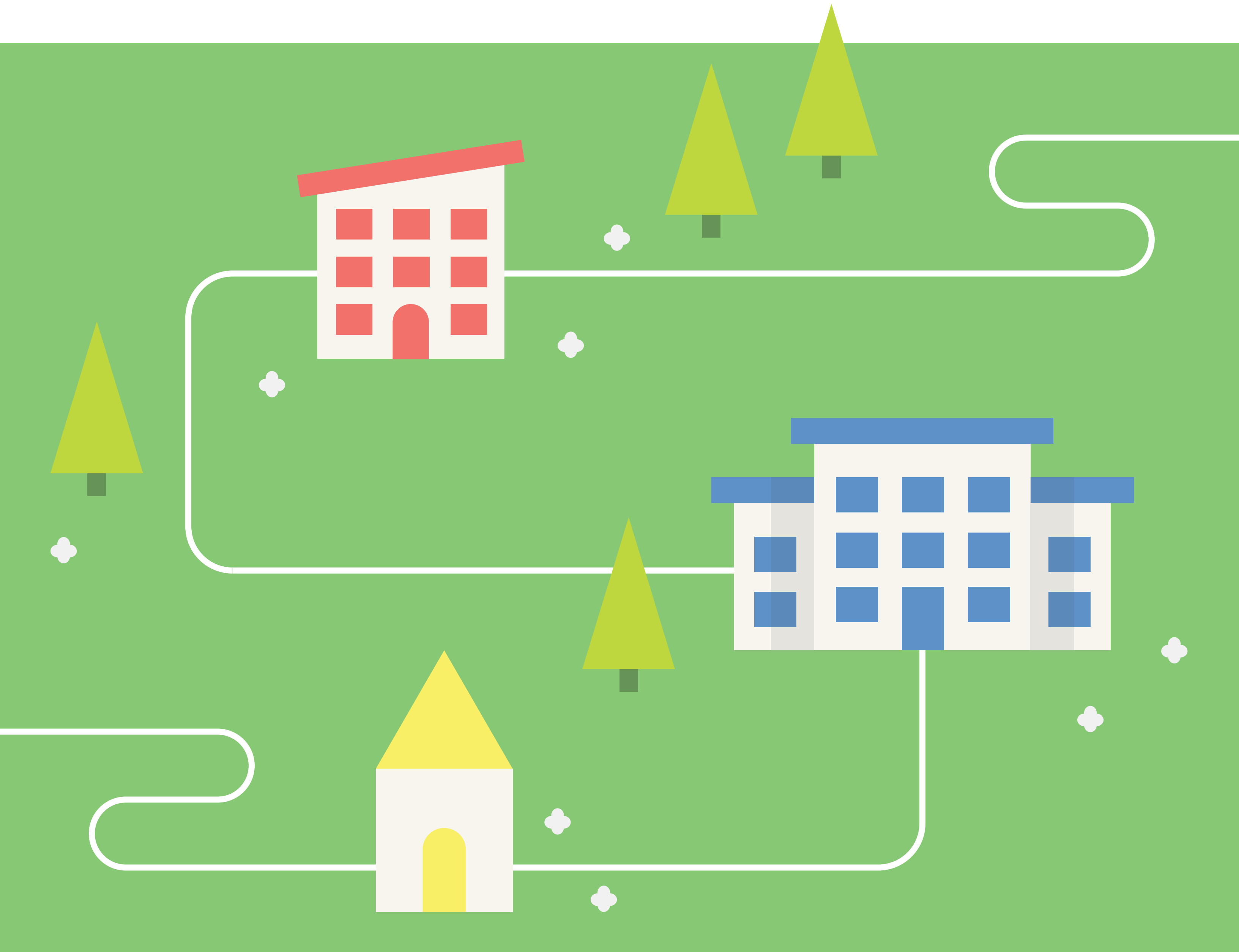
GIGABIT COMMUNITIES

Technical Strategies for Facilitating Public or Private Broadband Construction in Your Community



Abstract

Local governments have long pioneered efforts to expand broadband availability and competition; for more than a decade, they have tested public projects and public–private partnerships to deliver new broadband services. As they look to the future, localities that choose not to build their own networks can facilitate private investment in gigabit-speed networks by optimizing local processes at key touchpoints that impact deployment times and costs.

The key ingredient for private investment in gigabit deployment is true partnership. It is not enough for the locality to undertake all these steps if there is no willing and able private partner—one that is committed to building next-generation infrastructure rather than simply reducing costs on existing legacy networks.

The strategies that local governments can pursue to advance private broadband deployment fall into three general categories: (1) facilitating access to key assets such as fiber, conduit, utility poles, and real estate; (2) making useful information available; and (3) streamlining and publicizing essential local processes.

STRATEGIES FOR ACCESS TO KEY ASSETS

A primary challenge in broadband expansion is the high capital cost of network construction. New network deployments benefit from access to existing fiber optics; underground communications conduit in which fiber can be placed; and real estate where equipment or exterior huts can be located. These assets reduce the provider's construction costs. At the same time, the community benefits by speeding deployment, reducing construction disruption, and obtaining lease revenue.

"Dig-once" strategies enable local communities to expand their own fiber and conduit assets, as well as those of private providers. Such policies open rights-of-way to fiber/conduit construction when other projects are underway, thus realizing efficiencies in network construction. Such policies also protect roads and sidewalks from life-shortening cuts and minimize disruption from construction. Even if private entities do not take advantage of the opportunity, the locality can use dig-once opportunities to inexpensively install its own conduit and fiber—which can be leased to private providers in the future.

Another critical need is access to utility poles. Optimally, the network builder needs a swift "make-ready" process to prepare the poles for new fiber. In most communities, the poles are owned by phone and electric companies, which control both fees and time frames for new fiber attachments. Localities, however, can encourage private pole owners to consolidate attachments; reserve pole space; and undertake other steps that may reduce make-ready time and costs—thereby reducing the average cost of aerial fiber construction.

A further challenge is entry into a building or development. Localities can require by code—or incentive—that developers build additional pathways from the public rights-of-way to an in-building demarcation as well as internal, standards-compliant building cabling or cable pathways.

STRATEGIES FOR INFORMATION ACCESS

Most localities already devote considerable resources to collecting key data in such databases as Geographic Information Systems (GIS). Select data sets can be made available to network deployers. With this information, it becomes easier, faster, and cheaper to conduct the high-level planning phase of a large-scale broadband construction project. Similarly, by making available data regarding their existing fiber and conduit, localities can enable providers to consider leasing public fiber and conduit as part of their network designs.

STRATEGIES FOR PROCESS EFFICIENCY

Smooth processes enhance broadband buildout and deployment, as with any public project. Local governments balance the needs of broadband providers with the public cost of the processes necessary to support them and with other priorities that clamor for the same resources. To balance these competing interests, local processes such as permitting and inspection can be formalized and publicized. Timelines can be determined based on local needs, publicized, and then met. Transparency about processes and timelines enables broadband companies to expeditiously plan and deploy networks and enables localities to manage the costs and burdens of the processes necessary to meet broadband providers' needs. Localities and providers can cooperatively plan before construction so as to understand respective schedules and needs, and so that the provider can plan to stage its work around known and predictable local processes.

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1 Executive Summary

This paper presents strategies by which local governments can encourage broadband expansion, with a goal of becoming communities with gigabit speed networks—over 100x faster than most connections today. Localities can facilitate construction of gigabit-capable networks through a range of technical and process strategies that support such network deployment—whether the network is built by a private partner or by the locality itself.[1]

1.1 Enormous deployment cost is one factor standing in the way of a gigabit future

High-quality broadband services—both wireline and wireless—require wired infrastructure in the form of fiber optics. In order to deliver gigabit and beyond services to every household and business, a network operator must build fiber to every home and business. Even services that do not deliver fiber all the way to the premises, such as high-speed wireless, still require physical fiber construction to hub facilities and wireless antennas.

Construction of these facilities is costly and time-consuming. Fiber-to-the-premises, in particular, requires a massive construction effort—building fiber optics down every major and minor street where service will be offered, as well as from the curb to each user's home or business.

At the time of the Telecommunications Act of 1996, policymakers anticipated that most of the United States would shortly see the benefits of multiple facilities-based providers, all competing with each other to build better networks, deliver better services, and reduce prices. Nearly 20 years later, it is clear that robust facilities-based wireline competition did not emerge—in part because constructing large-scale networks is such a formidable economic challenge, particularly for a competitive provider that does not have the benefits of incumbency. Facilitating that construction is one way in which your locality can potentially help to bring new broadband networks and competition to your community.

1 This paper was prepared by the engineers and analysts of CTC Technology & Energy during the summer and fall of 2013. Funding to support preparation of this paper was provided by Google Inc., though this document and the views expressed herein solely represent the views and analysis of CTC and not the sponsor.

1.2 Localities have played an important role in hastening the gigabit future

Localities have long been at the forefront of working to expand broadband availability and competition in their communities. For more than a decade, local governments across the country have pioneered public projects and public–private partnerships designed to meet community needs.

Local efforts to enable broadband have ranged across the full spectrum of communications technologies (fiber optics, wireless, satellite) and across a wide range of business models (public ownership, public operations, public support for private efforts). In our experience, local broadband initiatives are an important success story that includes hundreds of examples of community fiber networks, tens of thousands of public wireless hotspots, and more than half a million Americans who have direct fiber connections to their homes and businesses that would not exist absent local government broadband networks.

And in the current era, the range of potential models for local broadband is expanding, to all our benefit.

1.3 Your community can help enable the gigabit future—either in partnership with a willing company or by building your own network

Among the alternatives to expand broadband locally is a model in which localities and companies partner to speed new construction. This public facilitation of private investment requires not only a willing locality but also a true partner from the private sector—*a partner that is willing and able to invest in state-of-the-art networks.*[2]

Indeed, if your community's goal is private investment in broadband, the single most important factor to make that strategy viable is a willing, able private partner—and in the event that such a partner emerges, there exists a range of efforts you can undertake that can facilitate the partner's investment in your community.

Even if no willing and able private partner exists, your community can choose to build and perhaps operate your own network, subject to the authority granted by your state.

2 In stark contrast, some incumbent providers do not plan to invest to upgrade their existing networks to gigabit-capability—but do ask localities to facilitate or subsidize their existing operations through access to public property and other benefits. It is our observation that this arrangement does not result in new, better broadband facilities; to the contrary, it serves merely to transfer some private costs of doing business over to local taxpayers and makes the status quo even more attractive for the incumbent company.

Whether you have a private partner or choose to build yourself, construction of gigabit networks is a process your locality should understand. With that knowledge, you can seek to optimize your local processes and assets at the key touchpoints where they can impact network deployment times and costs. At the same time, you can design policies and mechanisms to ensure that your agencies work together to take advantage of cost-effective opportunities to build new broadband facilities such as fiber optics and conduit.

In our experience, the strategies that advance broadband deployment can be grouped into three general categories: (1) ways to facilitate access to key assets such as fiber, conduit, utility poles, and real estate; (2) ways to make useful information available to potential broadband service providers; and (3) ways to streamline and publicize essential local processes.

Each of these areas is summarized in this executive summary and then discussed in detail in the body of this report. This list is not exhaustive, nor are these strategies guaranteed to result in new construction in your community, but they have the potential to reduce deployment costs—either your own or those of your private partner.

1.4 Strategies for access to key assets

One of the primary challenges to broadband expansion is the high capital cost of network construction. Your community owns assets that can reduce the need to construct some elements of new networks and thereby reduce total up-front capital costs. We recommend you consider what assets your community owns that can meet these needs and consider how to make them available, potentially on a lease basis, to those seeking to build state-of-the-art broadband networks. As a first step in this regard, you should document and publish information about these assets (see Section 1.5.2).

1.4.1 Lease public assets such as fiber, conduit, and real estate

First and foremost, new network deployments can benefit enormously from access to (1) existing community fiber strands located both underground and on utility poles; (2) underground communications conduit in which fiber can be placed; and (3) real estate where equipment or exterior huts can be located.

Community fiber and conduit represent valuable assets, particularly where construction is costly or difficult, such as urban areas; crossings of bridges, waterways, and rail lines; key building entries; and alongside major roads. Because each fiber cable has dozens or hundreds of separate fiber strands, and each fiber optic strand holds enormous capacity, a community can sell or lease excess strands within a fiber bundle without compromising the original purpose of the fiber (such as internal communications or traffic management). Excess strands in a local network can help in establishing a provider's network backbone. If the locality's fiber covers the key parts of the community, it can provide an immediate way to establish a point of presence in those key areas.[3]

A locality's available conduit can also assist in broadband deployment. Placing fiber cables in a locality's existing conduit can reduce a provider's need for construction—lowering its capital costs and time to build.

In leasing existing its fiber or conduit, the community benefits by speeding deployment, reducing damage and disruption to the rights-of-way, and obtaining lease revenue.[4]

And while not all communities have built their own fiber or conduit, almost all localities own real estate in locations that can help make a new network more feasible. They can enhance network deployment by providing access to secure spaces for network equipment and operations. Secure spaces can be used for a regional or community-wide central data center or network operations center. They can also host the network equipment that must be placed in or near the neighborhoods where homes and businesses are connected to the fiber—areas in which localities frequently own real estate and secure buildings.

In our experience, access to these assets can decrease the cost of initial buildout of physical infrastructure, potentially reducing total outside plant and hub construction costs by up to 8 percent, depending on how far the community's infrastructure extends.

Section 2 below includes a detailed discussion of why localities should consider leasing their fiber, conduit, and real estate assets, and how those assets can impact gigabit network construction.

3 This is known as a "middle mile" model, in which the network provider leases middle mile fiber from the locality to connect from the Internet/public network backbone to the neighborhoods. The network provider then constructs the "last mile" fiber to the homes and businesses, or provides wireless last mile services.

4 This paper frequently recommends leasing of public assets as a means of facilitating broadband deployment. The paper does not address the issue of pricing for leasing of public property. For a discussion of pricing mechanisms in the public and non-profit sectors for dark fiber, see http://goo.gl/xo3UGX. In our experience, some jurisdictions charge market price for access to these assets; some have elected to provide these assets at no cost in return for other valuable services to the community; and some offer economic development discounts or credits for providers who commit to expanding broadband service to unserved or underserved communities.

1.4.2 Facilitate underground construction, placement of conduit, a "dig-once policy," and construction specifications

In order to help build key assets such as conduit and fiber in your community, consider enacting policies that facilitate and encourage their construction. "Dig-once" policies open streets and rights-of-way to utility construction when related projects are underway, thus realizing efficiencies in network construction by giving multiple entities the opportunity to place their facilities—resulting in a more uniform and efficient means of constructing network infrastructure. Such policies also protect roads and sidewalks from frequent, life-shortening cuts and minimize traffic and other disruption from utility construction.

Dig-once opportunities are frequently followed by a moratorium on further construction for a year or more in order to incentivize providers to build together and realize these efficiencies. Notification and management can be accomplished in different ways, ranging from an approach where the locality has a strong hands-on monitoring and management role, to one in which the requesting provider or utility is required to provide notice to all potential providers, and coordination is accomplished among the providers and utilities.

Even where private partners do not place conduit, the locality can use dig-once opportunities to install its own conduit and fiber—which can be made available to private entities in the future. This outcome is particularly valuable in areas where construction costs are high, or in highly congested rights-of-way where construction can be more disruptive. Indeed, in highly congested and high-cost areas, the locality might choose to construct uniform conduit banks with sufficient capacity for all current and future providers, thus using both space and time more efficiently.

Public fiber and conduit construction entails costs for the locality, as does efficient administration of a dig-once policy. But the resulting benefit can be dramatic. Use of these assets can reduce the upfront cost of buildout of outside plant, whether by the locality itself or by a private entity, by up to 8 percent.

Section 3 below includes a detailed discussion of how localities can implement policies that enable efficient construction of fiber and conduit, both by private carriers and by the locality itself.

1.4.3 Facilitate aerial construction through access to utility poles

A critical item for any government or company building new broadband facilities is access to utility poles. Optimally, the network builder will secure efficient access to the poles and will have a swift, reasonable "make-ready" process to prepare the poles for the new fiber bundle attachments.[5]

In most communities, the poles are privately owned by phone and electric companies, which have control over both fees and timeframes for new fiber attachments to their poles (and which may be reluctant to facilitate the attachment of entities that will then compete with them to provide communications services). Localities, however, have relationships with the pole owners that frequently allow them some influence. Localities can use that influence on behalf of their broadband goals by working with the pole owners, either directly or through the state. This influence can be used to encourage pole owners to facilitate rather than obstruct the process of the new broadband provider attaching to the poles.

Some broadband advocates believe that new network buildout can be eased through state or local requirements that new entrants be allowed to attach to privately owned poles.[6] Indeed, some cities require shared use of facilities in the localities' rights-of-way as a function of their authority to promote the health and welfare of citizens and their authority to adopt reasonable requirements for right-of-way occupants to minimize disruption and hazards.[7] From a technical standpoint, such shared access opportunities would assist both localities and their private partners in cost-effectively and quickly constructing new broadband facilities.

Whether by choice or by law, pole owners should maximize attachment opportunities for new entrants. To this end, pole owners ideally should offer a swift negotiations process and reasonable make-ready costs. In addition, they should commit to a reasonable schedule for the make-ready process.

5 Many utility poles do not have sufficient space for new attachments, requiring existing attachments to be moved to accommodate the new provider. Moving utilities through the make-ready process can be time-consuming and costly, requiring weeks or months to coordinate providers and perform the move. Furthermore, the inefficient make-ready process has to be repeated each time a new entrant wants to attach.

6 The Fiber to the Home Council, for example, recently released a paper advocating that state and local governments "condition use of public rights-of-way to require incumbent users of this space to share their poles, ducts, and conduits on a non-discriminatory basis and at reasonable (cost-based) rates, terms, and conditions." Fiber to the Home Council, "State and Local Government Role in Facilitating Access to Poles, Ducts, and Conduits in Public Rights-of-Way," August 2013, http://goo.gl/nNnQKq. We are not qualified to comment on the legal basis for these requirements or the challenges localities may face from pole owners in attempting to enforce them—but we can affirm from experience that the technical benefits of such policies would be significant.

7 For example, Smyrna, GA requires users of its rights-of-way to share access to their poles, conduit, and related facilities. Smyrna, Ga., Code of Ordinances § 90-45. Superior, WI reserves the right to require joint use of poles or conduit. Superior, Wis., Code of Ordinances § 2-165(b). See Fiber to the Home Council, http://goo.gl/mYPiIt

Even better, pole owners can plan ahead to alleviate the need for make-ready by ensuring that poles have adequate room for new attachments. There are a number of simple means of accomplishing this. First, as poles are replaced, the owners can reserve vertical space of 12 to 16 inches for future attachments. Second, pole owners can consolidate their own infrastructure on the poles and remove unused cables to make room. (They can also require other users of their poles to do the same.) Third, pole owners can allow use of extension arms—metal or fiberglass extensions that jut out from the side of the pole and thus expand pole capacity horizontally. Fourth, the owners can require attachers to build their facilities in a way that allows other companies to "overlash"—to lash their fiber bundles over the existing bundle, a technique that does not require make-ready. With any of these strategies in place, new service providers can easily and swiftly attach new fiber to the poles without the need for any make-ready process.

The benefit can be enormous. In our experience, eliminating the time and costs around make-ready can reduce the average cost of aerial fiber construction from $10 to $15 per foot to $2 to $5 per foot.

Section 4 below offers a more detailed discussion of how the pole attachment and make-ready processes work, so that local governments can understand those processes and seek to work with pole owners to maximize access by new broadband builders.

1.4.4 Facilitate in-building access for wireline infrastructure

One significant barrier to new network providers is the entry into a building or development. A government can improve services to its residents and businesses if it requires by code—or creates an incentive for developers to build—additional pathways from the public rights-of-way to a demarcation point in the building, and then requires internal, standards-compliant building cabling or cable pathways in new construction or major renovations.

Developers and builders are already accustomed to providing pathways for telephone, power, and cable TV from the property line to a room designated for utility services within a new building. Ensuring the availability of spare conduit into buildings would reduce installation time, risk, and barriers to entry for new providers. The incremental cost to add an additional conduit for public fiber optic cable at the time of construction would be minimal. The conduit would originate in the room designated for utilities and follow the same path as telephone and cable TV conduit. At the time of construction an innerduct can be used to create cells within the conduit for spare capacity.

The incremental cost to the developer of a 200-foot conduit path from the utility room to the property line would be approximately $2 per foot for labor and $2 per foot for materials. This would total approximately $1,000 in additional construction costs for the outside plant portion of installing conduit.

In contrast, the cost for new construction of the same route can be $1,500 to $10,000 if a network provider needs to create a new entry path. The higher cost is realistic if the right-of-way is on the opposite side of a major road, if the provider needs to cross under a parking lot or driveway, and if restoration (both outdoors and in the building) is sensitive and expensive. In addition, constructing a new route into a building may involve days or weeks of delay for permitting, engineering, design, utility location, and coordination with the building owner.

Indoor cabling also is one of the largest costs and areas of uncertainty for a network service provider. This problem is especially pronounced in apartment buildings and office buildings, where the provider must cable long distances before reaching individual customers.

A local government can reduce costs and speed deployment by requiring in its code that developers or building owners place cable pathways or standardized cabling as part of construction or renovations.

Installing fiber optic cabling inside an apartment building can cost from $300 to $750 per apartment unit, depending on the design of the building, the availability of false ceilings and cable pathways, the existence of wiring closets, and permission to attach moldings or other materials. Each building is different and requires new strategies. Pricing and challenges are similar in multi-tenant office buildings.

The cost per unit can be reduced by half if there is sufficient capacity in the horizontal riser, and conduit, duct, or raceways exist from the riser to individual units.

Another strategy a locality can pursue is to require developers or building owners to install fiber as part of a new build or renovation. This strategy has the same benefits as installing conduit, and further reduces costs (by eliminating the need for a new provider to pull cables through a raceway or conduit). It is best suited to communities where broadband providers are already building according to a particular standard (e.g., single-mode fiber pair to each unit).[8]

These strategies represent a small burden for developers, and a potentially noteworthy incremental benefit to the locality—especially if the community is likely to see extensive rehabilitation of existing residential units over time.

8 This is because there is currently a diversity of service approaches (e.g., non-fiber technologies to the unit) and installing fiber to every unit in a particular manner may lead to a significant stranded investment if no fiber provider serves the building, or if the service provider insists on using another type of cabling to the unit.

This model was pioneered in the United States by the city of Loma Linda, California, through its Connected Community Program (LLCCP). In conjunction with the city's development of a citywide fiber optic network, the city council added connectivity standards to the building code. "The City building code now requires all new commercial and residential developments (or re-models involving greater than 50% of the structure) to equip the new structures with a fiber-optics interface and copper cabling throughout."[9]

Loma Linda has received international recognition for its ordinance, which provides that "[i]n recognition of the need to provide local residents and businesses within the community with additional options to meet their telecommunications needs, as adopted by city council resolution, all new development projects within the city, regardless of whether such new development falls within the fiber-optic master plan area, and additions that exceed more than fifty percent of the original structure that fall within the fiber-optic master plan area, will be required to participate in, and will be bound by, the connected community program…." (Ord. 629 § 1, 2004).[10]

The city of Sandy, Oregon has also passed an ordinance requiring developers to put conduit all the way into a home, and to deed that conduit to the city.[11]

A model such as that in Loma Linda or Sandy will have greater impact in areas of new construction and in rapidly expanding cities (such as Sandy, which is the fastest growing city in Oregon, and is developing into previously uninhabited areas). In established communities with less growth, the results are likely to be more modest.

9 "The Loma Linda Connected Community Standard," http://goo.gl/xErPxe

10 The city also provides the following specifications for new construction:
- Data cabinet in master bedroom
- Cable bundle set—2 Cat 6, 1 coax in each living space, 2 sets in master bedroom and family room
- Fiber into data cabinet and community MDF (main distribution frame)
- Fiber throughout the development
- Build a community MDF
- Deed the infrastructure to the city once completed
- City provides builders with design, scope of work (SOW), and bill of material (BOM)
- City provides list of certified and approved contractors
- Cost to the builder is estimated at approximately $3,500 per unit, assuming metro California labor costs

11 City Council Member Jeremy Pietzold notes that his only regret about the new conduit ordinance is that Sandy did not have the forethought to pass it 10 years ago—which would have better positioned the city and its private partner to build the FTTP network they currently plan. (CTC interview with Council Member Jeremy Pietzold, February, 2013.)

1.5 Strategies for information access

1.5.1 *Make data available wherever possible*

Most localities already devote considerable resources to collecting key data in such databases as Geographic Information Systems (GIS); these databases can potentially serve also to facilitate the community's broadband goals if certain data sets are made available to network deployers. GIS databases already hold such information as street centerlines, home and business locations, and demographics. Other data sets can be extremely helpful for a locality's own broadband planning, a public–private partnership, or a potential network service provider entering the community; for example, we recommend that localities compile information about existing utilities, locality infrastructure, rights-of-way, available easements, and locations that are potential co-location sites.

With this information, it becomes easier, faster, and cheaper to conduct the high-level planning phase of a large-scale broadband construction project in which the prospective builder examines options and determines what assets are needed both to plan and to build.

1.5.2 *Document and publish data regarding available conduit, fiber, and other assets*

By making available to potential partners data regarding their existing fiber, conduit, poles, and other assets, localities can enable providers to consider leasing public fiber and conduit as part of their network designs and business plans. Access to this information may both attract and speed new construction by private partners, while enabling the community to meet its goals for new, better broadband networks—and potentially to realize revenues for use of the assets.

It is essential that public fiber and conduit be well-documented during the locality's planning and construction in order to make the data usable to future private partners and to make the fiber and conduit marketable (as well as for the locality's own use). Keeping conduit and fiber well documented requires effort, consistency, and regular updating. Initiatives such as community fiber optic construction, utility improvements, and community development need to include documentation and GIS mapping as part of the initial and lifecycle budgets. A fiber or conduit network is a classic example of an asset that benefits from appropriate documentation from the outset, and loses reliability and integrity as it grows and ages without that documentation.

Section 6 below includes a detailed discussion of what data should be collected and documented to ease the process of broadband network deployment.

1.6 Strategies for process efficiency

Smooth processes enhance broadband buildout and deployment, whether your own or that of a private entity. Most localities understand this point based purely on their own experience—they recognize, for example, that an efficient procurement process is enormously helpful in any public project. Similarly, efficient processes around permitting, rights-of-way access, and inspections can help with broadband construction. Subject of course to the needs of the community to protect public interests and public safety, as well as the resources available to the locality, we recommend a few strategies for streamlining processes and publicizing them to maximum benefit.

1.6.1 Streamline and publicize procedures and timeframes for permitting and inspections

Efficient and streamlined processes can be one way in which broadband projects may proceed expeditiously, whether the entity building the broadband facilities is the locality itself or a private entity that seeks to deliver services to the community.

However, a locality, unlike a private sector partner, cannot focus its internal processes and efforts on one single end goal. Local governments must account for costs, implications, and other priorities that are not of interest to the broadband industry. In this context of understanding the totality of local needs and projects, all clamoring for the same resources, our experience suggests that there are some strategies that localities can use to facilitate broadband projects without sacrificing the localities' need to simultaneously attend to other projects and priorities.

We recommend that all processes required for a broadband project be formalized and well publicized to the industry. These range from rights-of-way access to permitting to final inspection and approval. In our experience, full transparency about these processes is the single most effective means by which to enable the communications industry to expeditiously plan and deploy networks.

For example, however long the locality's process for reviewing and approving permit applications, that process and timeframe should be publicized and then consistently met. Obviously, localities have limited resources—and sometime many different companies and industries can simultaneously require local permit review and other types of local support. Thus, local needs and resources should determine how long the process will take—while transparency about the amount of time, and a firm commitment to adhering to that timeframe, will meet the needs of the private entity. The private sector deployer may wish for a faster process, but at a minimum it will have the benefit of a transparent and open process—with a predictable timeframe under which it can plan its own project.

The need for transparency and communication is mutual: much as the locality should be open with information about its processes, the private deployer should do the same and should adjust and stage its build plans to maximize cooperation with the locality. Pre-construction conferences, for example, allow private providers and localities to understand each other's plans and timelines and to plan ahead. This kind of cooperative planning enables a willing provider to stage permit and inspection requests rather than filing for hundreds or thousands of permits at one time and overwhelming the locality's existing resources. Cooperation in this example is of mutual benefit.

Section 8 below includes a detailed discussion of why it is helpful for such processes to be cooperative, to the extent possible, and how publicizing all processes can benefit both the locality and the carrier.

1.6.2 Allow network operators to contract pre-approved third-party inspectors to speed processes and reduce local burdens

Unfortunately, attempts to streamline local processes frequently conflict with the need for resources to enable the processes—particularly for massive short-term projects such as a broadband network deployment. The need to issue thousands of permits and assess thousands of job sites in a very tight timeframe can be very challenging for local governments that do not have sufficient staff to support that enormous ramp-up on a short-term basis.

One potential solution is for the locality to find means by which local processes are respected but the broadband deployer can use its own resources to supplement public sector staff. For example, a locality can prequalify companies that can then be contracted by private deployers to inspect new broadband facilities on behalf of the locality. The locality can check the contractor's inspection efforts to verify quality, thereby incenting the vendor to work appropriately and enabling the locality to maintain quality control and quality assurance.

Section 9 below includes a detailed discussion of how the third-party approval mechanism can ease the burden on localities and speed the deployment process.

1.7 Hypothetical: impact of community efforts on network deployment costs

In our experience, the strategies described in this report can collectively reduce the cost of network deployment. The following hypothetical illustrates how a community can impact network deployment costs.[12]

Assuming construction of fiber to each location in a medium-sized community of 250,000 homes and businesses (of which 20,000 are located in 500 large multi-dwelling buildings or multi-tenant office buildings), the total cost of cable plant and hub construction may be reduced by approximately 8 percent in the aggregate. Most of the savings result from use of the community's own fiber assets; the next largest category of savings results from community assistance to the provider in reducing the provider's fees to private pole owners for make-ready. Additional savings result from the community leasing space in its facilities and requiring by code that conduit and cable pathways exist from the right-of-way into and inside office buildings and apartment buildings in new and renovated development.[13]

1.7.1 Community efforts to reduce costs

In this scenario, the community first provides access to its own fiber optic middle mile network. While some incumbent service providers generally refuse to use community-owned fiber, many competing, smaller providers are very willing to lease public fiber.

Second, the community provides locations for hub facilities where a new broadband provider can locate equipment.

12 This hypothetical is based on our own experience and data at CTC.

13 Our hypothetical assumes the following: the network is built to all or almost all of the 250,000 homes and businesses in the community. Approximately 3,300 miles of cable need to be built. Half of the cable is built aerially on utility poles and half underground, in conduit. A total of 300 miles of the cable construction is backbone cable, interconnecting approximately 40 hub facilities. There is a central network operations center and headend facility. Each of the hubs is connected over dedicated fiber optic cable strand to approximately 6,000 homes. The hubs house Active Ethernet electronics and are located in facilities with backup generators and diverse connectivity to the network backbone. The hubs require 300 square feet for fiber terminations and electronics, plus HVAC. The cost to build a hub facility is $100,000.
There are approximately 35 poles per mile of aerial cable plant. Poles are on average 20 years old and there are cable and telephone incumbents on the poles. Make-ready cost (both make-ready and engineering) is $500 per pole on average. Aerial construction in this scenario is $25,000 per mile for attachment of new strand and overlash to strand; with make-ready included, the total average cost per mile of aerial outside plant construction is $42,600.
Underground construction is primarily done through directional boring, with hand digging where necessary in sensitive areas, such as in the vicinity of other utilities. Where it is the most cost-effective approach for reaching premises, underground construction is done on both sides of the street; otherwise it is on one side with boring across streets. The average cost of underground outside plant construction is $100,000 per mile. If a street is cut, typically as part of a test pit for directional boring, the entire street is repaved 10 feet from the pit.
There are 500 multi-dwelling and multi-tenant office buildings in this scenario, with 50,000 residences and businesses in the buildings. The average cost of installing services to individual units is $500, assuming the installation of services to the majority of units in the buildings. The average cost of connecting a building to the cable plant in the rights-of-way is $5,000. Half the utility poles are owned by the investor-owned power utility and half by the incumbent telephone company.

Third, the locality requires owners and developers of multi-dwelling units and multi-tenant office buildings to construct conduit for broadband providers from the right-of-way to the building as part of construction or renovation.

Fourth, in a related vein, the community requires owners and developers of multi-dwelling units and multi-tenant office buildings to construct indoor cable pathways for broadband providers from the right-of-way to the apartment or business as part of construction or renovation.

Fifth (and most difficult), the community works with management of the companies that own utility poles—most likely an investor-owned utility and an incumbent phone company—to facilitate attachment by the new entrant. The locality may need to use its influence with state governments, state and federal regulators, businesses and other interests in order to make its case. In this scenario, the locality, through several years of work with the pole owners, has ensured that there is adequate space on the poles for new attachments such that a costly make-ready process is not necessary on 20 percent of the poles, thus eliminating a cost of potentially $500 for each of those poles.

1.7.2 Impact of these steps on construction costs

As a result of these steps, the broadband provider is able to build a backbone network around the community's middle mile infrastructure. The provider leases 150 miles of backbone fiber (out of a total backbone build of 300 miles) instead of constructing it, and that fiber is available within weeks of the agreement.[14]

The avoided cable construction cost is more than $16 million—a savings only marginally offset by the cost of leasing fiber; at $1,000 per mile per year, the fiber lease costs $150,000 annually, or $750,000 over five years. In addition, the use of locality facilities for hubs saves $100,000 in construction costs for each of the 30 hubs (out of the total 40 hubs), for a total avoided cost of $3 million. As with the fiber, lease fees are modest relative to the avoided construction cost.

In this scenario, the requirement for developers to construct outside plant has been in effect for a few years, and 20 percent of residential buildings have outside plant pathways for fiber to the rights-of-way. This reduces construction costs by $5,000 per building for 75 buildings, relative to a scenario with no outside plant requirement

14 In the event that fiber count is insufficient to meet the needs of both the locality and the private partner who seeks use of the locality's fiber, the existing fiber can be cost-effectively augmented through electronics (such as DWDM) or through placement of additional fiber (either in existing conduit or overlash of aerial plant). All of these strategies are significantly less costly than placing new fiber without the benefits of existing conduit or aerial fiber.

in which perhaps only 5 percent of buildings would have available conduit to the rights-of-way. The aggregate construction savings in this step is $375,000.

Similarly, the locality's requirement for inside plant cable pathways has also been in effect for some time, again resulting in 20 percent of buildings having inside plant pathways, compared to 5 percent in a community without the requirement. The potential savings under this scenario is $500 per unit, or a total of $1.5 million.

The opportunity to attach to the cleared space on the poles without make-ready on the 20 percent of poles where replacement or upgrade has been performed saves the provider both significant time and the cost of make-ready. (Significant savings also accrue to the other attachers, which do not have to dedicate resources to the make-ready process.) The savings from this benefit average $8 per pole, for a total avoided make-ready cost of $5.3 million.

In sum, the estimated capital savings for a service provider constructing a fiber network in the community is approximately $21 million out of the provider's total cable plant[15] and hub construction costs of $251 million (approximately $1,000 per passing). Table 1 lists the individual costs.

TABLE 1: NETWORK DEPLOYMENT COSTS

Cost Category	Cost (millions)	
	Community Facilitation	**Standard Build**
Backbone Aerial	$2.9	$6.4
Backbone Underground	$7.5	$15.0
Access/Distribution Aerial	$58.6	$63.9
Access/Distribution Underground	$150.0	$150.0
Business/Multi-Dwelling Unit Outside Plant	$2.0	$2.4
Business/Multi-Dwelling Unit Inside Plant	$8.0	$9.5
Hub Build	$1.0	$4.0

In this hypothetical, the majority of the total savings comes from leasing cable plant from the locality, rather than constructing new plant.

15 Inclusive of cable plant inside multi-dwelling residences and multi-tenant office buildings.

1.7.3 Impact of these steps on construction timing

Significantly, the cable plant construction and the hub buildings are costs that would have been incurred in the first year or two of construction, and the indoor cable pathways and building entrances in the first three years. These $21 million in savings are more significant than other cost reductions, because they are savings at a time when there is no subscriber revenue; therefore, the savings reduce the amount of capital that needs to be raised or borrowed. The savings, then, reduce the level of risk in the overall project.

The community's efforts also make it possible for the broadband operator to reach more customers more quickly. A broadband operator with rapid access to fiber or conduit throughout a locality can begin serving customers within months of starting construction. It can begin offering service near the community's fiber and conduit endpoints and focus on underground construction while negotiating pole attachment agreements and performing make-ready. As a result, the entire construction schedule could be accelerated by a few months to a year on a three-year project. The result is an early revenue stream and the ability to move quickly to provide services (and competition) in the community.

2 Asset Access Strategy 1: build and lease public assets such as fiber, conduit, and real estate

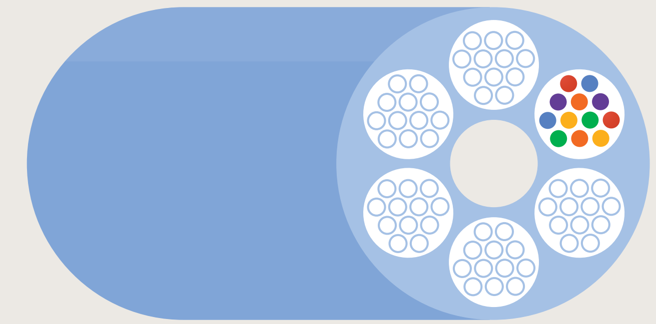
One of the primary challenges to broadband expansion is the high capital cost of network construction. Your community should build fiber at every reasonable opportunity. That fiber and other existing community assets can reduce the need to construct some elements of new networks and thereby reduce total up-front capital costs. We recommend you consider what assets your community owns that can meet these needs and consider how to make them available, potentially on a lease basis, to those seeking to build state-of-the-art broadband networks. Specifically, new network deployments can benefit enormously from access to (1) existing community fiber strands, both underground and aerial, that meet the network deployer's standards; (2) underground communications conduit in which fiber can be placed; and (3) real estate where equipment or exterior huts can be located.

2.1 Build and lease fiber assets

To the extent possible, localities should construct fiber at every cost-effective opportunity, including in conjunction with other planned capital improvements in the rights-of-way. (See Section 3 for a more detailed discussion.) By taking advantage of these opportunities, you will create over time an asset that can support your local government's internal needs and the ability of network providers to serve your community.

A locality can sell or lease fiber optic strands and thereby provide considerable capacity for a network provider. Fiber optic strands each have enormous capacity and, without compromising the original purpose of the fiber (such as internal communications or traffic management), a community can sell or lease excess strands within a bundle. Figure 1 illustrates a single 12-count fiber within a locality's typical 72-count fiber bundle.

FIGURE 1: FIBER BUNDLE WITH SPARE FIBERS



2.1.1 *Lease "middle mile" fiber*

Excess fiber strands in a local network can help in establishing a network backbone. If the locality's fiber covers the key parts of the community, it can provide an immediate way to establish a point of presence in those key areas. This is known as a "middle mile" model, in which the network provider leases "middle mile" fiber to connect from the Internet/public network backbone to individual neighborhoods. The network provider then constructs "last mile" fiber to homes and businesses, or provides wireless last mile services. The network provider can access the fiber at outdoor enclosures (see Figure 2, and discussed below) or locate its equipment in public buildings (see Figure 3).

FIGURE 2: TRANSITION BETWEEN GOVERNMENT AND PROVIDER FIBER AT OUTDOOR ENCLOSURE

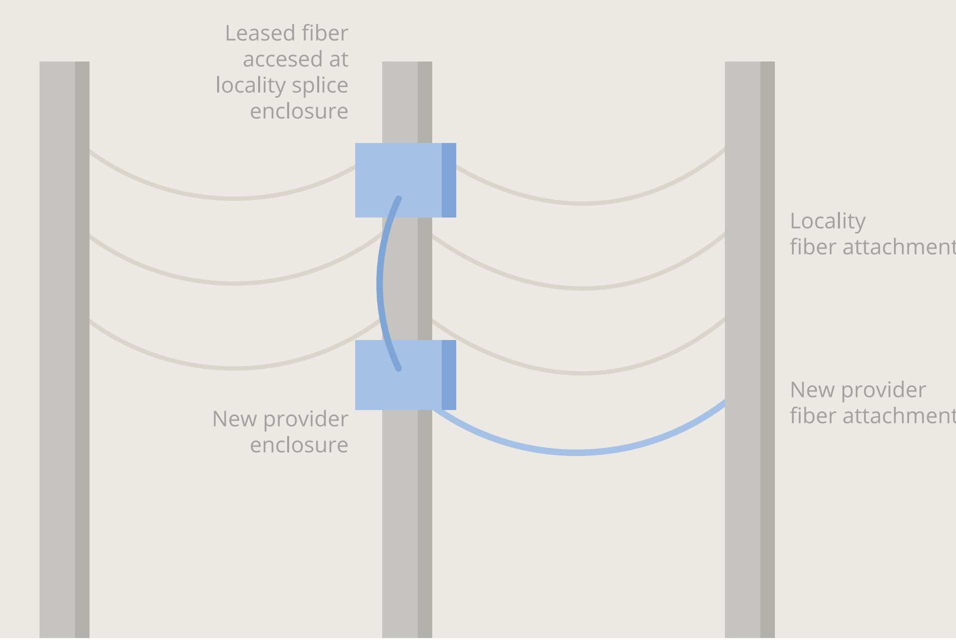
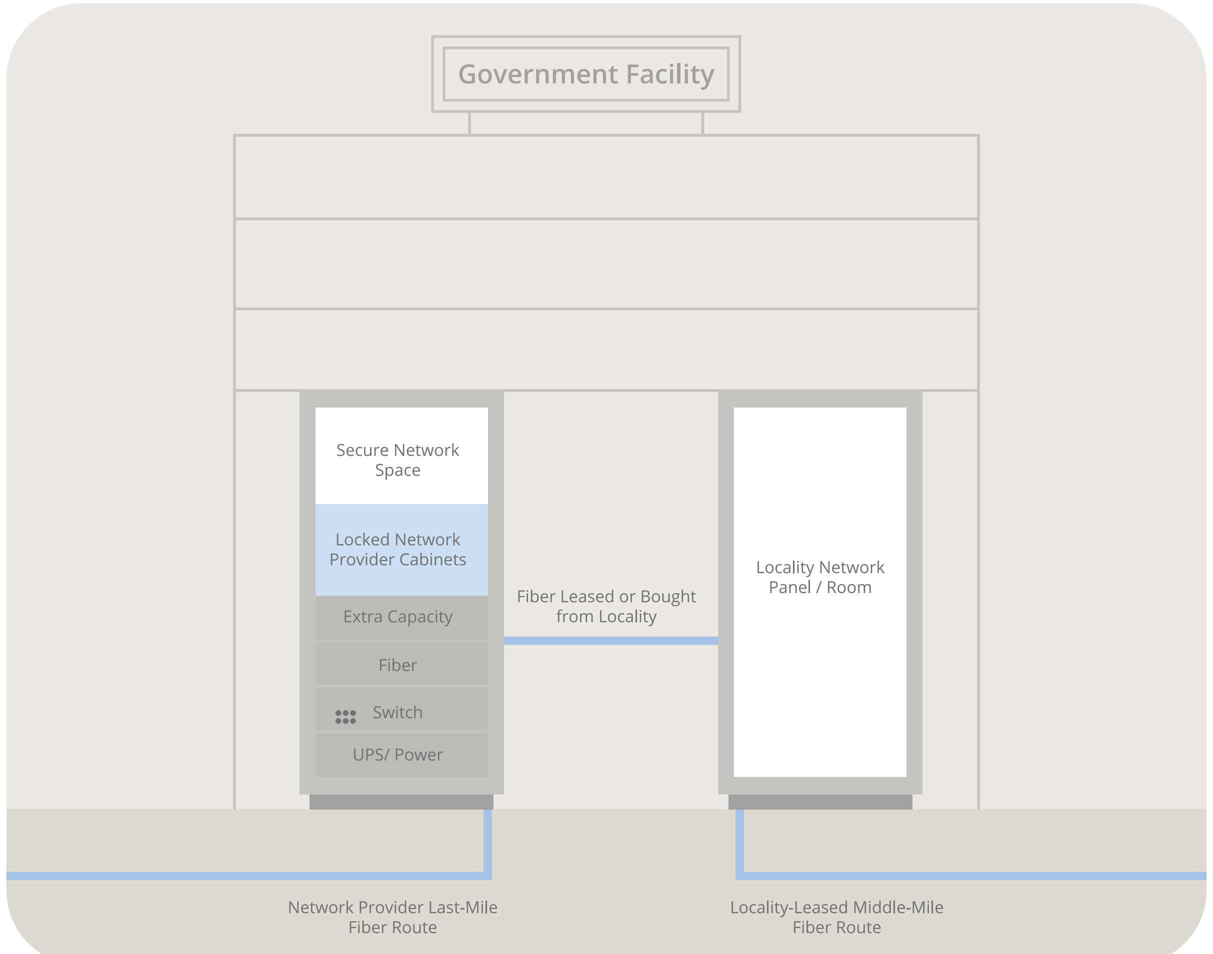


FIGURE 3: TRANSITION BETWEEN GOVERNMENT AND PROVIDER FIBER INSIDE GOVERNMENT FACILITY



A provider's middle mile does not necessarily require a large number of fiber strands. For this reason, leasing excess capacity on an existing public network—even where there may only be a dozen or so spare fibers—is frequently one of the most feasible, effective steps a community can take to help a private partner. If a community is building new fiber, we encourage considering a higher count than justified by immediate needs in order to ensure there is capacity for growth. The relatively low incremental cost of additional fiber in a cable may justify constructing a 288-count fiber cable instead of a 144-count cable in some cases.

This model has been extensively used in hundreds of communities in Sweden—most notably in Stockholm, where the city built extensive fiber over 15 years to most of the multi-dwelling buildings in the city, and made that fiber available to the private sector—substantially reducing the cost to private sector competitors of providing service in that market.

A recent economic analysis of the city of Stockholm's fiber initiative[16] concluded that the city's investment in fiber resulted in a net lease cost for dark fiber that is less than half that in other international capitals, and that has delivered a wide range of indirect benefits including the participation in Stockholm's vibrant broadband services market of many independent providers.

2.1.2 Lease fiber in hard-to-reach areas such as river crossings and urban locations

Another effective way to leverage a locality's fiber is to reach areas that are particularly expensive or difficult to construct. For example, the locality may have fiber in conduit on a bridge across a freeway or river; leasing that fiber could save the provider the enormous cost of securing the rights to cross, as well as the cost of making the crossing itself. Similarly, the locality may have fiber in highly built-up urban areas, where building fiber can be many times more expensive than in suburban or less densely populated areas.

Figure 4 and Figure 5 illustrate two scenarios, one in which a network provider is able to use existing backbone fiber for middle mile connectivity, and one in which the provider must construct its own fiber. The availability of a locality's middle mile fiber offers a range of benefits to network providers, including reduced up-front capital costs and increased predictability in the construction of a critical core asset. Using a locality's middle mile fiber also reduces deployment time—enabling a provider to immediately connect its core to neighborhoods, rather than waiting weeks or months to start connecting customers. The community benefits, as well, by collecting revenues for unused assets, reducing disruption and damage to the public rights-of-way, and assisting in getting broadband services to homes and businesses.

16 M. Forzati, C. Mattsson, Stokab, a socio-economic study, Acreo report acr055698, Stockholm, July 2013.

FIGURE 4: MIDDLE MILE FIBER PROVIDED BY LOCALITY

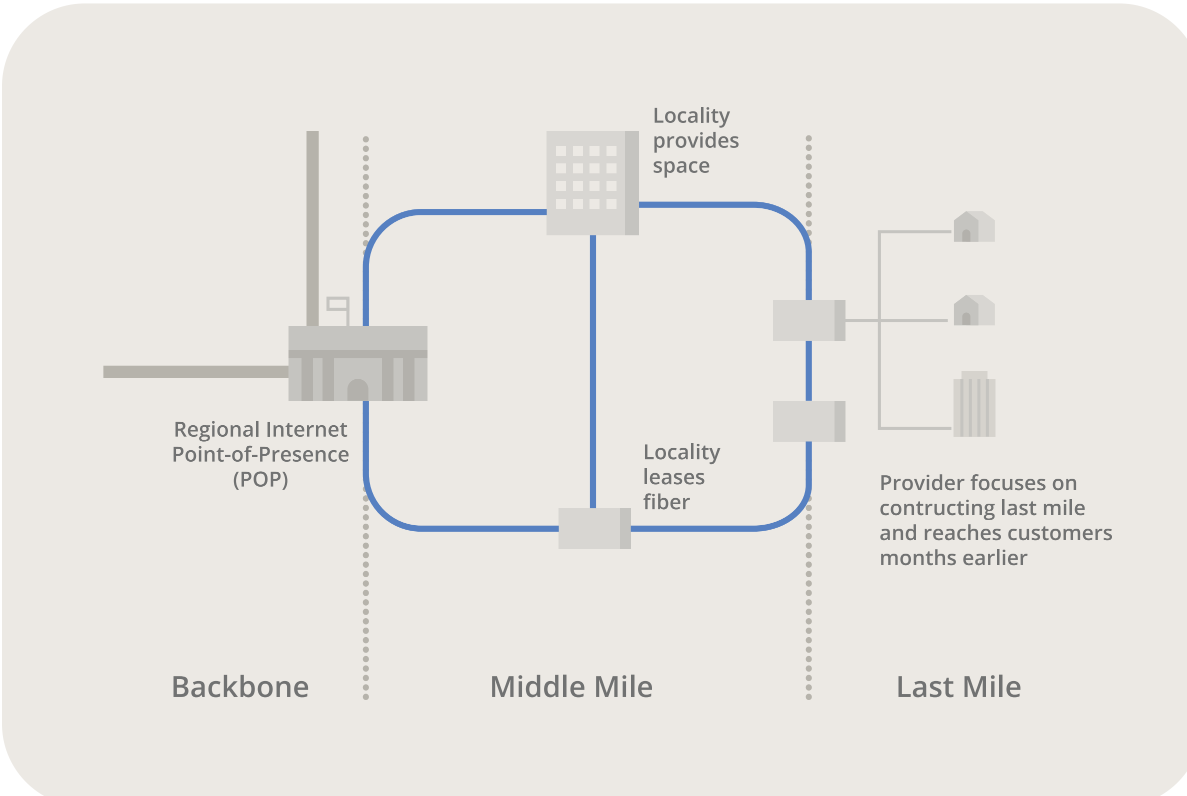
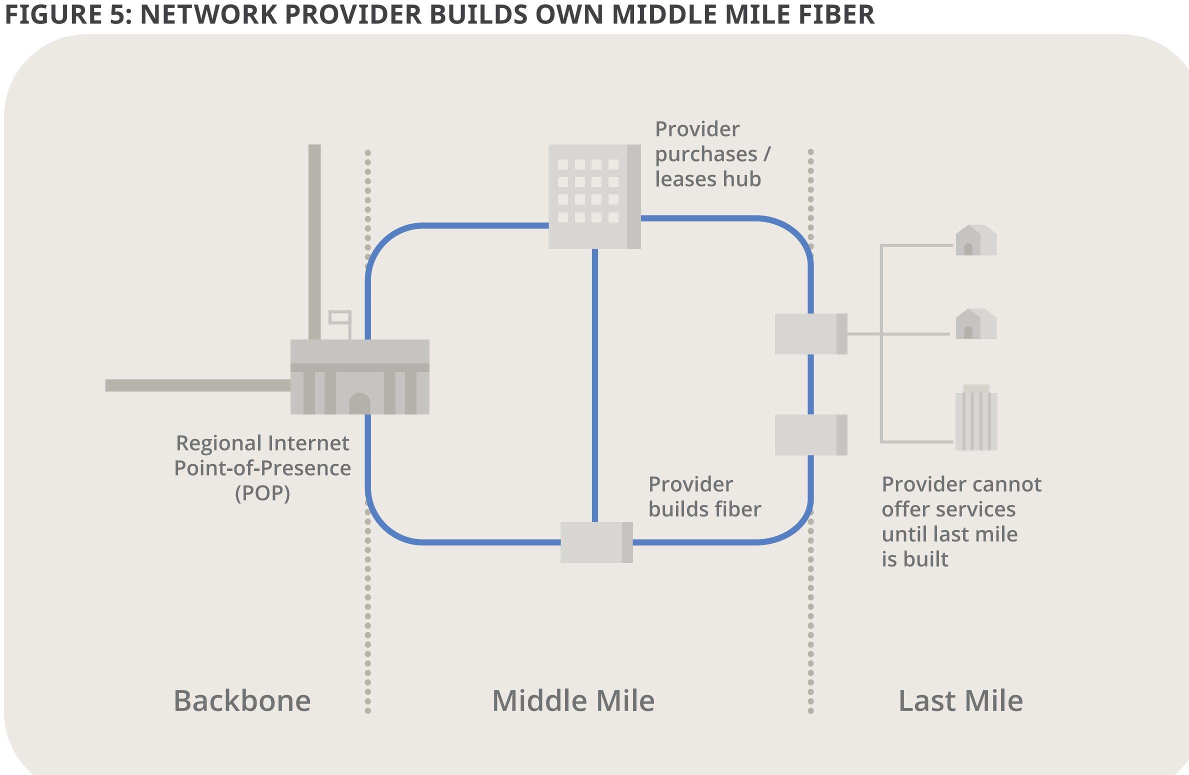


FIGURE 5: NETWORK PROVIDER BUILDS OWN MIDDLE MILE FIBER

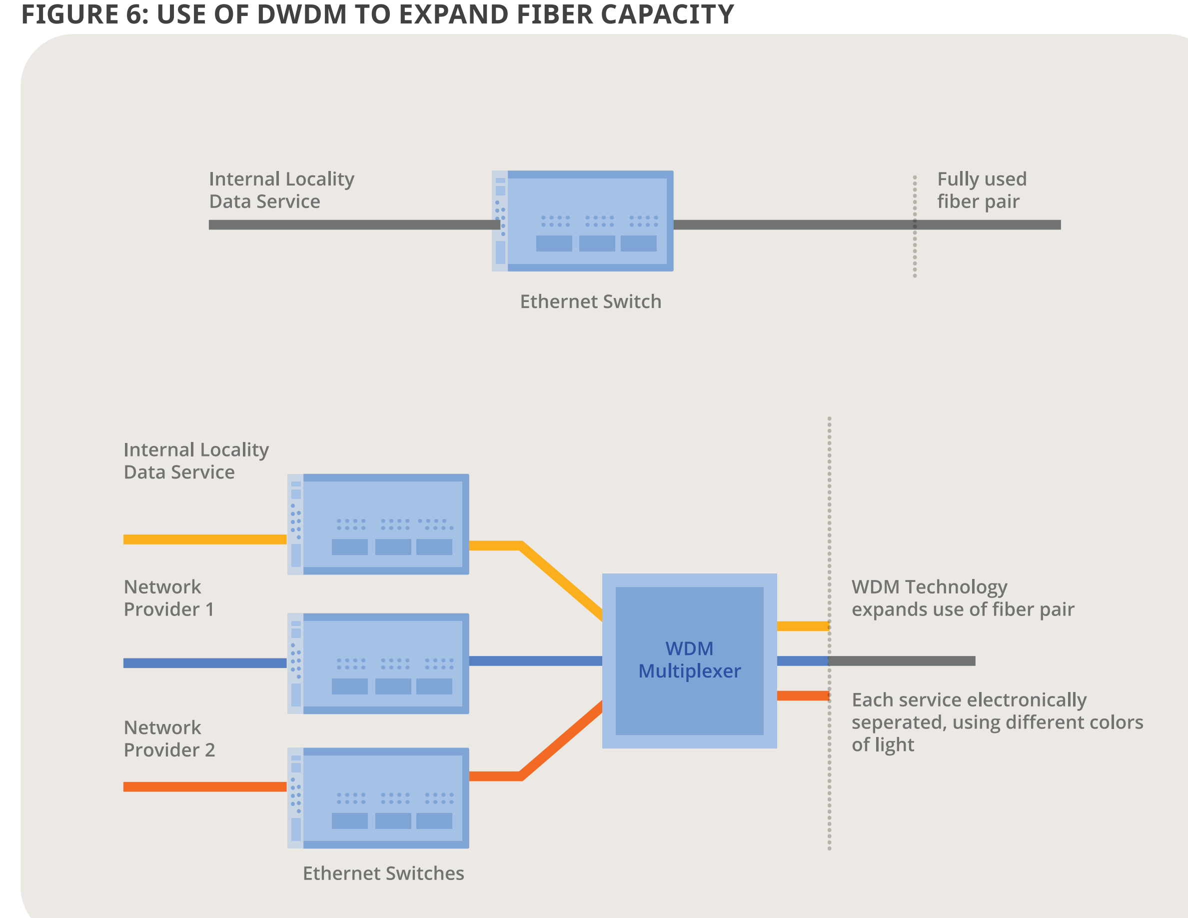


2.1.3 If insufficient fiber exists to facilitate leasing, stretch or increase existing fiber capacity in order to meet both internal needs and those of potential partners

Of course, if existing fiber is serving the internal communications needs of the community, sufficient capacity to meet long-term locality needs should be reserved or the capacity of the existing fiber should be expanded.

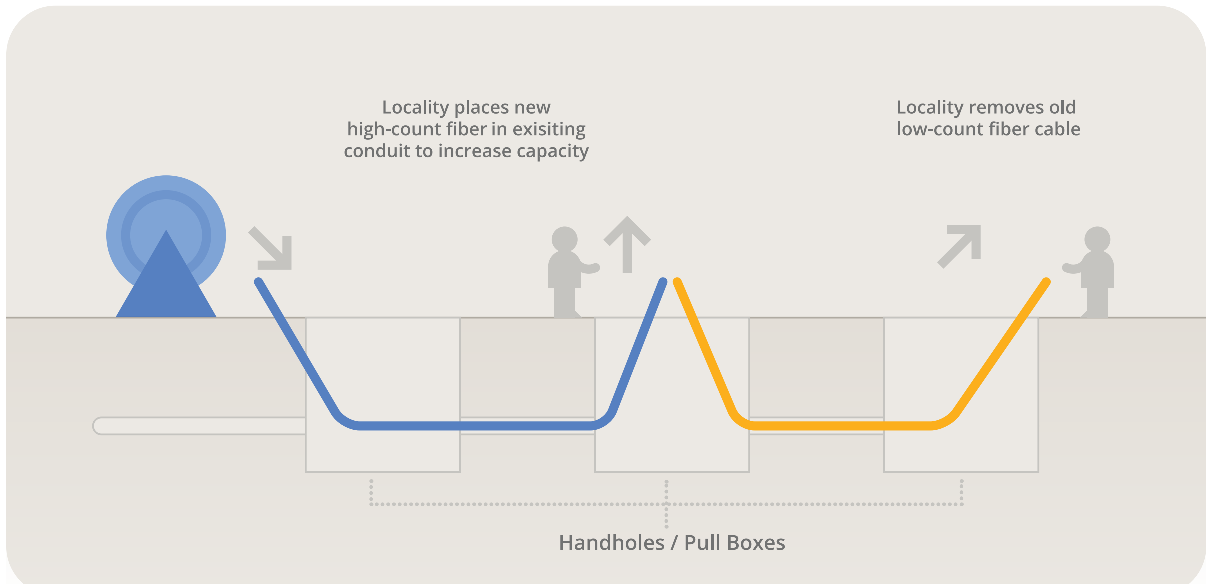
A community can free up excess capacity through technology solutions that consolidate its existing fiber uses. For example, dense wavelength division multiplexing (DWDM) technology places multiple transmission paths over the same fiber using separate wavelengths or colors for each transmission (see Figure 6). DWDM enables a single fiber to carry the capacity of dozens of fibers. DWDM may require additional community investment, but the locality can build those costs into the lease fees it charges for the fiber (as it would for other costs it incurs to offer fiber, such as upgrades, establishment of access points, maintenance, and fulfillment of service guarantees made to the lessees). Even with the costs of such solutions built into the lease fees, the aggregate expense to lessees is likely to be far lower than that of new fiber construction.

FIGURE 6: USE OF DWDM TO EXPAND FIBER CAPACITY



Replacing or supplementing an existing underground cable with a larger cable is another strategy for increasing a community's fiber count along a particular route. This can be done if the cable is in conduit. As illustrated in Figure 7, the existing cable is removed and replaced by one with a higher fiber count. Although this strategy is less costly and disruptive than installing new cable and conduit, it does entail labor costs (for the cable removal, installation, and splicing), material costs (for the new fiber), and disruptions of service for users of the existing fiber.

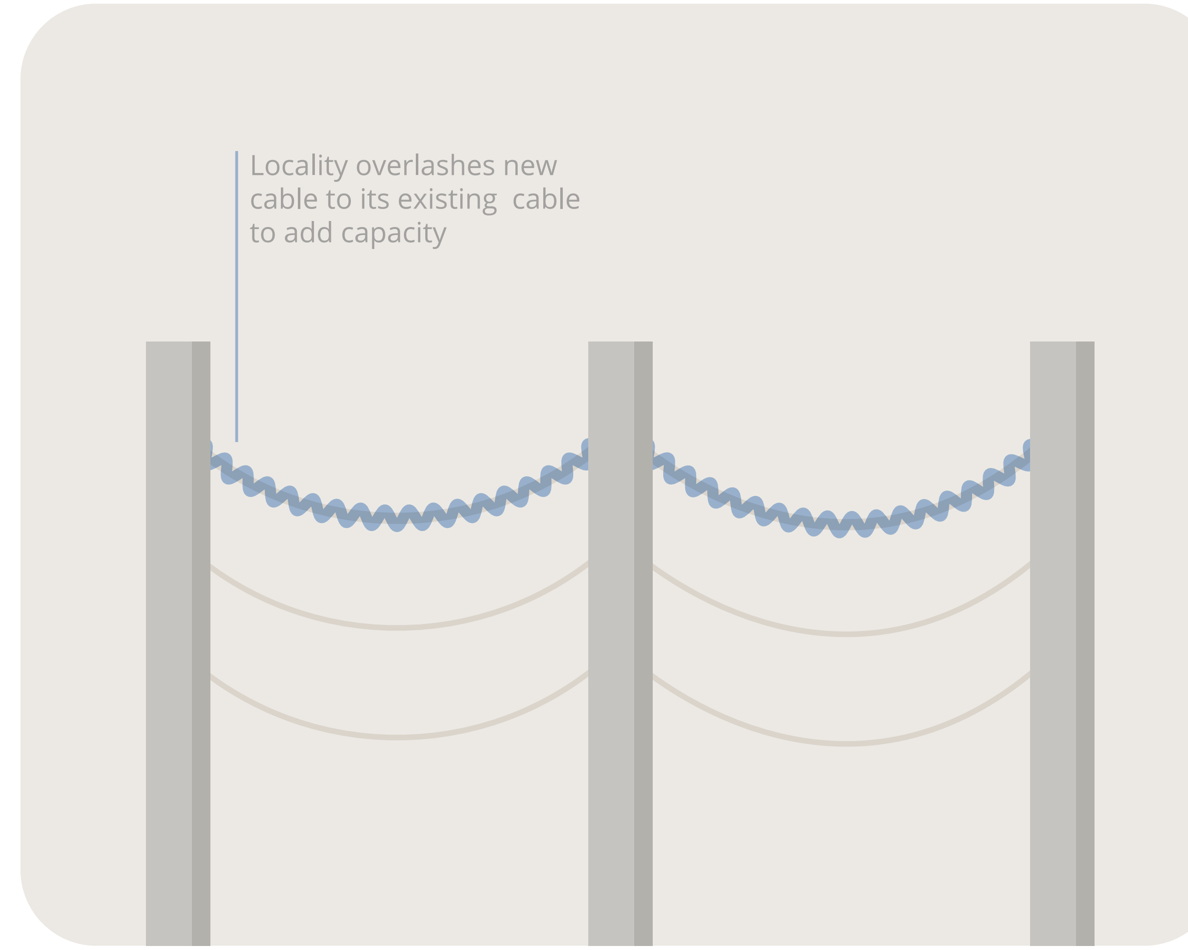
FIGURE 7: COMMUNITY REPLACES EXISTING FIBER WITH LARGER CABLE



Maryland's Inter-County Broadband Network (ICBN) and the City of Baltimore recently supplemented existing 48-count cable along sections of the city's public safety radio backbone ring. In addition, new conduit and fiber were constructed in many additional routes. In some existing conduit, 216-count fiber was pulled and 24-count set aside for future leasing to commercial providers. The fiber and conduit, which connect the Baltimore Technology Park to other parts of the city, were designed both to meet the city's own internal communications needs and to enable new private partners to build or expand broadband facilities in Baltimore. (Significantly, the fiber connects to extensive other public middle mile fiber in central Maryland, owned by the eight other members of ICBN, all of which are neighboring jurisdictions. All this fiber was designed to enable new private leasing and use.)[17]

Communities with aerial fiber infrastructure can also increase capacity by overlashing a new cable to an existing cable (see Figure 8). This strategy is commonly used by telecommunications and cable companies; a significant fraction of Verizon's FiOS fiber-to-the-premises (FTTP) system, for example, is overlashed to copper telephone cables. Cable operators typically expand fiber in their networks by overlashing it to their coaxial cables. Overlash is significantly less costly than creating a new attachment on the poles and does not typically require make-ready (i.e., the process of preparing utility poles for an additional utility), so it requires significantly less time and coordination with the pole owner. (See Section 4 for more details on make-ready.)

FIGURE 8: COMMUNITY OVERLASHES NEW CABLE TO EXISTING CABLE



Replacing existing fiber with a larger bundle in the same conduit, or overlashing a new cable to existing aerial strand, will cost on average about $15,000 to $60,000 per mile (materials and labor) depending on the fiber count. New construction can cost as much as hundreds of thousands of dollars per mile depending on local labor costs and the complexity of the build.

2.2 Build and lease conduit resources

Leasing conduit to broadband providers greatly simplifies construction, reduces capital costs, and reduces the time necessary to build. On average, the cost for a provider or locality of pulling fiber in existing conduit is 10 percent of the cost of underground construction without the conduit.

17 CTC interview with Ms. Lori Sherwood, former ICBN Program Director, October 20, 2013.

The community benefits from leasing its conduit by speeding deployment and competition, reducing damage and disruption to the rights-of-way, and obtaining revenue.

Conduit exists in a wide range of sizes, deployment scenarios, and topologies. Localities install conduit for a wide range of connectivity purposes, including:

- Community-wide communications
- Power
- Traffic signals (both from the signal to the cabinet, and from the cabinet to the communications network)
- Antennas and sensors (traffic, SCADA)
- CCTV cameras

Conduit is also installed to interconnect buildings (e.g., in a campus environment) and to provide capacity alongside public infrastructure, such as roads and canals.

We recommend that localities assess their conduit to determine its value for communications use. A community seeking to install conduit for a current or future communications use should make sure it is technically well-suited for this purpose. The ideal conduit for communications networks has the following characteristics:

- Continuity over a long distance
- Sufficient size (diameter)
- Proximity to locations of interest
- Handholes or manholes at regular intervals
- Empty, or segmented with spare innerduct
- Unobstructed
- Sealed
- Separated from power
- Accessible
- Accurately and completely documented

As with fiber, a locality can sell or lease conduit and provide considerable capacity for a network provider. For example, a three-inch conduit can be segmented into three innerducts, each of which can carry a cable with hundreds of strands of fiber. This can support backbone or local distribution/access fiber for middle mile or FTTP.

Conduit can be made available to a service provider by granting access at a designated manhole or in a public building. The service provider or the locality can be

responsible for the maintenance of the conduit. However, if the service provider is leasing innerduct within a conduit, or if the conduit is in a bank with other community conduit, we recommend that the locality be responsible for maintenance.

As with fiber, a conduit system with community-wide continuity can help in establishing a network backbone—and can provide an immediate, cost-effective way to reach throughout the locality, even if a provider's construction is starting in another part of the locality. Also like fiber, conduit is more valuable if it helps avoid expensive construction across a major road or other costly or difficult to build area.

One advantage of leasing conduit, relative to fiber, is that it affords the locality more separation from the operations of the service provider. Once the locality assigns a conduit and access points, it coordinates with the service provider less frequently for maintenance or repair than it would with a fiber lease.

Conduit leases also pose disadvantages relative to leasing fiber. One is that conduit and conduit banks are less segmentable and therefore provide less flexibility than fiber. A fiber cable has dozens and potentially hundreds of fiber strands, any of which can be used by the locality, leased, or kept in reserve. In contrast, there are rarely more than a few conduits in a route (sometimes only one) and only a few possible segmentations of each conduit, and therefore it is easier to run out of conduit over a given route.

The conduit strategy has been used effectively by the City of Mesa, Arizona, which pioneered underground communications conduit infrastructure in the 1990s. The city's joint trenching projects enabled construction of conduit in the least disruptive manner and offered low-cost construction opportunities for commercial providers and businesses. The city also capitalized on every opportunity to add new conduit; it evaluated the feasibility of construction cost-sharing for all underground trenching and boring opportunities, such as roadway widening, gas or utility pipeline installation, and commercial fiber optic construction (such "dig-once" strategies are discussed in detail below in Section 3.1). As a result, the city cost-effectively built robust conduit rings in key parts of the city—then made the conduit available to private parties.[18]

2.3 Lease facilities space

Network providers require secure, accessible, and suitable spaces for their equipment, data centers, and network operations centers (NOCs). Ideally, these spaces should be evenly geographically distributed through a service area. Availability of secure space relatively near customer homes and businesses enables greater performance and

18 Darrene L Hackler, Cities in the Technology Economy, page 115, published by M.E. Sharpe, 2006 http://goo.gl/EaLthh

variety of service—and offers the provider more flexibility to cost-effectively build or upgrade its network. For these reasons, local governments that lease such space (or create a mechanism for predictably and cost-effectively obtaining space) can reduce providers' deployment costs and enable new technology benefits.

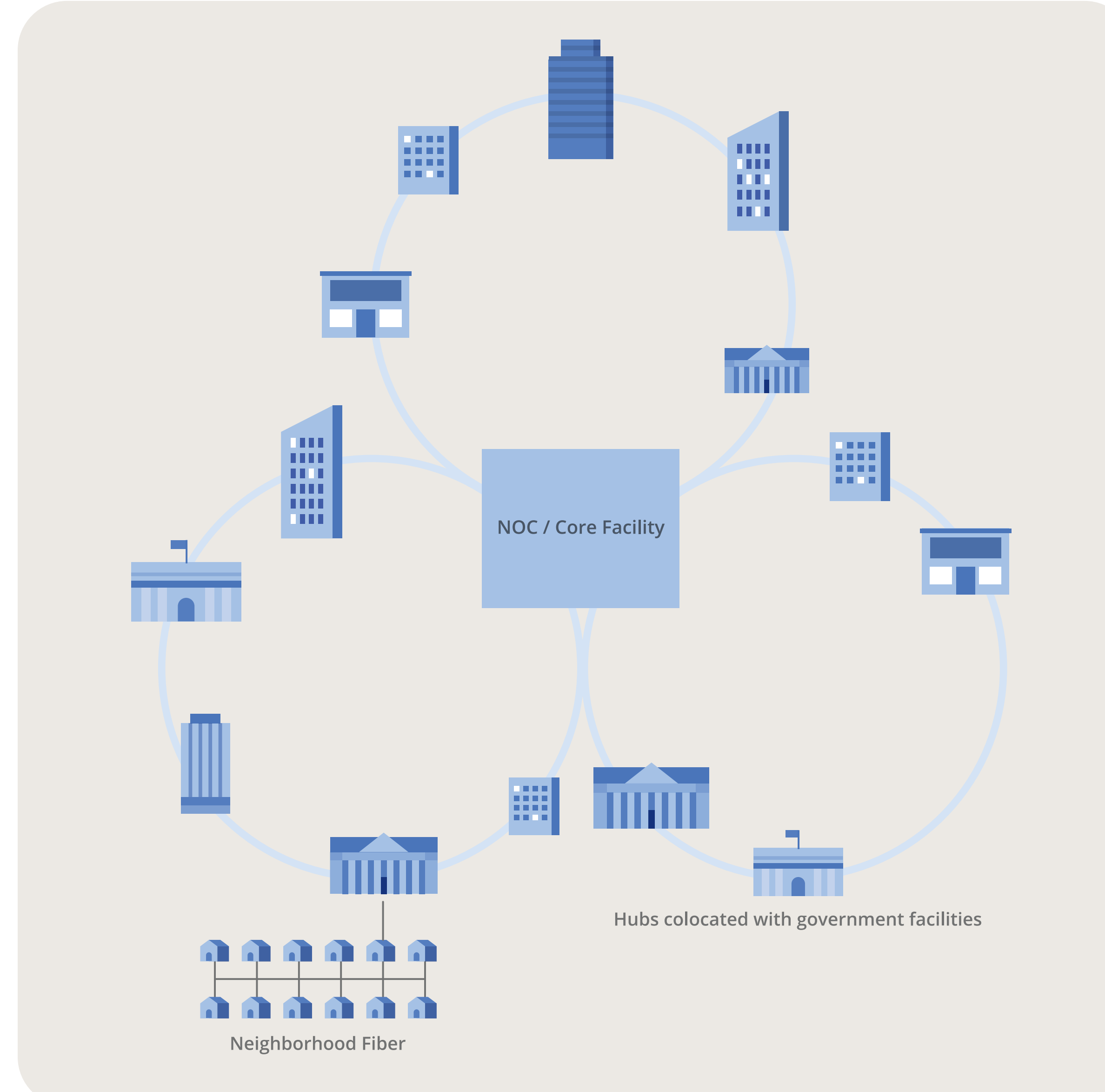
Locally owned buildings and their adjacent land can be logical locations for communications infrastructure. Such buildings include public safety buildings, schools, and libraries—all of which tend to be located in neighborhoods throughout a community, in a geographically even manner.

In our experience, localities can inventory their infrastructure to determine where space and access may be available for use by broadband providers, and then make this information available to private deployers. In addition, in planning areas of new development, localities can plan in light of the need for suitable locations in or near public buildings where a provider can locate equipment, in the same way it might plan for power transformers or water or sewer locations.

In an optimal scenario, the locality identifies and leases secure, accessible space for the NOC. The locality also identifies and leases space for hub locations in government facilities (primarily government buildings, public safety, public housing, libraries, and schools). In addition, the locality provides rooftop access for wireless antennas that are used by the provider to extend wireless Internet service to remote areas where fiber cannot be cost-effectively built.

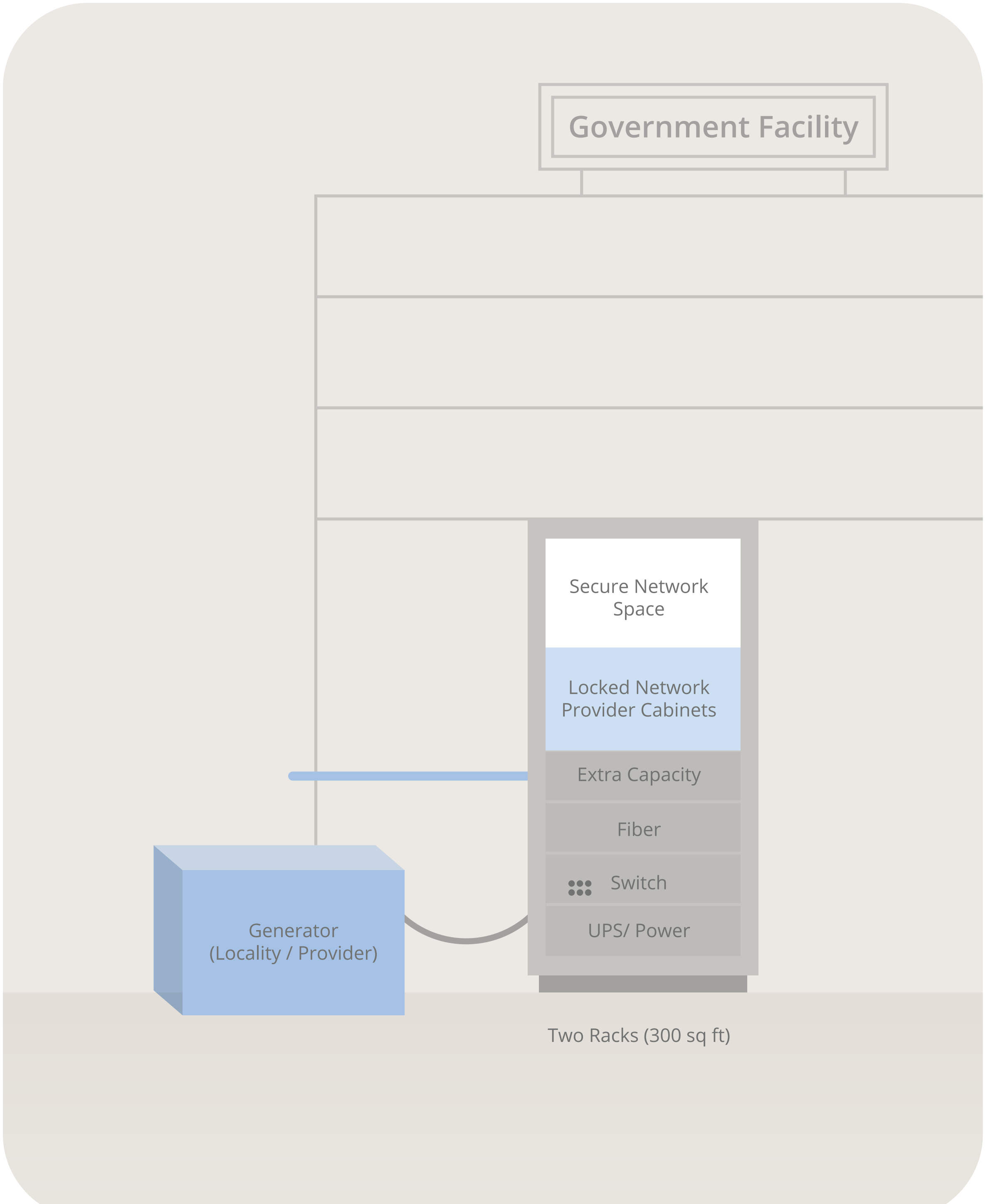
The benefits to the new broadband provider can be significant. First, if it is able to collocate its NOC with a hardened government facility such as an emergency communications center, the provider has the benefits of a secure facility; backup generator and battery power; multiple utility entry/exit points; and proximity to external networks. To activate a NOC that is collocated with a government facility, the provider needs only to place racks, upgrade and expand power and cable distribution, and purchase the network-specific equipment. (The NOC houses core electronics, management and content servers, staff offices, and the network's interconnection with external backbone networks (see Figure 9). It requires 1,000 to 3,000 square feet, depending on the system size and services provided).

FIGURE 9: SAMPLE SCENARIO FOR GOVERNMENT-PROVIDED FACILITIES



Second, the new provider also benefits if it can lease space in public buildings to serve as hub locations. In each of these, a smaller amount of space is necessary (see Figure 10), ideally collocated with the local government facility's network room or telecommunications closet. The service provider can install local switching and routing equipment capable of providing any speed Ethernet service—including 10, 40, and 100 Gbps services requiring dedicated fiber or wavelengths. Indoor facilities with standard racks and power give the provider flexibility to locate a wide variety of equipment and to upgrade and customize services. The hub facilities also contain backup battery and generator power. The provider has 24-hour access to the building, either through the existing building security or through a dedicated entrance. Although the types of buildings housing these network sites will vary, the locality can create a single contractual agreement for all of them and can ensure that the needs of the both network provider and the building users are met.

FIGURE 10: ILLUSTRATION OF PRIVATE PROVIDER USE OF GOVERNMENT BUILDINGS



The locality also benefits from this leasing arrangement: speeding new network deployment; maximizing use of government facilities that are optimized for such benefits as backup power and security; and realizing lease revenues. Operational benefits exist for the local government, too: because the network provider's hub infrastructure is present in many major government facilities, the locality can inexpensively connect individual buildings to the network and can locate its servers and data on-net.

As a result, access to public buildings can be a boon to providers. Where public buildings are not available, the new provider would need to lease indoor space from private landlords or build huts on leased private land. In our experience, this can be more challenging than leasing public property. Premium space, well located, must be found and leased or purchased in the private marketplace. The network provider needs also to install generators, backup power, racks, interconnection with external backbone networks, core electronics, management and content servers, and staff offices.

Absent access to public buildings, providers may encounter difficulty obtaining permission to install generators or may not be able to secure appropriate in-building space at all. In such circumstances, they may adopt cabinet-based architecture, which entails more limited service capabilities and more susceptibility to outages from power failure. A service provider using a cabinet architecture has to choose between a passive design, in which fewer customers can have the highest speed connections such as 1 Gbps or 10 Gbps (see Figure 11), or an active Ethernet architecture, in which all customers can generally have 1 Gbps or 10 Gbps symmetrical service, but the cabinets require remote power (see Figure 12).

FIGURE 11: OUTDOOR CABINET IN PASSIVE FIBER NETWORK

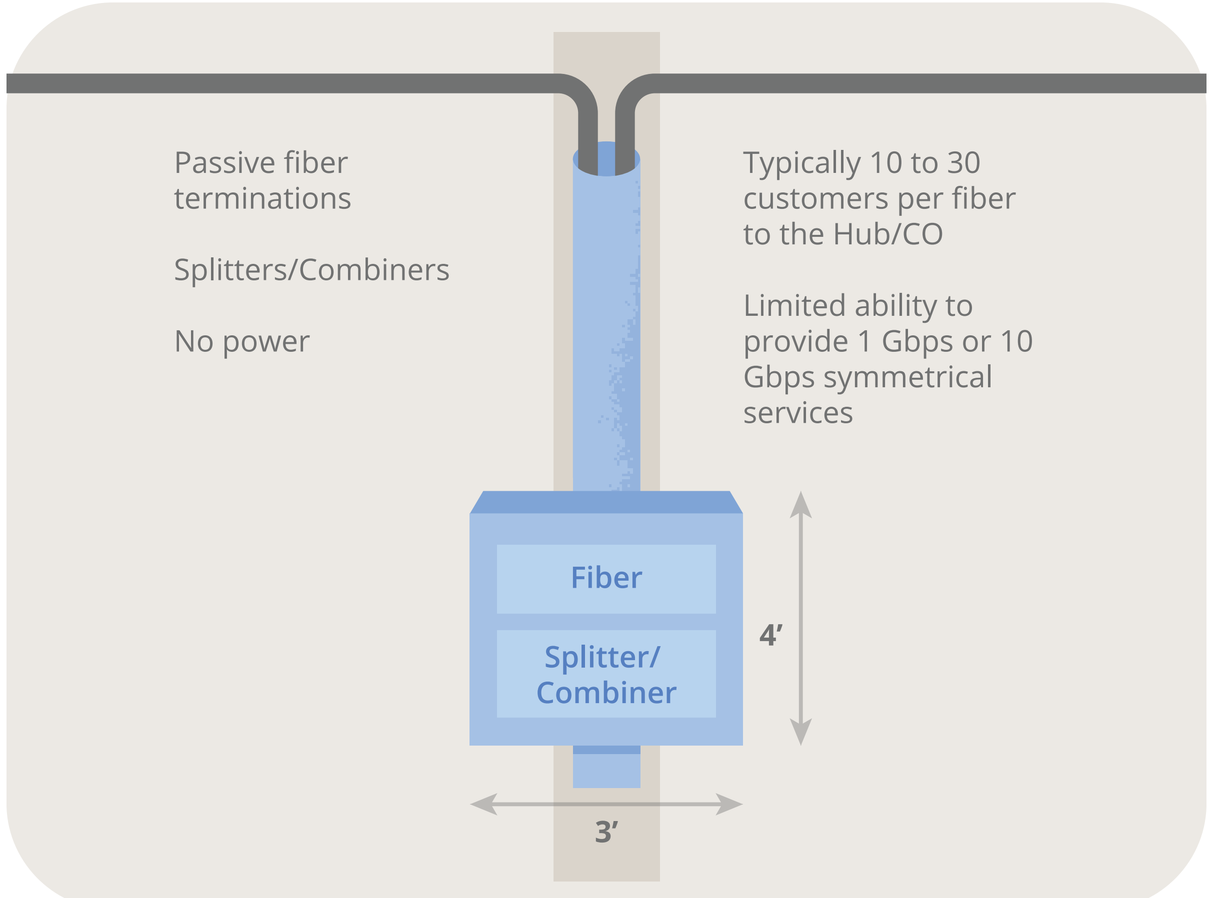
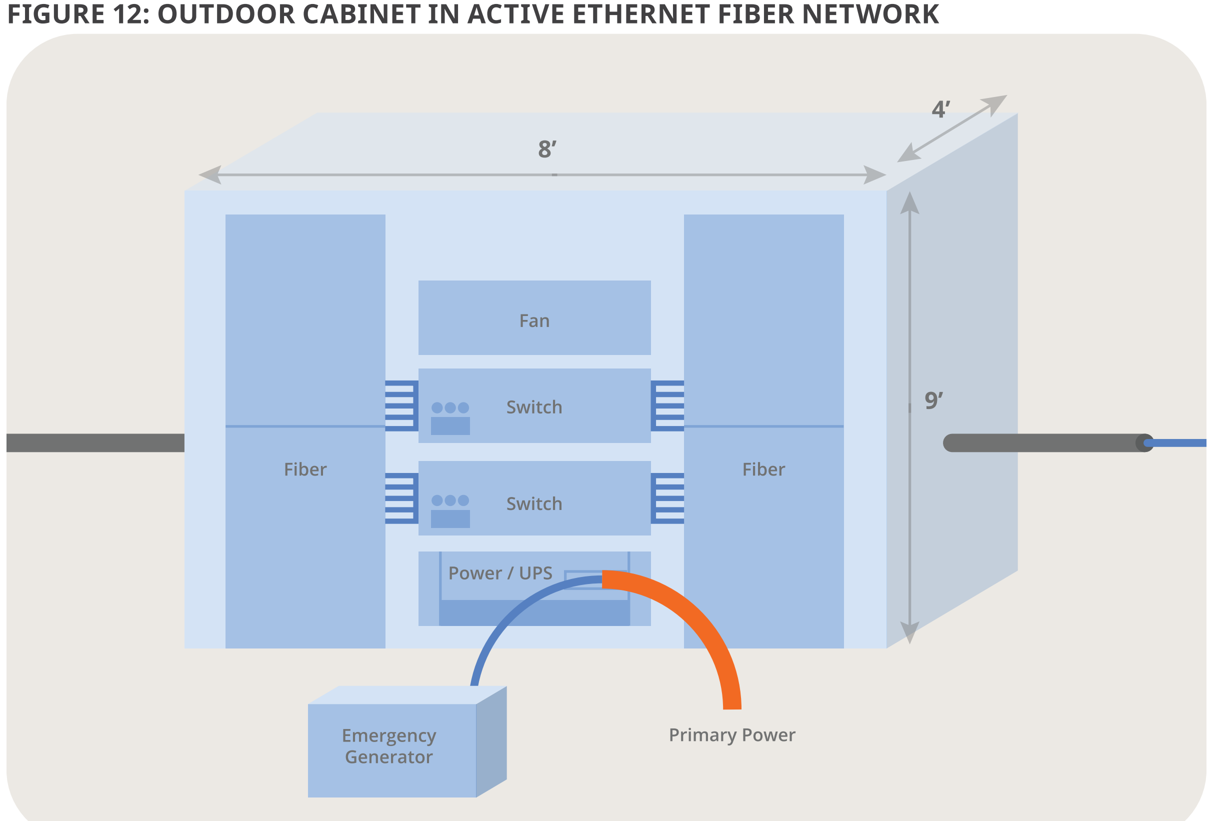


FIGURE 12: OUTDOOR CABINET IN ACTIVE ETHERNET FIBER NETWORK



3 Asset Access Strategy 2: facilitate underground construction

Underground construction can be costly and time-consuming, but where underground fiber or conduit are already available (see Section 2.2), new network construction can proceed remarkably swiftly.

3.1 Develop a "dig-once" policy to promote conduit and fiber construction

Many localities have adopted some form of "dig-once" policy that opens streets and rights-of-way to utility construction when related projects are underway. Such policies protect roads and sidewalks and minimize traffic and other disruptions related to utility construction — but also create a more uniform and efficient means of constructing network infrastructure by giving multiple entities, including the locality itself, the opportunity to place fiber or conduit inexpensively.

To build or expand a fiber footprint, localities can place conduit during all capital improvement projects to dramatically lower the cost of network construction.[19] Most communities are well situated to install conduit any time a capital improvement project requires breaking ground in the public right-of-way. To maximize the benefit of this strategy, localities can maintain awareness of opportunities to install or obtain fiber and conduit through activities in the rights-of-way and discover and pursue these opportunities by way of explicit, formal procedures.

Localities can also adopt guidelines addressing conduit construction so that they can quickly work with a potential partner to add conduit to a project and integrate with existing community conduit. Standards should be prescriptive, but there should be sufficient flexibility to modify them if impractical or unsuitable in certain circumstances. These documents can serve as references in developing, for instance, site plan conditions for utility- or developer-provided infrastructure.

New development areas, for example, offer important fiber and conduit placement opportunities. As the roads are developed, conduit can be installed and documented, enabling the locality to place fiber when needed at very low cost relative to the cost of retrofitting those roads for fiber infrastructure. Conduit burial during construction could enable the community to lease fiber to private providers or deploy services

19 See "Brief Engineering Assessment: Efficiencies available through simultaneous construction and co-location of communications conduit and fiber," White Paper, CTC, 2009. http://goo.gl/SkGOGl

itself, as the need arises. The incremental cost of the conduit during construction is negligible relative to the cost of building fiber later, after the development is complete.

The City of Lawrence, Kansas, for example, has used this strategy for a number of years. As the opportunities have arisen, the city has expanded its network infrastructure by installing fiber or conduit to support important internal needs, or in concert with a private partner. In Lawrence, the IT department, city engineer, traffic supervisor, and public works department have demonstrated, through collaborative effort and cooperation, the potential to realize efficiencies by placing conduit during other projects. The city engineer and IT department have developed a well-functioning process to take advantage of capital improvement projects in the rights-of-way to place conduit, and the city engineer reports that the incremental cost of the conduit placement has been negligible relative to the broader cost of the capital improvement project.

Localities can also watch for opportunities to install or obtain fiber and conduit through activities in the rights-of-way and discover and pursue these opportunities by way of explicit, formal procedures or ordinance. These opportunities may include grant-funded initiatives for particular departments; road construction; road widening; undergrounding of utilities; and construction of new and existing utility infrastructure (electric, telephone, cable, water, sewer).

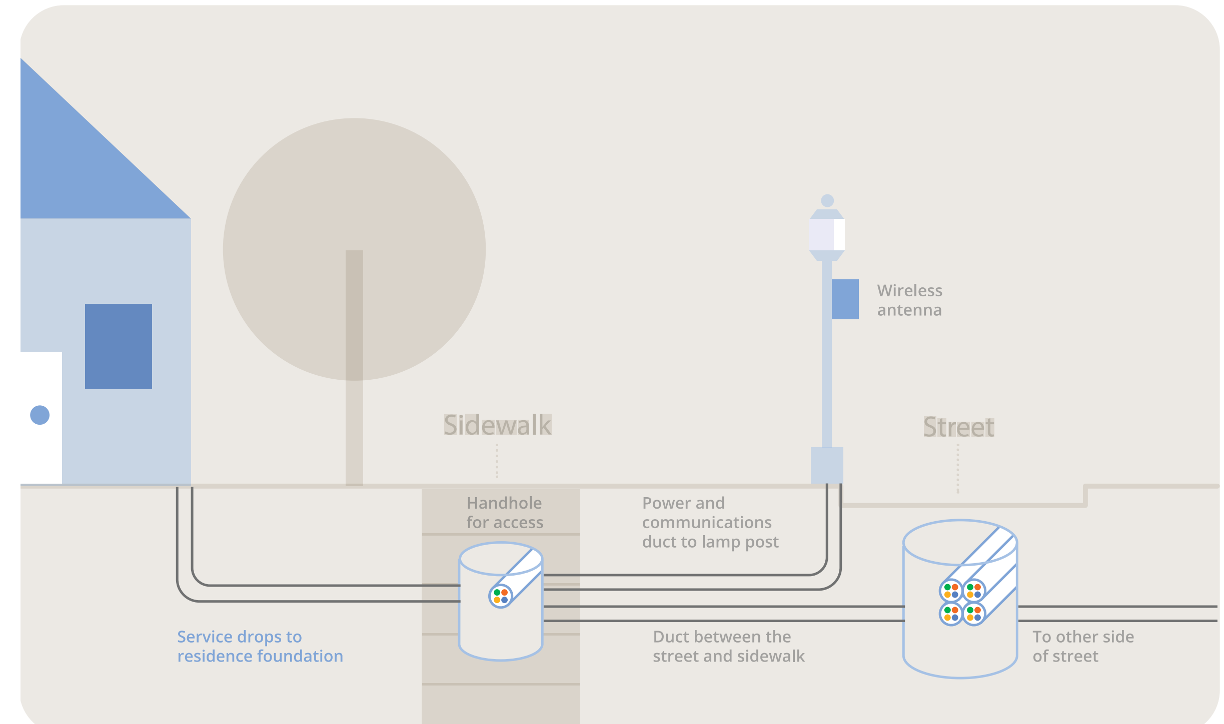
Localities can maintain contact with local utilities and service providers to be aware of their upcoming plans. Likewise, entities performing construction in the rights-of-way can provide sufficient information in the permitting process for the locality to judge if a co-location opportunity is available, and provide sufficient time for the locality to coordinate adding conduit and vaults as part of the construction.

To ensure that all entities have the opportunity to place conduit or fiber during other entities' construction, localities can put in place processes to alert itself as to the opportunities. It can set up capture points to bring new construction to the attention of the appropriate party—including through requests for permitting antennas, permits for rights-of-way construction, discussions in trade or business journals, coordination with other governments in the region, and discussions with regional economic development entities.

The potential benefits of this coordinated approach to conduit and fiber installation accrues not only to public agencies but also to private providers. A coordinated fiber network design can provide capacity for dozens of separate service providers. This strategy has the benefit of maximizing long-term value and minimizing the potential for future disruption.

One approach is to construct a high-capacity conduit bank connected to manholes at regular intervals according to a standardized design (Figure 13). The primary manholes in turn would connect to lower-capacity conduit connected to residential or business service drops or to wireless infrastructure. Small manholes or handholes can be managed by particular service providers for their proprietary access and service to particular customers.

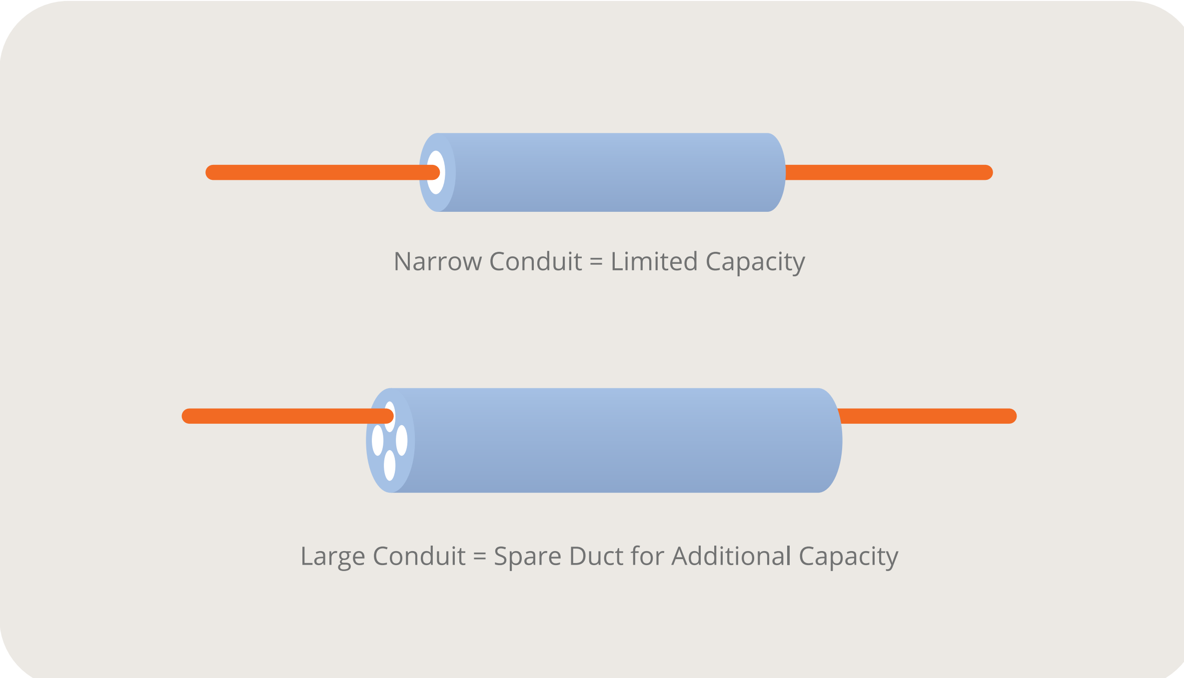
FIGURE 13: LONG-TERM CONDUIT INSTALLATION STRATEGY



3.2 To make conduit future-proof, use a robust specification with flexibility to add fiber in the future

Ideally, localities should maintain a specification for conduit that is sufficient to meet future needs (i.e., a relatively large conduit that is able to hold more than one bundle). Installing large conduit with multiple ducts and pull strings would create excess capacity that the locality could tap to meet its future needs or those of its partners, or could lease to the private sector. (See Figure 14.) Three-inch conduit can readily contain two or three innerduct, which each can carry a large-count fiber cable. Four-inch conduit can contain six innerduct.

FIGURE 14: ILLUSTRATION OF VALUE PRESENTED BY LARGER CONDUIT



The cost of installing larger conduit can be higher (not so much because the conduit itself is more expensive, but because the larger conduit requires digging a larger trench). For this reason, we recommend that localities seek opportunities for collaborative conduit installation with potential partners such as utilities and communications providers; localities may be able to negotiate a cost-sharing relationship if the conduit will offer access to key routes, and if it is large enough to hold multiple ducts that could be used by private sector providers as well as the locality.

Dig-once notifications and management can be accomplished in different ways, ranging from an approach where the locality has a strong hands-on monitoring and management role, to one in which the requesting provider or utility is required to notify other potential installers, and the providers and utilities coordinate activities.

An effective strategic planning process and consultation with current and potential service providers can help the locality define construction specifications for conduit in major rights-of-way, commercial areas, and neighborhoods. The outcome of the planning can be a summation of individual service provider needs for each neighborhood or type of area, plus capacity for future growth or new entrants.

An effective dig-once policy can result in greater conduit capacity throughout a community and thereby facilitate the entry of new service providers. This outcome is particularly valuable in areas where construction costs are high, or in highly congested rights-of-way where construction can be more disruptive. For example, in Arlington County, Virginia, an urban community bordering Washington, D.C., the county is using dig-once strategies to streamline the construction of a redundant, high-capacity middle mile fiber optic network to improve regional connectivity. The "ConnectArlington" project has coordinated with public works construction and the electric utility's fiber construction. The project has placed fiber during construction of public safety backhaul fiber to radio towers and during installation of fiber connections to traffic signals.[20]

Similarly, the City of Centennial, Colorado collaborates with entities that are undertaking construction projects in the city. Each opportunity is evaluated as a means to extend city-owned fiber and conduit in new routes. As a result of this strategy, the city has successfully built hundreds of miles of fiber and conduit at relatively low cost and is currently seeking referendum authority to make these assets available for private sector use.[21]

Since 1994, the City of Durango, Colorado has built fiber and conduit to connect government facilities and community anchor institutions and for leasing out to private providers. To take advantage of coordination and dig-once opportunities, the city builds fiber and conduit during sidewalk replacement projects, waterline replacements, and upgrades to electric utility plant. High-count fiber is installed based on assumptions about demand and future requirements, within the limits of budget and geography.[22]

3.3 Enable all parties to take advantage of "dig-once" opportunities

Once a provider initiates construction in an area covered by a dig-once plan, all providers and the locality should be made aware so that they can be ready to take advantage of the opportunity. Each individual provider can place its infrastructure while the "trench" is open (or use directional boring techniques to place the conduit), and the locality can build infrastructure for future growth (or require that another provider do so).

Providers can reduce both costs and the use of underground space by placing conduit as part of the same construction project. By placing their conduit at the same time, the providers can also reduce the instances of one conduit "wrapping around" another one—which occurs when a bore operator avoids existing conduit that is not readily seen. This reduces the complexity of repairs and reduces the risk of damaging infrastructure.

20 CTC interview with Mr. Rob Billingsley, Cable Administrator, Arlington County, VA, October 20, 2013; "ConnectArlington," http://goo.gl/RQlv5D

21 "FACTS: Potential use of the City's Fiber Optic Network to provide Advanced Telecommunication Services to the Community" http://goo.gl/KzXo28

22 CTC interview with Mr. Charles Powell, City of Durango Network Administrator, July 3, 2013.

This notification strategy has been successful in the City of Hong Kong, where private providers that open a road or sidewalk to build infrastructure are required to notify all other fixed service providers, including their competitors. Those entities are then provided with a set time interval in which they can place their own underground infrastructure. Once construction is complete, a multi-year moratorium along the path reduces disruption and wear-and-tear to the rights-of-way—and simultaneously incenting private carriers to place conduit efficiently and promptly while the road is open.[23]

3.4 Place conduit banks in congested areas

In highly congested and valuable areas, localities can construct uniform conduit bank with sufficient capacity for all current and future providers. Uniform conduit banks use space more efficiently because conduit can be more tightly packed together and share manholes and handholes. (See Figure 15.) Such banks can be maintained and managed by a single entity, whether the locality or a designated contractor.

Banks of conduits constructed simultaneously, or large conduits segmented with innerduct, provide multiple pathways for the installation of multiple fiber optic cables located in close proximity, as well as the ability to remove, add, or replace fiber optic cables without disturbing neighboring cables. Providers can select different colors for easier identification and repair. In contrast, rights-of-way that are crowded with conduit offer limited space and more costly options for adding infrastructure (see Figure 16).

23 The Office of the Communications Authority requires that all facilities-based network operators follow specific road opening coordination procedures, including: (1) that before they open any road for construction, they check with other operators to see if there is capacity or conduit on the planned route or any alternative route; (2) once they establish that there is not an alternative means of acquiring capacity, they must notify all other operators of the road opening to see if they want to place facilities at the same time; and (3) they must provide sufficient information for the other operators to take advantage of the opportunity. The other operators are then responsible to notify the first operator of their technical requirements so that the first operator can incorporate those requirements into the excavation permit to be submitted to the city's highways department. At that point, the parties are responsible to agree on a technical design and negotiate a commercial agreement on the sharing of effort and expenses for the construction project. Once this process is complete, the relevant routes are then not available for new commercial communications construction for a specified number of years. "Guidelines for Application of Road Opening Authorization and Procedure for Road Opening Works," http://goo.gl/OtSA9O; meeting with Mr. SK Ha, Deputy Director-General, and Ms. Olive Wong, Regulatory Affairs Manager, Office of the Communications Authority, Hong Kong Special Administrative Region, February 2013; correspondence with Mr. SK Yiu, Senior Telecommunications Engineer, Office of the Communications Authority, Hong Kong Special Administrative Region, October 2013.

FIGURE 15: UNDERGROUND CONDUIT BANK FOR MULTIPLE USERS

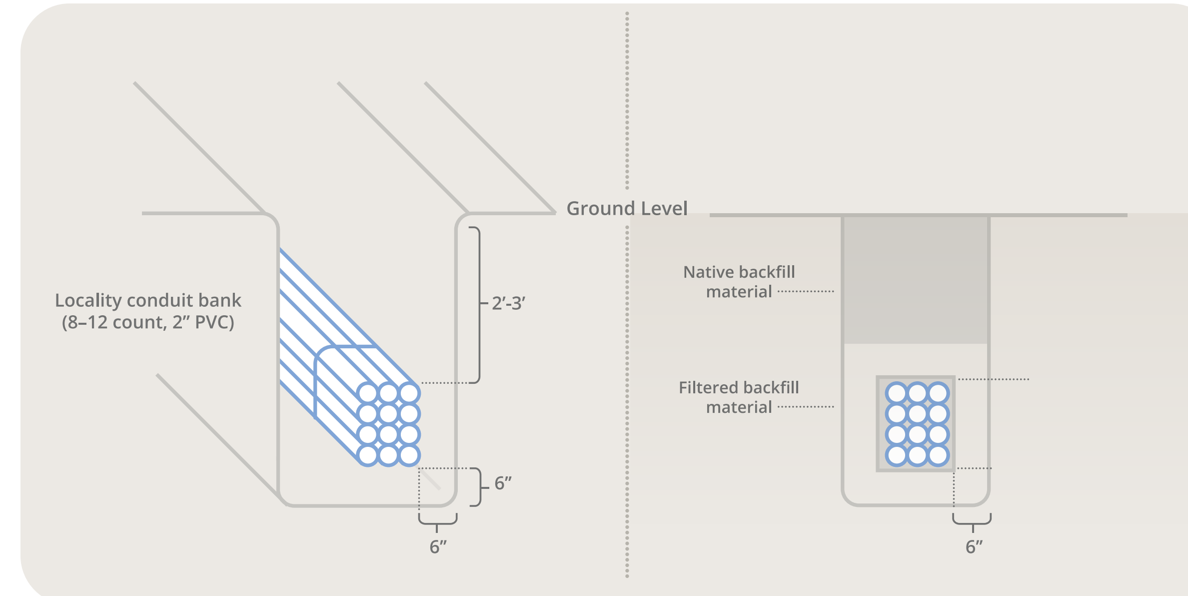
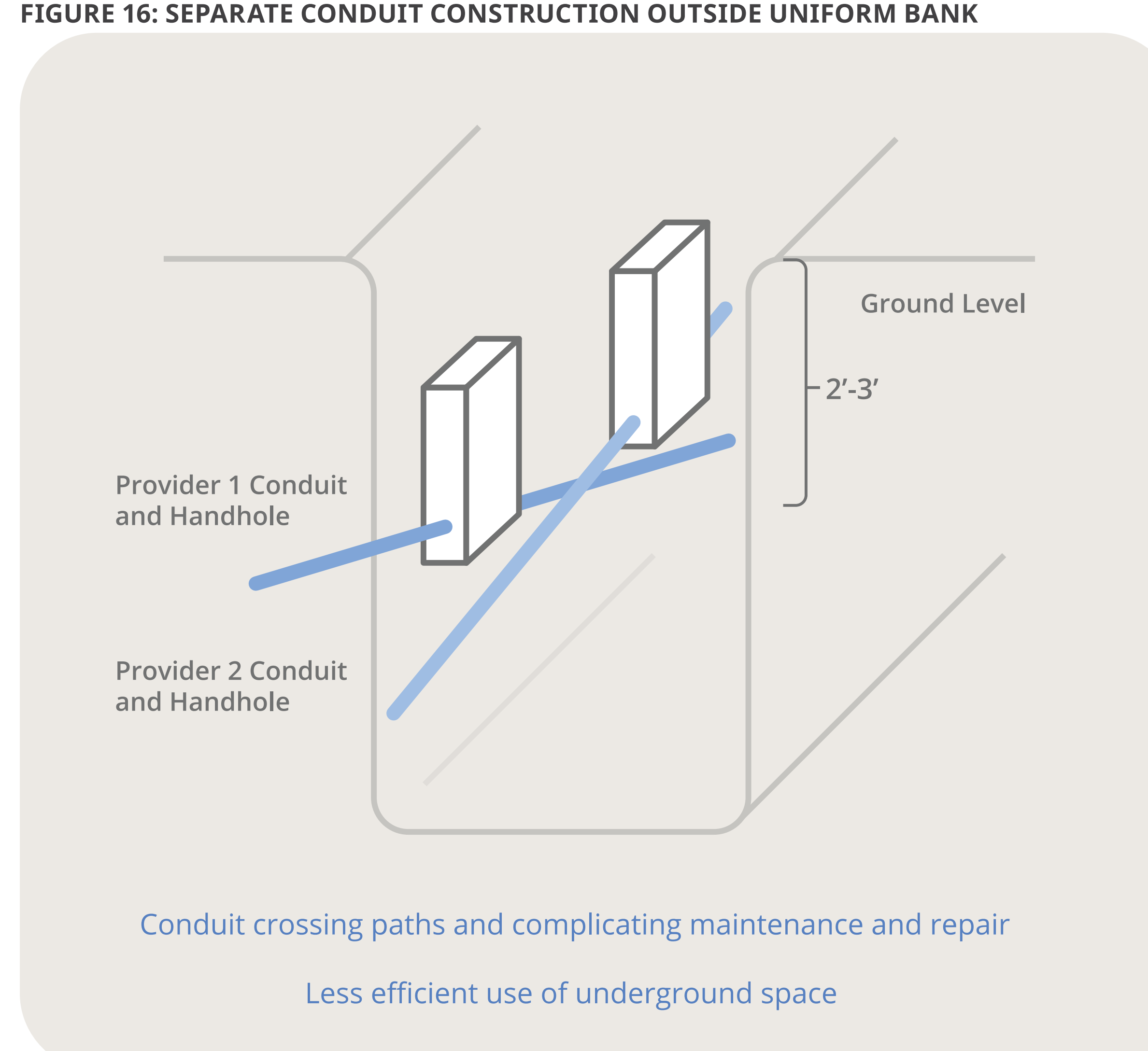


FIGURE 16: SEPARATE CONDUIT CONSTRUCTION OUTSIDE UNIFORM BANK



The State of Arizona recently initiated a program to place banks of conduit in state rights-of-way whenever other maintenance work is being performed in the same location.[24] The state owns the conduit but gives the private sector the opportunity to pull fiber through it. According to state officials, the up-front investment costs are justified by the cost savings and economic benefits that will accrue. The state's process streamlines the fiber construction process by making the conduit available to all comers and eliminating many of the requirements for construction permits, environmental and historical studies, and other one-time processes that were previously repeat costs for every provider for every new project in a state right-of-way. Under the new program, the state has addressed all of these in advance while building the conduit. State officials estimate that the incremental cost of placing the conduit during other construction processes is comparable to the cost of painting stripes on the highway.[25]

24 CTC interview with Mr. Mike Golden and Mr. Jeffrey Crane, Digital Arizona Program, September 2012; CTC interview with Mr. Galen Updike, Digital Arizona Program, May 2012; "The Two Highways Proposition," Digital Arizona Program, http://goo.gl/RhDWSl

25 "The Two Highways Proposition: Combined infrastructure projects save both time and money," Digital Arizona Program, Arizona Strategic Enterprise Technology. http://goo.gl/tfxvVR

4 Asset Access Strategy 3: facilitate aerial construction by working with pole owners to clear space and secure access for new entrants

A critical item for anyone building new broadband facilities is access to utility poles, which allows for aerial construction that is much less costly than underground construction. However, many existing utility poles either do not have sufficient space for attachment of new communications providers or have existing communications providers attached in an inefficient manner, requiring those attachments to be moved to accommodate the new provider.

Moving existing utilities as part of the "make-ready" process is costly and time-consuming, requiring weeks or months to coordinate providers and perform the move. Furthermore, the inefficient make-ready process has to be repeated each time a new entity wants to attach.

Localities may be able to improve the availability of broadband in their community by working with private pole owners to clear space and secure access for new builders of broadband.[26] Localities have relationships with the pole owners that frequently allow them some influence. Localities can use that influence on behalf of their broadband goals by encouraging pole owners to facilitate the process of the new broadband provider attaching to the poles.

Some broadband advocates believe that new network buildout can be eased through state or local requirements that new entrants be allowed to attach to privately owned poles.[27] Indeed, some cities require shared use of facilities in the localities' rights-of-way as a function of their authority to promote the health and welfare of citizens and their authority to adopt reasonable requirements for right-of-way occupants to minimize disruption and hazards.[28] From a technical standpoint, such shared

26 Pole owners control the timetable, cost, and procedures of attaching to their poles. In most American communities, the locality does not own the poles and has little or no control over those poles; rather, the poles are owned by electric utilities and telephone companies that do not answer to the locality.

27 The Fiber to the Home Council, for example, recently released a paper advocating that state and local governments "condition use of public rights-of-way to require incumbent users of this space to share their poles, ducts, and conduits on a non-discriminatory basis and at reasonable (cost-based) rates, terms, and conditions." Fiber to the Home Council, "State and Local Government Role in Facilitating Access to Poles, Ducts, and Conduits in Public Rights-of-Way," August 2013, http://goo.gl/zjnLFD. We are not qualified to comment on the legal basis for these requirements or the challenges localities may face from pole owners in attempting to enforce them—but we can affirm from experience that the technical benefits of such policies would be significant.

28 For example, Smyrna, Georgia requires users of its rights-of-way to share access to their poles, conduit, and related facilities. Smyrna, Ga., Code of Ordinances § 90-45. Superior, WI reserves the right to require joint use of poles or conduit. Superior, Wis., Code of Ordinances § 2-165(b). See Fiber to the Home Council, http://goo.gl/dZmT3K

access opportunities would assist both localities and their private partners in cost-effectively and quickly constructing new broadband facilities.

Pole attachment by a new broadband builder can be expedited if the pole owner:

1. Has a standard, predictable process for attachment
2. Commits to a schedule for each part of the process
3. Provides reasonable and consistent pricing for make-ready
4. Consolidates its own infrastructure on the poles and removes unused attachments
5. Requires existing attachers to consolidate attachments and remove unused attachments
6. Allows use of extension arms or overlash to increase capacity

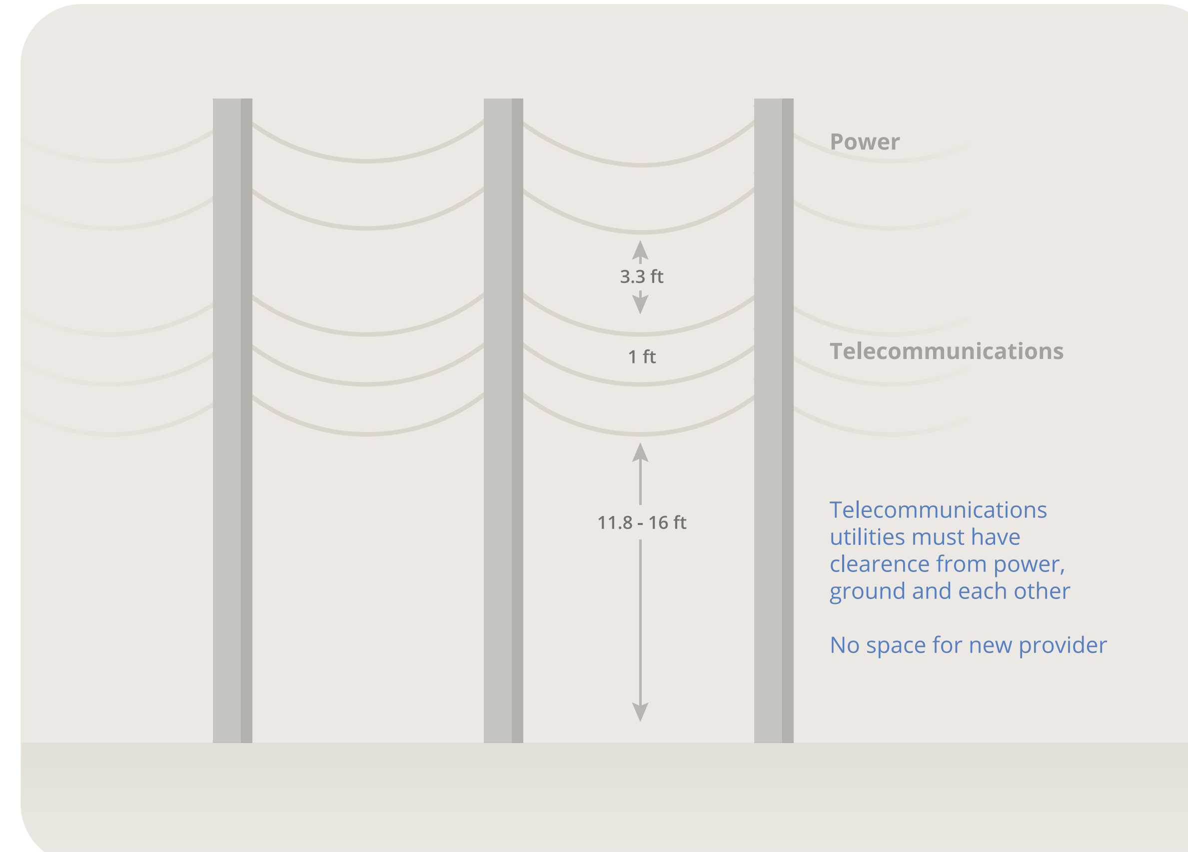
There exist considerable benefits to quick and efficient make-ready or easily available pole space. A service provider can enter a community and begin constructing its infrastructure in a matter of weeks instead of months. The provider can focus its construction purely on meeting customer need and demand, rather than being heavily biased toward areas of easier construction. It can also potentially double its speed of deployment, especially at the outset of construction. Finally, construction may cost on average $2 to $5 per foot, rather than $10 to $15 per foot.

Make-ready costs typically range from $100 to $1,000 per pole, and can increase to $25,000 or more in the event a pole replacement is necessary and all utilities have to be moved to the new pole. The following sections suggest strategies and best practices that can help to keep per pole costs in the low part of that range.

4.1 Facilitate make-ready to streamline pole access

"Make-ready" is an essential step in being able to attach new cables to existing poles. The term refers to the process of preparing utility poles for an additional utility in compliance with electrical code. In most cases, this means that existing utilities must be moved to accommodate a new entrant with the required clearance from electrical lines and the ground, and clearance between the communications utilities. If there is insufficient space to add a new attachment, a pole may need to be replaced, usually at the expense of the new entrant.[29] Figure 17 illustrates a pole with required clearances between power, telecommunications utilities, and the ground.

FIGURE 17: BASIC POLE DIAGRAM FOR MAKE-READY



The make-ready process typically starts with the entity seeking attachment (i.e., the new service provider) applying for and obtaining an agreement to attach to the poles, and meeting with the staff of the pole-owning utility. This establishes an understanding of the timeline, the process, the fees, and the likely speed at which the necessary work will be completed.

At the same general time, the new provider works on network design and routing. Sometimes, in early stages of network design, the provider may encounter "show-stopper" problems—these include exorbitant pricing for make-ready, a very slow or uncertain schedule, or, in the worst case, a refusal to allow attachment.

It is at this stage that local government intervention can be critical—because the problem is not technical, it is a matter of the pole owner's business decisions. Even though the locality is not typically a direct regulator of the pole owner, the relationship with the local government is usually important to the pole owner, and the locality can have significant influence—either directly or through the state (because regulation

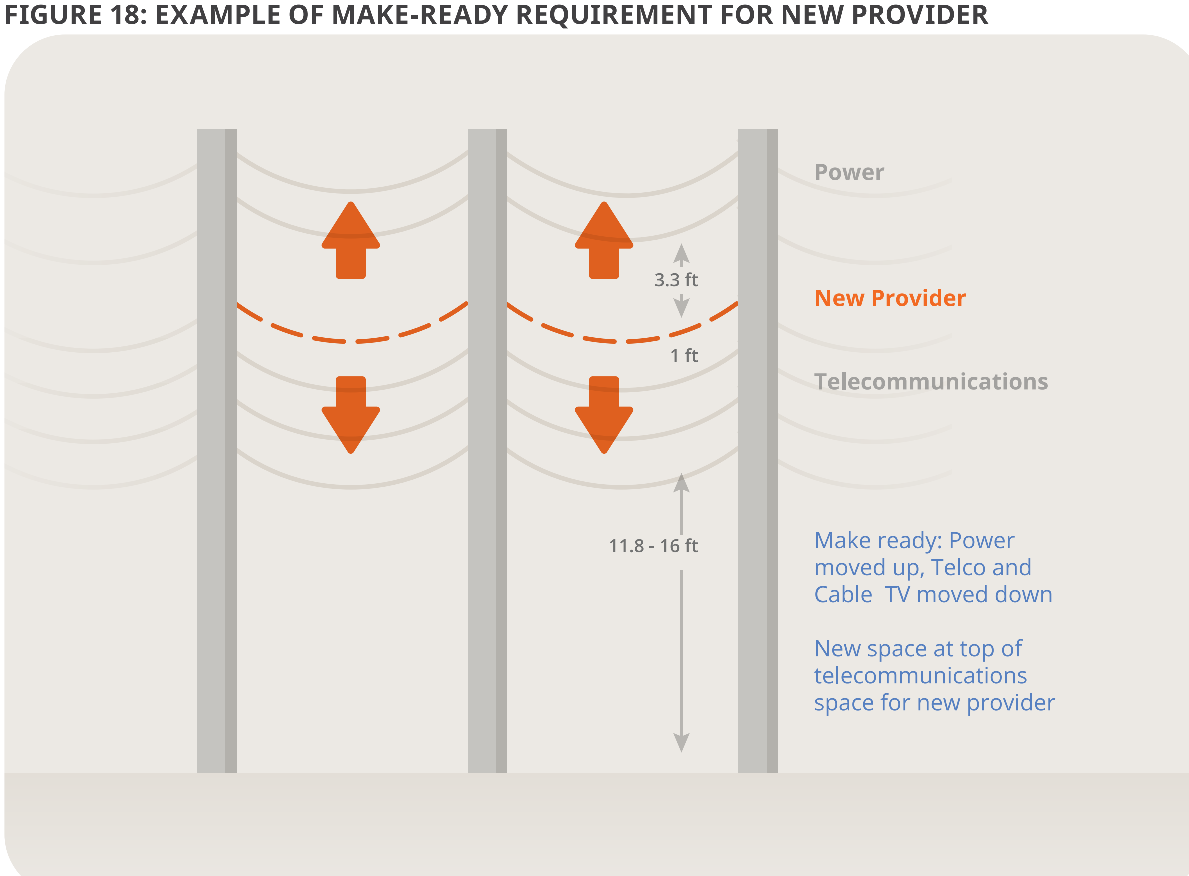
29 In some cases where the pole owner requires replacement of the entire pole, costs can be so excessive that the network deployer chooses to change the design to underground or reroute the fiber rather than pay for replacing the pole.

of the pole owner is often at the state level). Local influence may encourage the pole owner to work cooperatively with the new entity or may lead to a creative resolution of the problem—such as a strategy to share costs to augment the utility's staff in the event that the utility is burdened by the new entrant's needs.

Assuming the show-stopper problems are addressed, the new entrant then performs a survey of the poles. This process will differ in complexity depending on such local circumstances as the age of the poles, the density of the area, and other matters. To facilitate the process, new providers sometimes seek out an engineer who has worked with this utility—who knows both the formal and informal rules of the pole owner and the geographic area, and who has relationships with the appropriate individuals at the pole-owning entity. The locality can often help a new network entrant understand the unwritten customs and practices in the area and identify individuals who have been helpful in the past.

The engineer identifies the types of moves that need to happen on each pole. Figure 18 illustrates a typical set of moves required to make room for a new attachment.

FIGURE 18: EXAMPLE OF MAKE-READY REQUIREMENT FOR NEW PROVIDER



Make-ready timing is another hurdle for new entrants. While the make-ready process differs from community to community, it typically includes a multiparty walk-out of the route with representatives of all utilities on the poles. The walk-out may take weeks or months to schedule. Because some pole owners may not be incented to expedite a competitor's construction, the locality can encourage all parties to expedite their work, both for the walk-out and the moves. (Make-ready timing may be impacted by state or federal requirements and other terms of access, so these issues may be addressed if necessary through existing regulations.)

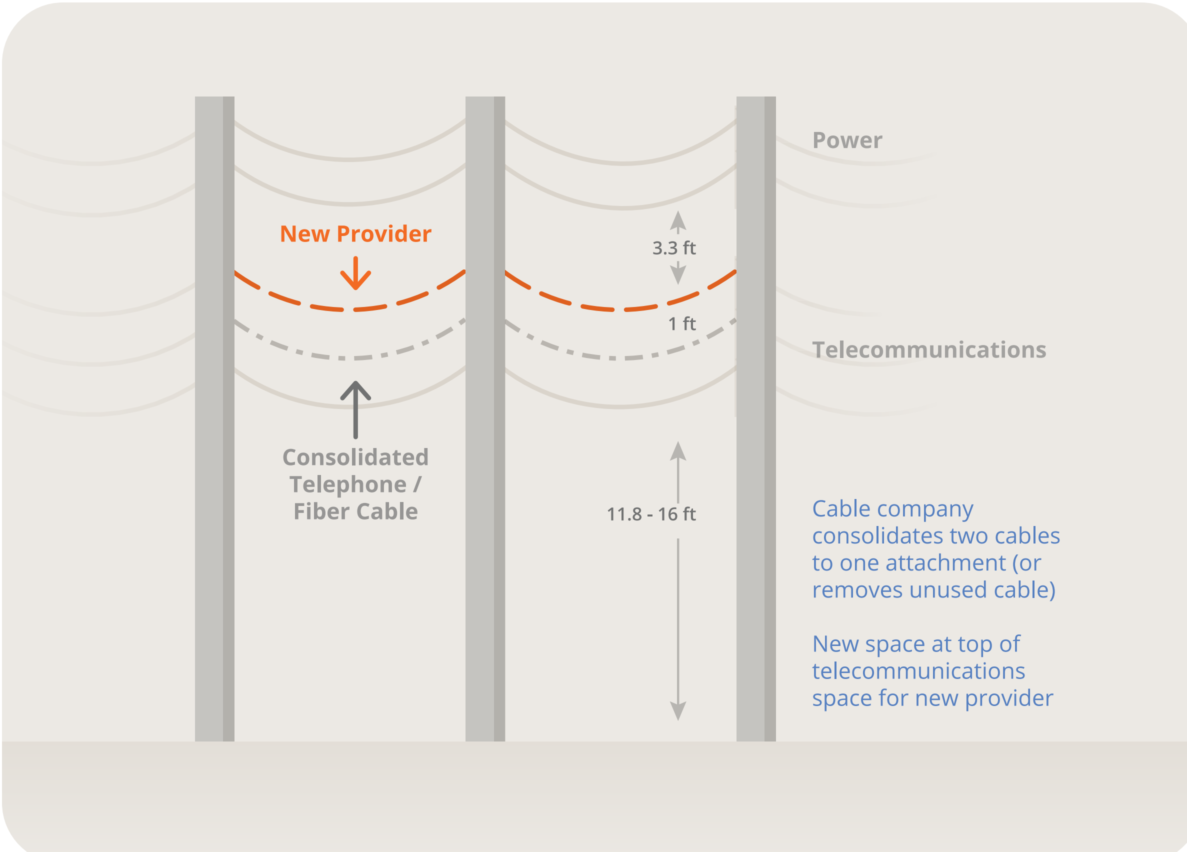
The actual make-ready work may also take weeks or months to complete. The individual attachers sometimes move their own facilities, or the pole owner can have a third party perform the work and pass the costs on to each attacher.

4.2 Eliminate the need for make-ready to speed pole access

Even more efficiency results if additional space is already available on the pole. There are a number of simple strategies that can enable this: first, "housekeeping" and consolidation of existing attachments to make space for new entrants; second, reservation of space for new entrants; third, allowing new attachers to use extension arms that create new room on the pole; and fourth, allowing and requiring "overlash" of new cables on existing attachments so as to efficiently use existing space.

First, pole owners can make space by undertaking "housekeeping" of its own infrastructure—for example, by consolidating power conductors, removing unused telephone cables, and consolidating telephone and fiber cables to the same attachment (see Figure 19). The pole owner can require other attachers to do the same or can create incentives for them to do so; for example, it can structure attachment fees to encourage efficient use of space and consolidation.

FIGURE 19: EXAMPLE OF MAKE-READY INVOLVING CABLE CONSOLIDATION



Second, pole owners can designate a space of at least 12 vertical inches, intended specifically for attachment by new service providers. If poles are full and space does not exist, this policy can be implemented when poles are replaced, or as part of regular maintenance. In many older neighborhoods, this will require the pole owner to install taller poles.

Twelve vertical inches is sufficient for one additional attachment. Each attachment can support two or three fiber optic cables, each of which can contain hundreds of fiber strands, enabling any sort of middle or last mile fiber network to enter the community.

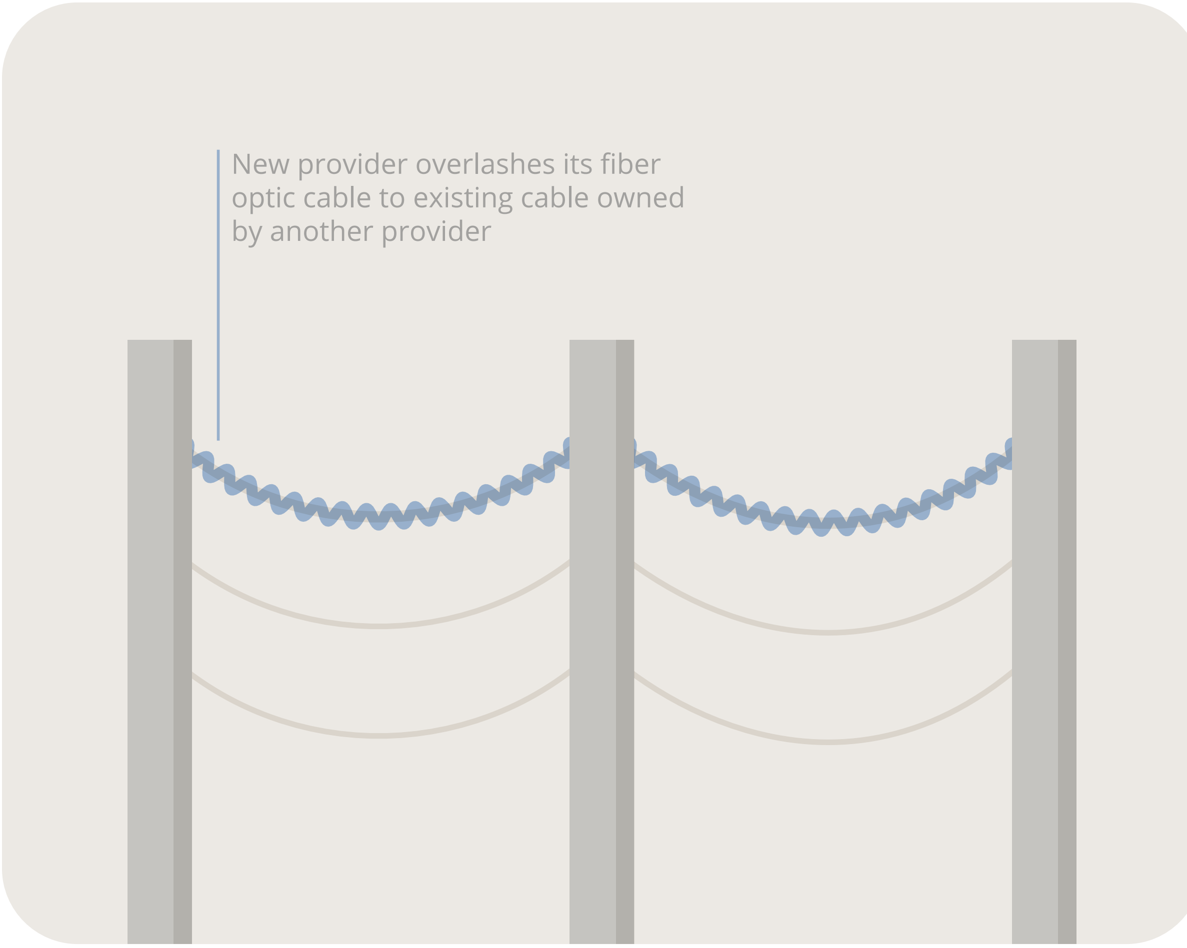
Third, new entrant construction can be greatly facilitated if pole owners allow use of extension arms to increase capacity in the communications space. Because the National Electrical Safety Code (NESC) requirements for clearance allow for horizontal as well as vertical clearance, one way to increase communications capacity on a utility pole is to install horizontal extension arms from the pole and install cables on the arm (see Figure 20). Extension arms are about 2 feet to 5 feet in length and are bolted to the utility pole. They are strong enough to support communications cables and are commonly used in congested environments. Not all pole owners allow extension arms despite their compliance with NESC requirements and their widespread successful use.

FIGURE 20: EXAMPLE OF EXTENSION ARM ON POLE, ENABLING HORIZONTAL EXPANSION OF CAPACITY

Fourth, make-ready can also be avoided if new providers are able to "overlash" their cables to existing cables on the utility poles (see Figure 21). Overlash is significantly less costly than creating a new attachment on the poles. It also does not typically require make-ready, so it entails significantly less time and coordination with the pole owner. Overlashing new cable to existing aerial strand costs on average about $15,000 to $60,000 per mile (materials and labor) depending on the fiber count. In comparison, new construction can cost as much as hundreds of thousands of dollars per mile depending on labor costs and the complexity of the build.[30]

30 Management of overlashing can be complex and the pole owners may not look favorably upon it. The integrity of the poles and the attached cables requires a clear model of responsibility for the attachment. These issues are, however, manageable and, in our experience, a number of models exist for this allocation of responsibility. In one model, which is most consistent with current attachment practices, the first provider to attach in this space is responsible to the pole owner for the attachment, including fees and compliance with loading, clearance rules, and maintenance; entities that overlash to the first cables are sub-lessors. In another model, a pro rata fee model is created in advance by the pole owner or the government managing the rights-of-way, and the overlashing entities coordinate their work and maintenance with the pole owner, or a joint pole authority.

FIGURE 21: NEW PROVIDER OVERLASHES NEW CABLE TO EXISTING CABLE



5 Asset Access Strategy 4: facilitate construction to and within buildings

Providing gigabit services to homes and businesses requires extension of high-speed networking to and within the premises. In apartment buildings and multi-tenant office buildings, this requires extension of fiber from the right-of-way to a central telecommunications distribution point, and from there to individual units. Lack of an affordable cable pathway from the right-of-way or to an apartment or office unit increases the cost of serving potential customers in a large building. Constructing a pathway during other construction or renovation can be done at a small percentage of the cost of retrofitting later to facilitate gigabit network deployment.

For these reasons, a government can improve services to its residents and businesses if it requires by code—or creates an incentive for developers to build—additional pathways from the public rights-of-way to a demarcation point in apartment and office buildings. Furthermore, it can require standards-compliant cabling or cable pathways inside new construction or major renovations to cost-effectively connect each unit.

5.1 Ensure the availability of conduit from the street to the building

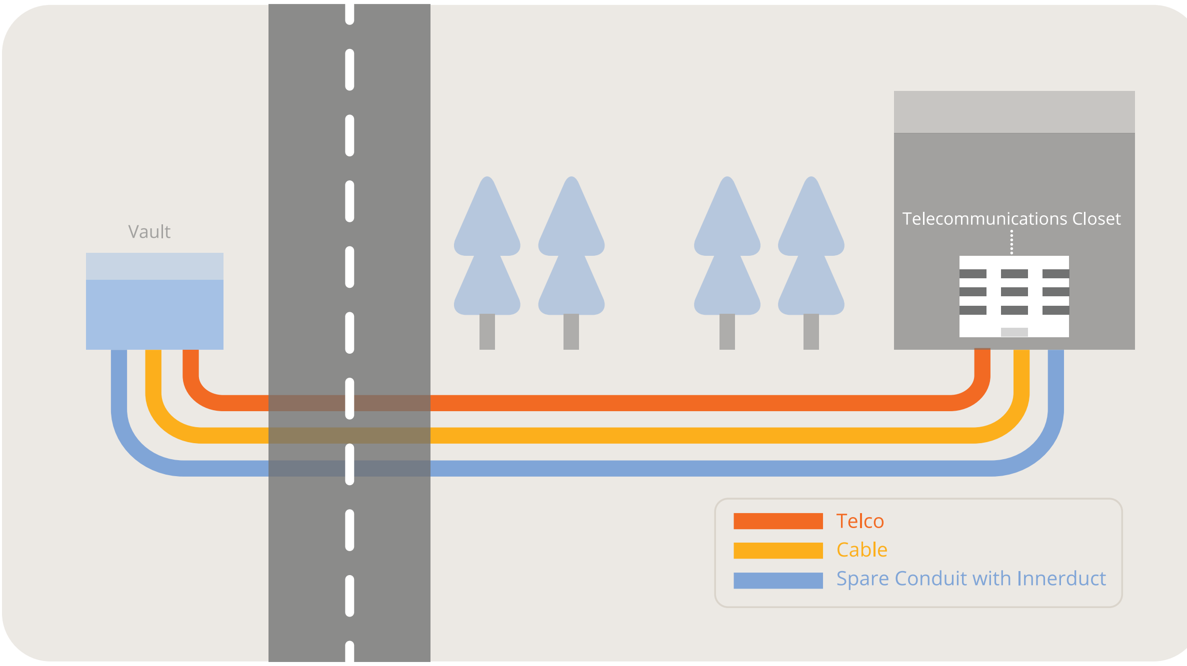
One significant barrier to entry for a new network provider is the physical entry into buildings. Ensuring the availability of spare conduit into buildings can reduce installation time, risk, and barriers to entry for new service providers.

Developers and builders are already accustomed to providing pathways for telephone, power, and cable TV from the property line to a room designated for utility services within the building. Typical practice for many developers is to coordinate with incumbent providers at the time of construction or renovation. The developer installs conduit from the room location to the exterior of the building, typically either encased in the slab or under floors, to and through the exterior wall. The developer then trenches conduit to the property line, where it is properly marked so that the utilities can determine which conduit is for their service. Traditionally, two 4-inch conduits are provided for the phone company, one 4-inch conduit for the cable company, and up to four 4-inch conduits for the electric utility.

The developer's incremental cost is minimal to add an additional 2-inch conduit for fiber optic cable in the same trench as the other utilities' conduit (see Figure 22). Adding a 200-foot path from a building's utility room to the property line would cost approximately \$2 per foot for labor and \$2 per foot for materials—or approximately

$1,000 in additional construction costs for the outside plant portion of installing conduit. To make the conduit even more valuable, an innerduct can be installed during construction to create cells for spare capacity.

FIGURE 22: EXAMPLE OF REQUIREMENT FOR DEVELOPERS TO INSTALL CONDUIT FROM PUBLIC RIGHT-OF-WAY TO BUILDING



In contrast, the cost for new construction of the same route can be $1,500 to $10,000 if a network provider needs to create a new entry path. The higher cost is realistic if the right-of-way is on the opposite side of a major road, if the provider needs to cross under a parking lot or driveway, and if restoration (both in the outdoors and the building) is sensitive and expensive.

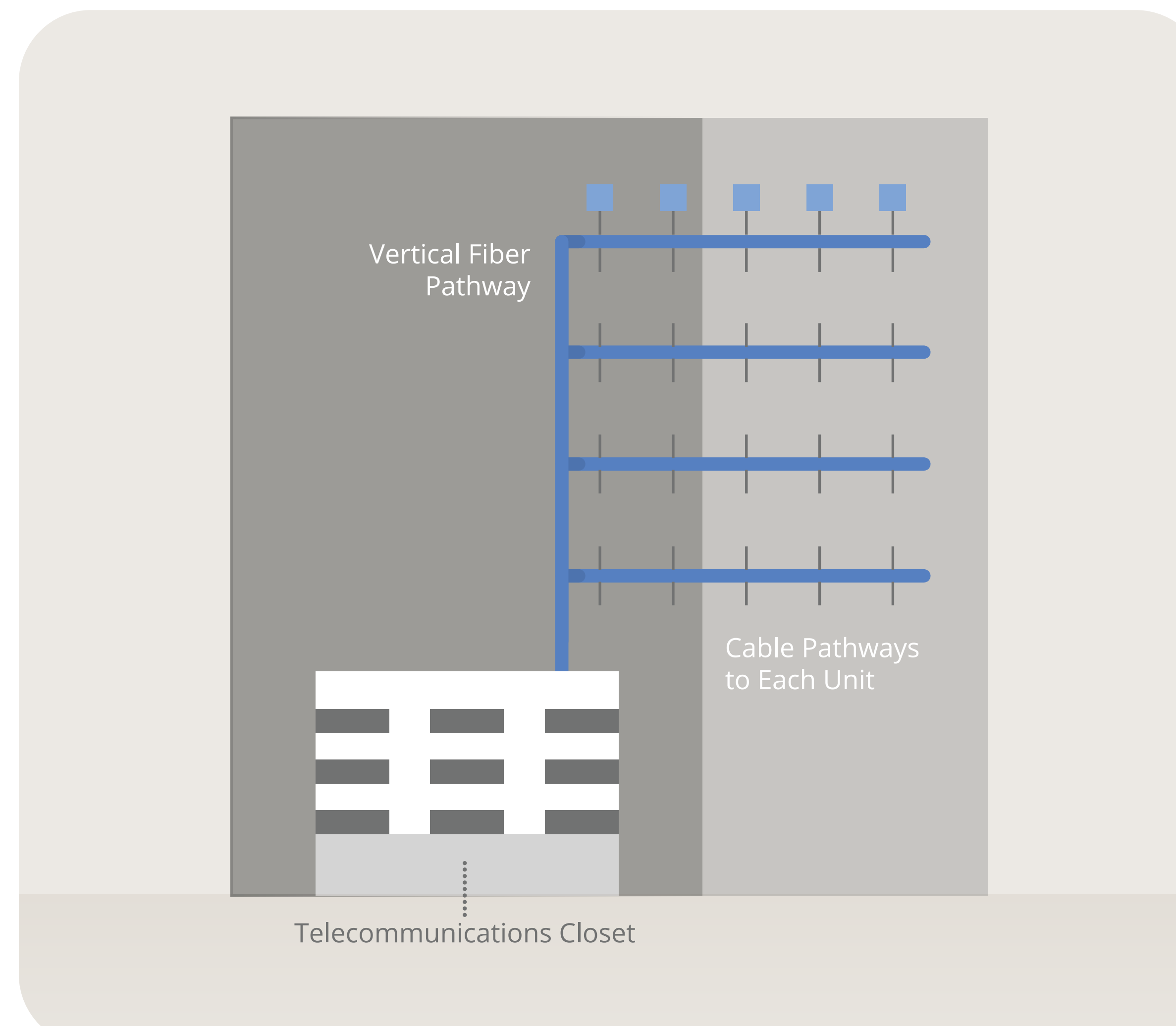
Constructing a new route into a building may also involve days or weeks of delay for permitting, engineering, design, utility location, and coordination with the building owner. These are delays that would be avoided if conduit already exists when a provider is ready to begin connecting customers.

5.2 Ensure the installation of in-building pathways and cabling

Indoor cabling is one of the largest costs and areas of uncertainty for a network service provider. This problem is especially pronounced in apartment buildings and office buildings, where the provider must cable long distances to reach individual customers.

A locality can reduce costs and speed deployment by requiring in its code that developers or building owners place cable pathways or standardized cabling as part of construction or renovations (see Figure 23). The pathways need to meet industry standards (TIA/ANSI) so that bend radius, distances, clearances, and locations of termination points are correct for the potential range of technologies that might be installed. Also, there should be secure telecommunications closets of appropriate size and number, based on the number of units and the distances between the units and risers.

FIGURE 23: EXAMPLE OF REQUIREMENT FOR DEVELOPERS TO INSTALL CABLE PATHWAYS TO APARTMENTS OR OFFICES



Indoor fiber optic cabling in an apartment building costs from $300 to $750 per unit, depending on the design of the building, the availability of false ceilings and cable pathways, the existence of wiring closets, and permission to attach moldings or other materials. The cost per unit can be reduced by half if there is sufficient capacity for the new fiber in the horizontal riser, and there is conduit, duct, or raceway from the riser to individual units. Pricing and challenges are similar in multi-tenant office buildings. For both apartments and offices, each building is different and requires new strategies.

Another strategy is to require developers or building owners to install fiber optic or other broadband cable as part of new construction or renovations. As with installing conduit, this strategy reduces costs by eliminating the need for a new provider to pull cables through a raceway or conduit—but it is better suited to communities where broadband providers are already connecting customers according to a specific standard (e.g., single-mode fiber pair to each unit). Given the diversity of potential service approaches (e.g., non-fiber technologies to the unit), installing fiber to every unit may lead to a significant stranded investment if no fiber provider serves the building, or if the service provider insists on using another type of cabling to the unit.

6 Information Access Strategy: publish data regarding available conduit, existing utilities, and other assets

By publishing data regarding their existing fiber, conduit, and other relevant assets, localities can enable providers to consider leasing public fiber and conduit as part of their network designs and business plans. Access to this information can both attract and speed new construction by private partners, while enabling the community to meet its goals for new, better broadband networks—and potentially to realize revenues for use of the assets.

6.1 Make GIS data sets available where possible

An organized government database of geographic information greatly increases efficiencies and reduces costs for the government itself and for the organizations with which it does business. Access to relevant data reduces the cost and time required to plan and build broadband infrastructure—whether by the locality itself, as part of a public–private partnership, or by a new provider entering the community.

Geographic Information Systems (GIS) are advanced mapping systems with high-resolution detail. GIS databases can be accessed for a range of purposes—many never considered by the creators of the system or the individuals who entered particular resource information (e.g., the location of streetlights or characteristics of private property in the locality).

While local data are not necessarily collected for the primary purpose of facilitating broadband construction, the following data sets can be extremely helpful in that regard:

- Addresses
- Streets
- Rights-of-way and easements
- Building footprints
- Streetlights
- Neighborhood boundaries
- Parcels
- Utility poles
- Overhead strand
- Conduit (both locality-owned and belonging to other utilities)

- Fiber (both locality-owned and belonging to other utilities)
- Manholes and handholes
- Zoning
- Existing underground utilities

With this information, it becomes easier, faster, and cheaper to conduct the high-level planning phase of a large-scale broadband construction project in which the prospective builder examines options and determines what assets are needed to plan and to build.

This kind of detailed information can enable a prospective broadband provider to plan efficiently in a range of areas. First, the provider can learn what resources exist (such as space in the rights-of-way space, manholes, poles, and conduits) that are usable and leasable for the project and who to contact about leasing those resources. Second, the provider can develop more accurate forecasts of construction costs and schedules and identify in advance areas of risk and critical path items, such as easement access and bridge crossings. Third, the builder can create a large percentage of the outside plant design from the existing information, reducing the time and effort needed for fieldwork.

Where this information is not tracked or centrally managed, it can be a considerable challenge for cash-strapped localities and heavily burdened GIS staff to add information and to seek the information. (We are cognizant of the costs of data collection and storage, and recognize that different communities collect different data sets based on their historical needs and capabilities.) One solution to that challenge is to require utility companies and developers to provide design and as-built information in a format compatible with the locality's mapping systems as new projects are proposed and completed, or to incorporate the cost of its entry into the permitting fee.

We note that incumbent broadband providers frequently are reluctant to add their data to such databases for business reasons. GIS systems enable the locality to protect particular layers of a map for internal use only, or limit access to authorized individuals and keep proprietary information from potential competitors.

6.2 Document your fiber assets

Public fiber's utility is frequently only as good as the documentation that enables the locality (or its private partners) to understand where and how it is built and maintained. Initiatives such as community fiber optic construction, utility improvements, and community development require high-quality documentation and GIS mapping as part of the initial and lifecycle budgets. For example, a public fiber network is a classic example of an asset that benefits from appropriate documentation from the outset, and loses reliability if it ages without that documentation.

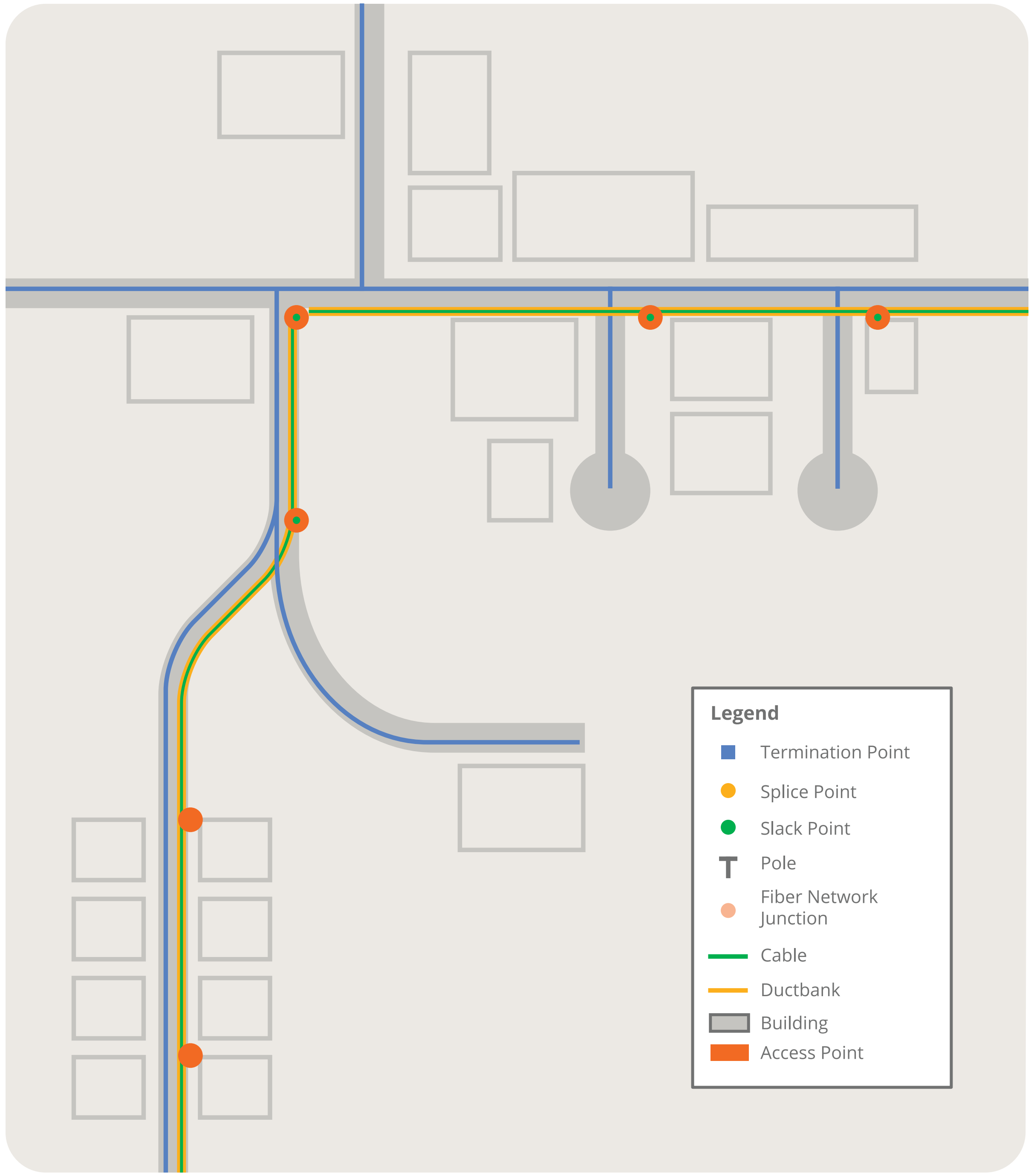
In our experience, community fiber is often documented on paper maps, in computer-aided-design (CAD) drawings, and with ad-hoc spreadsheets. At first, when there are only a few routes and no real complexity, these techniques appear to suffice. However, after a few changes, re-routings, and additions, the de facto documentation is only in the memories of the fiber team. The result may be re-work, fiber damage, accidental service outages, wasted time and money, and lack in confidence in the community's own infrastructure.

In our experience, lack of documentation has led some communities to doubt their own fiber assets to the point that they decline to use it for public safety purposes because of concerns regarding failure rate and reliability. These same communities decline to lease their fiber because of concerns that they could not meet contract terms for managing it or for uptime. And they sometimes find that their fiber counts are insufficient to meet their needs because lack of documentation has led to over-leasing or use of inefficient electronics.

In order to create value, the locality's fiber documentation should indicate where the fiber is, whether it is aerial or underground, and where it is located spatially on a pole or underground. The documentation should also include conduit color, fiber count, pole locations, and location of asset points.

Figure 24 illustrates a sample GIS map of a fiber route, including physical fiber placement, termination points, splice points, poles, duct banks, access points, and the endpoints of each strand of fiber. Even more detailed information can be generated within the GIS system, including the path of a single strand of fiber through the entire network. GIS systems also offer localities the ability to determine the optimal fiber assignment and splicing for a particular route, and the ability to quickly generate "what-if" scenarios for future planning.

FIGURE 24: COMPREHENSIVE GIS MAPPING OF FIBER ROUTE



6.3 Document your conduit assets

Underground fiber optic conduit is a valuable asset, particularly where construction is costly or difficult, such as urban areas, bridge crossings, rail crossings, and key building entries.

Many localities have conduit available as part of telecommunications, traffic, or other utility efforts. These range from mature, communitywide networks with consistent design and substantial capacity, to scattered conduit near traffic cabinets.

Well-documented conduit, like well-documented fiber, requires effort and consistency, and needs to be regularly updated. Conduit documentation should include the path, size, location (vertical and horizontal), access points, and design specifications (bends, availability of pull strings, composition).

While some communities may have a regularly maintained, reliable inventory of their conduit and a clear assessment of its usefulness and value, others, as with fiber, have only scattered documentation. Conduit information might be stored on paper maps or standalone CAD files of individual site plans or traffic intersections, or may be on separate permit applications (which may not be retained over time).

Moreover, the conduit itself might be crushed, blocked, full, or otherwise inaccessible. Conduit might have been given away, sold, traded, or simply taken by another utility. Also, conduit built for one purpose (twisted-pair copper, power) might not be suitable for broadband. In the case of conduit built for copper, the bend radius might not support fiber cables. In the case of conduit built for power, there may not be sufficient clearance from power lines to safely use for fiber.

Sufficient documentation can enable localities to track and understand these issues and plan accordingly.

7 Process Efficiency Strategy 1: build broadband into planning and staffing of all relevant agencies

Another strategy is to address organizational stovepipes within the locality—separations between information technology, permitting, engineering, and utility departments, for example—and again require that local infrastructure be documented as part of upgrade and improvement projects and regular maintenance.

As with fiber, the entities and agencies managing conduit may be separated from broadband and network planning agencies by internal reporting structures, and there may need to be leadership intervention for these entities to share and collaborate.

Localities should develop processes and structures that formalize the roles of department leadership in broadband planning, and ensure that any broadband opportunity is identified, receives proper review, and is acted upon promptly. Localities should establish durable reporting and accountability structures that do not rely on successful working relationships and ad-hoc communications of existing staff.

Processes and structures will work best if they are mandated by the community's legislative body, and the process is widely understood as a means of getting more for the locality as a whole. To that end, elected leaders and staff should be informed about progress or activity in broadband, which should create a positive feeling about the value of the process.

A strong coordination process has the following elements:

- A clear point of entry
- Applicability to small and large projects
- Review by expert individuals
- Consultation with all relevant departments
- Speed
- Accountability
- Transparency
- Support of local leaders

In our experience, a successful identification, review, and action plan may have the following elements:

1. Relevant broadband opportunities—such as new public facilities, new opportunities involving telecommunications available through grants, new applications that intensively use public networks, new services to be offered through the community networks (for example, substantial upgrades to GIS), and new construction projects and build opportunities in the locality—must be submitted as soon as possible to a central clearinghouse, such as a help desk. In the case of build opportunities, local government departments should inform the help desk as soon as they are aware of a service provider or developer. (Some construction projects considered "targets of opportunity," such as emergency repairs on utilities and co-location opportunities discovered close to the time of construction, must be acted on more quickly than others.)
2. The clearinghouse identifies items for technical review by a team representing the relevant departments (e.g., information technology, public safety, public works, facilities, transportation). Team members will be informed of the key facts, along with the urgency level of the review.
3. The clearinghouse identifies items for policy and legal review as needed and again forwards those to a team handling these issues.
4. On the due date of the review, the technical and policy/legal teams convene and present the review to project manager, who review the information, request supplementary information, and approve the completed analysis.
5. Project management submits the reviewed information to the appropriate decision-makers—the council, the manager, or department directors—for approval.

The end result of the process is a qualified technical review within a specified interval of time. There is accountability for the proposed initiative at each stage. The individuals who review the initiative provide written feedback, and decision-makers can see what was considered in the review and why.

8 Process Efficiency Strategy 2: streamline permitting and inspection where possible and provide transparency and predictability as to process and timelines

Every locality knows from experience that a government project in which certain processes are made as efficient and streamlined as possible can be more expeditiously initiated, executed, and concluded. For example, a technology project that requires services or equipment will to some degree turn on the efficiency of the procurement process. The same is true in a broadband project. And that is the case whether the entity building the broadband facilities is the locality itself or a private entity.

However, a locality, unlike a private sector partner, cannot focus its internal processes and efforts on one single end goal. While we agree with industry suggestions that streamlined government processes could facilitate broadband deployment, we also note that localities have to account for costs, implications, and other priorities that are not of interest to the broadband industry. Localities juggle a range of considerations, including that: (1) broadband projects can impact other areas of local responsibility, such as the need to manage rights-of-way so commerce and movement are not disrupted; (2) broadband process efficiency efforts will entail public costs, such as for hiring of new staff; and (3) other local interests and projects compete with broadband projects for localities' resources and attention.

In this context of understanding the totality of local needs and projects, all clamoring for the same resources, our experience suggests that there are strategies that localities can use to facilitate broadband projects without sacrificing the localities' ability to simultaneously attend to other projects and priorities.

First, whatever the processes are for addressing a broadband project, ranging from granting rights-of-way access to permitting to final inspection and approval, we recommend that these processes be formalized and well publicized to the industry. In our experience, full transparency about these processes is the single most effective means by which to enable the communications industry to expeditiously plan and deploy networks.

For example, whether your community commits to review permit applications within three days or 10 days or 20 days, that commitment should be publicized and then consistently met. Localities have limited resources—and sometime many different companies and industries can simultaneously require local permit review and other types of local support. Thus, local needs and resources will determine how long that process will take—while transparency about the amount of time, and a firm commitment to adhering to that timeframe, will meet the needs of the private sector broadband provider. The provider may wish for a faster process, but at a minimum it will have the benefit of a transparent and open process—with a predictable timeframe under which it can plan its project.

The need for transparency and communication is mutual: much as the locality should be open about its processes, the private deployer should do the same and should stage its buildout to maximize cooperation with the locality. Pre-construction conferences, for example, allow private providers and localities to understand and coordinate each other's plans and timelines. This kind of cooperative planning enables a willing provider to stage permit and inspection requests rather than filing for an overwhelming number of permits at one time.

Using this strategy, a number of large suburban districts in the Washington, D.C. metropolitan area have seen expeditious, non-acrimonious deployment of wireless broadband facilities that require local approval for siting under federal law. Montgomery County, Maryland, for example, has had extensive success encouraging deployment from the earliest cellular voice networks to the most recent 4G and small-cell technologies.

The county's success arises partly from a formal, efficient, structured process with clear requirements and timeframes, both for the private sector entity seeking to site facilities and for the county's own oversight process. The transparency and predictability have enabled a win-win outcome, in which both parties understand their relative obligations, the steps necessary for progress, and the timeframe. Montgomery County residents and businesses benefit from buildout of multiple state-of-the-art wireless broadband networks in a quick and efficient way—while their interests and ability to participate in the process have been protected through the process established by the county.

9 Process Efficiency Strategy 3: consider allowing providers to contract pre-approved third-party inspectors to speed processes and reduce local burdens

Unfortunately, attempts to streamline local processes frequently conflict with the need for resources to enable the processes—particularly for massive short-term projects such as a broadband network deployment. The need to issue thousands of permits and assess thousands of job sites in a very short timeframe challenge localities without sufficient staff to support such enormous short-term efforts. Also, it is not financially feasible for localities to maintain sufficient staff for such intensive short-term efforts, because those staff members will have little or nothing to do during the interim periods when large projects are not underway.

This significant public sector challenge poses a problem for both the locality and the private broadband provider, both needing deployment to proceed as quickly and efficiently as possible. One potential solution, in our experience, is for the locality to find means by which local processes are respected but the broadband provider can use its own resources to supplement public sector staff.

For example, a locality can undertake a procurement process in which it prequalifies contractors with the experience and the independence to serve as third-party inspectors of new broadband facilities. Through the preclearance process, the locality qualifies companies that can be contracted by a broadband provider to supplement the locality's own inspection staff. The locality's own staff can check a sample of the contractor's inspection work and verify its quality and validity—to ensure that the contractors remain independent and meet the locality's needs, even as the contractor is hired and paid by the provider. Any contractor whose inspections do not meet the locality's standards can be removed from the list of approved vendors—a penalty that incents the vendor to work appropriately and enables the locality to maintain quality control and quality assurance.

This mechanism was used effectively, in our experience, during the large cable upgrades of the late 1990s. Some local governments allowed cable operators to pay third parties (either directly or by reimbursing the locality) to independently verify compliance with design and construction standards, thus enabling fast approval of the operator's design and construction even where the locality did not have the necessary internal resources.

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Andrew has planned and overseen the implementation of superregional and statewide networks for public safety, government, health care, and education. Among other large projects, he designed NCRnet, the multi-state public safety fiber architecture in the National Capital Region. He also developed the reference architecture for the New Zealand national fiber-to-the-home project and served as a senior technical adviser to Crown Fibre Holdings, the public entity directing that initiative.

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Broadband Strategies Checklist

Access to Key Assets

- ✓ **Lease public assets such as fiber, conduit, and real estate**
  - Lease middle-mile fiber
  - Lease fiber in hard-to-reach areas
  - Increase existing fiber capacity if insufficient fiber exists
- ✓ **Facilitate underground construction**
  - Develop a "dig-once" policy
  - Maintain future-proof conduit specifications
  - Enable all parties to take advantage of "dig-once"
  - Place conduit banks in congested areas
- ✓ **Facilitate aerial construction through access to utility poles**
  - Facilitate make-ready process to streamline pole access
  - Eliminate the need for make-ready
- ✓ **Facilitate in-building access for wireline infrastructure**
  - Ensure availability of conduit from street to building
  - Ensure installation of in-building pathways and cabling

Information Access

- ✓ **Make data available wherever possible**
  - Make GIS data sets available
- ✓ **Document and publish data regarding available conduit, fiber, and other assets**
  - Document your fiber assets
  - Document your conduit assets

Process Efficiency

- ✓ **Build broadband into planning and staffing of all relevant agencies**
- ✓ **Streamline and publicize procedures and timeframes for permitting and inspections**
- ✓ **Allow network operators to contract pre-approved third-party inspectors to speed processes and reduce local burdens**