶ 29, February 4, 2015, https://apps.fcc.gov/edocs_public/attachmatch/FCC-15-10A1_Rcd.pdf (accessed October 2016); Verizon, "Sharing Speed with Multiple Connected Devices" at 1 http://www.verizon.com/cs/groups/public/documents/adacct/bandwith-and-multiple-device.pdf (accessed October 2016).

[5] James Manyika, et al., "Disruptive Technologies: Advances That Will Transform Life, Business, and the Global Economy" McKinsey and Company, May 2013, http://www.mckinsey.com/business-functions/business-technology/our-insights/disruptive-technologies (accessed October 2016).

access to compete—and large businesses increasingly look to locate in areas with very high-speed access. Home-based businesses may emerge or fail based on the Internet speeds available to them. Affordable access to very high-speed broadband also incents development of the collaborative, distributed work that is a hallmark of the emerging global economy.

High-bandwidth broadband is also regarded as a facilitator of political discourse and activity—the most important medium for communication and expression of political ideas since the advent of television.

2.2 Fiber Optics to the Business Represents the Best, Most Future-Proof Communications Infrastructure

Fiber optics all the way to the business offer current and future speeds that are several orders of magnitude higher than the other technologies that are considered to compete with it today. As a technical matter and as a matter of physics, those other technologies cannot deliver the same capacity and scalability as fiber-to-the-premises (FTTP). For example:

- Copper networks, operated by the phone companies, have fiber in the backbone of the network, but much of the "last mile" copper dates back many decades and, in some cases, a century. Copper networks cannot keep up with today's requirements and are in many cases already at or near obsolescence.

- Coaxial networks, operated by the cable companies, also have fiber in the core of the network, but with coaxial cable in the last mile that was deployed in the 1970s and 1980s. These networks can be engineered to offer higher speeds that will be quite competitive in the short term, particularly for residential applications, but cannot keep pace in the long-run with fiber's ability to scale to dramatically higher speeds that are needed to attract and retain data-driven businesses.

- Wireless networks, which offer tremendous benefits with respect to mobility and convenience, are limited in speeds and therefore serve as complements—not alternatives—to high-bandwidth wired connections like fiber.

A service or product that meets even the FCC's minimum broadband definition (25 megabits per second downstream) will deliver a fraction of the speed that fiber can deliver using existing, affordable, off-the-shelf technologies (i.e., Gigabit Ethernet, 1,000 times one megabit). These speeds will grow dramatically as new equipment become available. The speeds possible over copper, coaxial cable, and wireless networks will also grow, but as a matter of physics, cannot keep up with fiber's ability to scale.

As a result, fiber all the way to the business represents the Holy Grail of communications infrastructure—a future-proof investment that can be easily, inexpensively upgraded to new speeds as more advanced electronics are developed.

In planning for the future, it is clear that FTTP will be the standard, and if the State or its local governments is going to invest time or resources into advancing digital infrastructure deployment, we recommend that it be future-proof fiber technology.

Fiber also represents the new standard for world-class markets. This is the infrastructure that already exists in New York City and its suburbs, and that is emerging in Salt Lake City; Charlotte; Raleigh/Durham; Atlanta; Louisville; Los Angeles; Austin; and nearly 100 other cities selected either by Google Fiber, AT&T, or CenturyLink.

The following graphics illustrate the capacity of different communications technologies. (Detailed discussion of the different capabilities of these technologies is included in Section 7 below.)

Figure 1 illustrates the comparative upload (sending data up to the Internet) and download (pulling data down from the Internet) speeds of various technologies. Note that the faster speeds all require fiber optics all the way to the home or business, as are under construction by Google Fiber, AT&T, and CenturyLink.

Figure 1: Comparative Speeds of Various Technologies

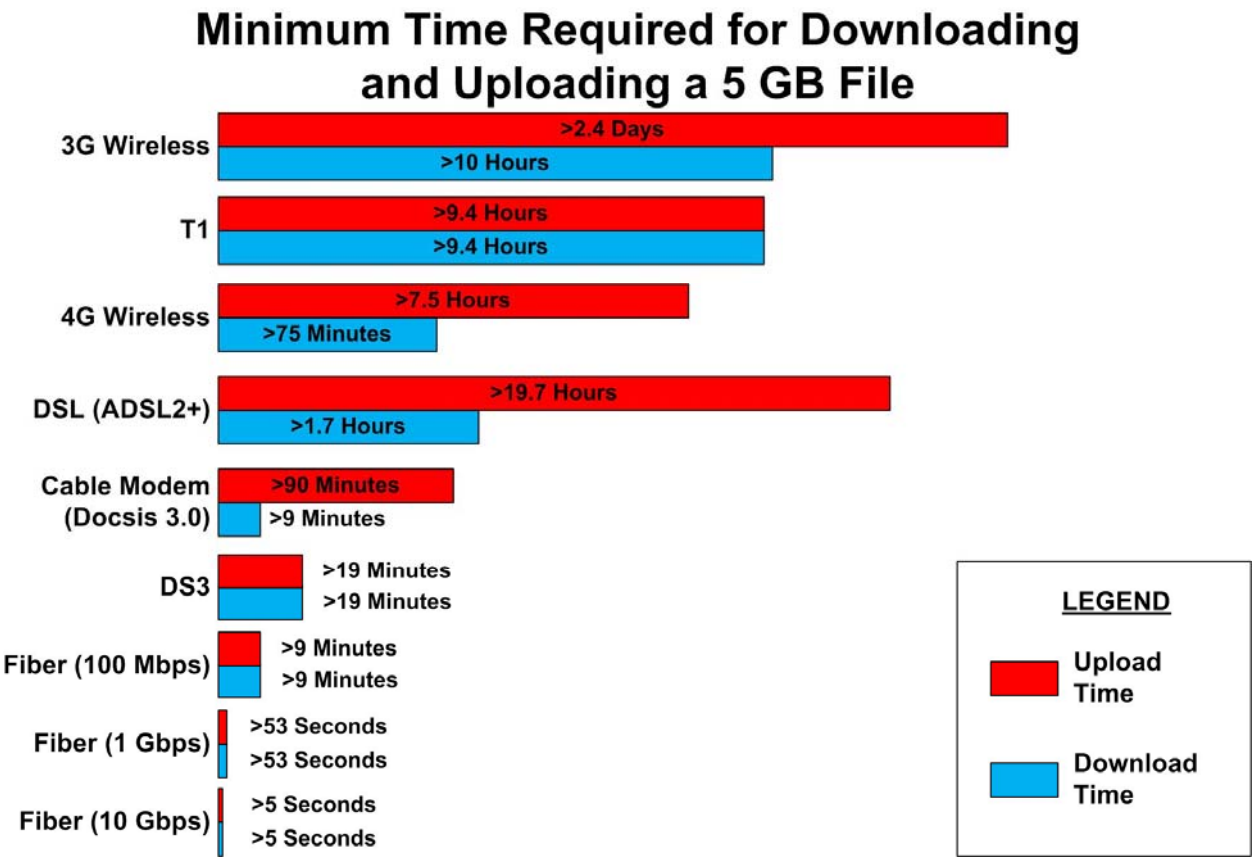
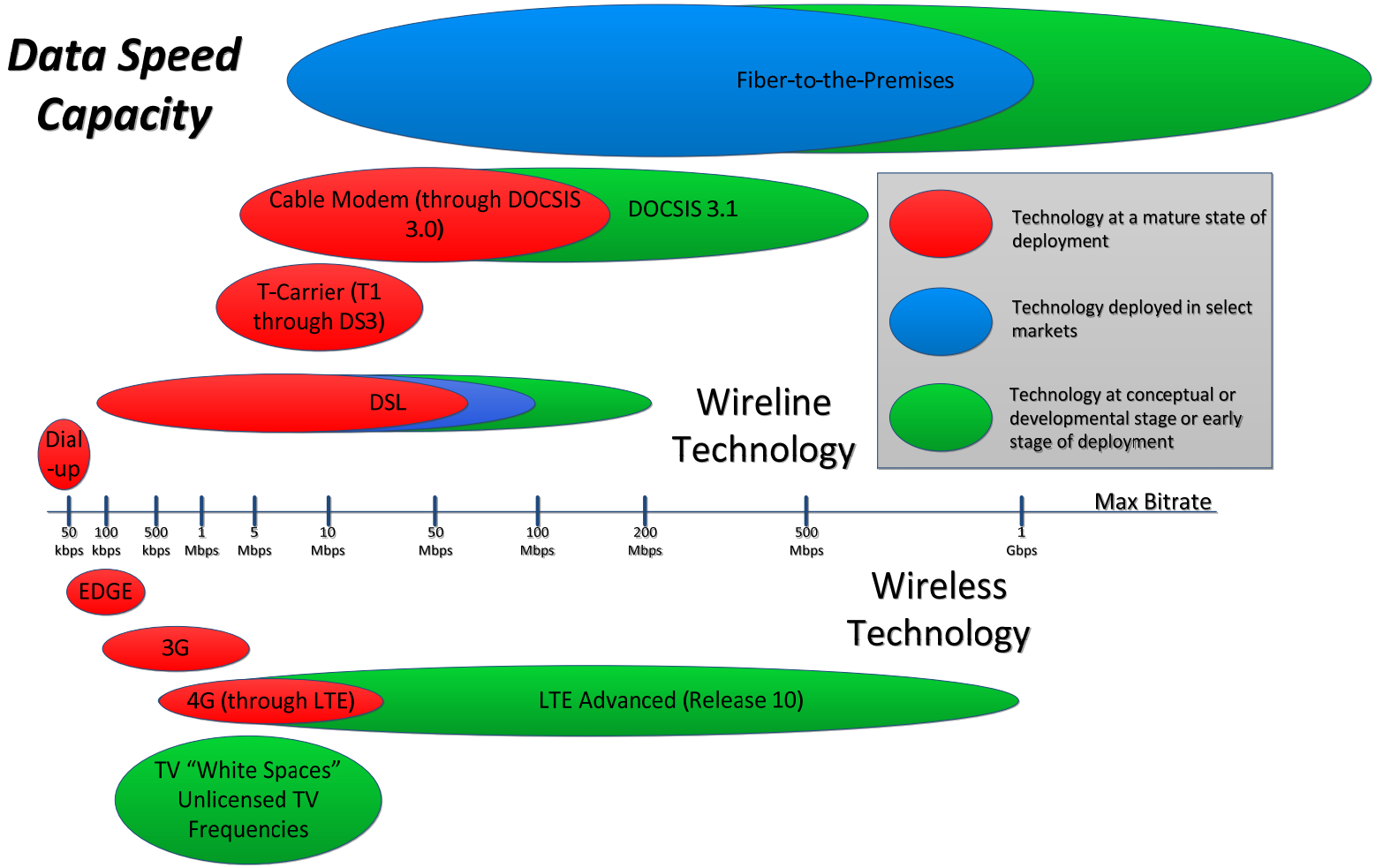


Figure 2, below, illustrates the current and likely future capacity of various technologies, including the new DOCSIS 3.1 technology that Comcast plans to implement at some point in the coming years. Note that the wireless technologies depicted below the line in the graphic generally cannot match in speed the wireline technologies (above the line) and thus serve as a mobile complement to wireline rather than as an alternative.

In the figure, LTE Advanced specifies the capability of 1 Gbps download speeds for users. We note that this relies on a development path of LTE that provides premium quality of service to high-bandwidth users, as well as the deployment of smart antenna technology and sufficient fiber and base station deployment to make all of this available. (As described in Section 7 below, advanced wireless technologies require fiber optics very close to the wireless radios to offer the capacity illustrated here.) We also note that in the same period that this type of speed becomes available for LTE, typical fiber speeds to the premises will be in the 10 to 100 Gbps range.

Figure 2: Wireline and Wireless Capacity



2.3 Though Many New Mexico Consumers Currently Are Well-Served by Existing Networks, State and Local Leaders Should Further Enable the Deployment of Next-Generation Broadband

New Mexico and its cities have not yet experienced extensive private sector investment in the most robust, most future-proof communications infrastructure.

While there are many parts of New Mexico that are reasonably well-served today by current providers, some parts of the State are unable to access high-speed Internet at affordable prices. In our visits to the State, we documented cases where businesses only have access to lower-speed DSL; we understand that this situation persists in some commercial areas and in certain rural towns.

2.4 Affordability of Service Is as Important as Availability

Affordability is obviously a crucial aspect of enabling New Mexico businesses to enjoy broadband speeds enabled by fiber networks. In some pockets where FTTP is technically available, the installation costs can be prohibitively expensive.

3 Short-Term Recommendations for Advancing New Mexico's Broadband Environment

3.1 Consider Staffing and Funding Requirements for Any New Program or Mandate

The strategic and tactical recommendations below were developed as a reflection of best practices and innovative approaches in State-level broadband planning—independent of financial considerations such as budget or staffing requirements. Pursuing any or all of these strategies, even the relatively modest and low-cost approaches, will require adequate funding and staff allocations for OBGI.

Continuing to maintain OBGI and its various initiatives is also a prudent investment in future capacity and institutional knowledge. For example, if State or federal infrastructure funding were to become available, OBGI would be well-positioned to quickly and effectively begin planning and implementing statewide, regional, or more targeted efforts to maximize the impact of that funding.

3.2 Consider Adopting a "Dig Once" Policy

We recommend that the municipalities and State leaders consider a "Dig Once" policy to require any excavation plans fitting specified criteria to include municipal use conduit or fiber, unless the State or municipality opts out of the excavation project. This would require the installation of State or municipal communications infrastructure in excavation projects where the municipality determines that it is both financially feasible and consistent with the municipality's long-term goals to develop the municipality's communication infrastructure.

3.2.1 The Case for Dig Once Policies

The construction of fiber optic communications cables is a costly, complex, and time-consuming process. The high cost of construction is a barrier to entry for potential broadband communications providers. In addition, available space is diminishing in the public rights-of-way (ROW). Moreover, cutting roads and sidewalks substantially reduces the lifetime and performance of those surfaces.

Accordingly, encouraging or requiring simultaneous construction and co-location of facilities in the public ROW will reduce the long-term cost of building communications facilities. This is because there are significant economies of scale through:

1. Coordination of construction with road construction and other disruptive activities in the public ROW.

2. Construction of spare conduit capacity where multiple service providers or entities may require infrastructure.

The reason that these economies are available is primarily because fiber optic cables and installation materials alone are relatively inexpensive, often contributing to less than one-quarter of the total cost of new construction. While material costs typically fall well below $40,000 per mile (even for large cables containing hundreds of fiber strands), labor, permitting, and engineering costs commonly drive the total price toward $200,000 per mile if conducted as a standalone project.

Moreover, as the ROW becomes more crowded with communications infrastructure and other utilities, the cost of new construction can grow rapidly. In general, however, it is in the best interests of both public and private entities for the public sector to identify construction collaboration opportunities that share the burden of expensive and duplicative labor-related costs and efficiently utilize physical space in the ROW.

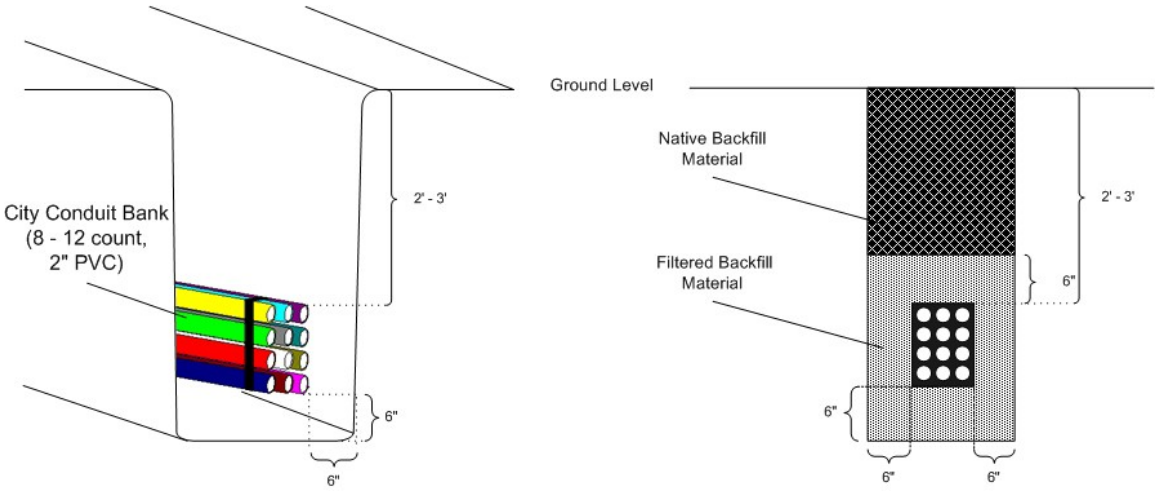
If fiber construction is coordinated with a major road or utility project that is already disrupting the ROW in a rural area, the cost of constructing the fiber, communications conduit, and other materials can range from $10,000 per mile up. However, if fiber construction is completed as part of a separate standalone project, the cost of constructing fiber and communications conduit can range from $95,000 to $200,000 per mile and even higher in complex urban environments.

There are numerous methods for constructing fiber optic infrastructure. In particular, underground construction using protective conduits generally provides the most scalable, flexible, and durable method for developing long-term communications infrastructure, but is also typically more expensive than aerial construction methods requiring attachments to utility poles. Underground construction can be preferable despite the cost because of the limit in the quantity of cables and attachments that can be placed on existing utility poles in more crowded areas, and because aerial construction is more exposed and vulnerable to outside conditions.

Banks of conduits constructed simultaneously (Figure 3), or large conduits segmented with inner duct, provide multiple pathways for the installation of multiple fiber optic cables located in close proximity, with the ability to remove, add, or replace fiber optic cables without disturbing neighboring cables.

Conversely, multiple conduits installed at different times must be physically spaced, often by several feet, to prevent damage to one while installing the next. Once the ROW becomes crowded, often the choices of construction methods are reduced, leaving only less desirable methods and more costly locations for construction of additional infrastructure.

Figure 3: Underground Conduit Bank for Multiple Users



Some of the key savings achieved through coordinated construction efforts include:

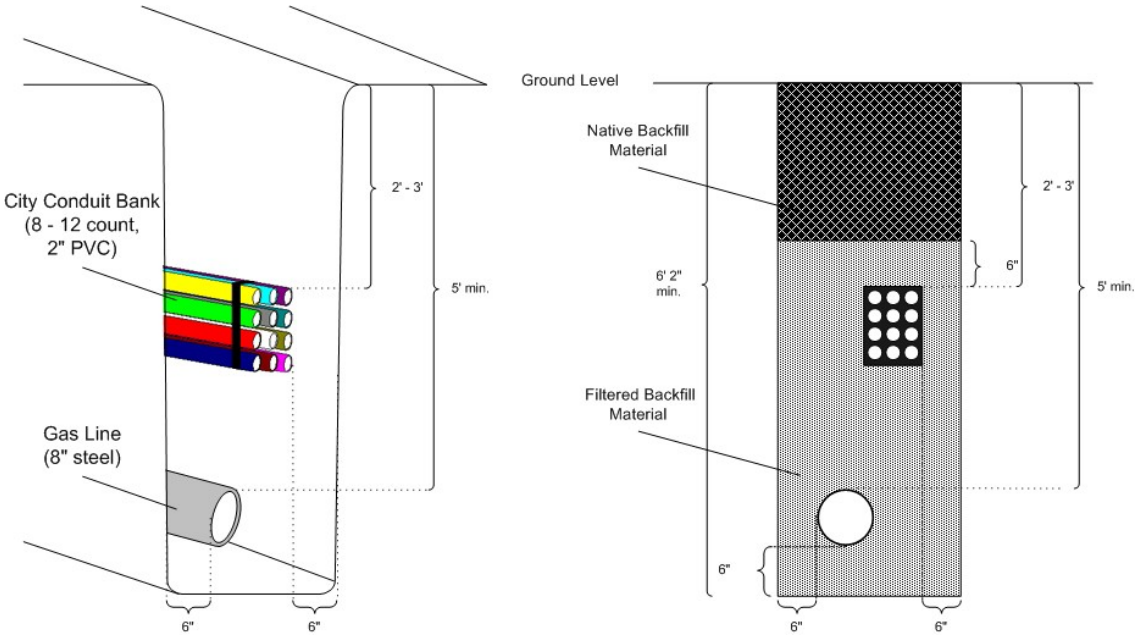
- Incremental labor and material costs, through reduced crew mobilization expenses and larger bulk material purchases
- Trenching or boring costs, particularly when coordination enables lower-cost methods (e.g., trenching as opposed to boring) or allows multiple entities to share a common trench or bore for their independent purposes
- Traffic control and safety personnel costs, particularly when constructing along roadways requiring lane closures
- Engineering and survey costs associated with locating existing utilities and specifying the placement of new facilities
- Engineering and survey costs associated with environmental impact studies and approvals
- Lease fees for access to private easements, such as those owned by electric utilities
- Railroad crossing permit fees and engineering
- Restoration to the ROW or roadway, particularly in conjunction with roadway improvements
- Bridge crossing permit fees and engineering

3.2.2 Coordinating Broadband Infrastructure Construction with Other Utility Projects Reduces Costs

Where other types of construction are occurring within or along the ROW, such as highway construction or resurfacing, roadway widening, sidewalk repairs, bridge construction, and water or gas main installation, there is an opportunity to place telecommunications infrastructure at an overall reduced cost and with reduced disruption to public ROW.

Figure 4 illustrates how a multi-user conduit bank might be installed with a gas main, water main, power line, or other large utility installation requiring trenching. We note that in a case like this, it is important to ensure proper backfill of trench material and facilitate future access to both the conduit and the other utility for repair by offsetting the two utilities horizontally and requiring a somewhat wider trench. This offsets somewhat the potential cost savings by requiring a larger trench and multistep backfill process. Nonetheless, cost savings are still substantial.

Figure 4: Example Coordinated Conduit Bank and Gas Main Installation



3.2.3 Criteria for Prioritization

The cost of installing conduit is drastically reduced when a trench is already dug. However, the cost is still significant, and the State or municipality will need to prioritize projects that achieve the most value for the money spent and maximize the likelihood of the conduit being used. To ensure that Dig Once projects are both financially feasible and consistent with the State or municipality's long-term goals, we propose prioritization based on the following range of factors:

- Ability to place conduit over long, continuous corridors across the State or municipality

- Proximity of the project to State or municipal facilities requiring service
- Lack of existing State or municipal communications infrastructure in the vicinity
- Potential interest in conduit from partners or customers (e.g., local government departments, service providers, or developers)
- Lack of cost-effective alternatives due to physical constraints in the vicinity (e.g., targets of opportunity such as bridges or freeway underpasses)
- Lack of capacity on utility poles along the route
- Risk to Dig Once communications infrastructure (e.g., water, gas, and sewer need to be placed deep underground and Dig Once infrastructure placed far above that infrastructure to reduce likelihood of damage to the Dig Once conduit during an emergency utility repair; this is less true of electrical and communications excavation that is in closer proximity to the Dig Once conduit, making the Dig Once conduit easier to avoid)
- Delays to critical infrastructure (i.e., the incremental days for Dig Once coordination must not create a public safety risk)
- Project cost (i.e., prioritizing projects with lower-than-average costs)
- Synergies with opportunistic major projects, such as highway mass transit, or bridge replacement
- Major right-of-way crossings, such as railroad, water, highway, interstate etc. Often times these are difficult for private carriers to facilitate or justify
- Conduit placement for building laterals into key sites, data centers, or facilities deemed potential targets for redevelopment
- In addition to Dig Once, we recommend that where pedestrian sky bridges or tunnels are being installed as part of the downtown redevelopment efforts, conduit be placed along these access corridors where appropriate.

As opportunities emerge, or as existing opportunities are reviewed, we recommend they be evaluated based on the above prioritization. We recommend scoring and ranking each potential project on the above criteria.

3.2.4 Standard Specification

The challenge in developing a standard specification for a Dig Once project is to incorporate the requirements of known and unknown users, and to provide sufficient capacity and capability without excessive costs.

We considered the following factors in developing a conduit specification:

1. Capacity—sufficient conduit needs to be installed, and that conduit needs to have sufficient internal diameter, to accommodate future users' cables and to be segmented to enable conduit to be shared or cables added at a future date

2. Segmentation—users need to have the appropriate level of separation from each other for commercial, security, or operational reasons

3. Access—vaults and handholes need to be placed to provide access to conduit and the ability to pull fiber. Vaults need to be spaced to minimize the cost of extending conduit to buildings and other facilities that may be served by fiber

4. Costs—materials beyond those that are likely to be needed will add cost, as will the incremental labor to construct them. Beyond a certain point, trenches need to be widened or deepened to accommodate conduit

5. Robustness—the materials, construction standards, and placement need to reasonably protect the users' fiber, and not unduly complicate maintenance and repairs

6. Architecture—sweeps, bend radius, and vault sizes need to be appropriate for all potential sizes of fiber

We recommend further discussions with private carriers to better develop a specification. It may be appropriate to have a different specification for different projects. Based on our knowledge of similar efforts in other cities, and our analysis, we believe the following standardized approach is suitable for major corridors and can be modified as discussion continue with excavators in the rights-of-way:

- Four two-inch conduit, minimum SDR 11 HDPE, each of a separate color or unique striping to simplify identification of conduits within vaults and between vaults, in the event conduit must be accessed or repaired at intermediate points. Conduit count can be reduced if the corridor is assess not to justify the capacity.

- Composite vaults having dimensions of 30" x 48" x 36" (W x L x D), placed in the sidewalk or available green space within the city or municipality right-of-way, as close to the curb or gutter as possible

- Vaults spaced at intervals of 600 feet or less, typically at the intersection of a city or municipality block
- Sweeping conduit bends with a minimum radius of 36 inches to allow cable to be pulled without exceeding pull-tension thresholds when placing high-count fiber cables (e.g., 864-count)
- Conduit placed in the same trench directly above the excavator's infrastructure or, where this is not possible, placed with minimum horizontal offset, to minimize cost

It is important to note that the proposed approach is designed to create consistency and predictability in costs and deployment and, of necessity, is a compromise among the potential users. If an excavation project has a long time horizon and sufficient budget, it is possible to customize the Dig Once build, potentially adding conduit or adding vaults at particular locations. This plan provides a baseline approach.

The approach is a compromise among different types of users of conduit constructed under dig once. Some users might prefer larger conduit for consistency with earlier builds. Others sought a larger count of smaller conduit, to provide more flexibility and the capability for more providers to participate with smaller cable counts.

Two-inch conduit has become a standard size for a wide range of construction projects, and can support the widest range of use cases. A single two-inch conduit can accommodate a range of multi-cable configurations, while retaining recommended fill ratios, allowing a single user to serve its backbone and "lateral"/access cable requirements with a single, dedicated conduit. A few example cable configurations supported by a single two-inch conduit, which are not supported by smaller conduit, include:

- Two medium backbone cables (e.g., 144-strand to 288-strand cables) and one smaller "feeder" cable (e.g., 24-strand cable);
- Large backbone cable (e.g., 864-strand) and two or more smaller feeder cables; or
- Three medium backbone cables.

Compared to placing fewer, larger conduits segmented with innerduct, this approach provides greater opportunity for individual conduit to be intercepted and routed for future vault installation by a particular user. Additionally, two-inch conduit is substantially cheaper to install and physically more flexible than larger varieties, offering more options to route around existing utilities and other obstructions. Placing four conduit will provide a standard allotment of one or two conduit for State or municipality use and provide capacity for other use and for spares.

We recommend SDR 11 HDPE in all cases except where conduit is exposed in to the elements (for example, as a riser to building entry), or under extreme levels of pressure (such as under a train or trolley track). SDR 11 HDPE designs will generally support standard highway and railway loads with less than 1 percent deflection when buried with two feet of cover.

3.3 Consider Creating a Certification Program to Identify Office Buildings with Robust Broadband

In our observation nationally, even in the most sophisticated markets it can be difficult for businesses to determine what communication services are available in a given area. This challenge applies both to businesses already located in a given market and those that are considering relocating to that market. Even though, in a recent survey, office location decision-makers ranked connectivity as their top priority when selecting an office location, the same survey revealed that less than half receive detailed information on connectivity services prior to signing their lease.[6]

A voluntary program that certifies the quality of connectivity services available in New Mexico office buildings could provide critical information for office location decision-makers, and incentivize building owners to take steps to improve available services and relevant internal building infrastructure.

Such a program could be modeled on the WiredScore initiative in New York City—a program launched in 2013 under Mayor Bloomberg in partnership with the New York City Economic Development Corp. WiredScore is now a standalone company that "evaluates a building's connectivity by examining the number and quality of Internet service providers (ISP) as well as the bandwidth capabilities and reliability of connections that are based on the building's infrastructure."[7] The company also provides technical assistance to business owners that wish to improve their ranking.[8]

[6] "Office Workers Rank Reliable Internet Connectivity #1 Priority in New Survey," PR Newswire, June 29, 2015, http://www.prnewswire.com/news-releases/office-workers-rank-reliable-internet-connectivity-1-priority-in-new-survey-300105711.html (accessed October 2016).
[7] PR Newswire, "WiredScore, First Ever Connectivity Certification Service, Expands Nationally," http://www.prnewswire.com/news-releases/wiredscore-first-ever-connectivity-certification-service-expands-nationally-300072080.html (accessed October 2016).
[8] "Frequently Asked Questions, WiredScore, http://wiredscore.com/public/faq (accessed October 2016).

WiredScore is expanding to additional cities including Chicago, Boston, Washington, D.C., Seattle, San Francisco,[9] and London.[10] To date, WiredScore has certified more than 400 properties in 30 cities.[11] In the case of London, the mayor partnered with WiredScore, contributing £50,000 to cover the initial consultation and certification costs for a handful of London office buildings.[12] Presumably, once a critical mass of buildings receive a connectivity score, other building owners in the area feel pressure to certify their property in order to remain competitive.

If State leaders do not wish to create a New Mexico-specific certification tool, the State could enter into a similar partnership with WiredScore, promoting its services across the State and providing an initial subsidy to help some building owners to cover the initial cost of certification.

WiredScore, or a similar tool built specifically for New Mexico, could help prospective tenants identify buildings with sufficient broadband access and encourage building owners to take greater steps to enhance available broadband services in commercial buildings. These steps could include paying the upfront costs to wire buildings in a way that enables more than one provider to serve tenants, or allowing competitive providers to install infrastructure within the building. In addition, building owners may have a greater incentive to pay the necessary construction costs to connect their buildings to additional providers' core fiber network.

As the availability of communication services becomes more transparent, building owners and developers will feel an increasing amount of pressure to secure high-quality broadband services for their tenants. While building owners alone may be unable to overcome a local lack of fiber infrastructure, incentivizing them to improve services may encourage them to partner with grassroots and municipal efforts to improve communication infrastructure in the area.

3.4 Consider Creation of a Grant Program or Low-Cost Financing Mechanisms to Incent Private Investment and Stimulate Projects at the Local Level

CTC recommends that State leaders consider creating a broadband grant program to catalyze and incent local government and private investment in the infrastructure that enables gigabit

[9] PR Newswire, "WiredScore, First Ever Connectivity Certification Service, Expands Nationally," http://www.prnewswire.com/news-releases/wiredscore-first-ever-connectivity-certification-service-expands-nationally-300072080.html (accessed October 2016).
[10] "Wired Certification Awarded to Ten London Buildings, Kicking off Partnership with Mayor of London," Market Wired, October 22, 2015, http://www.marketwired.com/press-release/wired-certification-awarded-ten-london-buildings-kicking-off-partnership-with-mayor-2066048.htm (accessed October 2016).
[11] "Exclusive Q&A: What you need to know about Wired Certification," *Bisnow*, December 2, 2015, https://www.bisnow.com/san-francisco/news/office/wiredscores-david-weinstein-on-wired-certification-53069 (accessed October 2016).
[12] "Mayor of London launches major drive to boost connectivity in capital," Mayor of London, June 15, 2015, https://www.london.gov.uk/press-releases/london-technology-week (accessed October 2016).

and beyond services—FTTP. We summarize this recommendation here, provide parameters for such a program in Section 5, and provide detailed case studies in Appendix C.

A grant program could catalyze new efforts at the local level, in both urban and rural communities. And a grant program would enable New Mexico to compete for private broadband investment that might otherwise flow to neighboring states.

Significant opportunities for progress exist at modest levels of funding. For example, in 2015, the Minnesota state legislature included $10,588,000 in funds for the Border-to-Border Broadband Infrastructure grant program.[13] The funds were targeted at expanding broadband service in unserved and underserved regions throughout Minnesota with grants up to $5 million that could provide up to 50 percent of project development costs.

Construction of a new fiber optic network to residences and farms is underway in rural, south-central Minnesota thanks to a public-private partnership, called the RS Fiber Cooperative, and the state's grant program. The network will eventually pass more than 6,200 potential customers across 10 cities and 17 townships. The network will be built in phases, with the first phase expected to cost $15 million. The state contributed $1 million to the effort through the rural broadband grant program, and the participating municipalities have financed the rest with $8.7 million in general obligation bonds, as well as additional bank loans. Once completed, the first phase of the network will allow the cooperative to offer better broadband than is currently available in the area using wireless transmitters. The cooperative will use the revenue it begins to generate to service the bonds and finance the construction of the last-mile portion of the fiber network.[14]

Similarly, under Governor Pat Quinn, Illinois launched the "Illinois Gigabit Communities Challenge." The program awarded up to $4 million in seed funding to "the most promising ultra high-speed broadband deployment projects in Illinois."[15] The challenge was open to any private or public organization and required projects to connect at least 1,000 end users to an ultra-high-speed broadband network capable of delivering speeds of 1 Gbps.

In another useful example, the California Advanced Services Fund (CASF) offers both grants and loans to assist in construction or upgrade of broadband infrastructure in areas that are not served

[13] "Broadband Grant Program," Minnesota Department of Employment and Economic Development, http://mn.gov/deed/programs-services/broadband/grant-program/ (accessed October 2016).
[14] Nancy Madsen, "Minnesota Rural Broadband Development a Game Changer," *Government Technology*, July 20, 2015, http://www.govtech.com/dc/articles/Minnesotas-Rural-Broadband-Development-a-Game-Changer.html (accessed October 2016).
[15] "Illinois Gigabit Communities Challenge," Broadband Illinois, http://www.broadbandillinois.org/Use-it/Illinois-Gigabit-Challenge.html (accessed October 2016).

or are underserved by existing broadband providers.[16] The CASF program also has a Consortia Grant program that funds regional consortia to promote ubiquitous broadband deployment and to advance broadband adoption in unserved and underserved areas.[17]

At even more modest levels, the State might find success in incenting private investment. For example, absent a grant program, the State could develop creative approaches to supporting individual deployers. As one option, it could empower OBGI or an economic development agency to subsidize the interest portion of a deployer's debt service during the first two to three years of network deployment; from a financial perspective, this low-cost subsidy would reduce the deployer's cash flow requirements during the early phases of the deployment, before revenue develops.

3.5 Consider Enabling Public-Private Partnerships in Broadband Through a Range of Business Models

There exists great promise for local and State government to work with the private sector to deploy broadband networks that serve the needs and interests of both sectors. Given the complexity of the topic, we describe these business models in detail in Section6.

[16] An "unserved" area is an area that is not served by any form of wireline or wireless facilities-based broadband, such that Internet connectivity is available only through dial up service. An "underserved" area is an area where broadband is available, but no wireline or wireless facilities-based provider offers service at advertised speeds of at least 6 Mbps download and 1.5 Mbps upload. *California Advanced Services Fund (CASF) Infrastructure Grant and Revolving Loan Account*. http://www.cpuc.ca.gov/General.aspx?id=8246 (accessed October 2016).

[17] In 2011, the program approved Year 1 budgets and three-year budget allowances for seven regional consortia totaling $1.7 million. An additional seven grants were approved for $1.05 million in 2012 and two additional grants totaling $550,000 in 2014. *California Advanced Services Fund –Rural and Urban Regional Broadband Consortia Account.* http://www.cpuc.ca.gov/General.aspx?id=870 (accessed October 2016).

4 Areas for Additional Study and Long-Term Consideration

4.1 Consider Creating a "Climb Once" Pole Access Environment

We recommend that the parties in New Mexico consider developing a mechanism for more efficient "make-ready" in the communications space on utility poles. This recommendation is based on our experience in other parts of the country, our brief high-level surveys in New Mexico, and our discussions with broadband stakeholders and pole owners. Reducing the number of entities needed to perform simple, previously approved moves of existing attachments in the communications space on poles may significantly improve the speed and cost of building new communications infrastructure in the State.

This type of policy, referred to as "one-touch" make-ready (OTMR) can reduce the time to construct or improve infrastructure, reduce overall cost, reduce complexity, and reduce the negative impact on the public as the various parties work to prepare the communications space on the poles for new or enhanced attachments.

In the absence of OTMR, the standard practice for an attacher is to go through several steps to attach to poles. These can be costly and time-consuming and still leave the attacher with substantial potential delay and cost—because it must rely on the good will and timeliness of the existing attachers to take steps to provide space on the poles. In many cases, existing attachers are competitors that do not have an interest in a swift process.

With OTMR, many steps in the process of building or upgrading infrastructure can be skipped, saving time and money, and reducing the burden on existing and new broadband providers, while still retaining the parts of the process that ensure safety.

4.1.1 The Traditional Make-Ready Process

In a traditional process, the attacher obtains a pole attachment agreement from the pole owner (or in joint-ownership areas, the multiple pole owners) that certifies the attacher as an entity entitled to be on the pole and establishes the rules for being on the poles. The attacher then applies for permits for each pole.

The new attacher conducts its own engineering analysis of the current situation at the pole and then proposes to the pole owner(s) where and how it will attach. The pole owner then conducts its own analysis. Depending on local rules and practices, the attacher, pole owner, and existing attachers may conduct a multi-party survey that includes all the parties with attachments, which could be three, four, five, or more entities. Alternatively (or in addition), the pole owner(s) may determine which utilities need to move and how, and whether a pole must be replaced.

In the traditional process, existing attachers are then required to move their infrastructure within a set period of time. If these deadlines are respected by the pole owners and attachers, they have the potential to greatly speed deployment and provide predictability for the new attacher and its investors.

In our experience across the country, the make-ready process that follows permitting can in practice prove slow. In most cases, each existing attacher separately sends a crew to make the move. These moves are not generally coordinated and may require lane and sidewalk closures each time. The total cost is higher than necessary, because each move is planned and executed separately. The existing attachers then invoice the new attacher separately. The new attacher must wait until all existing attachers are done before it can get started in placing its own attachment.

As a practical matter, then, the new attacher can face delays as a result of this multi-party, multi-step process. Delays on a short stretch of poles, or even a single pole, can slow down deployment of large-scale projects.

Where poles need to be replaced, the pole owner will place a second pole. If the existing attachers are slow to move their attachments to the new pole, the old pole is left in place for an extended period. A large number of "double poles" offers visual evidence that make-ready is frequently a slower process than intended.

The traditional approach is not designed for a world with multiple providers on a pole—it scales poorly and becomes complex and expensive with multiple cable and wireless providers and highly burdensome on the pole owners and attachers.

4.1.2 The One-Touch Make-Ready Process

In an environment where the parties adopt OTMR for the communications space on the poles, there will be small but important changes. The first is that a qualified contractor that meets applicable industry standards can be hired by the new attacher or the pole owner (depending on the details of the agreement). The existing attachers are notified, and the work is done and documented.

The public and the parties all benefit from the work being done at once in a number of ways:

- There is only one set of lane closures, which accommodates the make-ready and the placement of the new attachment.
- The time and place of make-ready becomes predictable, both on a week-by-week basis and on an aggregate project-level basis.

- The total cost (both to attachers and electric rate payers) is reduced.
- Existing attachers do not need to invoice or be reimbursed.
- Work is done safely by a professional, qualified contractor who is a central point of contact for information on work status, work supervision, and documentation.
- There is no need for a long period of double poles in the event poles need to be replaced, which reduces both the public safety concerns associated with double poles and the aesthetic concerns.

The incentives in the one-touch approach for the communications space vastly improve on the traditional approach—existing attachers are not required to expend time and attention on make-ready for new attacher, and there is no temptation created for an existing attacher to delay or effectively block a new entrant or upgrade.

The one-touch process enables efficiency and other benefits not only for incremental construction, but also for high-volume construction as in where a new competitor enters the market.

A one-touch environment for the communications space will benefit not only new attachers but also existing incumbent attachers by making it easier for incumbents to upgrade. For example, as Comcast upgrades to DOCSIS 3.1 technology, it will need to modify attachments to build fiber deeper into its network. In a one-touch environment, its upgrades will likely be more efficient.

At the same time, one-touch maintains important safety precautions. Attachers still need to get a pole attachment agreement, they still need to do pole engineering according to the rules of pole owner, and work needs to be performed by a contractor certified by the pole owner. OTMR is not typically done for make-ready in the electrical space, which requires a contractor certified by the electric utility for that work and must be overseen by that utility.

Generally, one-touch policies do not apply to make-ready that might interrupt service (as opposed to routine movements of attachments in which there is no risk of service interruption). In the OTMR policy recently adopted by the City of Louisville, for example, make-ready that may interrupt service can only be conducted after 30 days if the attacher does not perform the make-ready itself.[18]

[18] Though it has drawn praise for its innovative approach to speeding deployment times, the Louisville OTMR policy has also resulted in a lawsuit by AT&T, which claims that the state and federal governments—not the city—have authority over such matters. See https://goo.gl/5BCQvN (accessed October 2016).

In New Mexico, the vast majority of communications infrastructure in the State is on aerial poles, and underground construction is extremely costly in rocky areas. If OTMR can speed make-ready, it can drastically reduce cost and risk to new deployers and increase speed to build.

OTMR policies are widely regarded as efficient ways to speed broadband deployment, including by some phone and cable companies. CTIA-The Wireless Association, for example, recommended in 2010 that the FCC consider rules enabling attachers to "use pre-approved and pre-certified contractors to complete make-ready work."[19] Comcast Corporation also spoke approvingly of proposals to expedite infrastructure access, such as timeframes for stages of make-ready attachment and use of third party contractors…."[20]

The policies have received significant support from the competitive side of the industry,[21] as well as from public sector groups focused on enabling new broadband opportunities.[22]

4.2 Consider an Infrastructure Bank

We use as an analogy here the first-in-the-nation "Connecticut Green Bank," which has successfully leveraged limited public funds to spur a significant amount of private investment in clean energy infrastructure. Using similar financing tools in a Broadband Bank, New Mexico could enable a new wave of investment in the critically important, next-generation broadband infrastructure the State needs to compete in the 21st century.

The Connecticut Green Bank has offered a variety of low-cost financing options, enabling municipalities, companies and consumers to cover the initial cost of investing in renewable energy generation and improving energy efficiency. This allows borrowers to spread the payback period across the full useful life of their investment. Though only in its fourth year of operation, the Connecticut Green Bank has already become a much heralded model that many have encouraged other states to emulate in order to curb greenhouse emissions.[23] The Green Bank's successful track record has led private financial institutions to step in and offer their own clean

[19] Filing with Federal Communications Commission by CTIA – The Wireless Association, 2010, https://prodnet.www.neca.org/publicationsdocs/wwpdf/81710ctia2.pdf (accessed October 2016).
[20] Filing with Federal Communications Commission by Comcast Corporation, August 2010, http://apps.fcc.gov/ecfs/document/view?id=7020708182 (accessed October 2016).
[21] For example, the Fiber to the Home Council has strongly endorsed this approach. http://www.ftthcouncil.org/d/do/1959 (accessed October 2016).
[22] The Next Century Cities organization of broadband-focused local governments has also endorsed one-touch strategies. http://nextcenturycities.org/2016/01/06/one-touch-make-ready-policies-the-dig-once-of-pole-attachments/ (accessed October 2016).
[23] Ellen Kan, "Connecticut Leads in Energy Efficiency," Yale Daily News, October 29, 2015, http://yaledailynews.com/blog/2015/10/29/connecticut-leads-in-energy-efficiency/ (accessed October 2016); Andrew Belden, et al. "Financing Clean Energy," Union of Concerned Scientists, July 2015, http://www.ucsusa.org/sites/default/files/attach/2015/07/financing-clean-energy.pdf (accessed October 2016).

energy financing products,[24] and has attracted substantial private investment in the Bank, allowing it to scale and expand its offerings.[25]

The success of the Green Bank in Connecticut demonstrates that state's ability to work in partnership with private financial markets to jump-start investment in a sector of the economy that offers numerous benefits beyond the balance sheet. In order to incent the markets to increase delivery of affordable, high-speed broadband to unserved or underserved areas, New Mexico could create a similar Broadband Bank, using the Connecticut Green Bank as a model.

A robust, reliable broadband network is a public good that benefits businesses, schools, hospitals, local governments and private residents in a variety of ways. However, these benefits do not always factor in to private companies' decision whether or not to take on capital-intensive network build-outs and upgrades. Private companies reasonably invest only when they can cover their costs and earn a profit. They are not incentivized to make their investment decisions solely on economic development goals or educational opportunities in the region.

Modeling a Broadband Bank on the Green Bank to create a 21st century infrastructure bank that provides low-cost financing options for next-generation telecommunication networks would help increase levels of investment to reflect the way communication infrastructure serves the public good. Similar to clean energy infrastructure, fiber networks have a high upfront cost, and deliver their return over a long period of time. Private capital markets are unlikely to be attracted to investments that are likely to take decades to offer robust returns. By taking actions to jump-start investment in fiber optic networks, New Mexico can ensure that it is doing what it can to enable its citizens are at the leading edge of digital technology and are positioned to best reap the benefits from the many applications that are currently being developed to make use of high-capacity data networks, such as high-fidelity meeting tools, telemedicine, and augmented reality.[26]

Making lower-cost financing available for investment in telecommunications infrastructure would allow both private and public entities to increase their investments in broadband networks. Municipalities that determine that they need additional investment to keep their region economically competitive would find it easier to achieve positive cash flow in their own

[24] "Greenworks Lending Announces Closing C-PACE Transactions Totaling $1 Million," Connecticut Green Bank, August 26, 2015, http://www.ctgreenbank.com/1172-2/ (accessed October 2016).
[25] "Green Bank and Hannon Armstrong Partner for Commercial Clean Energy Financing," PR Newswire, December 17, 2015, http://www.prnewswire.com/news-releases/green-bank-and-hannon-armstrong-partner-for-commercial-clean-energy-financing-300194976.html (accessed October 2016).
[26] "Killer Apps in the Gigabit Age," Pew Research Center, October 9, 2014, http://www.pewinternet.org/files/2014/10/PIP_KillerAppsinGigabitAge_100914.pdf (accessed October 2016).

investments in broadband infrastructure. They could service the debt in a variety of ways, ranging from leasing network capacity to private carriers, offsetting internal communication costs, offering retail data transport services, raising property taxes in the area, using incremental tax revenues from the increased property values that have historically followed new fiber networks,[27] or a blend of many of these. As the market matures and successful business models begin to prove out, private financial institutions will become more willing to finance municipal network build outs themselves.

In addition to lowering the cost of the financing, an infrastructure bank can play a valuable role in bringing both expertise and creativity to next-generation infrastructure. At this time, it is not certain how business models will develop. Traditional financing entities have been hesitant to enter these new markets with long pay-out periods. Just as in the energy realm, it might be that the borrowers could be local governments, non-profits, neighborhood cooperatives, or even individuals, paying for last-mile connections themselves to lower the cost of monthly services. A bank with expertise in the economics and a public mandate to encourage new solutions can be a critical catalyst in accelerating adoption.

The low-cost financing options may also allow private companies to invest in infrastructure in regions where the potential return on investment is relatively low, such as rural and low-income areas. Lowering the cost of capital helps encourage investment in these areas, where the time needed to achieve positive cash flow can be significantly longer than in wealthy, urban areas. If the incumbent carriers choose not to make such investment themselves, the bank's financing options would make it easier for a start-up or business from another sector to enter the broadband market.

In Europe, the European Infrastructure Bank has already made capital available at a low cost for both public[28] and private sector[29] actors that wish to expand telecommunication infrastructure in underserved regions. While support for infrastructure banks has swelled in the US in recent years, thanks in part to Connecticut's Green Bank's success in spurring investment in clean energy

[27] Ryan Knutson, "How Fast Internet Affects Home Prices," *Wall Street Journal*, June 30, 2015, http://www.wsj.com/articles/SB11064341213388534269604581077972897822358 (accessed October 2016).
[28] "Germany: EIB and NBank promote broadband rollout in Lower Saxony," European Infrastructure Bank, November 12, 2015, http://www.eib.org/infocentre/press/releases/all/2015/2015-260-eib-und-nbank-fordern-breitbandausbau-in-niedersachsen.htm (accessed October 2016).
[29] "Gigaclear Rural Broadband Plan Gets €25M EIB Support," January 20, 2016, http://www.fibre-systems.com/news/story/gigaclear-rural-broadband-plan-gets-%E2%82%AC25m-eib-support (accessed October 2016).

infrastructure,[30] there are few working examples of infrastructure banks in the United States at this time. Connecticut Congresswoman Rosa DeLauro has introduced legislation to authorize a National Infrastructure Bank multiple times,[31] and although her proposal has gained support amongst environmental and union groups,[32] the legislation has not made it through the political gridlock in Congress.

During the recent campaign, President-elect Donald Trump spoke extensively about funding infrastructure—and such a plan, if it materializes and makes it through the legislative process, could support or complement efforts by the State of New Mexico.

4.3 Consider Applying Economic Development Mechanisms to Broadband

Another potential approach to maximizing the effects of minimal funding would be to apply key economic development mechanisms to broadband. This would be a novel approach using established tools. For example, the State might consider the value of extending the Labor and Economic Development Act (LEDA), or creating a broadband version of the LEDA, as a means of stimulating job creation and community development.

4.4 Consider Creating a Non-Profit Entity to Further the Digital Inclusion Approach

New Mexico may also be able to further its goals in a less direct way by participating in the creation of a 501(c)(3) non-profit dedicated to expansion of broadband interests within the State.

A non-profit will serve as a private entity with which the public sector can partner to work together to accomplish the State's goals. The public-private partnership strategy has been adopted with impressive results by many jurisdictions, including the states of California, Minnesota, and North Carolina.

Creation of a non-profit affords the cause of digital inclusion numerous benefits. Primarily, 501(c)(3) status opens the cause to external funding resources not previously available. The non-profit can access funding sources (such as foundations and certain grants) in a way that no current government entity is able. Further, a non-profit Board of Directors and Advisory Board can retain

[30] "Connecticut Homeowners Investing Heavily in Solar, Reducing Energy Costs with Connecticut Green Bank Financing," Connecticut Green Bank, http://www.ctgreenbank.com/connecticut-homeowners-investing-heavily-solar-reducing-energy-costs-connecticut-green-bank-financing/ (accessed October 2016).
[31] "DeLauro Introduces National Infrastructure Development Bank Act," Congresswoman Rosa DeLauro, January 23, 2015, https://delauro.house.gov/index.php?option=com_content&view=article&id=1799:delauro-introduces-national-infrastructure-development-bank-act&catid=41&Itemid=177 (accessed October 2016).
[32] Erin Bzymek, "Infrastructure Bank Will Jumpstart National Investment in Transportation, Water, Communication Systems and Electric Grid," Blue Green Alliance, June 27, 2013, http://www.bluegreenalliance.org/news/latest/infrastructure-bank-will-jumpstart-national-investments-in-transportation-water-communication-systems-and-electric-grid (accessed October 2016).

State and agency (DoIT, OBGI) input without requiring the State to assume any of the burden of maintaining related programs. A non-profit can also act as an intermediary to support adoption and inclusion efforts for the time being, as a temporary entity that may later be incorporated by the State if and when appropriate.

Establishing such an entity will not come without challenges. Partnering agencies and individuals must work together to come to agreement on key goals, activities, responsibilities, and leadership. Further, efficient process is necessary to prevent any loss of momentum or current programming, and as such, funding must be secured in a timely manner. Effort is required on the federal, state, and local levels to facilitate creation of the non-profit.

Central to this model is the augmented benefit to the progress already accomplished by the State. State interests are both furthered and protected by the non-profit, while advisory boards, local government, and consumer advocacy groups have an entity with whom to discuss suggestions, give guidance, and voice concerns. The non-profit serves as an addition to the State's positive progress in broadband adoption, and should be viewed as such—a collaborator in the cause of digital inclusion.

5 Potential Parameters for a State Funding Program

Based on best practices developed in other states, as well as our experience and observations of federal and state-level broadband programs, we offer the following analysis and considerations for program parameters that the State and OBGI might consider if funding becomes available.

5.1 Scored Grant Mechanism

We recommend a scored grant mechanism that in our experience has been the most successful way of distributing modest broadband funding, both at the federal and state levels. In a scored program, as distinguished from some kind of auction mechanism, funding is awarded based on key selection criteria that flow from policy goals and risk containment strategies. Scored grants are a tested model that have been used by the U.S. Department of Commerce, the U.S. Department of Agriculture, and all of the states that have thus far awarded broadband funding.

Generally, a scored grant process will involve the following steps:

- First, the State would create a program management team or entity that ideally should include representation of multiple agencies of State government with expertise to understand broadband and evaluate grant applications.
- Second, once this program management mechanism has been created, the members of the selection team would develop the selection criteria for the grants, and direct development of the grant application itself, as well as forms for required data submission.
- Third, the entity would publish an RFP that includes the application materials, forms, and criteria.
- Fourth, the program management team would assemble a broad representation of agencies to evaluate the applications.
- Fifth, the team would award funding.
- Finally, and just as critically, award funding would be followed by verification of outcomes and auditing of the appropriate use of State funds.

A grant program of this sort has significant advantages in light of the State's goals. Among other things, it allows quantitative and qualitative evaluation of key criteria, including not only cost but also such matters as the track record of the applying entity, community support, the likely pricing for services under the program, commitment to customer service, likelihood of service to community anchor institutions (CAI), and likely impact on advancing digital inclusion and digital equity goals. In other words, this kind of process and program would allow the State to award

funding based on more factors than just cost—unlike most FCC Universal Service funding programs, where awards are based primarily on cost, usually through a reverse auction process.

Administering a grant program can be quite labor intensive. But it allows for custom analysis and, ideally, maximization of State resources. The states of California and Minnesota have had tremendous success in administering scored grant programs that enable the states to give targeted awards to entities that present the strongest business case and best use of state funding.

5.2 Eligible Entities

CTC recommends that the State open eligibility for the funding program as broadly as possible, in order to spur participation, planning, and creativity. We recommend this breadth of eligibility in part because many communities may choose to partner with private for-profit or non-profit entities, and their grant applications may be stronger as a result.

5.3 Eligible Areas

We recommend that the State create a pilot program for funding that would benefit both metropolitan and rural areas. For example, the State could potentially fund two metropolitan area programs and two in rural communities. This pilot approach would enable the State to test the viability and some of the parameters of funding programs in a full range of communities, rather than focusing only on metro or rural areas.

Further, we suggest that the State target both urban/suburban and rural markets for the pilot funding in order to test the interest of cities, as well as rural localities, in taking further steps. A State funding effort will require significant effort, and most likely significant additional funding from the local governments that apply for the State funding. If local governments (which understand the needs of their communities far better than outside entities) choose to apply for the funding and demonstrate interest in the program, the State will have confirmation of the breadth of interest and need.

5.4 Scoring Criteria

CTC recommends that the State entity or team charged with establishing the grant program and making awards consider the following criteria, among others, in scoring awards. These criteria are based on experience and best practices, both at the federal and state levels, over nearly a decade of broadband grant program experience. (There will be other criteria for award, of course, but in our experience, these are the principal ones that bear consideration from the very beginning.) Other states' experience with these and other factors is described in Appendix C.

5.4.1 Financial Viability

For obvious reasons, the first criterion we recommend is the financial viability of the project. We note that many projects will be in the planning stage rather than ready for execution, but we encourage the State to require a showing of financial viability as a means of determining how extensive the planning has been, and how far along the project is. A more sophisticated and extended planning process is likely evidence of long-term effort, extensive local input, and working through some of the pragmatic challenges likely to arise. Among other things, the State can require detailed description of the business model, and potentially business plan as well as financial projections and an explanation of the assumptions underlying them.

While it is never possible to remove all risk from a broadband project, as the economics of a broadband project are inherently challenging and risky, vetting a business model for viability and sufficiency is one means by which to identify high-quality applications.

Related to this requirement, we note that the State should also require that the entities partnering with the localities that apply for the funding are indeed themselves financially viable. The states of Illinois and Wisconsin, among others, encountered challenging situations when private sector grant awardees turned out not to have sufficient experience, depth of resources, or capability to overcome challenges.

The FCC overcomes this concern by requiring private sector applicants for federal funding to provide documentation of their financial viability in the form of letters of credit and multiple years of audited financials. Such documentation or other means of determining viability represent a best practice for protecting public funding.

5.4.2 Additional Funding Commitments

Depending on the size of the financial commitment the State makes, some level of additional funding—and indeed, possibly considerable additional funding—will be necessary. Among the potential sources of that funding could be investment by private partners, public entities, potential commercial users of the network, and other parties that stand to benefit.

A showing of commitments for additional funding, whether by public or private sectors, should be a necessary requirement of the grant scoring process, as an additional means of assessing the viability of the application and the likelihood of success. The showing can be made in a range of ways, from letters of interest to lease fiber, to commitments to invest, to local government documentation of pledged resources, proposed bonding, or budget allocations. Both the federal programs and most state grant programs have required commitments of this sort.

5.4.3 Technical Viability and Sufficiency

As with financial viability, we recommend that the State require a strong showing of technical capacity by the applicant or consortium of applicants. This capacity can be demonstrated through partnerships that a locality develops with other entities if the locality itself does not have experience building or operating communications networks. The technical viability can be shown in the form of discussion of experience, both with regard to construction and operations, including provision of service to the public.

While the requirement of this kind of experience may have the impact of reducing the participation of start-up companies, it will at the same time provide protection for the public funds involved. In our experience, one way to enable newer companies to participate is to take into account the depth of experience of the management team in the broadband industry—which can be an indication of technical capacity, if it is supported by the business and financial viability discussed above.

5.4.4 Breadth of Community Support

One critical criterion for assessing the viability and likely success of the grant application is demonstration of local community need and support. In our experience, this broad support usually exists in any community that applies for broadband funding. But it is advisable to request a showing of that support as means of ensuring that the community has been consulted and engaged, and a broad range of stakeholders has been part of the planning process and has demonstrated their interest and need—not only to support execution for the program, but to be users and customers of the broadband program that will emerge from the effort.

Both federal and state grant makers have found that letters of support—including, by way of example, organizations as diverse as business improvement districts, Boys & Girls Clubs, and religious organizations—serve as indicators of need and local commitments.

5.4.5 Digital Inclusion Benefits

Among other criteria, we recommend that the State include a showing that the program will benefit those in the community who have the least access to broadband services—whether that lack of access is because services are not available or not affordable. This is an area in which applicants should be encouraged to develop creative solutions and build them into their business and technical models, so they can meet the unique needs of their own communities.

Digital equity and digital inclusion goals often drive community broadband efforts—as does a clear understanding that lack of access to affordable broadband puts Americans who lack that access at a huge disadvantage relative to education, healthcare services, access to government services, and many of the other benefits conferred by broadband access.

6 Potential Broadband Public–Private Partnership Models for Local Governments

6.1 Incremental and Targeted Fiber Construction

In this model, a community would offer dark fiber[33] connections, through a lease, to institutions and businesses.

CTC's experience suggests that this is the business and technical model with the highest possibility of financial success and with the lowest risk for New Mexico localities. This model can facilitate a modest portion of the public goals related to new broadband deployment while still minimizing risk. This model requires a smaller capital investment than does more extensive fiber deployment and could allow the community to realize a modest revenue stream from this model—at the same time as meeting its own communications needs and reducing the cost of leasing circuits.

This model for fiber construction and leasing has been successfully implemented by a range of localities across the United States for nearly two decades.

Significantly, though this model will fill a market vacuum for selected business customers, it will not necessarily address the needs of residents and small businesses. The model does offer some incentives for a private provider to construct FTTP infrastructure, but is unlikely to be enough to attract all necessary private sector investment in FTTP because it does not significantly lower the costs of market entry.

6.2 "Concessionaire Models" in Public–Private Partnerships: Public Funding and Private Execution

In this model, localities negotiate formal public–private partnerships that resemble transit and toll-road construction projects, with public funding and private execution.

This model, which involves a substantial amount of public investment, is a variation on the traditional municipal ownership model for broadband infrastructure—but with private rather than public sector execution. In this model, a selected private partner takes responsibility for some combination of design, construction, financing, operations, and maintenance,[34] funded by the public partner over some period of time.

[33] Dark fiber refers to the lease of point-to-point fiber strands. The lessee of dark fiber is responsible for adding electronics to "light" the fiber.

[34] "Financial Structuring of Public–Private Partnerships (P3s)," U.S. Department of Transportation, 2013, http://goo.gl/gCJIZK (accessed October 2016).

The model offers considerable benefits to the public sector by removing significant logistical barriers from large-scale public broadband projects and offering a comprehensive solution (including extensive turnkey private execution and private capital) for the entire community.

These variations on the private execution, public funding model are as of yet untested; we urge caution for that reason. But we note that this model is a promising means by which to develop a network that can—if funded by the public sector—serve the entirety of the community, not just the parts selected by a private investor.

6.3 Public–Private Partnerships: Shared Risk and Execution

In this model, localities create hybrid models where a locality and private partner find a creative way to share the capital, operating, and maintenance costs of a broadband network.

Shared risk models are in their early days. We have only a few emerging projects and it's hard to conclude anything on that basis. But the shared risk models are more likely to emerge in more metro areas where private capital is going to find greater return. The public risk, private execution model can obviously benefit more rural communities because the public is providing a revenue stream to the private partner and is essentially guaranteeing the debt in order to make the financing viable and low interest. These private execution public risk models have potential import and applicability for rural areas and less dense areas, but they come at a real cost, which is inevitable because rural broadband is simply a very costly proposition.

A public–private partnership model based on shared investment and risk plays to the strengths of both the public and private sector partners. Most localities consider FTTP deployment not as a moneymaker, but as a powerful tool for education and economic development. Thus in a shared investment model, the risk is shared but the community still receives 100 percent of the benefits it seeks—recognizing that the benefits do not all appear on the project's financial statements. For the private partner, a shared investment means less upfront capital (risk), with an opportunity for future revenues.

Among other enormous benefits to this model, cities can not only provide fiber to the private sector—for compensation and to get gigabit and beyond service to the public—but can also secure extensive fiber throughout their communities for internal uses, including municipal and municipal utility operations, public safety, and emerging Smart City and Internet of Things (IoT) applications.

This model will provide an institutional or public sector network of the future—more extensive than any network that served city or county needs in the past, because the fiber will go everywhere in the community. It will have the potential to serve every conceivable application,

from traffic signal control to air quality monitoring, from robust and secure public safety communications to high-end videoconferencing between universities and schools.

Public sector use is ancillary to the core benefit of enabling a competitive gigabit (and beyond) product over fiber to every home and business in the community—but, in the long run, it has the potential to enable transformative public sector use and services. And indeed, local governments' track record of securing considerable savings and enormous operational capabilities over fiber is already demonstrated.[35]

We note, however, that while this model offers an extraordinary opportunity for innovation, it is in no way a sure thing for communities. We do not have the data points to develop the best practices necessary for success. At the moment, early actors are developing new and exciting partnerships to bring next-generation broadband to their communities. We describe some of those projects in the brief case studies below.

6.3.1 Case Study: Westminster, Maryland

The City of Westminster, Maryland, is a bedroom community of both Baltimore and Washington, D.C. where 60 percent of the working population leaves in the morning to work elsewhere. The area has no major highways and thus, from an economic development perspective, has limited options for creating new jobs. Incumbents have also traditionally underserved the area with broadband.

The city began an initiative 12 years ago to bring better fiber connectivity to community anchor institutions through a middle mile fiber network. In 2010, the State of Maryland received a large award from the federal government to deploy a regional fiber network called the Inter-County Broadband Network (ICBN) that included infrastructure in Westminster.[36]

Westminster saw an opportunity to expand the last mile of the network to serve residents. At the time, though, it did not have any clear paths to accomplish this goal. City leaders looked around at other communities and quickly realized that they were going to have to do something unique. Unlike FTTP success stories such as Chattanooga, Tennessee, they did not have a municipal electric utility to tackle the challenge. They also did not have the resources, expertise, or political will to develop from scratch a municipal fiber service provider to compete with the incumbents. As a result, they needed to find a hybrid model.

As the community evaluated its options, it became clear that the fiber infrastructure itself was the city's most significant asset. All local governments spend money on durable assets with long

[35] *See, for example:* "Community Broadband Creates Public Savings," Fact Sheet, Institute for Local Self-Reliance, https://goo.gl/kCEZeC (accessed October 2016).
[36] "The Project," Inter-County Broadband Network, http://goo.gl/GjBC26 (accessed October 2016).

lifespans, such as roads, water and sewer lines, and other infrastructure that is used for the public good. The leaders asked, “Why not think of fiber in the same way?” The challenge then was to determine what part of the network implementation and operations the private sector partner would handle and what part could be the city’s responsibility.

The hybrid model that made the most sense required the city to build, own, and maintain dark fiber, and to look to partners that would light the fiber, deliver service, and handle the customer relationships with residents and businesses. The model would keep the city out of network operations, where a considerable amount of the risk lies in terms of managing technological and customer service aspects of the network.

The city solicited responses from potential private partners through a request for proposals (RFP). Its goal was to determine which potential partners were both interested in the project and shared the city’s vision.

The city eventually selected Ting Internet, then an upstart ISP with a strong track record of customer service as a mobile operator. Ting shared Westminster’s vision of a true public–private partnership and of maintaining an open access network. Ting has committed that within two years it will open its operations up to competitors and make available wholesale services that other ISPs can then resell to consumers.

Under the terms of the partnership, the city is building and financing all of the fiber (including drops to customers’ premises) through a bond offering. Ting is leasing fiber with a two-tiered lease payment. One monthly fee is based on the number of premises the fiber passes; the second fee is based on the number of subscribers Ting enrolls.

Based on preliminary information, given that this is a market in development as we write, we believe this is a highly replicable model.

What is so innovative about the Westminster model is how the risk profile is shared between the city and Ting. The city will bond and take on the risk around the outside plant infrastructure, but the payment mechanism negotiated between the city and Ting ensures that Ting is truly invested in the network’s success.

Because Ting will pay Westminster a small monthly fee for every home and business passed, Ting is financially obligated to the city from day one, even if it has no customers. This structure gives the city confidence that Ting will not be a passive partner, because Ting is highly incented to sell services to cover its costs.

Ting will also pay the city based on how many customers it serves. Initially, this payment will be a flat fee—but in later years, when Ting’s revenue hits certain thresholds, Ting will pay the city a

small fraction of its revenue per user. That mechanism is designed to allow the city to share in some of the upside of the network's success. In other words, the city will receive a bit of entrepreneurial reward based on the entrepreneurial risk the city is taking.

Perhaps most significantly, there is also a mechanism built into the contract that ensures that the two parties are truly sharing risk around the financing of the outside plant infrastructure. In any quarter in which Ting's financial obligations to the city are insufficient to meet the city's debt service, Ting will pay the city 50 percent of the shortfall. In subsequent quarters, if Ting's fees to the city exceed the debt service requirements, Ting will be reimbursed an equivalent amount. This element of the financial relationship made the deal much more attractive to the city because it is a clear demonstration of the fact that its private partner is invested with it.

6.3.2 Case Study: Google Fiber/Huntsville, Alabama

In February 2016, the city of Huntsville, Alabama, a technology hub for the area, announced that its municipal electric utility will build fiber optics throughout its community (presumably, to pass all or most businesses and homes), and that Google Fiber will lease much of that fiber in order to provide gigabit services to residences and small businesses

The announcement between Huntsville and Google Fiber is a variation on the model pioneered in Westminster, though the payment terms are different and provide a key contrast. Google Fiber will lease fiber from Huntsville based on a rate sheet that provides for various levels of pricing based on amounts and volume. In contrast, Ting's obligations to Westminster are based in part on how much fiber it uses and in part on how many customers it secures and revenues it generates. As a result, Westminster will have less predictability and certainty about its revenues from Ting, but has the potential to share in upside in the event that Ting is very successful in that market.

As in Westminster, the Huntsville model puts the locality in the business of building infrastructure, a business it knows well after a century of building roads, bridges, and utilities. The model leaves to the private sector (in this case, Google Fiber and any other provider that chooses to lease Huntsville fiber) all aspects of network operations, equipment provisioning, and service delivery.

Interestingly, the Huntsville model holds the potential for competition among providers, as Google Fiber will not be the exclusive user of the fiber and other entities can also choose to lease fiber based on Huntsville Utilities' established rates. We anticipate that there will be other ISP users of the city's fiber, particularly to serve larger businesses and institutions, though we question whether the economics exist for another provider to compete against Google Fiber in the residential market, as least in the short-term. Over the long term, however, market demand and structures may change and new opportunities for competition may arise. By building and

owning its own fiber assets, the city of Huntsville has ensured it will be able to react to those changes and maximize its benefits.

6.4 Shared Risk Rural Wireless Strategies

In rural areas throughout the United States, where the cable and phone industries have not built robust communications infrastructure, there exists a significant deployment challenge: The extremely high capital costs for deploying communications infrastructure and services, and the relatively modest potential revenues. Both the high costs and the low likely revenues are driven by the fact that rural areas have low population density.

The State of New York is addressing this challenge through a massive rural broadband funding program of $500 million that is intended to be matched by an equivalent amount of private capital. The Commonwealth of Massachusetts is addressing its rural challenge with an infusion of $50 million for the rural unserved towns in the west of that state.

Frankly, absent proportional amounts of public funding, whether state, local, or federal, we see no clear path to deployment of next-generation FTTP infrastructure in the rural parts of New Mexico (or any other rural area of the United States not eligible for substantial FCC subsidy), though we note that the State is fortunate that its rural footprint is smaller than many other states, including New York and Massachusetts.

Rather than the kind of comprehensive rural solution for FTTP and next-generation gigabit services that are inconceivable absent massive public funding, we note that there are some targeted and lower bandwidth strategies emerging that require less public funding but could potentially enable development of new competitive broadband services with the capability to address the needs of rural New Mexico, but that frankly will be at lower bandwidth than the optimal gigabit networks that are more viable for the densely populated parts of the State.

Among the potential solutions are creative public-private partnerships that can be seeded with modest public funding and developed at a local level to address unserved and underserved areas and gaps in coverage. For example, rural Garrett County, in far western Maryland, is a relatively remote Appalachian community bordered by West Virginia and Pennsylvania. The county has struggled to get broadband in a number of its remote, mountainous areas. Where broadband is available, it is inadequate DSL service that does not meet the Federal Communications Commission's new speed benchmark for broadband service, let alone the requirements for home-based businesses or home schooling. The incumbent provider has not made any plans to expand or upgrade service offerings.

Though mobile broadband is available in some parts of the county, data caps mean that it is not viable for economic or educational activities. (Parents who homeschool their children can run

through their monthly bandwidth allotment in one day of downloading educational videos.) Beyond these challenges for residents, the county has struggled to attract and retain businesses and teleworkers.

In response, the county has gradually and incrementally built out fiber in some areas, with a focus on connecting specific institutions. And, in September 2015, the County Council approved a contract with a private partner to leverage some of that fiber and additional public funding to support the deployment of a fixed-wireless broadband network that will serve up to 3,000 currently unserved homes in the most remote parts of the county. The private partner, Declaration Networks Group (DNG), will also put its own capital toward the construction of the network, and will apply its technical and operational capabilities to managing the network.

The partnership involves cost to the county, but also massive benefit for residents and businesses in the newly served areas.

The county's outlay of funds will be $750,000, which will be matched by a grant from the Appalachian Regional Commission (ARC)—and which will be more than matched by DNG's commitment of both capital and operating funds. That relatively modest county contribution (which was then leveraged for the ARC economic development funding) made the economics of this opportunity very attractive to DNG, and secured a broadband buildout for an area that would otherwise not be attractive for private sector broadband investment.

From an economic development perspective, the county's investment represents enormous value for the dollar. This investment will enable residents in 3,000 homes to buy cost-effective broadband service that they cannot access now, and that will make possible telework, home-based businesses, and home schooling. This investment will also enable the county to close the homework gap for many students in the county schools who do not currently have broadband in their homes—an increasingly critical lack of service.

As the network is deployed over the next few years, the county will reduce to nearly zero the number of homes in the county that do not have access to some kind of broadband communications options. These options may be modest—not the robust speeds available in metro markets—but they are significantly better than nothing, and a huge economic development achievement from the county's standpoint.

7 Fiber Is Superior to Alternatives for Capacity, Security, and Long-Term Cost

The quality and speed of a connection will vary based on the capacity and limitations of the last-mile technology used. This report presents an overview of the four most common technologies used to deliver last-mile broadband data services to homes and businesses: fiber-to-the-premises (FTTP), digital subscriber line (DSL), hybrid fiber-coaxial (HFC), and wireless. Figure 2, above, shows the current and predicted capacity of broadband technologies.

7.1 Fiber-to-the-Premises (FTTP)

Fiber optic cables are the medium of choice for data transfer. They have enormous bandwidth capacity, which enables operators to offer symmetrical download and upload speeds. Fiber is also not subject to interference, and does not require amplifiers to carry a signal long distances.[37] This is why the vast majority of the Internet backbone comprises bundles of fiber cable strands.

Once a premises is connected to fiber, there is no need for significant outside plant infrastructure investment for decades. If more bandwidth is needed, the operator need only upgrade the network electronics, rather than having to replace the cables.

The electronics needed to provide 1 Gbps speed over a fiber-to-the-premises (FTTP) network are already widely available at an affordable price, and the price of the electronics needed to support 10 Gbps connections are declining rapidly.

7.1.1 Technical Capacity and Limitations

Fiber is one of the few technologies that can legitimately be referred to as "future-proof," meaning that it will be able to provide customers with better and faster service offerings to accommodate growing demand.

The biggest advantage that fiber offers is bandwidth. A strand of standard single-mode fiber optic cable has a theoretical physical capacity in excess of 10,000 GHz,[38] far in excess of the entire wireless spectrum combined, and thousands of times the capacity of any other type of wired medium, which can be symmetrically allocated between upstream and downstream data flows using off-the-shelf technology.

Further, modern fiber can provide extremely low losses within a wide range of frequencies, or wavelengths, of transmitted optical signals, enabling long-range transmissions. Compared to a signal loss on the order of tens of decibels (dB) over hundreds of feet of coaxial cable, a fiber

[37] Maximum distances depend on specific electronics—six to 25 miles is typical for fiber optic access networks.
[38] Conservative estimate derived from the channel widths of the 1285 to 1330 nm and 1525 to 1575 nm bands in G.652 industry-standard single-mode fiber optics.

optic cable can carry a signal of equivalent capacity over several miles, without amplification, with minimal signal loss.

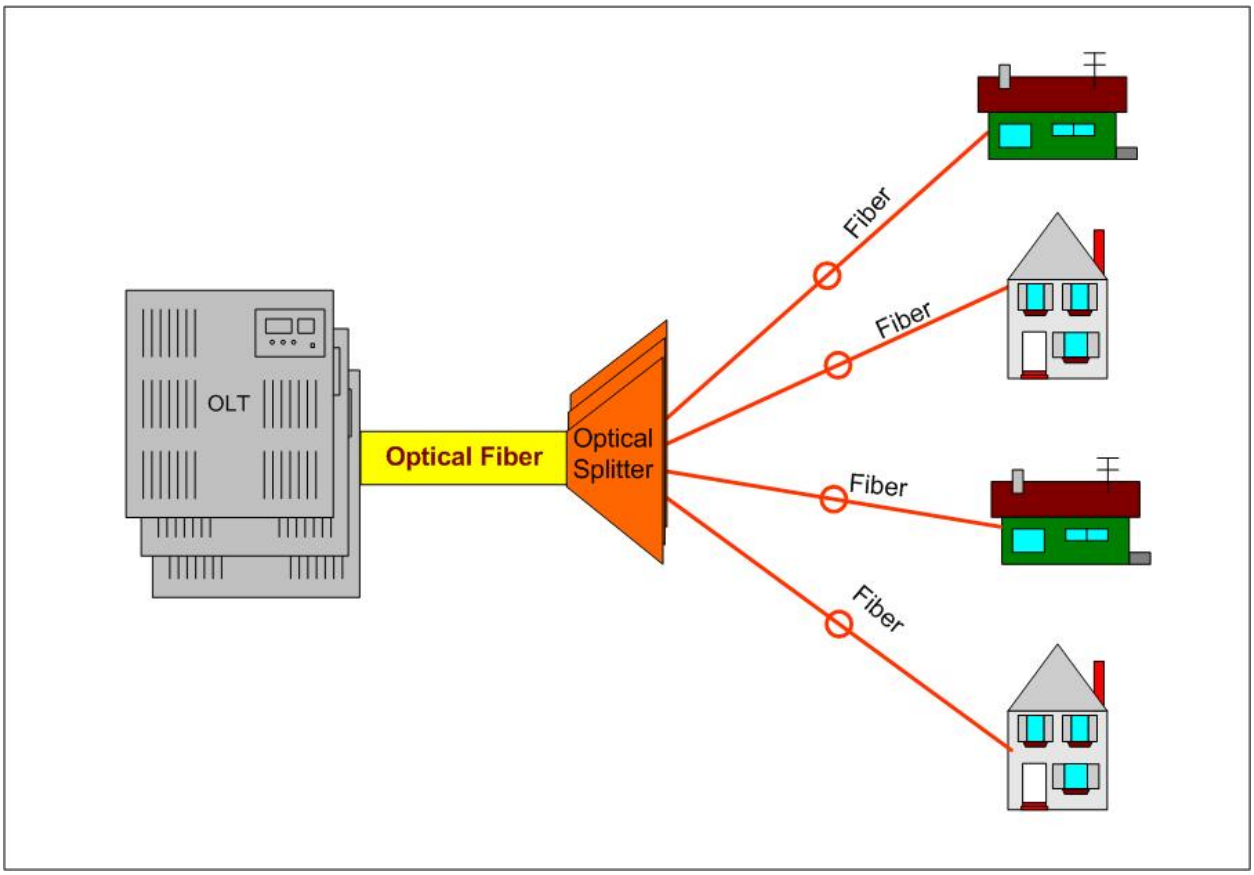
Moreover, weather and environmental conditions do not cause fiber cables to corrode over time in the way that metallic components can, which means that fiber has lower maintenance costs.

7.1.2 Factors Impacting Quality and Speed of Service

The following factors will determine an FTTP customer's service speed and quality:

- **Network electronics:** Core equipment in an FTTP network is housed at a central office (CO) or video headend office (VHO). As network electronics continue to improve, FTTP providers will be able to add higher tiers of service.
- **Network architecture:** Some FTTP operators use passive optical network (PON) technology, splitting the fiber capacity in a neighborhood cabinet to connect up to 64 users (Figure 5). This architecture provides less capacity per user than a direct fiber network (also known as active Ethernet or point-to-point) but is still able to sustain 100 Mbps to users. Currently deployed PON networks have capacity of 2.5 Gbps/622 Mbps (GPON) or 10 Gbps/2.5 Gbps (10GPON) for a single shared PON.

Figure 5: FTTP-PON Network Architecture



7.1.3 Future Capacity and Lifespan of Investment

Using off-the-shelf electronics, an FTTP network can deliver speeds well in excess of what most customers need today, and service providers can continue to upgrade network electronics to offer improved tiers of service. The outside plant can last for decades with minimal maintenance.

7.2 Hybrid Fiber-Coaxial

Cable broadband technology is currently the primary means of providing broadband services to homes and businesses in most of the United States. Because of its relative ubiquity in the majority of urban, suburban, and small-town areas and its inherently greater capacity than commercial wireless solutions and copper telephone lines (the medium underlying digital subscriber line, or DSL, service), HFC cable networks will be the main pathway for broadband communications for most homes and businesses for the foreseeable future.

Coaxial cables were originally designed to provide video services, and were sufficient in the early years of data communications, when usage was low compared to our current expectations. However, as demand for data capacity increased, coaxial networks became insufficient to support high-speed services. On an increasingly large scale, cable operators are now deploying

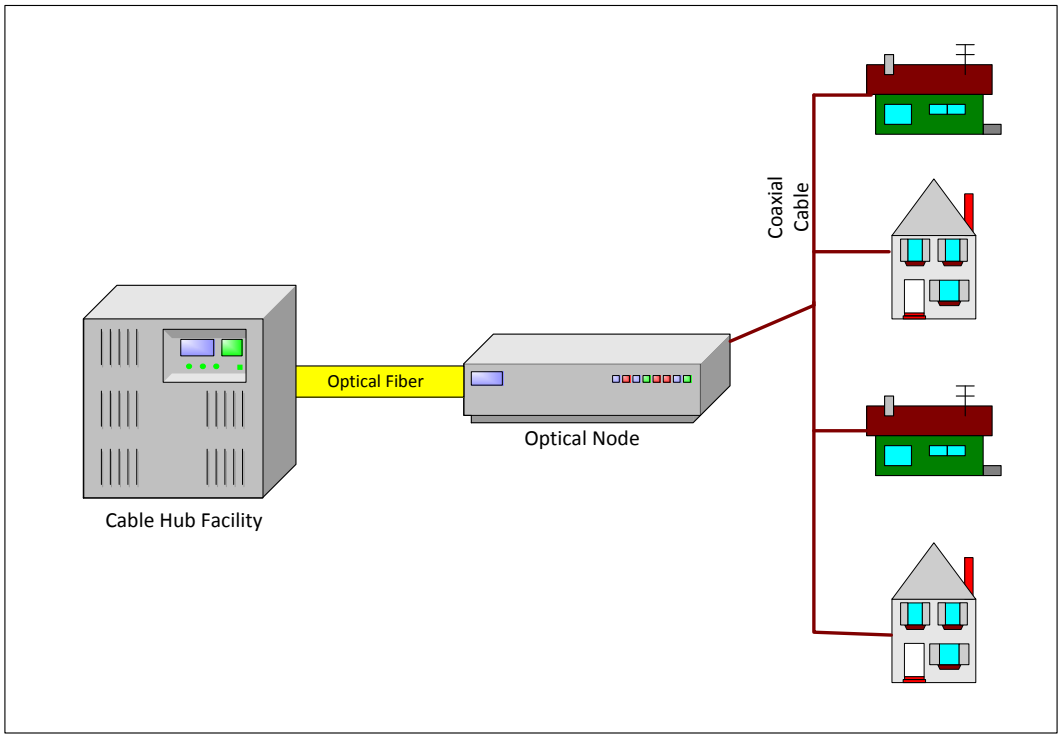
fiber to replace large portions of their networks because, for a given expenditure in communications hardware, fiber can reliably carry many times more capacity over many times greater distances than coaxial cable or any other communications medium. Thus, coaxial cable networks have transformed into hybrid fiber-coaxial (HFC) networks.

7.2.1 Technical Capacity and Limitations

Although there are a number of limitations inherent in cable systems relative to fully fiber optic networks, cable system capabilities will increase over the next few years with the deployment of new technologies and the extension of fiber closer to customers.[39]

In an HFC network, headend or hub locations house the core transmission equipment. Fiber connections extend from these hubs to multiple nodes, each of which serves a given geographical area (e.g., a neighborhood). These optical nodes are electronic devices located outdoors, attached to aerial utility lines or placed in pedestals. The equipment in the node converts the optical signals carried on fiber into electronic signals carried over coaxial cables. Coaxial cable then carries the video, data, and telephony services to individual customer locations (Figure 6).

Figure 6: HFC Network Architecture



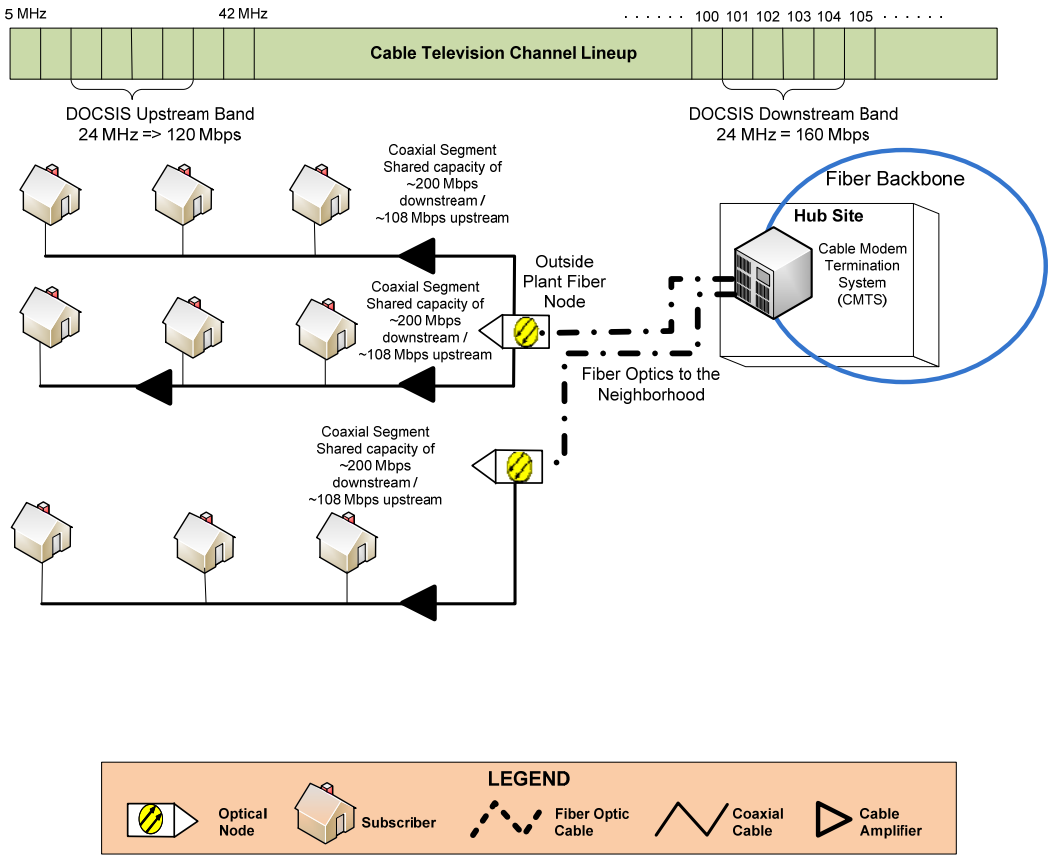
[39] Cable is not as scalable "out of the box" as communications systems that were designed from the outset to provide Internet-type broadband data services. Issues include coaxial cable's limitations in terms of physical capacity, a physical architecture optimized for broadcast communications, and a significant remaining migration path to full end-to-end Internet Protocol (IP) operations.

Cable operators have extended fiber optics progressively closer to their subscribers, but for cost reasons have generally stopped at nodes about one mile from the premises. Comcast, for example, typically only constructs fiber to the premises of customers that subscribe to Metro Ethernet and other advanced services.

The current leading cable technology for broadband data, known as data over cable service interface specifications version 3.0 (DOCSIS 3.0), makes it possible for cable operators to increase capacity relative to earlier cable technologies by bonding multiple channels together (Figure 7). The DOCSIS 3.0 standard requires that cable modems bond at least four channels, for connection speeds of up to 200 Mbps downstream and 108 Mbps upstream (assuming use of four channels in each direction). A cable operator can carry more capacity by bonding more channels.

It is critical to note that these are peak speeds, and that the capacity is shared by all customers—typically hundreds of homes or businesses—on a particular segment of coaxial cable. Speeds may decrease during bandwidth "rush hours," when more users simultaneously use greater amounts of bandwidth. For example, residential bandwidth use typically goes up considerably during evening hours, when more people use streaming video services and other large data applications.

Figure 7: DOCSIS 3.0 Network Architecture



Although the standard is still in the test phase, both Comcast and Time Warner have announced plans to begin upgrading their systems to DOCSIS 3.1 in 2016. The cable industry states that DOCSIS 3.1 will provide 10 Gbps downstream capacity and 1 Gbps upstream. This will not be possible for most actual cable systems—a typical system with 860 MHz capacity might have the first 192 MHz assigned to upstream, leaving approximately 660 MHz for downstream.[40] Even with 10 bps/Hz efficiency, the actual downstream capacity for a shared node area would be closer to 6 Gbps than 10 Gbps, and that capacity will be aggregated among a few hundred users.

Expansion of downstream spectrum to 1.2 GHz (and potentially to 1.7 GHz) is also being considered.[41]

7.2.2 Factors Impacting Quality and Speed of Service

The following factors will determine a cable broadband customer's service speed and quality:

1. **Bandwidth capacity of cable plant:** Most coaxial portions of a cable network have capacity of 750 or 860 MHz, but they can be upgraded to 1 GHz and beyond. If the cable corrodes, the available bandwidth shrinks, limiting possible connection speed.
2. **Number of customers sharing a node:** Cable capacity is shared among all the users connected to a given node, so connection speeds will decrease significantly during peak usage hours. Cable companies can reduce the number of customers sharing a node by putting fiber deeper into their systems and moving the node closer to the customers.
3. **Proximity of customer to node/fiber:** Another advantage of moving the node closer to the customer is that signals travel less distance on coaxial cable. With progressively shorter stretches of coaxial cable, the inherent problems with reliability and interference decrease.
4. **Standards and protocols:** Cable operators can make faster connection speeds available by dedicating more channels to data services and upgrading their networks to later versions of industry standards. DOCSIS 3.1 makes more efficient use of available spectrum, freeing up more bandwidth for data download and upload. However, customers would need to purchase new, DOCSIS 3.1-enabled cable modems.

Cable operators often offer services with "blast" or "burst" speeds of "up to" more than 100 Mbps. Although a customer may be able to access these speeds on occasion, the actual speeds available will probably be significantly lower during peak usage hours.

[40] Almost all cable systems in the U.S. currently have less than 50 MHz of bandwidth in the upstream direction.
[41] "An evolutionary approach to Gigabit-class DOCSIS," *CED Magazine*, July 5,2012, http://www.cedmagazine.com/articles/2012/07/an-evolutionary-approach-to-gigabit-class-docsis (accessed October 2016).

7.3 Digital Subscriber Line (DSL)

During the last century, phone companies connected virtually every home and business in the U.S. to a strand of copper wire. Copper has a fraction of the bandwidth capacity of coaxial cable, and suffers from greater signal loss and interference—but because of its ubiquity, digital subscriber line (DSL) technology over copper has been an important way for people to connect to the Internet.

In some scenarios, DSL operators can offer speeds that fit the FCC's definition of broadband. However, while DSL has been an impressive retrofit of existing infrastructure, copper cable is reaching its physical limitations as a broadband medium, and will not be able to meet future bandwidth needs.

7.3.1 Technical Capacity and Limitations

Bandwidth limits on copper cables are directly related to the underlying physical properties of the medium. Higher data rates require a broader frequency range of operation. Twisted-pair copper wire is limited to a few tens of megahertz in usable bandwidth, at most, with dramatic signal loss increasing with distance at higher frequencies.

The main determinant of DSL speed is the length of the copper line from the telephone company central office. In systems operated by large telecommunications companies, the average length is 10,000 feet, corresponding to available DSL speeds between 1.5 Mbps and 6 Mbps. In systems operated by small companies in rural areas, the average length is 20,000 feet, corresponding to maximum speeds below 1.5 Mbps.

The fastest copper telephone line technologies widely deployed in outside cable plant in the United States are VDSL and VDSL-2, the technologies underlying AT&T's U-verse and other services. Because these technologies use high frequencies, they are limited to 3,000 feet over typical copper lines and require fiber to the node (FTTN)—much closer than in most HFC systems. Therefore, in order to operate VDSL and VDSL-2, telecommunications companies must invest in large-scale fiber optic construction and install remote cabinets in each neighborhood.

In practice, telephone companies using VDSL-2 over highly upgraded copper lines have been able to provide 25 Mbps over a single copper pair and 45 Mbps over two pairs to the home or business—but it took a significant investment to make it possible for a small percentage of the copper phone lines to temporarily keep pace with cable. Providing even greater speeds will require some combination of even deeper fiber construction, a breakthrough in transmission technology over copper lines, and conditioning and upgrading of the existing copper lines.

New "G.Fast" technology standards enable speeds up to 1 Gbps over a single twisted-pair copper cable (and declining to about 150 Mbps as distances increase).[42] In early 2015 Sckipio demonstrated G.Fast speeds greater than 100 Mbps over nearly 500 meters, and in October 2015 Calix demonstrated speeds over 1 Gbps up to approximately 250 meters (820 feet).[43] Alcatel-Lucent has conducted a trial of the technology with more than 30 operators worldwide, but commercial deployments are just beginning.[44] Because the G.Fast standard is designed to work over short lengths of copper loop, deployments will still require significant investments to deploy fiber close to end-user premises. As a result, G.Fast has so far mostly been focused on deployments using telephone wires inside buildings.

7.3.2 Factors Impacting Quality and Speed of Service

The following factors will determine a DSL customer's service speed and quality:

- **Length of copper line/proximity to fiber:** The longer a signal has to travel over copper cable, the slower the possible connection speed.
- **Condition of copper cable:** Copper cable corrodes over time. As it deteriorates, interference increases and the available bandwidth shrinks, limiting the possible connection speed.
- **Number of copper pairs available:** To overcome the inherent limits of copper cable, some operators bundle multiple copper pairs.

7.3.3 Future Capacity and Lifespan of Investment

It is only a matter of time before the growing demand for bandwidth comes up against the physical limitations of copper as a medium for transporting data. Even if an operator can satisfy present demand using existing copper assets, it is a significant challenge to upgrade a DSL network in a way that the majority of a large scale network can continue to serve future demand. Many telecommunications companies are minimizing their investment in copper lines, and some are abandoning copper lines for wireless services or migrating to FTTP. New investment in DSL will likely become obsolete within a decade.

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[42] Mikael Ricknas, "Gigabit speeds over telephone wires get closer thanks to new G.fast standard," *PCWorld*, http://www.pcworld.com/article/2856532/gigabit-speeds-over-telephone-wires-get-closer-thanks-to-new-gfast-standard.html (accessed October 2016)

[43] "Calix Announces Innovations in G.fast and Vectoring at Broadband World Forum," Calix, October 20, 2015, https://www.calix.com/press-release/2015/10/calix-announces-innovations-in-g-fast-and-vectoring-at-broadband.html (accessed October 2016).

[44] Sean Kinney, "G.fast deployments need to pick up," *RCR Wireless News*, January 6, 2016, http://www.rcrwireless.com/20160106/network-infrastructure/g-fast-deployments-need-to-pick-up (accessed October 2016).

7.4 Fixed Wireless

The high cost of building wired networks in low-density rural areas often leaves rural residents without a wired broadband option. Wireless Internet Service Providers (WISPs) are potentially able to fill these coverage gaps, sending signals from base stations to antennas on or near customer premises. But WISPs are not able to offer connection speeds on a market-wide basis comparable to cable or FTTP built to each premises, and often need to impose data caps on customers to manage limitations on capacity. Accordingly, although fixed wireless service is an important tool to connect the unconnected, it will not offer the quality of service that the most advanced wireline providers can provide. Even as wireless technologies continue to advance, they will still lag the performance available from fiber optics, simply because of the relative challenge in providing high-capacity connections wirelessly over long distances.

7.4.1 Technical Capacity and Limitations

Smaller WISPs like the New York capital region's Hudson Valley Wireless use the same unlicensed spectrum bands as Wi-Fi, which does not have strong long-distance transmission qualities. (This is in contrast to the large mobile carriers like AT&T, Sprint, T-Mobile, and Verizon Wireless, which offer 3G/4G service using licensed spectrum.) WISPs may also use other unlicensed or semi-licensed bands like 3.5 GHz or 900 MHz, but these also have low data speed capabilities.

Most wireless networking solutions require the antenna at the customer premises to be in the line of sight of the base station antenna. This can be especially challenging in mountainous regions. It is also a problem in areas with dense vegetation or multiple tall buildings. WISPs often need to lease space at or near the tops of radio towers; even then, some customers may be unreachable without the use of additional repeaters. And because the signal is being sent through the air, climate conditions like rain and fog can impact the quality of service.

Some wireless providers in rural areas have begun to use vacant television frequencies called TV white space (or simply white space) to provide service. These TV bands have much better non-line-of-sight transmission qualities than the unlicensed bands; however, because white space technology is still in an early phase of development, compatible equipment is far more expensive than other off-the-shelf wireless equipment.

Wireless equipment vendors offer a variety of point-to-multipoint and point-to-point solutions. Point-to-multipoint solutions are more affordable to implement and are typically used in a WISP environment. However, they limit the capacity of the network, particularly in the upstream, making the service inadequate for applications that require high-bandwidth connections.

Fixed wireless systems built with off-the-shelf equipment today tend to have an aggregate capacity between 100 and 250 Mbps. With innovations like higher-order multiple input, multiple output (MIMO) antennas, and the use of spatial multiplexing, these capacities will likely increase

across vendors to as fast as 750 Mbps. It is important to note, however, that this is the aggregate capacity; bandwidth will be shared among up to 200 users connected to a single base station.

7.4.2 Factors Impacting Quality and Speed of Service

The following factors will determine a fixed wireless customer's service speed and quality:

- **Wireless equipment used:** Different wireless equipment has different aggregate bandwidth capacity and uses a range of different spectrum bands, each with its own unique transmission capabilities.
- **Backhaul connection**: Although the bottleneck tends to be in the last-mile connection, if a WISP cannot get an adequate connection back to the Internet from the tower, equipment upgrades will not be able to increase available speeds beyond a certain point.
- **Unobstructed line of sight:** Most wireless networking equipment require a clear, or nearly clear, line of sight between antennas for optimum performance. WISPs often lease space near the tops of radio towers in order to cover the maximum number of premises with each base station. In mountainous regions, many premises may not have a clear line of sight to a radio tower.
- **Weather conditions and foliage:** Depending on the spectrum used, weather conditions like rain or fog may cause interference. Also, line-of-sight paths that are clear during the winter may be obstructed by foliage during the warmer months.

7.4.3 Future Capacity and Lifespan of Investment

Wireless equipment generally requires replacement every five to 10 years, both because exposure to the elements causes deterioration, and because the technology continues to advance at a rapid pace, making equipment from a decade ago mostly obsolete. The cost of deploying a wireless network is generally much lower than deploying a wireline network, but the wireless network will require more regular investment.

7.5 Mobile Wireless

Cellular wireless carriers have been consistently increasing their data speeds with the rollout of faster and higher capacity technologies, such as Long-Term Evolution (LTE)[45]. Over the past few years, they have provided data plans with speeds comparable and in many cases greater than a typical residential customer's Internet service.

7.5.1 Technical Capacity

Wireless providers operate a mixture of third-generation (3G) and fourth-generation (4G) technologies. The service providers typically provide devices (telephones, smartphones, air cards,

[45] LTE is a 4G cellular wireless technology offering data speeds of typically around 30 Mbps.

tablet computers) bundled with 3G or 4G services. Devices may not be easily portable from carrier to carrier, because differences in the technologies used by the carriers limit compatibility of the devices (discussed below). Therefore, the purchase of a device may restrict a user's choice of service providers.

The strict definition of 4G from the International Telecommunications Union (ITU) was originally limited to networks capable of peak speeds of 100 Mbps to 1+ Gbps depending on the user environment.[46] According to that definition, 4G technologies[47] are not yet deployed.

In practice, a number of existing technologies (e.g., LTE, WiMAX) are called 4G and represent a speed increase over 3G technologies as well as a difference of architecture—more like a data cloud than a cellular telephone network overlaid with data services. The ITU and other expert groups have more or less accepted this.[48]

[46] "Development of IMT-Advanced: The SMaRT approach," Stephen M. Blust, International Telecommunication Union, http://www.itu.int/itunews/manager/display.asp?lang=en&year=2008&issue=10&ipage=39&ext=html (accessed October 2016).
[47] Such as LTE Advanced under development.
[48] "ITU softens on the definition of 4G mobile," *NetworkWorld*, December 17, 2010, http://www.networkworld.com/news/2010/121710-itu-softens-on-the-definition.html (accessed October 2016).

Table 1: Typical Performance for Advertised 2G/3G/4G Services

Applications	Technology (Download/Upload Service Speeds)[49]		
	2G/2.5G–EDGE/GPRS, 1xRTT (128 Kbps–300 Kbps/ 70 Kbps–100 Kbps)	3G–EVDO Rev A, HSPA+ (600 Kbps–1.5 Mbps/500 Kbps–1.2 Mbps)	4G – WiMAX/ LTE (1.5 Mbps–30 Mbps/500 Kbps–5 Mbps)
Simple text e-mail without attachments (50 KB)	Faster (2 seconds)	Faster (1 second)	Faster (1 second)
Web browsing	Faster	Faster	Faster
E-mail with large attachments or graphics (500 KB)	Average (14 seconds)	Faster (3 seconds)	Faster (1 second)
Play MP3 music files (5 MB)	Slower (134 seconds)	Average (27 seconds)	Faster (7 seconds)
Play video files (100 MB for a typical 10-min. YouTube video)	Slower (45 minutes)	Average (9 minutes)	Faster (3 minutes)
Maps and GPS for smartphones	Slower	Average	Faster
Internet for home	Slower	Average	Faster

7.5.2 Limitations

Most businesses and residents will find that wireless broadband has technological limitations relative to wireline. These include:

1) *Lower speeds.* At their peaks, today's newest wireless technologies, WiMAX and LTE, provide only about one-tenth the speed available from FTTP and cable modems. In coming years, LTE Advanced may be capable of offering Gbps speeds with optimum spectrum and a dense build-out of antennas—but even this will be shared with the users in a particular geographic area and can be surpassed by more advanced versions of wireline technologies (with Gbps speeds already provided by some FTTP providers today).

2) *More asymmetrical capacity, with uploads limited in speed.* As a result, it is more difficult to share large files (e.g., video, data backup) over a wireless service, because these will take too

[49] This table assumes a single user. For downloading small files up to 50 KB, it assumes that less than 5 seconds is faster, 5–10 seconds is average, and more than 10 seconds is slower. For downloading large files up to 500 KB, it assumes that less than 5 seconds is faster, 5–15 seconds is average, and more than 25 seconds is slower. For playing music, it assumes that less than 30 seconds is faster, 30–60 seconds is average, and more than 100 seconds is slower. For playing videos, it assumes that less than 5 minutes is faster, 5–15 minutes is average, and more than 15 minutes is slower.

long to transfer; it is also less feasible to use video conferencing or any other two-way real-time application that requires high bandwidth.

3) *Stricter bandwidth caps.* Most service providers limit usage more strictly than wireline services. Though wireless service providers may be able to increase these caps as their technologies improve, it is not clear whether the providers will keep ahead of demand. A *Washington Post* article about Apple's iPad with 4G connectivity highlights the issue: "Users quickly are discovering the new iPad gobbles data from cellular networks at a monstrous rate. Some find their monthly allotment can be eaten up after watching a two-hour movie. That has left consumers with a dilemma: Pay up for more data or hold back on using the device's best features."[50]

From a residential customer's perspective, a mobile wireless data cap may still be sufficient for a light user of the Internet. And, for certain users, higher connection speed may be considered a more desirable feature than unlimited, unfettered data.

Mobile broadband is only available where cell service exists. Furthermore, there are some areas, particularly in rural areas, where the cell service is relatively weak, or where upgrades have not taken place, and the broadband service is limited to slower service with speeds comparable to telephone dial-up. In contrast, "4G" LTE mobile data service is available with download speeds up to 30 Mbps and upload speeds up to 5 Mbps.

For most residential users, video streaming is the largest use of data. Use of streaming online video on smartphones, TVs and tablets through applications like YouTube, Netflix, Hulu, HBO Go, and other over-the-top (OTT)[51] services continues to increase. If a mobile broadband carrier offers 20 Mbps speed at the 8 GB data limit, one could only stream YouTube videos for six hours or watch two movies on Netflix with the 8 GB data cap. This is a major limitation for the average customer.

[50] Cecilia Kang, "New iPad users slowed by expensive 4G network rates," *Washington Post*, March 22, 2012, http://www.washingtonpost.com/business/economy/new-ipad-users-slowed-by-expensive-4g-network-rates/2012/03/22/gIQARLXYUS_story.html?hpid=z2 (accessed October 2016).

[51] "Over-the-top" (OTT) content is delivered over the Internet by a third-party application or service. The ISP does not provide the content (typically video and voice) but provides the Internet connection over which the content is delivered.

8 Federal Funding Opportunities for Local Governments

Federal funding is an important element of most large-scale public sector broadband deployments. Federal funding opportunities vary dramatically in size and target a wide variety of deployment scenarios and end users. This section provides information on a few of the significant federal funding opportunities available to communities in New Mexico in late 2016. Additional smaller opportunities may emerge in any given year—examples of the always-changing landscape of broadband funding.

8.1 Economic Development Administration Grants for Distressed Areas

The U.S. Department of Commerce's Economic Development Administration oversees programs that have provided economic assistance to distressed communities for many years. Public broadband projects in distressed communities are eligible for funding under both the Public Works and Economic Adjustment Assistance programs.

Broadband funding has not been a significant part of the EDA funding portfolio to date; the program's online annual reports (2007-2014) include only five references to relevant projects.[52] One of those grants was given in 2013 to the Vermont Digital Economy Project, a partnership between EDA and the Council on Rural Development, to "improve online access within twenty-five core communities and other targeted locations, strengthen online communications within the state, and enhance community and non-profit economic development functions." The size of that award is unclear, although Vermont received a total of six grants together worth $6.5 million in 2013.[53]

That said, both construction and technical assistance are eligible for EDA funding. Moreover, it appears that applicants can apply existing federal funds toward the cost-share, which allows them to leverage available resources. A brief overview of the program follows (based on the Federal Funding Opportunity announcement, or FFO).

For FY2016, the EDA requested $85 million for Public Works and $53 million for Economic Adjustment Assistance (EAA).[54] The average Public Works award is $1.4 million, with investments ranging from $200,000 to $3 million. EDA has historically awarded 80 to 150 Public Works projects annually. The average EAA award is $820,000, with investments ranging from $100,000 to $1.25 million. EDA has historically awarded funds for 70 to 140 EAA projects annually.

[52] EDA annual reports are available online at https://www.eda.gov/annual-reports/ (accessed October 2016).
[53] "Annual Report: Vermont," EDA, https://www.eda.gov/annual-reports/fy2013/states/vt.htm (accessed October 2016).
[54] "EDA Fiscal Year 2016 Budget Request At-A-Glance," EDA: Newsroom, March 2, 2015, http://www.eda.gov/news/press-releases/2015/02/03/fy16-budget.htm (accessed October 2016).

Applicants must typically make a matching contribution of at least 50 percent of the total award. In cases of extreme economic distress (i.e., substantially lower per capita income or higher unemployment than the qualifying levels), this requirement may be reduced to only 20 percent. The cost-share can be provided through "in kind" contributions.

In recent years, EDA has shifted to rolling deadlines for applications.[55] The application period is considered open until the EDA makes the next FFO announcement. The FY2016 FFO was issued on December 10, 2015.

The funding announcement repeatedly emphasizes the importance of consulting with the appropriate regional EDA contacts. Regional staff is available to review project proposals, assess proposed cost shares, and preview all application materials. Though optional, we believe that such consultation will be very advantageous.[56]

8.2 E-Rate Program for Services to Schools and Libraries

The Schools and Libraries Universal Service Fund program, known as E-rate, provides financial assistance to help schools and libraries obtain affordable broadband. The program is administered through the Universal Service Administrative Company (USAC) under the authority of the Federal Communications Commission (FCC).

Under the program, eligible schools and libraries may receive discounts ranging from 20 percent to 90 percent of the pre-discount price of eligible services. The discount rate given to schools and libraries is based on the percentage of students eligible for free or reduced price lunch or an alternative mechanism to determine need. (Libraries receive funding at the discount level of the school district in which they are located.)

For example, a school with 75 percent to 100 percent of students eligible for free or reduced price lunch would receive a 90 percent E-rate discount on eligible broadband services, and thus pay only 10 percent of the cost of those services. In addition, schools and libraries located in rural areas may also receive an additional 5 percent to 10 percent discount compared to urban areas.

Eligible schools, libraries, and consortia of schools and libraries apply for E-rate support every funding year (July 1 through June 30). E-rate applicants are generally required to seek competitive bids for the services they seek to purchase using E-rate funds; the price of eligible products and services must be the primary factor in selecting the winning bid. Requests for telecommunications services and Internet connections (commonly referred to as Category 1

[55] This is a change from previous grant cycles, which included separate funding cycles with establishes deadlines. *See, e.g.,* EDA, FY2015 FFO Fact Sheet (noting FY2015 phased application period), https://www.eda.gov/funding-opportunities/files/2015-EDAP-FFO-Fact-Sheet.pdf (accessed October 2016).
[56] EDA regional contacts are available online at: https://www.eda.gov/contact/ (accessed October 2016).

services) receive first priority for funding. The remaining funds are allocated to requests for support for internal connections and basic maintenance of internal connections (referred to as Category 2 services), beginning with the most economically disadvantaged schools and libraries.

The FCC recently announced improvements to the program designed to achieve new efficiencies with the available funds and maximize its benefits for the nation's schools and libraries. The FCC established three new goals for the program:

1. Ensuring affordable access to high-speed broadband.
2. Maximizing the cost-effectiveness of spending for E-rate supported purchases.
3. Making the E-rate application process and other E-rate processes fast, simple, and efficient.

Generally, the E-rate process begins in the fall and closes in the spring. The USAC website provides a detailed overview,[57] including video guides documenting each step of the application process.[58] The window during which schools and libraries can apply to USAC for funding is open from winter to spring preceding the start of the funding year.

USAC opens the application window in mid-winter and closes the window the following March or April. The exact dates differ each year and are announced on the USAC website.

8.3 Healthcare Connect Program for Services to Rural Hospitals

The Healthcare Connect Fund (HCF) provides a 65 percent subsidy to eligible health care providers and facilities for broadband service from providers including municipal or state organizations. While the focus is on serving rural facilities, teaching hospitals and urban/suburban facilities will be eligible if they are part of an in-state consortium that includes rural facilities. The program is administered through USAC under the authority of the FCC.

The HCF is intended to provide Health Care Providers (HCP) access to broadband services, particularly in rural areas, and to encourage the formation of state and regional broadband networks linking HCPs. Significantly, while the program is intended to benefit rural providers, consortia of urban and rural providers may also participate, so long as the majority of the members of the consortia (at least 51 percent) are rural.[59] HCPs may include public or nonprofit

[57] *See,* USAC, Schools and Libraries (E-rate), "Applicant Process" (with separate links describing each of the requisite forms), http://www.usac.org/sl/applicants/default.aspx (accessed October 2016).
[58] *See* USAC, Schools and Libraries (E-rate), "Online Learning Library" (providing dozens of short videos for each step of the application process), http://www.usac.org/sl/about/outreach/online-learning.aspx (accessed October 2016).
[59] Applicants can determine if an HCP is located in a rural area by using the Rural Health Care (RHC) Program's Eligible Rural Areas Search Tool.

entities including post-secondary schools offering health care instruction (e.g., teaching hospitals or medical schools); community health centers or health centers providing health care to migrant; a local health department or agency; a community mental health center; a not-for-profit hospital; a rural health clinic, or a dedicated emergency room of a rural for-profit hospital.

In particular, the HCF is intended to achieve three goals:

1. Increase broadband access to primarily rural HCPs.
2. Encourage the development of interconnected broadband health care networks.
3. Maximize the cost-effectiveness of the federal Universal Service dollars spent on services for health care.[60]

The HCF is intended to help expand health care providers' access to the high-bandwidth connections they need for modern telemedicine by:

- Addressing the artificial limitations on broadband connection types that have been a part of Universal Service support;
- Fostering the creation of consortia among rural and urban HCPs to share resources;
- Increasing the participants' portion of financial responsibility, but reducing their overall costs by improving buying power through the creation of a more competitive marketplace;
- Supporting a broad range of broadband services from a diverse set of providers and encouraging HCPs to build their own broadband networks where cost-effective; and
- Including service upgrades that are required to support new health care applications.[61]

Significantly, the FCC order creating the HCF states that the fund will, in addition to expanding broadband access for rural HCPs, "encourage the creation of state and regional broadband health care networks."[62]

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[60] Oliver, L., Jan. 10, 2013, "The FCC's Healthcare Connect Fund," http://www.usac.org/_res/documents/rhc/training/2013/healthcare-connect-fund-webcast.pdf (accessed October 2016).

[61] *See* FCC, USAC, Dec. 12, 2013, Press Release: "FCC Creates Healthcare Connect Fund to Expand Access to Robust Broadband Healthcare Networks, Improve Care and Lower Costs for Patients Nationwide," http://www.fcc.gov/document/new-healthcare-connect-fund-expands-access-broadband-healthcare (accessed October 2016).

[62] In the Matter of Rural Healthcare Support Mechanism, Dec. 12, 2012, Report and Order, WCDocket No. 02-60, at 3, https://apps.fcc.gov/edocs_public/attachmatch/FCC-12-150A1.pdf (accessed October 2016).

States and municipalities can benefit from the Healthcare Connect Fund by being selected as service providers to build broadband networks using federal funding. Unlike grants, which offer one-time money, the HCF offers a sustainable source of financial subsidy for rural HCPs, just as E-rate does for schools and libraries. Moreover, because funding is provided through the Universal Service Fund, it is not subject to annual appropriations. This means that HCF provides an ongoing funding stream for rural broadband projects. The FCC has capped funding for all Rural Health Care (RHC) programs, including HCF, at $400 million per year on a first-come, first-served basis. This cap is seldom reached, however; in FY 2015, for instance, funding requests for HCF totaled roughly $61 million.[63]

[63] USAC, Rural Healthcare, "Funding Information", http://www.usac.org/rhc/healthcare-connect/funding-information/default.aspx (accessed October 2016).

Appendix A: Glossary of Technical Terms

Asymmetric Data service with more capacity in the downstream (network to user) direction than the upstream (user to network) direction. Asymmetric services are often less costly to deploy and, because many uses of the Internet are heavier in the downstream direction, asymmetric services can suit the needs of many types of users. Asymmetric services are less well-suited to users who host data, who use many interactive multimedia applications, or who frequently upload large files.

Bandwidth Available range of frequencies (or number of channels) over a cable or over the air. Bandwidth is typically measured in the frequency range available (kHz or MHz).

Backhaul The transport of telecommunications network traffic from the outer edge of the network back to the central core. A common example is wireless backhaul, which is the connection from a wireless base station or tower to the wireless network core.

CableCard A device that is provided by the cable service provider or embedded in a retail device (e.g., television monitor) that allows access to digital cable services and maintains signal security without having to use a cable provider's set-top box.

CCAP Converged Cable Access Platform—Integration of the data and video portion of the cable architecture into one platform.

CODEC EnCOder-DECoder—converts between different types of video streams. A CODEC provides video in a known format, such as MPEG-2 or H.264.

Compression Reduction in the size of a video stream by computer processing, which takes advantage of symmetry and repetition in images and the stillness of a video picture over time. Widely available compression algorithms reduce the size of video by factors of tens or hundreds.

DOCSIS 3.X The latest version of a Data Over Cable Service Interface Specification telecommunication standard that enables the transmission of high-speed IP-based data and voice over the cable network and provides interoperability between devices of different manufacturers. Like Wi-Fi and Ethernet, DOCSIS made it possible to build less expensive, mass-produced devices.

Ethernet The name of the technology invented by the Xerox Corporation for a 10 Mbps shared resources LAN, subsequently incorporated into Institute of Electrical and Electronics Engineers standard IEEE 802.3. Ethernet, like Wi-Fi, is a widely adopted

standard that creates interoperability between different vendor devices and a widely adopted technical approach to networking. Almost all wired computer network interfaces are Ethernet, and Ethernet is now a typical interface on a digital television.

FTTP Fiber-to-the-premises

Headend A cable system operator's central cable TV facility, which receives satellite and off-air video feeds and inserts signals into the cable system. The headend also includes data and voice switching and administrative services.

HFC Hybrid Fiber Coax—A standard cable TV architecture in which the backbone network is fiber optic cable and the last-mile access network is coaxial cable. HFC is a scalable architecture, in which capacity can be increased by building fiber closer to users.

HDTV High-Definition Television—Video/images of higher resolution than standard definition (SD), resulting in enhanced picture quality. Common HDTV signal resolutions are 1920 x 1080 and 1280 x 720.

Hub Key facilities on a network that are served by the network backbone. Typically, hubs are connected to each other and the headend over redundant fiber paths.

IP Internet Protocol—A set of networking standards and an addressing scheme which emerged with the Internet and is also frequently used in private networks.

MHz Megahertz—Unit of measurement for frequency and bandwidth. One MHz is one million cycles per second. AM radio is between 0.54 and 1.6 MHz; FM radio is between 88 and 108 MHz; and over-the-air television frequencies range between 54 and 700 MHz.

Modem MOdulator-DEModulator, typically providing an interface between a cable (telephone, cable TV, or fiber optic) and data terminal equipment.

MPEG Motion Picture Experts Group—A video standard for full-motion, entertainment-quality television. Most cable television uses the MPEG-2 standard.

Node A component in a Hybrid Fiber Coaxial network that converts between optical and electrical signals and resides at the boundary between the fiber optic cable and coaxial cable. Since the capacity of fiber optics is much greater than coaxial cable, a cable system with optical service nodes serving fewer subscribers provides greater capacity for interactive services.

PEG Public, Educational, and Governmental programming. PEG channels, studios, and equipment are provided in cable franchise agreements. Public access is typically operated by a nonprofit entity or by the cable operator, and is intended to provide members of the public with the ability to produce and broadcast television programs. Educational channels are operated by schools or higher education institutions. Government channels are operated by local governments and typically air public meetings and government information.

QAM Quadrature Amplitude Modulation—The presentation of data on a carrier signal in a cable or over the air by using different combinations of its phase and amplitude. QAM is the technique used on cable systems for digital video and cable modem services. It makes it possible for a cable system to carry six (64-QAM), eight (256-QAM), or 10 (1024-QAM) Mbps of data for each MHz of frequency used.

Spectral Efficiency A measure of the efficiency of data transmission over bandwidth (or spectrum), which determines the amount of useful information per unit of spectrum (devoid of error correction and other parameters aiding smooth transmission). It is usually measured in bps/Hz.

Appendix B: Checklist for Localities for Building a Partnership

1. Determine your priorities
    a. Competition?
    b. Enhanced service?
    c. Equity and service to all?
    d. Public control over infrastructure?
    e. Risk avoidance?
2. Consider private investment and public facilitation
    a. Make available public assets like fiber and conduit
    b. Share GIS data
    c. Streamline permitting and inspection processes
    d. Offer economic development incentives to attract private broadband investment
3. Consider private execution with public funding
    a. Identify revenue streams that can be directed to a private partner
    b. Issue RFP for private turnkey execution
4. Consider shared investment and risk
    a. Evaluate using assets to attract private investment
    b. Evaluate funding new assets to attract private investment
    c. Evaluate building new fiber assets to businesses and/or homes for leasing to private ISPs

Appendix C: Overview of Other States' Broadband Funding Programs

California Advanced Services Fund

The California Advanced Service Fund (CASF) was created in 2007 to provide grants to bridge the digital divide in unserved and underserved parts of the state. The CASF is administered by the California Public Utilities Commission (CPUC) and began with $100 million from the state to first provide broadband services to areas without any broadband access, then to build out infrastructure in underserved areas with any remaining funds.

In 2010, Governor Schwarzenegger allocated an additional $100 million to the Broadband Infrastructure Grant Account, the sub-program of the CASF that handles grants for broadband construction.[64] In 2011, Governor Brown signed legislation to expand the CASF to $225 million through 2018. The CASF is being funded through a small assessment on telephone and VoIP services.[65]

The goal of the CPUC is to approve funding for infrastructure projects that will provide broadband access to no less than 98 percent of California households.

Projects Eligible for Funding

The CASF provides both grants and loans to assist in the building and/or upgrading of broadband infrastructure in areas that are not served or are underserved by existing broadband providers. The funded projects are a mix of middle mile and last mile, including DSL, wireless, and FTTP projects. The State prioritized unserved and underserved areas, specifically focusing on households, but also provides direct and indirect support for anchor institutions that are working on bridging the digital divide through deployment of broadband technology, education of the public about the availability of service options, promotion of use of service options, and provision of consumer outreach and training.

Underserved is defined as no wireline or wireless carrier offering service at advertised speeds of at least 6 Mbps download and 1.5 Mbps upload; unserved is defined as only having dial-up service available. Organizations looking to build infrastructure in served areas are not permitted to apply,

[64] *California Public Utilities Commission*, "California Advanced Services Fund (CASF): Background and History," http://www.cpuc.ca.gov/PUC/Telco/Information+for+providing+service/CASF/index.htm (accessed November 25, 2015).
[65] *TechNet*, "2012 State Broadband Index," http://www.technet.org/wp-content/uploads/2012/12/TechNet_StateBroadband3a.pdf (accessed November 12, 2015).

unless the organization can prove that speeds in that area are not, in actuality, as high as initially assessed.[66]

As of December 2014, the CPUC had authorized $99.19 million for 47 projects that were expected to benefit nearly 300,000 households. Of these households, around 16,000 were previously unserved and 276,000 were underserved.

Applicants Eligible for Funding

In the original legislation, CASF funding was available to entities with a Certificate of Public Convenience and Necessity (CPCN) that qualify as a "telephone corporation" or wireless carriers that are registered with the CPUC. CASF funding is now also available to non-telephone corporations that are facilities-based broadband service providers. Non-telephone corporations must provide last-mile broadband access and only receive funding to provide access to unserved or underserved households. The program allows incumbent telephone providers in underserved areas a right of first refusal for grants, if they make a commitment to upgrade their facilities in the areas using their own funds.

The majority of the projects have been partnerships. The State provides grants for up to 70 percent of construction costs for projects in unserved areas and up to 60 percent of construction costs for projects in underserved areas. The Revolving Loan Program provides supplemental financing for up to 20 percent of projects costs, with a maximum of $500,000.[67]

Lessons Learned

The CPUC concluded that its eligibility requirements for grant applications were too constrictive, resulting in too few applications and too large a surplus of funding—the CPUC received only five applications in the October 2012 application period, even though it still offered more than $40 million of the second $100 million allocated in 2010. Based on letters from private companies and the California public, the CPUC realized that requiring applicants to possess a CPCN or a Wireless Identification Registration (WIR) was the aggravating factor, because it cut out the 28 wireless ISPs (WISP) already operating cost-effectively in rural areas, as well as American Indian tribes trying to build infrastructure on their tribal lands, among other entities.

Additionally, the large telecommunications companies were using their grant money to focus almost exclusively on middle-mile infrastructure instead of serving individual homes and businesses, because that was the cheaper portion of the overall network to build. This meant

[66] *California Public Utilities Commission*, "California Advanced Services Fund (CASF): Infrastructure Grant and Revolving Loan Account," http://www.cpuc.ca.gov/PUC/Telco/Information+for+providing+service/CASF/CASFGrantLoan.htm (accessed July 16, 2015).

[67] Wells, Diane, "State Broadband Infrastructure Programs," *Minnesota Office of Broadband Development*, February, 2015.

that a lot of public money was being used, but the original mission of the program to supply broadband access to 98 percent of California households was not being fully realized.

To remedy the situation, the CPUC lobbied the state legislature to remove the restrictions. At the end of 2013, after several attempts, CPUC was successful. Now, more types of entities are eligible to apply for grants. The legislature initially rejected the idea because organizations not holding CPCNs or WIRs are subject to less direct regulatory control, which raised concerns about the potential for waste, fraud, and abuse. However, the CPUC has been able to make use of previous grant-allocation models to develop pathways to oversee and regulate the work of the grantees, satisfying the legislature. No grants had been made to non-CPCN, non-WIR entities as of the end of 2015, but multiple applications are currently under review and likely to be funded.[68]

Illinois Gigabit Communities Challenge

This program was launched by Governor Pat Quinn in February 2012 to award up to $4 million in seed funding to "the most promising ultra-high-speed broadband deployment projects in Illinois" under Governor Quinn's multi-year Illinois *Jobs Now!* economic development program.

The project was coordinated by the Illinois Broadband Opportunity Partnership (IBOP), a statewide consortium of public and private sector partners organized by Governor Quinn and led by Illinois State University's Central Illinois Regional Broadband Network (CIRBN) and the State of Illinois Department of Central Management Services (CMS).[69]

The targeted, long-term goals of the project were to: "Improve employment opportunities; enhance economic development through the development of 'smart communities;' bring Illinois closer to the goal of increasing the proportion of residents with high-quality degrees and credentials to 60 percent by the year 2025; connect health care professionals with their patients; and position Illinois' universities to continue to lead the nation in research, technology, and innovation."[70]

Projects Eligible for Funding

The program funded broadband infrastructure projects to connect major higher-education institutions and high-density corridors, prioritizing high-impact connections over connection of more rural, lower-access areas of the state. However, projects that extended broadband

[68] *California Public Utilities Commission*, "Order Instituting Rulemaking to Consider Modifications to the California Advanced Services Fund," October 25, 2012, pp. 6–21, http://docs.cpuc.ca.gov/PublishedDocs/Published/G000/M032/K728/32728734.PDF (accessed November 30, 2015).
[69] *Broadband Illinois*, "Illinois Gigabit Communities Challenge," http://www.broadbandillinois.org/Use-it/Illinois-Gigabit-Challenge.html.
[70] *Broadband Illinois*, "Illinois Gigabit Communities Challenge," http://www.broadbandillinois.org/Use-it/Illinois-Gigabit-Challenge.html.

infrastructure to the unserved and underserved were also funded. Higher-density areas were prioritized with the idea that the extended infrastructure would reduce the cost for private providers to build last-mile broadband infrastructure off the State's backbone.

Applicants Eligible for Funding

The challenge was open to any private or public organization and required projects to connect at least 1,000 end users to an ultra-high-speed broadband network capable of delivering speeds of 1 Gbps.[71]

One of the State's priorities was expanding higher education through broadband deployment, so the areas prioritized were those with large higher-education institutions such as the University of Chicago, Northwestern University, and Southern Illinois University.

Each project prioritized universities and/or community anchor institutions first, then expanded to business interests, such as commercial resale of ultra-high-speed broadband services.[72]

Funded Projects

A total of $8 million was awarded under the program. The partnership of Gigabit Squared, Cook County, the City of Chicago, and the University of Chicago received $2 million to deploy fiber and wireless in nine neighborhoods in Chicago.[73] The second award of $1 million went to OnLight Aurora to connect the City of Aurora's fiber optic network to its education, business, and healthcare institutions.[74] The third award, also for $1 million, was granted to the City of Evanston and Northwestern University for a $2.5 million project to promote business, medical service, and educational opportunities for the City, and research programs for the university.[75] The City of Carbondale—in partnership with Frontier Communications, Southern Illinois University, and Connect SI—earned the fourth grant of $1.5 million for fiber deployment to businesses, schools, hospitals, and neighborhoods, as well as the university.[76]

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[71] *Broadband Illinois*, "Illinois Gigabit Communities Challenge," http://www.broadbandillinois.org/Use-it/Illinois-Gigabit-Challenge.html (accessed November 24, 2015).
[72] Clark, Drew, "Onlight Aurora, Most Advanced Illinois Gigabit Communities Awardee, Shows How to Leverage Its Fiber Network," *Broadband Breakfast*, http://broadbandbreakfast.com/2013/11/onlight-aurora-most-advanced-illinois-gigabit-communities-awardee-shows-how-to-leverage-its-fiber-network/ (accessed November 11, 2015).
[73] *Broadband Illinois*, "Governor Quinn Announces First Winner of Illinois Gigabit Communities Challenge," press release, http://www.broadbandillinois.org/news/194 (accessed November 24, 2015).
[74] *Broadband Illinois,* "Governor Quinn Announces Second Illinois Gigabit Communities Challenge Winner" press release, http://www.broadbandillinois.org/news/196 (accessed November 24, 2015).
[75] *Broadband Illinois,* "Quinn Grants $1 Million to Evanston in Gigabit Communities Challenge Program," press release, http://www.broadbandillinois.org/news/226 (accessed November 24, 2015).
[76] *Broadband Illinois*, "Gov. Quinn Awards $1.5 Million to Carbondale Area as Part of Gigabit Communities Challenge" press release, http://www.broadbandillinois.org/news/307 (accessed November 24, 2015).

Lessons Learned

The Illinois experience demonstrates two areas of peril: First, it is critical to fully vet potential grant applicants if they are private sector. Illinois, in one case, funded an impressive looking but, in reality, unstable and inexperienced company. The company defaulted on its obligations after spending much of the funding granted by the State, with the result that the local community's hopes were deeply disappointed and the State was deeply embarrassed. Funding granted to public and higher education entities does not entail this kind of risk, as these entities offer both stability and long-term relationships with the State that they will not endanger recklessly.

The second lesson learned in Illinois is the importance of providing grants to entities that are ready and able to execute, based on prior planning and internal capacity. In one Illinois project, the university and city partnership was so slow commencing the build-out of the project that when a new governor was elected, he demanded the money back. Since the network had not broken ground and the funding was still available, the city and university were forced to relinquish it. Proven ability to execute in a reasonable time frame should therefore be a criterion for funding.

Maine ConnectME Authority

The State of Maine created the ConnectME Authority in 2006 with the goal of stimulating investment in communications technology infrastructure in unserved or underserved areas. Since that time, the Authority has conducted nine grant rounds.[77] From 2007 through 2014, the Authority awarded 122 grants totaling nearly $10 million through a process that solicited, scored, and awarded bids from public–private partnerships.[78]

Areas Eligible for Funding

The ConnectME Authority focuses entirely on underserved or unserved areas of the state and the Authority included defining the terms as part of its mission. However, the Authority has thus far focused almost entirely on defining and serving unserved areas, as they are numerous.[79]

The networks were built as small FTTP or wireless projects, often off the backbone of the Three-Ring Binder fiber project, which built three rings of fiber along the eastern and southern sides of

[77] *ConnectME*, "ConnectME Authority Grant Program—Funds for Broadband Infrastructure Projects," http://www.maine.gov/connectme/grants/index.shtml (accessed November 6, 2015).
[78] "ConnectME Authority Grant Program—Funds for Broadband Infrastructure Projects" (accessed November 6, 2015).
[79] Based on interview by CTC staff of Executive Director of the ConnectME Authority of Phil Lindley, November 25, 2015.

the state, connecting the northernmost tip to the southernmost tip. The Three-Ring Binder is an open-access, middle-mile network completed in 2012.[80]

Entities Eligible for Funding

The communities applying for grants were required to partner with one of the five approved telecommunications providers already serving customers in Maine. Each grant applicant was required to show a partnership between a municipality, county, or regional authority, and an established ISP.[81]

The ConnectME Authority's funds come from a 0.25 percent surcharge on all communications, video, and Internet service bills in Maine, as well as a $2.5 million cash contribution from Verizon, per its agreement with the Maine Public Utilities Commission as a condition of the sale of its local telephone lines. To fund itself, the Authority can also require every provider to contribute on a competitively neutral basis.[82]

Public–private partnerships applied for and won grants for higher-impact areas in the first five grants rounds, leaving more difficult and costlier projects for the most recent four grant rounds. The ConnectME Authority is now facing declining revenues and is only able to fund smaller and smaller projects. One difficulty is geography; another is population density and demographics. The terrain over which the grantees are building is more treacherous and remote. The number of households served per grant dollar is lower because the population is less dense and what people there are, are less likely to sign up for broadband service with the ISP than those in higher-density areas.[83]

Of the 122 projects the ConnectME Authority has funded over past eight years, all but eight projects have been completed to date: one project that was declined by the grant awardee before work began, two projects that were begun in 2013 and were granted extensions based on make-ready issues encountered, and five from 2014 that have either finished and have not yet filed paperwork or are finishing soon. The tenth grant round will be opening in early 2016 and will for the first time include funding for feasibility studies and other such projects, in addition to construction projects.

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[80] *Maine Fiber Company*, "Our History," http://www.mainefiberco.com/about/history/ (accessed November 30, 2015).
[81] *ConnectME*, "ConnectME Authority Grant Program—Funds for Broadband Infrastructure Projects," http://www.maine.gov/connectme/grants/index.shtml (accessed November 25, 2015).
[82] Wells, Diane, "State Broadband Infrastructure Programs," *Minnesota Office of Broadband Development*, February, 2015.
[83] *ConnectME*, "ConnectME Authority, Draft of Detailed Triennial Strategic Plan for Broadband Service," October 30, 2015, p. 10, http://www.maine.gov/tools/whatsnew/attach.php?id=660801&an=1 (accessed November 25, 2015).

Lessons Learned

In the beginning, the ConnectME Authority allowed incumbent ISPs to challenge grant applications if they already had infrastructure or plans to construct it soon. Over the course of the ConnectME project, incumbents made roughly half a dozen challenges, most of them successful. The intent was to allow the private sector to take care of areas they were already covering or planning to cover, thus reserving public funds for unserved areas. However, a challenge was overturned in one case, when local citizens acted collectively to prove the incumbent's services actually provided speeds below the "served" definition. The challenge option has since been removed for that and other reasons.[84]

A critical component of success is strong and steady support from the State legislature and executive branch. Local activism and organization efforts should also get sufficient attention: in some communities, local economic development groups and councils actively drew attention to their areas' needs and the benefits that would accrue from increased broadband access. In Maine, the State legislature, executive branch, senators, and representatives were all highly supportive of the ConnectME Authority's efforts and need for funding.[85]

Massachusetts Broadband Institute (MBI)

In August 2008, Governor Deval Patrick signed into law a Broadband Act establishing the Massachusetts Broadband Institute (MBI), which leveraged public and private resources to bring broadband to communities found to have no access to high-speed Internet.[86] The legislation set out a timeline of three years to complete all expansion projects and placed the MBI within the Massachusetts Technology Collaborative. The program's focus was to close the digital divide in Massachusetts, particularly expanding broadband availability in the unserved areas of western and central Massachusetts.

Since 2008, the program has been renewed and funding expanded several times. Most recently, in 2015, $50 million was set aside by the state legislature to continue the project into fiscal years 2015 and 2016. The current main focus is projects that can utilize the MassBroadband 123 fiber network, a middle-mile network connecting 123 communities.[87] In addition, MBI provides support for communities and providers in the form of grants, access to infrastructure, and technical assistance.

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[84] Based on interview by CTC staff of Executive Director of the ConnectME Authority of Phil Lindley, November 25, 2015.
[85] Ibid.
[86] "Broadband Bill," *Massachusetts Broadband Institute*, http://broadband.masstech.org/history/broadband-bill.
[87] "MassBroadband 123," *Massachusetts Broadband Institute*, http://broadband.masstech.org/building-networks/middle-mile/massbroadband-123.

Areas Eligible for Funding

Ninety-five communities in Massachusetts were assessed to have either limited or no broadband availability, particularly in the western half of the state, which meant that more than 220,000 households and more than 25,000 businesses lacked adequate broadband. The Commonwealth determined that adequate broadband availability would improve public safety and access to health care, provide more educational opportunities, and encourage higher civic participation. The Department of Revenue estimated the Commonwealth would save $300,000 annually once each town hall could conduct business online.[88]

In early 2013, Governor Deval Patrick authorized $40 million in new bonds to fund the last mile.[89] Later in 2013, Governor Patrick allocated an additional $10 million toward "a swifter solution to one of its major hurdles: delivering high-speed broadband connections to the homes of people in the state's 45 most unserved and underserved communities," which will be "invested into the Last Mile portion of the project, which expands the fiber optic network to individual homes and small businesses."[90] When Governor Charlie Baker was sworn into office in 2015, he upheld and pledged support for the program, which is still funded and operating.

Prior to 2013, roughly $194,000 was awarded to four entities for wireless infrastructure buildouts and the remainder paid for four feasibility studies for FTTP or wireless infrastructure.

Of the funds allocated in 2013, the Town of Leverett was the first to complete a last-mile project, utilizing a $27,700 grant from MBI and making up the balance with local funds.[91]

The grants from the 2011-2012 program were up to a maximum of $50,000 per provider and project, and recipients were required to provide 25 percent in matching funding.[92]

The grants for the last-mile initiatives were given out based on ability of the entity to quickly provide last-mile service to underserved areas.

The Commonwealth prioritized unserved communities, primarily in the western half of the state, that were without any type of broadband service.

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[88] *Massachusetts Broadband Institute*, "Governor Deval Patrick Signs Broadband Access Law," press release, http://broadband.masstech.org/sites/mbi/files/documents/who-we-are/broadband-pr808.pdf.
[89] "History: The MBI Timeline," *Massachusetts Broadband Institute*, http://broadband.masstech.org/what-we-do/history.
[90] Ibid.
[91] "MBI Broadband Last Mile Broadband Policy," *Massachusetts Broadband Institute*, http://broadband.masstech.org/sites/mbi/files/documents/building-the-network/mbi-last-mile-program-policy-07-30-2015%20.pdf.
[92] "History: The MBI Timeline."

For the current phase of the Broadband Extension Program, communities that have neighborhoods with lower than 96 percent cable penetration rates are eligible.[93]

The MBI utilized the MassBroadband 123 fiber optic network, which was specifically designed to provide a regional framework to support the expansion of services in the underserved communities. MassBroadband 123 lays the groundwork for private ISP investment into last-mile service to residents and businesses, by providing any broadband service provider open access to connect and offer services. The Commonwealth also offers technical assistance and contracts with a network operator to increase efficiency.[94]

Projects Eligible for Funding

Local governments have a choice of three frameworks: a regional fiber-to-the-home (FTTH) network, a single-town FTTH enterprise option, and a single-town wireless-fiber hybrid Enterprise option. In the first option, fiber in a town will extend along all streets and be accessible to all premises in a town (business as well as residential). The MBI network design for the regional network will enable towns to select a single regional operator, multiple regional operators, or their own town operator. In the second option, a town partners with a private company that designs, constructs, and operates the network for the town. In the third, a town partners with a private company that designs, constructs, and operates the network on behalf of the town, through a multi-year agreement.[95]

Applicants Eligible for Funding

The Commonwealth took the approach of a public–private partnership with a co-investment model, using public bonds to fund futureproof fiber or long-lived wireless infrastructure, while the private partners funded complementary infrastructure and provided services.

The Town of Leverett was the first to complete its planned project of connecting all residences and businesses to the MassBroadband 123 fiber backbone, which was itself completed in 2014. More than 75 percent of Town residents signed up for the Commonwealth -funded broadband program, which is owned by the Town and served by the local ISP Crocker Communications of Greenfield.[96]

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[93] "Broadband Extension Program," *Massachusetts Broadband Institute*, http://broadband.masstech.org/building-network/last-mile-resources/broadband-extension-program.
[94] "2011-12 Grant Program."
[95] "MBI Broadband Last Mile Broadband Policy."
[96] Bray, Hiawatha, "'Last mile' of Internet lit up in Leverett," *The Boston Globe*, October 2, 2015, http://www.betaboston.com/news/2015/10/02/last-mile-of-internet-lit-up-in-leverett/.

Minnesota Border-to-Border Broadband Development Grant Program

In 2010, Minnesota adopted the goal that no later than 2015, all state residents and businesses would have access to broadband service that provides a minimum download speed of 10 Mbps to 20 Mbps and a minimum upload speed of 5 Mbps to 10 Mbps. The law provides that the State's goal is to be in the top five in the nation for universally accessible broadband speed, the top five states for broadband access, and the top 15 when compared to countries globally for broadband coverage.

In 2013, legislation created the Office of Broadband Development (OBD), and in 2014, the Governor created a $20 million program called the Border-to-Border Broadband Infrastructure grant program.[97]

The goal is to extend broadband access to unserved and underserved areas of the State, which the State defines in this way: An unserved area is one in which households or businesses lack access to wireline broadband service that meets the FCC threshold of 25 Mbps download and 3 Mbps upload. An underserved area is one in which households or businesses do receive service above the FCC threshold but lack access to service that meets the State goals of 10 to 20 Mbps download and 5 to 10 Mbps upload.[98]

The Minnesota Border-to-Border Broadband Development Grant Program funds the acquisition and installation of middle-mile and last-mile infrastructure that supports symmetrical broadband service scalable to at least 100 Mbps.[99]

During the 2015 special session, the legislature included almost $11 million in funds. Funding for projects for 2014 reached almost $20 million.[100] The total value of the projects to be deployed is over $45 million.[101]

In 2014, the State selected 17 projects for funding, 16 of which eventually accepted the funding. Awards ranged from just over $100,000 to the maximum of $5 million and in total equaled just under $20 million.

Two examples of programs selected in 2014 are the following:

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[97] Wells, Diane, "State Broadband Infrastructure Programs," *Minnesota Office of Broadband Development*, February, 2015.
[98] Ibid.
[99] *Minnesota Department of Employment and Economic Development*, "Broadband Grant Program: Overview," http://mn.gov/deed/programs-services/broadband/grant-program/.
[100] Ibid.
[101] Wells, Diane, "State Broadband Infrastructure Programs."

Federated Telephone Cooperative was awarded $3.92 million to construct broadband infrastructure that will make service available to more than 1,000 unserved premises. The full project cost is $7.92 million; the remaining $4 million (51 percent) in matching funds will be raised through tax abatement bonds, with the county loaning the bond proceeds to Federated.

Rock County Broadband Alliance (RCBA) FTTP project was awarded $5 million to deploy FTTP service for more than 1,000 underserved and almost 300 unserved locations in a rural county. The total project costs are $12.85 million; the remaining $7.85 million (61 percent local match) will be provided by Alliance Communications Cooperative as an equity infusion to RCBA, which is a wholly owned subsidiary of Alliance.[102]

One example of a project funded in 2015 is *Paul Bunyan Central Itasca County Fiber*, which will build out a $1.98 million broadband infrastructure in Itasca County in three townships and the former Iron Range Township—now incorporated into a nearby city. High-speed Internet service will be available to 1,193 households, 53 businesses, and five CAIs. Total project costs are $5.52 million. Paul Bunyan Communications, Itasca County, and the Iron Range Resources and Rehabilitation Board—a State development agency—will provide the remaining $3.54 million (64 percent local match). The project aims to reach the estimated 3,500 people and about 100 small businesses in the area, in order to improve market access, options for education, and health care services, and "the region's viability and attractiveness to telecommuters, freelancers, and others who depend on technology and the Internet for work."[103]

Projects Eligible for Funding

The program pays up to 50 percent of the infrastructure deployment costs for a qualifying project, including project planning, the cost of obtaining permits, facilities construction, construction of middle-mile and last-mile infrastructure, equipment, and installation and testing of the broadband service. The maximum grant amount is $5 million.

Applicants Eligible for Funding

Groups eligible to apply included: Incorporated businesses or partnerships, political subdivisions, American Indian tribes, Minnesota nonprofits, Minnesota cooperative associations, and Minnesota LLCs organized for the expressed purpose of expanding broadband access.[104]

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[102] *Minnesota Department of Employment and Economic Development (DEED)*, "Broadband Grant Program: Grantees," http://mn.gov/deed/programs-services/broadband/grant-program/ (accessed November 4, 2015).
[103] *Minnesota DEED*, "Minnesota Awards $11 Million for Broadband Projects," press release, November 20, 2015, http://www.mn.gov/deed/newscenter/press-releases/newsdetail.jsp?id=466-175352 (accessed November 24, 2015).
[104] *Minnesota DEED*, "Broadband Grant Program: Overview," http://mn.gov/deed/programs-services/broadband/grant-program/ (accessed November 4, 2015).

The State made funding available to invest in broadband infrastructure with the goal of continuing to create more partnerships and supporting providers working to implement next-generation gigabit service. Many partnerships were forged, with private and public entities sharing costs and risks. The State and local governments made use of grants, loans, and funds allocated by the legislature to cover their portion of the costs.[105]

The Governor's Taskforce on Broadband drew from a year of programs, research, and outreach to recommend continued funding for the Office of Broadband Development (OBD). The OBD plans to expand its focus by continuing its tracking and measurement of broadband access levels across the state, making broadband projects more feasible by expediting permitting processes, and establishing an accurate inventory of public investments in broadband at an institutional and building-specific level, in addition to funding further broadband projects.[106]

All of the 16 projects funded in 2014 are currently ongoing, with a portion close to completion. A 17th grant was awarded, then declined by the applicant, so it never became an active project. The active projects have a completion deadline of June 2017.[107]

Lessons Learned

According to the leadership of the Minnesota program, one lesson learned is to develop strong relationships with smaller providers who are interested and willing to participate. A state needs to make an effort to build them into the process, consult with them, and get their thoughts about how to structure and execute the program. Their buy-in and participation are essential.

Another piece of advice is to strive to keep up relationships with grantees, so as to identify issues before they become problems. Also essential is the development of a strategy to integrate with and leverage Connect America Fund II funding, to maximize the benefit to the State.

Cable provider opposition can potentially hurt formation of a program. However, demonstrating to the cable companies early on that a rural grant program will not impact the primarily metropolitan territories they serve can win their trust and cooperation.

There is also a need to develop a pre-established pipeline, if such is possible, and to require robust feasibility studies from vendors, which will dramatically increase the chances of funding successful projects.

[105] Ibid.
[106] "Broadband Grant Program: Overview," (accessed November 4, 2015).
[107] Based on email correspondence between CTC staff and Minnesota DEED Director of Communications, Madeline Koch, November 24, 2015.

Building the program within an agency that has experience and expertise giving and overseeing competitive grants also contributes to success. Alternatively, the agency tasked with the program is well advised to create opportunities to consult with state agencies that have that capacity. [108]

Wisconsin State Broadband Office's LinkWISCONSIN Broadband Initiative

In November 2009, the NTIA awarded almost $2 million to a statewide broadband mapping and planning effort, named LinkWISCONSIN, which is charged with developing a long-term, sustainable plan for increasing access to and use of broadband across the State.[109] In June of 2013, the State of Wisconsin created the Broadband Expansion Grant Program, which falls under the administration of LinkWISCONSIN, to allocate funding to reimburse a portion of the construction costs for projects extending or improving broadband infrastructure to underserved areas of the state.

The mission of the State Broadband Office's LinkWISCONSIN Initiative is to make Wisconsin more competitive through advancing the availability, adoption, and use of broadband technologies, especially in underserved areas. As part of the Public Service Commission of Wisconsin, the State Broadband Office works with stakeholders to build partnerships with providers and consumers.[110]

Projects Eligible for Funding

The State Broadband Office administers broadband improvement funding through the annual Broadband Expansion Grant Program. This program provides reimbursement for equipment and construction expenses incurred to extend or improve broadband telecommunications service in underserved areas of the state, defined as areas with only two ISPs operating.[111]

In 2014 and 2015, $500,000 was made available annually for funding broadband projects and seven awards were made in each fiscal year.[112] The Commission has set aside $1,500,000 during Fiscal Year 2016 for projects proposed by one or more public and private entities that meet the eligibility requirements.

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[108] Based on interview by CTC President, Joanne Hovis, of Executive Director of Minnesota Office of Broadband Development, Danna MacKenzie, November 11, 2015.
[109] *Public Service Commission of Wisconsin, State Broadband Office*, "About LinkWISCONSIN," http://www.link.wisconsin.gov/about-link-wisconsin (accessed November 4, 2015).
[110] *Public Service Commission of Wisconsin, State Broadband Office*, "Connecting Wisconsin to the World," http://www.link.wisconsin.gov/ (accessed November 4, 2015).
[111] Ibid.
[112] *Public Service Commission of Wisconsin, State Broadband Office*, "Funding," http://www.link.wisconsin.gov/funding (accessed November 30, 2015).

In 2014, seven grants were awarded: two for small DSL projects, three for medium and large fixed wireless projects, and two for medium-sized fiber projects. In 2015, another seven grants were awarded: one for a small DSL project, two for large fixed wireless projects, and four for small cable and/or fiber projects.[113]

Entities Eligible for Funding

Each year, the State has accepted applications for grants from for-profit or non-profit organizations or cooperatives, telecommunications utility companies, and municipal or county governments that have formed a partnership or joint-venture agreement with one of the previous two types of entities.[114]

Grant funds can only be used to reimburse the construction of broadband facilities. The program is not intended to fund the operating costs of a service provider or the monthly bills of individual users of Internet services.[115]

Areas Eligible for Funding

The State targeted underserved areas, defined as areas where two or fewer carriers offered broadband services, or areas where only DSL service was available.[116]

The networks were constructed with a mix of fixed wireless, middle-mile fiber, last-mile fiber, and DSL technology. In one area, existing fiber routes passed prime locations for wireless towers, so the existing infrastructure was connected to cellular towers in four locations.

Of the projects approved for 2016, 10 of the 11 are projects that bring broadband to the home. The 11th project is to build out a middle-mile fiber backbone in one community. Of the 10 last-mile projects, one is for fixed wireless and seven are for FTTP construction.[117]

Entities Eligible for Funding

The goal was to use public money as seed funding for private investment or local public–private partnerships. Of the 11 projects approved for 2016, nine involve partnerships. In Wisconsin,

[113] LinkWISCONSIN Blog: News & Events: Broadband Expansion Grant Award Maps, 2014–2015," http://www.link.wisconsin.gov/blog/news-and-events/post/broadband-expansion-grant-award-maps-2014-2015 (accessed November 30, 2015).
[114] "Broadband Expansion Grant Program" (accessed November 12, 2015).
[115] *Public Services Commission of Wisconsin*, "Broadband Expansion Grant Program," http://psc.wi.gov/utilityInfo/tele/broadband/grants/bbGrantApplicationPage.htm (accessed November 12, 2015).
[116] State Legislature of Wisconsin, "2013 Assembly Bill 40: 2013 WISCONSIN ACT 20," Date of publication: July 1, 2013, p. 495, http://docs.legis.wisconsin.gov/2013/related/acts/20.pdf (accessed November 30, 2015).
[117] Based on interview by CTC staff of the Public Service Commission's Program and Policy Analyst, Dennis Klaila, November 30, 2015.

almost all counties have some form of County organization for economic development, so private companies are often partnering with those organizations.[118]

The program has enjoyed enough success and support that the State authorized the Broadband Expansion Grant Program for an additional two years, with $1.5 million allocated for each year. There is good support for the projects in the state legislature and from the Governor.

Of the projects initiated in 2014, four are complete, two are on target to finish by the end of 2015, and only one is behind schedule. Using the lessons learned in the previous year, the State Broadband Office approved projects it assessed to have higher chances of success, resulting in on-target progress on the 2015 projects. Two of the projects are complete and five are progressing according to schedule.[119]

Lessons Learned

The State's first clear lesson learned is that permitting and land use permissions are critical path items, and that grantees should demonstrate progress in this area early—perhaps even as early as during the grant application process. In the State's experience, all of the grants were issued with deadlines, with the understanding that the deadlines could be extended by request. In most cases, those deadlines were met or the extensions were reasonable. In one instance, a service provider for a fixed wireless project tried to build a wireless tower in a public park and encountered environmental and other land-use problems. The project called for building one very tall tower in a public park in the center of the county, high enough to reach most county residents. Unfortunately, residents thought the tower would be an eyesore and an inappropriate use of park land. Also, environmental groups raised objections to cutting down trees in the proposed construction site before spring, because a large number of bats were wintering in those trees.

As a result of these experiences, the State Broadband Office more closely scrutinizes wireless projects for land-use permissions progress. Reviewers favor proposals that show the applicant has started securing permissions.

Another clear lesson learned is the importance of vetting smaller companies for robustness and viability. The State Broadband Office decided to set aside funds for smaller companies, to spread opportunities beyond large, incumbent providers. However, one awarded company was too small to work with smoothly. The company retained too few employees to be fully responsive to the State's requests or even fulfill basic communication needs. Since that time, the State

[118] Ibid.
[119] Based on interview by CTC staff of the Public Service Commission's Program and Policy Analyst, Dennis Klaila, November 30, 2015.

Broadband Office has more carefully assessed the health and reputation of companies before approving their grants. As a result, larger, more responsive, and better-established providers are winning grants. In 2015, all projects remained on target.[120]

[120] Ibid.