Before the
FEDERAL COMMUNICATIONS COMMISSION
Washington, D.C. 20554

Comments NBP Public Notice # 12 Cost Estimates for Connecting Anchor Institutions to Fiber	GN Docket Nos. 09-47 09-51 09-137

COMMENTS OF THE
NATIONAL ASSOCIATION OF TELECOMMUNICATIONS OFFICERS AND ADVISORS ("NATOA")

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NATIONAL ASSOCIATION OF TELECOMMUNICATIONS
OFFICERS AND ADVISORS

The National Association of Telecommunications Officers and Advisors ("NATOA") hereby files these comments in response to NPB Public Notice # 12.

NATOA's membership includes local government officials and staff members from across the nation whose responsibility is to develop and administer cable franchising and telecommunications policy for the nation's local governments. Many NATOA member jurisdictions have been operating fiber optic communications networks to and among anchor institutions (including government, education, libraries, and public safety) for a decade or more.

NATOA strongly believes that connecting anchor institutions, such as schools, libraries, hospitals, and community colleges, to fiber optics is essential to the success of a National Broadband Plan. Therefore, NATOA supports the efforts of the Federal Communications Commission ("Commission") to investigate the cost of connecting anchor institutions to fiber in developing the National Broadband Plan.

NATOA believes that the FCC will find that anchor institution networks, which join health, education, public safety, and governmental buildings are critical to the expansion of broadband services to the unserved and underserved. These networks are uniquely positioned to give the communities they serve the full benefit of the externalities of broadband services. This is achieved at prices and levels of capacity that are not available from traditional commercial broadband providers in the same communities.

In an ex parte meeting on September 16, 2009, with the Commission's Broadband Task Force on the importance of anchor institution networks, NATOA provided a study conducted by Dr. Andrew Afflerbach of Columbia Telecommunications Corporation (CTC) for the Schools, Health, and Libraries Coalition, titled "Cost estimate for building fiber optics to key anchor institutions." That study concluded that the average, per-site construction cost of connecting anchor institutions to fiber would be $50,000. To keep this cost low, the study recommended (1) maximizing economies of scale; (2) flexibility in choosing technical solutions; and, (3) the coordination of network intelligence with the needs of users. To illustrate these conclusions, the study provided case studies of large urban areas and small cities. The study is attached as Exhibit 1.

In a second ex parte meeting on October 16, 2009, NATOA presented a series of case studies illustrating the costs, benefits, and catalytic elements that allow Anchor Institution networks to develop and expand. That ex parte presentation and related case studies are attached as Exhibit 2.

In addition NATOA is submitting a further illustrative case study on anchor institution costs, Exhibit 3. The study was just completed by Dr. Andrew Afflerbach of CTC for NATOA and examines the cost of extending underground fiber (including the

cost of electronics to operate the fiber and offer services) to anchor institutions in Prince George's County, Maryland in the suburban Washington, DC region. The study presents the detailed costs associated with expanding the existing governmental anchor institution network in that jurisdiction to nine community anchor institutions including schools, libraries, fire stations, and government buildings.

The study concludes that the total cost to complete the project would be approximately $1,205,980. This amount equals a per-site construction cost of approximately $134,000. This amount is right in the middle of the cost per-site that was estimated by the Bill and Melinda Gates Foundation in their September 25, 2009 report.[1]

Based on our analysis of the Gates Foundation study and on the case studies we have conducted, we believe that the Gates Foundation study is accurate and helpful. We believe that the attached materials go even further to provide detailed analysis of the costs of installing fiber to all anchor institutions in specific communities, including providing critically important information on the details and price of electronics.

Taken together, these materials illustrate the reasonableness of fiber construction and deployment costs that can be achieved to serve anchor institutions. These anchor networks are essential within their communities and NATOA recommends that enabling non-profit and government networks of this sort should be a core recommendation in the FCC's Broadband Plan. As an additional benefit, the extension of bigger broadband pipes deep into our communities can also be achieved in a manner that "last mile" consumer broadband services can be supported. NATOA believes the evidence shows

[1] See "Preliminary Cost Estimates on Connecting Anchor Institutions to Fiber," Bill and Melinda Gates Foundation (September 25, 2009).

anchor institution networks are the catalyst for the deployment of last mile broadband services, especially in unserved and underserved areas.

NATOA plans to file a comprehensive filing in response to the Commission's request for information on "The Contribution of Federal, State, Tribal, and Local Government to Broadband" (NBP Public Notice #7) by November 6, 2009. In that filing, we plan to provide our complete recommendation for the National Broadband Plan and will discuss how the connection of anchor institutions through municipal fiber networks has led to successful broadband deployment in many communities across the country.

Respectfully submitted,

The National Association of Telecommunications Officers and Advisors

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EXHIBIT 1

“Cost Estimate for Building Fiber Optics to Key Anchor Institutions”

Brief Engineering Assessment: Cost estimate for building fiber optics to key anchor institutions

Prepared for the Schools, Health, and Libraries Coalition
September 2009

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1. Introduction

The following is a brief engineering assessment of the cost of building fiber optics to America's key anchor institutions: schools, health care facilities, and libraries.

The cost and completion time of large-scale fiber optic deployments depend on a wide range of factors, including overall program management, access to the public right-of-way, the quality and quantity of available labor, coordination between the builder and the entities being connected, supply of materials, and the integration of the physical and electronic portions. Successfully operating a fiber network also requires effective governance, a business model, and qualified entities performing maintenance, moves, adds, and changes.

Good planning practices can reduce the risk inherent in large-scale infrastructure projects and help the project owners complete the project cost-effectively and in a way that best suits the people to be connected and served. This document 1) outlines strategies for network deployment, 2) briefly illustrates key cost factors, and 3) provides case studies and approximate deployment costs.

2. Network Costs

Averaged over a large sample size, it is probably suitable to estimate $50,000 as a national goal for per-site construction cost of large networks serving community anchors such as schools, libraries, and government facilities. As this report suggests, the designers of the network should seek opportunities to take advantage of existing fiber and other infrastructure.

However, this cost would be limited to areas where sufficient density (i.e., sites per fiber mile) exists—*urban, suburban, or small town areas where two or more sites, on average, can be reached per mile of fiber.* It would also assume the existence of a national or regional backbone to interconnect the various resulting fiber "islands" (many of which are not currently fiber-connected by any carrier) to provide true fiber speed universally.

Finally, this cost is for a minimum level of "transport-only" networking. In order for a new community anchor network to provide added value over incumbent networks, it is worth analyzing the level of redundancy, network management, and other value-added features that community anchor users require. Depending on the level of network intelligence required, the additional cost may average an additional $25,000 to $50,000 per site.

3. Strategies to Control Construction Costs

A number of strategies have been found to effectively reduce the cost of a network deployment and increase the likelihood of success:

1) Maximize economies of scale
2) Be flexible in choosing specific technical solutions
3) Coordinate network intelligence with users' needs

Maximize Economies of Scale

Constructing a network requires coordinating many moving parts—everything from determining the needs and vision, creating a design, and acquiring funds, to facilitating procurement, selecting contractors, obtaining right-of-way access, preparing the right-of-way, obtaining permits, performing construction, performing restoration, overseeing the work, testing the network, and activating users.

Constructing fiber also requires coordination with entities that are indifferent to or opposed to the network—for example, incumbent telecommunication companies, power providers, and utility companies that control utility poles and conduit and are potential competitors. Those companies may require a new network provider to pay—not only to create space for its fiber optics, but to optimally relocate other utilities on the poles or create other "improvements" in a process known as "make-ready," which may lead to high cost and delay.

Construction may also require negotiation of franchise, right-of-way, pole attachment, and building-entry agreements—in our experience, most local governments that control many of these areas are highly motivated to facilitate the entry of new broadband providers into their communities.

Although the number of separate facets and issues definitely grows with the size of the network, they tend not to grow more than linearly with the number of sites and entities. Therefore, the larger the network implementation and the larger the user base, the less complexity there is per user—and the more optimal is the use of resources.

It is also significant that a larger "player" in the right-of-way tends to have more leverage over other entities in the right-of-way, such as other utilities, regulators, and building owners. Therefore a project that serves an entire city or region, with powerful stakeholders in government, may be better able to move roadblocks than one that will serve only a few buildings or one type of user. For example, a larger entity may be able to have a skilled and experienced group of government professionals dedicated to "expediting."

In addition to the political advantages of being a larger entity, most network construction projects have shown economies of scale for most aspects of planning, buying, and building networks (see below—Cost Factors). From a merely logistical perspective, the

program manager of a large-scale project can reassign workers to other tasks if there are unexpected impediments in a particular area. In a smaller-scale project, the workers may need to stand idle, or the plan redesigned.

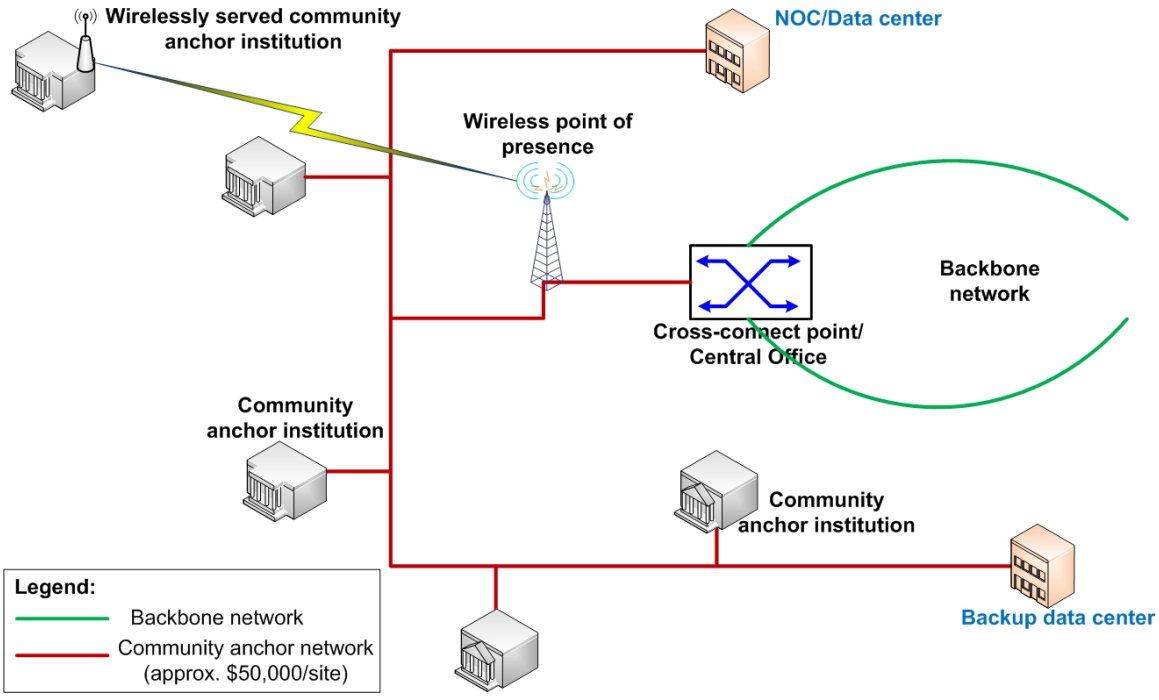
Be Flexible in Choosing Specific Technical Solutions

In almost any fiber optic construction project, there are "outlier" locations that cost significantly more than others or create exceptional risk of delay or other uncertainties. This can be because of distance, anomalous construction circumstances (obstructions, road or rail crossings, historical area, or other conflicting construction), or uncooperative building owners.

Because of these outliers, it is not unusual, in the first stage of a fiber project, to have 50 percent of the proposed construction cost assigned to serve the most costly 10 percent of the locations. It would be more beneficial to the project to cost-effectively and expeditiously serve the first 90 percent of locations, however, and serve the costly 10 percent in a second phase.

One solution is to have a "Plan B," such as a wireless system or a virtual private network, to accommodate those difficult locations, at least for a temporary period (Figure 1). Depending on the location of the locations to be served, adding a construction "Plan B" can reduce the construction cost of a network first phase by 50 percent and significantly reduce the risk of delay. It may also be possible that the extra time could be used to find other users or partners that would make fiber construction more cost effective, on a per-user basis, to the outlier locations.

Figure 1 – Community Anchor Network



Coordinate Network Intelligence with Users' Needs

Networks are growing in the features and flexibility they offer, and a cost estimate and design should incorporate the appropriate level of features and "smartness." Owning and operating the physical network and electronics, end-to-end, gives the operator wide latitude, including the ability to dedicate levels of physical and electronic redundancy to sites, have complete knowledge of the degree of network security, determine where and how to connect to the Internet and other outside networks, manage intrusion detection, and determine how quickly service will be restored if fiber is cut or other problems emerge. It also enables the operator to determine what service and capacity levels to offer and perform its own upgrades on network architecture and electronics.

Some networks operate multiple networks within each network—offering public safety grade, medical/HIPAA grade, private network, and public network security over the same physical platform. The type of service can be assigned at the port or user interface at the site. Some network operators are also combining their services with other value-added services customized to the user group, including data and server mirroring across a metropolitan area or national network, hosted virtual presence or video conferencing, turnkey telecommuting and telemedicine, national Intranet access, direct access to state and federal networks, and peering with service providers. Other networks are firmly limited to "transport only," providing only a "pipe" and perhaps Internet access, with the users responsible for any other needed features.

When the network designer and operator understand the unique needs of their users and customers, the network design can incorporate particular features, such as data centers, ring topology, options for very high capacity links, and network segmentation. When these needs are known up-front, the network operator can incorporate those features and a reasonable upgrade path, yet not require costly over-engineering. The network operator can also consider the needs of its users in subsequent generations of network electronics upgrades and reconfiguration.

The network designer must include the cost of the added network intelligence, beyond mere transport. Depending on the degree of need and architecture, the additional cost of the intelligence can be 25 percent to 100 percent beyond the cost of the construction and site electronics.

3. Cost Factors

Any planner or designer with years of experience in fiber optic projects will report a wide range of unit costs for construction. However, understanding some general factors will help understand and anticipate these costs.

Labor

Labor forms the majority of the cost of construction—approximately 50 to 80 percent. Therefore the quantity of fiber strands and cables, a materials cost, is typically a secondary consideration.

Labor costs are highly variable. Affluent areas have significantly higher labor costs in all categories, for example. And while poor economic conditions may lead construction companies to reduce their fees,[1] the companies may increase their bid rates if there is suddenly high demand for immediate construction. In general, large-scale ventures have an advantage in managing costs, because construction companies feel comfortable offering lower rates when they expect to profit from the volume and duration of a project.

Mobilization of Contractors

There is considerable time and expense in beginning construction work. Even with a completed design, the network builder must develop detailed specifications, find a potential pool of contractors, issue bid documents, review bids, select contractors, order materials, and prepare the right-of-way. The network builder will also need to go through its procurement process and legal reviews. The added expense is usually borne by the entity managing the network build—directly through the staff and engineering time, and indirectly through costs built into the rates of the building contractor.

Therefore, to the extent that it can have a single start and be managed through a single entity, a network project can minimize the time and expense spent on mobilization.

Aerial Versus Underground

Typical construction is a mixture of aerial and underground techniques, in part because aerial construction also is more vulnerable to extreme weather, particularly in wooded areas and areas with frequent ice and high winds.

In many cases, a network can be built more cheaply using aerial utility poles. This is particularly true when the poles are not crowded, and when the network builder has ownership of the utility poles (construction by power and utility companies). Best case, aerial construction can be completed for $25,000 per mile. Aerial construction may be more expensive when poles are crowded or when the utility pole owner charges high rates for access. Worst-case costs can be $100,000 per mile (which usually would lead a network owner to build underground or over another route).

Underground construction also has a wide cost range. In areas where restoration is not important and long continuous runs are possible (e.g., rural areas, in dirt, on the side of interstate roads), "plowing" the fiber into the ground is an inexpensive option—approximately $70,000 per mile. In more built-up areas, directional boring is necessary, because it is less destructive to the right-of-way and requires less restoration. Boring is more expensive, approximately $90,000 to $400,000 per mile. Boring also limits the amount of cable and conduit that can be built. (Two 2-inch conduit is a typical limit, corresponding to four medium-sized fiber optic cables.)

[1] "Strategies to Control Construction Costs: More Bang for the Stimulus Buck as Firms Clamber for Contracts," Eric M. Weiss, the Washington Post, April 8, 2009, http://www.washingtonpost.com/wp-dyn/content/article/2009/04/07/AR2009040703828.html, accessed September 13, 2009.

Density of Sites

As noted above, unit construction costs are per mile, not per site. A high density of sites enables more sites to be reached per mile of construction. Again referring to economies of scale, if more participants can connect to a given mile of fiber, the per-site cost of a network falls substantially.

Ability to Use Existing Infrastructure

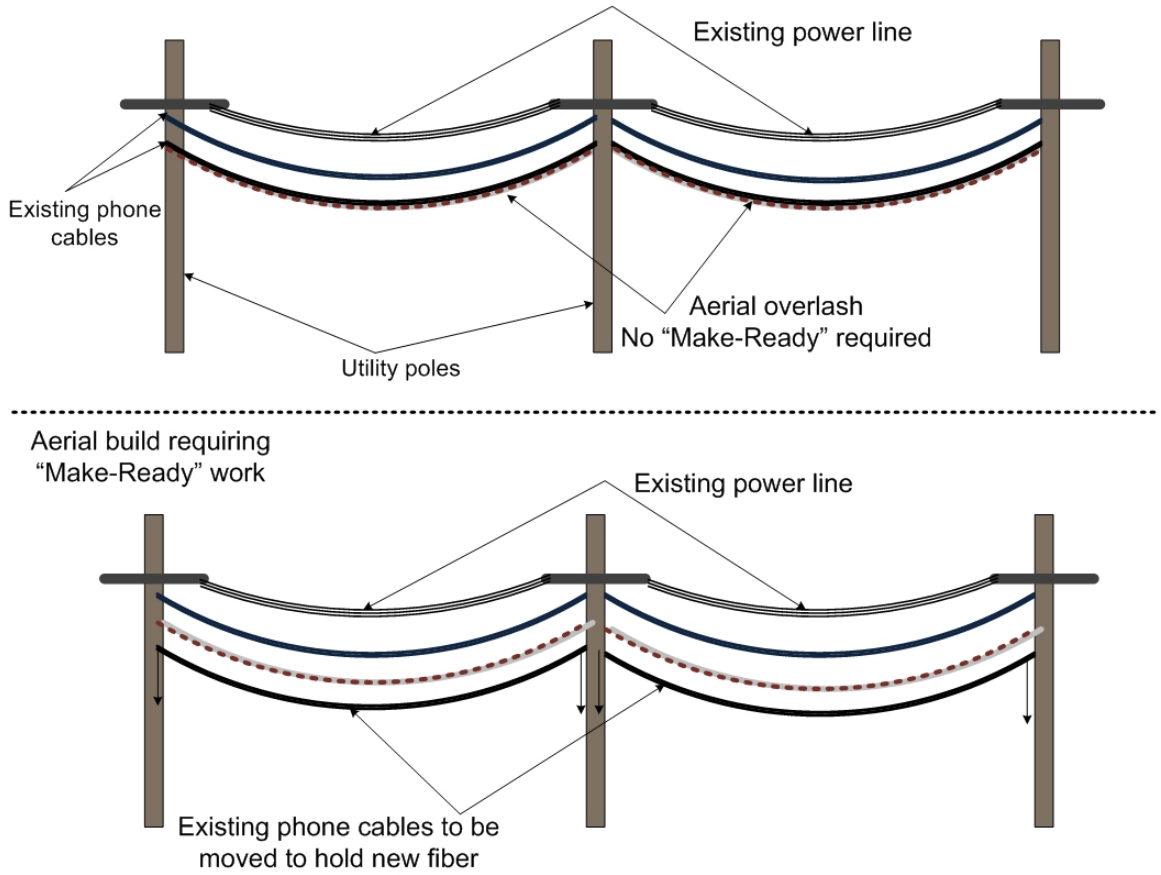
Where it is available, using existing cable infrastructure and pathways offers a range of benefits. There are a number of options for using existing cable infrastructure.

Some communications providers have excess fiber strands. Fiber count in cables ranges from 6 to 24 near residences and individual businesses to more than 1,000 on backbone routes. The cost of a 6-count fiber cable is $2,000 per mile, while an 864-count cable is $50,000 per mile, implying a marginal cost of approximately $50 per fiber per mile. Actual costs for fiber purchase or lease, of course, reflect market costs and depend on the total availability of fiber over the route–and are thus, typically, considerably higher; however, fiber lease or purchase may be a serious consideration over routes where construction is difficult or costly and considerable fiber has already been installed (e.g., river crossings, tunnels).

Utility pole attachments can be loaded with multiple fiber cables in a process called overlash. Overlashing enables a network provider to attach to utility poles without taking up more space (Figure 2). Overlashing requires the permission of the entity being attached and is limited to the loading capacity of the attachment. Some communities have the right of attachment to cable company cables on poles as part of the cable franchise agreement.

Using overlash eliminates make-ready costs and reduces construction costs to approximately $13,000 to $20,000 per mile.

Figure 2 – Overlash Construction Reduces Cost and Utilization of Utility Poles



Some entities (utilities, service providers, governments) have conduit available for purchase, lease, or trade. Pulling cables through available conduit costs $20,000 to $50,000 per mile, instead of $90,000 to $400,000 for new construction.

Redundancy and Survivability Needed

The specific requirements of the network (e.g., public safety grade, mission criticality, cost of outages) will determine the physical and electronic architecture of the network. For availability above 99 percent (fewer than eight hours of downtime per year), a building will generally need two redundant physical paths from the network to its location, along with an electronic infrastructure to accommodate failure of a fiber route or an electronic component, and backup power of sufficient duration. The network will also need to provide a 24-hour network operations center, a fiber repair crew, intrusion detection, and backup management and recovery facilities.

If network users do not require this level of availability, the network operator should determine their actual current and future requirements, and which subset of survivability and redundancy tools are needed.

Ideally, any needs for physical redundancy will be included in the initial project design. In a network designed with redundancy in mind, each portion of the network is constructed as part of a ring and economical construction is possible. In our urban case study (Section 4), the fiber cost for each site is approximately $23,000, including ring fiber construction.

On the other hand, when redundancy is constructed after the fact, it requires a custom cable pathway, usually doubling (or more) the construction cost.

4. Case Studies

Urban Case Study

One urban community designed and constructed a fiber optic network to reach community anchor and government facilities. It has the following characteristics:

- designed for public safety grade, with almost all fiber in rings;
- the right to overlash fiber to other aerial fiber optic cable in the right of way and to use existing telephone conduit, where it is available
- a citywide footprint, with no location more than ½ mile from existing fiber
- 24x7 network operations center
- On-call fiber repair staff
- In-house engineering and design
- 250 locations connected
- Typical construction costs of $8 per foot aerial and $12 per foot underground
- Individual users segmented into separate virtual private networks
- Available speeds per user from 2 Mbps to 1 Gbps
- Point-to-point services available if fiber is not cost-effective

When the community sought to expand to 220 additional community anchor sites and establish new sub-networks for secure public health and government applications, the city designed additional fiber and rings and planned to enhance its NOC. The cost to expand was estimated at $5,300,000 for the fiber optic cable (providing redundant rings to almost all users), $4,500,000 for network electronics at the new community anchor sites, and $4,900,000 for new core electronics, new network management systems and network intelligence.

On a per-site basis, the average cost for fiber was $24,000, the site electronics was $20,500, and the core electronics, management systems, and network intelligence was $22,300, for a total of approximately $67,000 per added community anchor site.

Small City Case Study

A representative small city constructed a network with:

- Fiber optic ring to key locations, single path to others
- Construction and operation by municipal power utility, which owns all utility poles and has existing underground conduit for most underground routes
- 73 mile of fiber and 84 sites
- Hub buildings inside power substations
- Services from 100 Mbps to 1 Gbps per site
- Repair and maintenance by city

The cost for fiber optic construction was $26,000 per mile for aerial, $173,000 per mile for underground, and $2,208,000 total. The cost of network electronics was approximately $1,000,000.

The average fiber cost per site was $26,300, $38,200 including electronics.

EXHIBIT 2

"Government Fiber Networks Enable Efficiencies and Dramatic Public and Private Cost Savings"

Government Fiber Networks Enable Efficiencies and Dramatic Public and Private Cost Savings

- **Local Government Participants**
  - **Mary Beth Henry, City of Portland and NATOA Board of Directors**
  - **Tony Perez, City of Seattle and NATOA Board of Directors**
  - **Joanne Hovis, NATOA President-Elect**
  - **Nick Miller, Miller & Van Eaton, PLLC**
  - **Jim Baller, The Baller Herbst Law Group**
  - **Mark Ansboury, CTO, OneCommunity**

- **Overview**
  - **Issue Definition**
  - **Key Characteristics**
  - **Case Studies**
  - **Common Characteristics**
  - **Lessons Learned**

  Issue: impact of government anchor/institution networks
  - **On second and middle mile deployment**
  - **On last mile deployment**

- **Key Characteristics—These Networks Capture the Externalities of Broadband**
  - **Cost and price savings**
  - **Sustainability**
  - **Scalability**
  - **Incentives encourage**
    - **Big pipes**
    - **Aggregated demand**
    - **User defined services**
    - **Access for competing private sector providers**

- **Case Studies**
  - **IRNE (Portland, Oregon)**
    - **Overview: regional intergovernmental cooperation**
    - **Favorable state and local law**
    - **Good price and cost information**
    - **Multiple uses and users**

- **Ontario County (New York)**
  - **Regional middle mile network built through strong regional cooperation**
  - **Fiber backbone to provide foundation for private carriers to offer services**
  - **Low-cost access has spurred interest of new last mile providers**
  - **Business plan demonstrates that projected revenues will meet OpEx and repay debt**

- **Seattle**
  - **Overview: shared fiber demonstrates construction efficiencies, sustainability, and enabling of affordable higher bandwidth services**
  - **Partnership members (anchors and government agencies) control how they meet needs**
  - **Flexible access to massive amounts of connectivity at low cost**
  - **40 Gbps connections possible under this model—not available or affordable from private carriers**
  - **Enables cost savings through collaboration in other areas—eg, sharing of data storage facilities**
  - **Enables free public wireless last mile**

- **San Francisco**
  - **Overview: uses network externality to reach underserved and vulnerable communities**
  - **City fiber to public housing; private partner equipment donations for high bandwidth wireless for residents**

- **DC-NET (District of Columbia)**
  - **Overview: local government deploys state of the art**
  - **Self-sustaining**
  - **Superior architecture with greater scalability and security/redundancy than carrier-grade networks**
  - **Plans for bridging last mile in underserved and vulnerable neighborhoods**

- **OneCommunity (North-Eastern Ohio)**
  - **Overview: open, non-profit, multi-stakeholder community network**

        - **Aggregates demand and investment (both public and private) to increase availability, capacity, services**
        - **Lowers total cost of ownership**
        - **Aggregates demand across stakeholders and industries for sharp collective cost reductions**
        - **Provides open, facilities-based neutral network**
        - **Leverages shared infrastructure and aggregated services to realize greater investment and lower costs**

    - **Palm Beach County (Florida)**
        - **Overview: county-wide middle mile fiber to anchors with free last mile wireless to vulnerable communities**
            - **Construction and operations savings through shared construction and aggregated demand for anchors**
            - **Fiber enables free last mile wireless for students eligible for free and reduced school lunch programs**

    - **OpenCape (Massachusetts)**
        - **Overview: regional consortium of anchors, K-12, higher education, public safety, and local governments**
        - **Consortium ownership; private sector management and operations**
        - **High bandwidth connectivity to anchors**
        - **Open middle mile fiber for multiple last mile private providers (projected at 50 percent below current cost of existing, insufficient middle mile)**

- **<u>Common Characteristics</u>**

    - **Scale economies in construction**
        - **Fiber has declining incremental costs**
        - **Fiber has lower fully distributed costs**
            - **More service for less cost**
                - **Lower CapEx**
                - **Lower OpEx**
            - **Declining per unit incremental cost**

    - **Sustainable: government, ironically, has the correct incentives**

- **More service**
- **Lower cost**
- **Aggregated demand—networks are sustained (and investment enabled) through lower cost, better services/bandwidth**
- **Public institutions have lots of demand but few revenues**
- **Local government and related anchors have many facilities spread over entire region**

- **Capture externalities**
  - **Smaller jurisdictions can share in the benefits**
  - **Non-commercial uses bring value to the network**
  - **Reaching the underserved is economically feasible**
  - **Network can stimulate economic activity without compensation**
  - **These networks can be opened to commercial Last Mile Providers**

- **<u>Lessons Learned</u>**
  - **First—do no harm**
    - **These are valuable and essential**
    - **Be aware of unintended consequences**
  - **Second-- aggregated demand is essential**
    - **Public institutions have lots of demand but few revenues**
    - **Local government needs high-bandwidth to many anchor buildings, widely distributed**
  - **Third--cost savings are real and make the networks viable**
    - **Multiple forms of cost savings from local government control:**
      - **Joint trenching**
      - **Overlashing and pole attachments**
      - **"Shadow" conduit**
      - **Dark fiber**
      - **REQUIRES: local government negotiating reasonable terms and condition for use of public property**
    - **Multiple forms of cost savings in ongoing connectivity expenses of government tenants and anchors**
      - **Significant savings relative to leased services, even assuming no increase in lease expenses/connectivity needs in the future;**

once the need to scale to higher bandwidth is included, savings are even more dramatic

- **REQUIRES: government opportunity to provide services to its own agencies and anchors rather than be forced to be customer**

- **Fourth--Capture externalities**
  - **Smaller jurisdictions can share in the benefits**
  - **REQUIRES: legal authority to act inter-jurisdictionally**
    - **Reaching the underserved is economically feasible**
  - **REQUIRES: creative financing to cover incremental costs**
- **Fifth--These networks can be opened to commercial Last Mile providers**
  - **REQUIRES: eliminating restrictions on government provisioning**

Portland: Integrated Regional Network Enterprise (IRNE) Case Study

The Integrated Regional Network Enterprise ("IRNE") is a fiber optic telecommunications network designed to carry all voice, video and data communications traffic for the City of Portland ("City"). In addition, IRNE provides high speed data transmission to other state and local government agencies. The IRNE is a high-capacity, highly reliable design that costs less and offers more than conventional telecommunications services available in the region.

Before the advent of IRNE, the City spent over $8 million dollars annually on private telephone services to serve roughly 7,000 telephone extensions. The City also had a limited ($100,000) data communications budget, which provided T -1 services at major city buildings (like the 911 Center) but only 56 Kbps Frame Relay services at most other locations. The City's limited budget prevented it from providing high-speed broadband service to most of its buildings, notwithstanding a growing demand.

Meanwhile, the City was investing in a variety of separate telecommunications projects. For instance, the Department of Transportation was building a fiber optic network to connect traffic signals, the Bureau of Environmental Services was investigating the use of fiber for SCADA controls, and the Office of Cable Communications and Franchise Management was negotiating with the region's cable company to provide a fiber optic institutional network (the INET), as contemplated by the Cable Act of 1984.

In response to these growing needs - and limited resources - the City launched IRNE in 2002. IRNE is a collaborative effort that capitalizes on the City's varied telecommunications projects. It brings together municipal, county and State ITS fiber investments to create a redundant loop fiber system around the City that can be used for

many purposes. By establishing a public sector-owned shared communications backbone, IRNE leverages funds, expertise and infrastructure. In this way, the $14 million dollar IRNE reduces costs for both phone lines and high-speed Internet connections.

History

In the 1990s, the Oregon Department of Transportation ("ODOT"), the City of Portland's Office of Transportation ("PDOT"), and the regional transit system, TriMet, entered into intergovernmental agreements to share their respective communications infrastructure in the Portland area to better coordinate their traffic information and control system. At about the same time, the City of Portland was reviewing its own more general communications needs. It determined that it could dramatically increase its communications and telecommunications capacity if it joined in a general partnership with the transportation agencies that were already cooperating. Putting the transportation communications infrastructure together with other available or obtainable infrastructure would allow the City to create a sophisticated high-speed, redundant fiber optic communications system. In addition to "voice service", the real advantage to such a joint infrastructure project would be the vast increase in data transport capacity, speed, and security for the region's governmental agencies. The City Council made the financial decisions necessary to create the regional system, including the sale of bonds. It sought and received a certificate from the Oregon Public Utility Commission to operate as a telecommunications carrier. It entered into an "interconnection" agreement with the local incumbent phone company (Qwest Corporation, an affiliate of plaintiff QCC), to connect the system to the larger regional and national public telecommunications network. The City Council ultimately allocated $14 million in public funds to build and "light" the

Integrated Regional Network, IRNE.[1]

- The physical facilities used by IRNE were obtained in several ways. Of the segments of conduit and aerial runs connecting the various nodes of IRNE, by segment count approximately 43% were built by the City itself, 38% were built by other public entities (especially the State of Oregon and TriMet), 5% were built by the City in cooperation with other public entities, and 3% were constructed by the City in cooperation with private telecommunications providers. Finally, about 11% of the IRNE conduit infrastructure, by segment, was dedicated to City use by "in-kind" contributions of various City telecommunications franchisees. Each such franchise provides that partial payment of the franchise fee can be made "in-kind," providing duct to the City along routes being constructed by the private firms in City streets. The incremental cost of this construction was minimal, particularly when compared to the potential cost of providing the capacity as a stand-alone project at a future date.

IRNE Today

The bulk of IRNE's communications traffic is generated by the City itself. The system meets most of the City's communications needs, both voice and high-speed data. But, under a series of intergovernmental agreements ("IGA's"), the City also provides high-speed data communications services to other governments, including: the State of Oregon, Port of Portland, Cities of Hillsboro and Sherwood, Portland Public Schools ("PPS"), Multnomah County, Multnomah Educational Service District ("MESD"), and the Metropolitan Service District ("Metro"). The City also leases "dark fiber" to Portland State University and the United State Army Corps of Engineers.

The IRNE network links various government offices, including law enforcement and emergency services, using secure, high-speed technology. These agencies can share critical information, such as law enforcement files, efficiently and securely. IRNE assets help connect transportation agencies, allowing better traffic control and response to emergencies.

[1] IRNE is not a separate legal entity from the City. For instance, the Oregon PUC granted the City, "doing business as IRNE," a certificate to operate a telecommunications carrier.

None of the City's "outside customers" obtain all their telecommunications services from the City. Instead, the City provides them a special, high-speed data transmission capacity called "Ethernet" service. For instance, IRNE connects the State Office Building, Portland Public Schools, Multnomah Educational Service District, and Metro to a downtown location, called the Pittock Block, where they can easily connect to the Internet using whatever Internet service provider they wish. It connects Multnomah County and the Port of Portland to the 911 Emergency Center and to the downtown Portland police headquarters and County office buildings. IRNE also provides a dedicated, secure fiber infrastructure system to the cities of Hillsboro and Sherwood allowing them and five other Washington County law enforcement agencies to connect directly to the City of Portland's crime data computer.

The IRNE system currently allows governmental agencies to communicate at speeds up to 155 megabits per second (mbps) and has the capacity to serve full gigabit (1000 mbps) per second. A typical fast DS-1 line, often used for Internet connections, runs at 1.5 mbps. The City's customers all attest to the high quality and cost effectiveness of the IRNE system.

Viability. Although it required a considerable ($14 million) infrastructure investment, the costs per participating organization are low, given the large number of partners that benefit from the network.

Reliability. The private network solution of loop architecture and redundancy optimizes the network architecture for public-safety grade reliability so the network is engineered for zero downtime. Such redundancy would have been cost prohibitive if the City had to rely exclusively on leased data circuits. This reliability facilitates

the City's growing reliance on e-government and electronic learning technologies.

Sustainability. The historic government practice of implementing network solutions without an over-all architectural strategy created a proliferation of dissimilar devices, network management strategies, replacement cycles and applications platforms which were very costly and regularly abandoned. By unifying these efforts into a single, integrated network, IRNE has enabled a coherent solution.

IRNE Future Plans

Portland is in the process of overlaying a 10 Gbps ring that will connect major City locations to increase non-SONET bandwidth. The City is also expanding its partnerships within its governmental fiber cooperative (Cooperative Telecommunications Infrastructure Consortium, "CTIC") to include additional counties in Oregon as well as exploring the possibility of interconnecting its fiber networks with several partners in Washington State (Washington Department of Transportation, Clark County, and the City of Vancouver) to enable further benefit for public safety agency cooperation.

Comcast Corporation's Institutional Network

The City's IRNE is inter-connected to another regional fiber network, called the Institutional Network or I-Net. The I-Net is owned and operated by Comcast Corporation and provides communications for local governmental and educational institutions. The I-Net was built pursuant to provisions of the federal Cable Communications Policy Act, 47 USC § 521 *et seq.* That law confirmed the right of local communities to include in their cable franchises a kind of "in-kind compensation" from cable companies – the provision of institutional networks. 47 USC § 531(b), (f). The Portland metropolitan I-Net is provided by Comcast under cable franchises issued to Comcast by Multnomah County

and the cities of Portland, Fairview, Gresham, Wood Village, and Troutdale.

The I-Net capital cost, borne by Comcast, was over $6 million, with another $4 million in upgrades planned through 2010. The I-Net currently connects over 270 public facilities and serves over 20 public agencies. These include eight school districts (all of the County's K-12 institutions, totaling 272 sites), a regional educational service district, four local governments, the county libraries (17 sites), two community colleges (at eight sites), the Housing Authority of Portland, the State of Oregon and one large, non-profit, social service organization. The I-Net provides a wide range of public benefits, including data and phone connectivity at more than two dozen County-run free and low-cost health, human service and dental clinics. I-Net produces these wide-ranging public benefits at a fraction of the cost that might be expected with leased facilities and commercial services.

Prior to the availability of I-Net services, most of the public agencies used Qwest or Verizon for their data services. The State of Oregon has a current service contract with *Qwest/Verizon* (the telecommunications providers for the Portland area) that public agencies can access. Through this contract, Qwest provides 10 Mb. Service for approximately $1,300 per month (or $15,600 annually), per site. By comparison, I-Net users pay $616 per month ($7,400 annually), per site for 400 Mb service per site. Thus, I-Net provides 40 times the speed at one-half the cost of a private lease.

Comcast provides network facilities, infrastructure, transport operations and maintenance for the I-Net. *See* web site of Mount Hood Cable Regulatory Commission, http://www.mhcrc.org/content.asp?n=ine&s=inet_about. Through a contract between Portland and Comcast, the City provides customer service for INET users. The City has designated its telecommunications staff, which operates IRNE, to provide the I-Net

services.

Synergy: the Interconnection of IRNE and Comcast's INET

The I-Net itself only connects I-Net users – that is, it connects one school to another school or one governmental office to another governmental office. To enhance service to all users of IRNE and I-Net, Comcast and the City agreed to interconnect the two networks. The interconnection allows transmissions to originate on one network and terminate on another, in effect extending the reach of both.

I-Net users also realize significant cost savings because the City uses the same staff to support both networks (i.e., IRNE and l-Net). The dual management of both networks preserves resources that would otherwise have to be invested in technicians, tools, and fiber equipment. In return for I-Net services, its users paid a total of about $1.055 million to Comcast and the City last fiscal year, .

Interconnection of the two networks expands opportunities for their users. For instance, most of East Multnomah County's public schools are connected to each other and to the Multnomah Educational Service District by the I-Net. MESD itself is connected, by IRNE, to the downtown "teleco hotel" at the Pittock Block. From there, MESD pays private Internet service providers to connect it and all its schools to the Internet. The result is that the schools of East Multnomah County can all have a very high-speed Internet connection at relatively low cost. Portland Public Schools, too, are all connected to each other by the I-Net. PPS headquarters is then connected to the Pittock Block by IRNE and then on to the Internet by private firms.

Summary. IRNE is reliable and scalable with demonstrated efficiencies. IRNE is an engineering collaboration among public sector agencies leveraging multiple sources of funds and telecommunications plans to form a well-engineered and well-executed network architecture and service operation. This collaboration has led to dramatic network efficiencies, providing very high-bandwidth at relatively low cost for public agencies.

Finger Lakes Regional Telecommunications Development Corp. (Ontario County, NY): Middle Mile Public-Private Partnership

In 2004, a countywide telecommunications study in Ontario County[1] defined telecommunications within Ontario County as segmented and diverse, and rife with issues relative to telecommunications infrastructure, including the availability of redundant, reliable and affordable connectivity, competition, and more. During the study, focus groups representing education, public safety, healthcare, business, economic development, and municipalities each cited the diverse telecommunications culture as a major negative issue to doing business in the County. Furthermore, it was discovered that technology-based businesses were considering relocating due to the lack of diversity, redundancy, competition and in general, access to broadband.

Open Access Model: The County considered many options to rectify the issues, but chose the development of an Open Access fiber backbone to provide consistency throughout the County. The countywide project called for the installation of 180-plus miles of fiber cabling to interconnect key middle-mile entities throughout the County, including county facilities, town and village offices, schools, colleges, healthcare facilities, fire stations, public safety facilities, communications towers, larger industries and economic development sites (current and anticipated).

The governance of this fiber backbone is managed by a Local Development Corporation (LDC) established by the County Board of Supervisors. The LDC named Finger Lakes Regional Telecommunications Development Corporation (FLRTDC) as responsible for all aspects of the project. FLRTDC is managed and supported by a Board of Directors, qualified consultants and contractors.

The basic premise of the fiber backbone is that it would directly address and resolve the fragmented nature of the telecommunications culture within the County — and potentially the Finger Lakes Region as a whole as it expanded into neighboring counties. The fiber backbone would provide a consistent foundation for all carriers, incumbent and competitive, to expand and provide services. In addition, the creation of public-private partnerships with the carriers and service-providers has proven to be a tremendous strength of the Open Access model. Low-cost access to the fiber backbone has spurred development and investment of last-mile solutions, as well as competitive access throughout the County. It should also be noted that, early on, the project's business plan showed that potential revenues from the project would be very capable of meeting operating costs as well as the repayment of debt. The projected cost of the project is $7.5 million for the entire 180 miles of fiber.

Assumptions and principles: FLRTDC was incorporated on October 25, 2005. The Board of Directors began meeting in January 2006. FLRTDC received New York State Public Service Commission certification as a "Common Carrier" in 2006. Not-for-profit (501(c)(3)) certification was received in 2006. The construction and leasing of the fiber backbone is well underway with an anticipated completion date of December 2010. Sixty miles completed and being leased. The project was designed using the following assumptions and principles:

- Fiber to be open to everyone to lease
- Fiber will touch all municipalities (to include police, fire and communications towers)
- Public-private partnerships with the carriers and service providers are crucial

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[1] NATOA thanks Edward Hemminger, Chief Executive Officer of FLRTDC, for this case study.

- Backbone dark fiber infrastructure only, no services (thus no competition with the private-sector service providers)
- FLRTDC will manage the infrastructure with private-sector contractors building, operating and maintaining the infrastructure
- Costs not subsidized by taxpayer funds

Countywide Public-Private, Middle-Mile Backbone Network

As described, Ontario County has developed a 180-mile, middle-mile Open Access fiber backbone running throughout the County with regional connections to three additional neighboring counties. This fiber backbone — which is developed in partnership with many local service providers and enterprise entities — is seen as the foundation to the 21st-century, technology-led economic development strategic plan of the County.

- **Benefit** – The middle-mile fiber backbone provides the foundation for critical, high-bandwidth telecommunications services. It also encourages competition, thus driving telecommunications costs down. The fiber provides a significant advantage for our economic-development recruitment and retention goals as we pursue our technology-led economic development strategic plan.

- **Partners** – Ontario County created the local development corporation (LDC). The LDC has partnered with numerous telecom providers, as well as the local community college and private businesses. These partnerships ensure that globally competitive telecommunications service is available to our businesses, governments and educational organizations, as well as our public safety and healthcare communities.

- **Viability** – Although it requires a considerable infrastructure investment, the costs for leasing the dark fiber, per participating organization, are lower than the current market price. In addition, dark fiber — other than the LDC's fiber — is only available in a very small area of the County. Furthermore, because the not-for-profit LDC will own the network, the monthly rates are very attractive and conducive to the use and expansion of the fiber backbone.

- **Sustainability** – The Open Access model for dark fiber provides a very sustainable model. Carrier and service providers — who, for "return on investment" reasons, have not made commitments to build infrastructure into the more rural areas of the County — are finding it viable to justify the leasing of this infrastructure. This, is turn, has enabled them to invest in last-mile solutions, further penetrating services into underserved and unserved areas. Revenues from the lease of the fiber are anticipated to cover the operations and maintenance of the fiber for the foreseeable future.

- **Scalability** – The fiber backbone has proven to be very scalable and cost-effective. Incumbents, service providers, and enterprise users are driving the expansion of the fiber backbone deeper into the rural areas, as well as into neighboring counties, making this a true regional initiative. Each of the five surrounding counties — Wayne, Livingston, Yates, Seneca and Monroe counties — are developing independent business plans to integrate with, or expand, the fiber project into their communities. Among other components, each must demonstrate sustainability and public benefit.

Facts and Figures

- Capital Expenditures
  - Total cost of the project was estimated at $7.5M for approximately 180 miles of dark fiber
  - As of today, the anticipated cost of the project is $5.6M
    - We take every opportunity to partner with local telephone providers to lease dark fiber, thus reducing our project costs.
- Anticipated Annual Operating Expenditures

    - The corporation operates with no employees. All operating tasks are provided by local contract support.
    - We anticipate our annual O&M to ramp to $400,000 across the following categories:
        - CEO support contract (provided by Ontario County as part of its contract)
        - Legal, CFO and Management support contracts
        - Mark and Locate contract
        - Fiber Maintenance contract
        - Lease of dark fiber contract (thus reducing our build costs)
        - Public Relations and Marketing Contract
        - Pole Attachment Fees
- Capacity Offered
    - Since we offer dark fiber, the capacity is as great as the equipment installed on the fiber. The fiber has been tested and will support virtually any level of capacity available today. Most users are running gigabit services today.
- Annual Revenues projected to ramp to nearly $1 million over five years with existing first-year revenues at greater than $225,000. Some of the existing revenues are:
    - CLEC revenues, $40,000 per year
    - Cellular company revenues, approximately $168,000 per year
    - Education Revenues, $25,000 per year
    - Healthcare revenues, $6,000 per year
    - Additional customer and revenues being developed
- Cost Savings
    - The County has and will realize a significant reduction in telecommunications costs over 20 years by pre-purchasing connectivity around the entire ring ($1M for 12 strands for 25 years).
    - Cellular and service providers are realizing savings as much as 66 percent over prior costs, which are being reinvested into new technologies and better services countywide.
- Demand Aggregation
    - The business plan is based on the aggregation of demand model, which was used to justify moving forward.
    - It is anticipated that we may enter into agreements with the towns and villages to aggregate their technology needs (networking and computer support), as well as their Internet access.
- Community Benefits
    - Technology-led economic development will make the entire community stronger with competitive wages and comfortable workplaces
    - FTTx providers are considering using the fiber backbone to offer fiber and triple-play — and potentially quintuple-play — services to County residents, which will reduce monthly telecom costs and the development of higher capacity services
    - Creating a globally competitive environment will enhance all aspects of the community including cultural, business, residential, and more. The County has already seen a number of new technology-based jobs relocating into the County as a direct result of the development of the Open Access fiber backbone.

Seattle: Shared Fiber for High Bandwidth Connectivity to Anchors

The City of Seattle[1] was one of the first cities in the nation to deploy fiber connections to facilitate internal communications. In 1986 it established a six mile fiber connection between its downtown offices and the Seattle Center to serve City voice needs and electrical substations. Building on the success of this effort, in 1995 the City planned a 1 ½ mile fiber connection between its downtown Municipal Building and the City's Emergency Operations Center (EOC). When other public agencies learned about the City's plans they inquired about participating in the project and sharing costs since portions of the City's fiber route would pass near their locations that required high speed communications services but were not being served by the private sector. At the time the commercial sector did not provide dark fiber connections.

A Model Fiber Share agreement was adopted in December of 1995 for the purpose of promoting government efficiency and establishing principles for fiber sharing among other public agencies. The Model agreement defines the roles, responsibilities, general terms and conditions and procedures for shared fiber projects among participating public agencies. The City of Seattle's Department of Information Technology (DoIT) was designated as the lead agency for 100% of the fiber share projects. DOIT plans and constructs fiber to locations based on the needs of partners and obtains all relevant permits.

Participation in any fiber project is voluntary. When a project is proposed, an email is sent or a meeting is held to determine who else may want to participate and share the costs. As a general principle partners share costs proportionately based on their ownership share of the active fiber strands in any deployment. Any special configuration, such as a routing change to accommodate a particular entity, is paid for in whole by that entity. Building entrance costs are borne by each customer. Participating agencies must pay DoIT their pro rata share within 30 days of receipt of billing. If subsequent to project completion another participating public entity wants to purchases excess fibers, they reimburse other paying parties for their pro rata share of the total project cost.

DoIT keeps track of the specific project participants, costs and other details and allocates costs proportionally based on the amount of fiber strands from each participant. The current fiber network extends 485 miles consisting mostly of 192 count fiber. Since 1995 the partners have spent approximately $20 Million in fiber and construction costs. It is important to note that the savings and efficiencies are such that no bonds were used to finance construction. Participating agencies were able to finance the shared construction out of their operating budgets.

Partners

The partnership includes the following City of Seattle departments: Information Technology, Transportation; Seattle Police Department; Parks; Public Utilities; City Light; Fleets and Facilities; Seattle Center; Seattle Public Libraries; and the City's EOC. It also includes the following public agencies: Seattle Public Schools; WA State Departments of Information and Department of Transportation; State General Services Administration; Washington GIS; University of Washington; Seattle Community College District; King County ; National Oceanic

[1] NATOA thanks Tony Perez of the City of Seattle Department of Information Technology for this case study.

and Atmospheric Administration; General Services Administration; US Coast Guard; Port of Seattle; City of Edmonds; State EOC; and the Pierce County EOC.

Benefits

- Today partnership members (anchor institutions and government agencies) control how they meet their communications needs. For example by connecting at the physical layer with dark fiber they can continue to save and use their legacy systems and control the timing of their evolution to all IP networking.
- In addition to control of their communications needs the partners receive flexible access to massive amounts of connectivity at very low cost.
- The network is extremely reliable and secure
- The partnership has been an enabler that has allowed them to do things they could not have done because they received low cost high-speed connectivity. It is simply not cost effective and at times not possible to purchase 40 Gbps connections from private companies.
- The partnership has resulted in opportunities for extensive collaboration on other issues such as sharing of data storage facilities.
- When the Seattle Public Schools (SPS) did not have sufficient funds to participate in a planned project the partners agreed to route fiber to school facilities anticipating that the schools would ultimately receive the necessary funds. When SPS finally received funding through a special levy it reimbursed partners for their proportional share of the costs.
- We are using partnership fiber to provide backhaul for the City's free public Wi-Fi locations

Sustainability

The partners view the partnership as a long term strategic investment. The large and increasing number of public fiber partners ensures payment of the approximately $500k annually in pole attachment fees, conduit lease and maintenance expenses. Participating agencies include their proportional share of the costs within their budgets.

Viability

The partnership has a proven track record and has been an unqualified success. There is simply no economical way to purchase connections like 40 Gbps economically from private providers. The relatively low costs and the flexibility and control allowed by physical layer connections continue to attract increased interest from other public organizations. In addition the Eastside cities of Bellevue, Redmond, Kirkland and other jurisdictions are currently in discussions about replicating the model.

Scalability

One of the greatest benefits cited by fiber partners is the ability to access almost unlimited bandwidth on demand and at very low costs since the infrastructure is in place. This positions partners to meet any future communications needs that may arise. For example the City of Seattle plans to use some of its excess capacity to support a 700 MHz radio system for first responders. In addition the physical network is continually expanding based on the needs of the individual partners.

San Francisco: Fiber to City Anchors and Free Wireless to Low Income Communities

The City and County of San Francisco's Department of Technology ("DT")[1] has established a Community Broadband Network ("CBN") to provide broadband access via City fiber to low income communities. The network is currently providing free wired and wireless access to over 3000 units within public housing developments, as well as broadband access for several anchor community sites. This network is small prototype of what a fully-deployed fiber network could provide to residents of San Francisco.

Historically, the City's fiber network had been used to serve only other City departments. Beginning in 2004 under the direction of Mayor Gavin Newsom, the City launched its Digital Inclusion Initiative. The Digital Inclusion Initiative relies on collaboration of a wide range of community based organizations, public agencies commercial vendors and DT. This initiative seeks to leverage city assets, including over 90 miles of fiber plant, to provide broadband access, hardware, training and content—key elements necessary to bridge the digital divide.

The Community Broadband Network Model

DT's Community Broadband Network (CBN) uses unique strands of City fiber, which are physically separate from the City fiber network used for City purposes. DT has deployed a fiber ring that connects to the Internet at a San Francisco data center. At the data center the fiber connects to DT's community fiber switch.

DT has extended this fiber network to 12 low income housing developments in San Francisco and currently provides wireless or wired broadband access at 3000 low income housing developments. Wired access is provided at locations with pre-wired CAT-5 cable to the units. At other locations, DT staff install wireless radios and associated hardware. For ISP service, we partner with the Internet Archive, a national non-profit based in San Francisco. Speeds from the core fiber switches are around 100mbps. Residents of the wired housing developments receive broadband service at speeds ranging from 45 to 50 mbps, while residents with WiFi service obtain speeds of 2 to15 mbps, all at no charge to the resident. At several developments, broadband is also available in community computer rooms, providing an access option for residents without a personal computer.

DT is also working on innovative projects beyond community broadband. This includes working with the California Academy of Science on webcam for the Farralon Islands. The islands are about 30 miles off the coast. DT installed a set of wireless radios on DT towers to deliver bandwidth to the island. In addition to a webcam that is used by scientist at the Academy the network is providing VOIP service to the National Park Rangers and others who manage the Island. The radios are connected to the community fiber network. DT has taken advantage of fiber that has been brought into public housing

[1] NATOA thanks Chris Vein and Barry Fraser of the City and County of San Francisco for this case study.

sites for community cameras and other public safety uses. When we bring fiber to projects, we always deploy additional strands for future use.

- **Benefit --** This network model provides free broadband Internet to residents of low income housing developments by connecting the housing sites to the City fiber network. In addition, anchor institutions are beginning to derive benefits from the network. For Example, San Francisco's Department of Public Health ("DPH") is working with DT and the University of California San Francisco ("UCSF") to connect health clinics via City fiber. At several sites clinicians at community clinics are able to connect to video medical interpretation services located at San Francisco General Hospital.

- **Partners --** DT is working with partners throughout the City on expanding broadband access. This includes neighborhood groups, tenant associations at public housing sites and other City departments. As described above, we partner with a nonprofit group to obtain Internet access and hardware for network installation. We have also worked with commercial vendors, such as Meraki, to extend the network at reduced cost.

- **Viability –** The network model is based on multiple network uses, which ensures that the network will remain viable regardless of the status of any one class of user. As described above, the City deploys fiber infrastructure for multiple purposes with surplus fiber available for community use. When DT brings fiber through a neighborhood for public safety, health clinics or for other City needs, additional fiber is deployed. This allows the cost of deployment to be spread among many users.

- **Sustainability –** Again, because the network is built for multiple purposes and has drawn the interest of a high number of public, private and nonprofit partners, we believe that this model will be sustainable over the long term. Anchor tenants such as Housing Agency, DPH, UCSF, and SF General Hospital have achieved initial success and will attract additional institutional partners.

- **Scalability –** The core network could be expanded to a City-wide network at lower cost due to the multi-user efficiencies described above. In addition, additional public housing developments and institutional partners can be added to the network at low costs.

  Most importantly, we believe that the fiber network can be deployed City-wide in a way that would allow it to serve as the "middle mile" for a fiber to the premises network that would provide fast broadband service to all San Franciscans. Such a network could serve as the backbone for last mile deployment, either by a commercial provider leasing the core network, by a public-private partnership with the City, or, if no last-mile partners come forward, by a municipally-owned network service.

DC-NET: District of Columbia Anchor Network

DC-NET[1] was completed in 2007 and serves as a metropolitan-area network to provide data and voice services for the use of the District of Columbia Government and public educational institutions. By the end of FY2009, DC-NET has 267 lit sites with fiber, including most District government sites. This marks an increase from 135 lit sites in 2007. It currently provides:

- High-speed data network transport and interconnection services;
- Full-featured wireline voice service; and
- Network and application deployment consulting services.

DC-NET is responsible for providing the highest standard of network reliability and for responding to the needs of District agencies. The network was designed to maximize its reach to all District facilities, reliability, and flexibility to serve the diverse, separate needs of agencies.

In order to provide these services, DC-NET owns and operates the following:

- Outdoor fiber optic cable plant;
- Network electronics and management systems;
- Voice switches and management systems; and
- Telephones.

DC-NET has internal staff that plan, design, install, operate, and maintain systems and provide help desk support. DC-NET also maintains contracts with the private sector for tasks it has determined are better managed by contractors, such as fiber optic construction, fiber optic maintenance, and specialized professional services.

DC-NET bills the entities it serves for services according to published rates and fees.

- **Benefit.** DC-NET offers the District both cost and functional/ safety benefits that commercial carriers cannot offer because of its singular focus on public safety, education, and other applications. Its fiber optics enable the District to maintain end-to-end control of the entire network, providing flexibility in adding and upgrading sites and services and providing a minimum quality of service throughout the network. DC-NET can cost-effectively add new sites to diversely routed fiber optic rings because of widespread existing fiber infrastructure, business processes, and its focus on District government and school customers. The District can achieve security on the network, because it owns and controls all fiber and electronics. Densely constructed fiber optic rings and more than 30 redundant hub sites throughout the District provide the basis for a highly reliable service.

- **Partners.** DC-NET serves more than 76 District agencies. Its partners include:
    - Department of Health (DOH);
    - DC Public Schools;
    - DC Public Libraries;

[1] NATOA thanks Tegene Baharu of DC-NET for this case study.

- Office of Unified Communications (OUC);
- Metropolitan Police Department (MPD); and
- University of District of Columbia (UDC).

- **Security and Control of Infrastructure.** The District can assure security on the network because it owns and controls all fiber and electronics. DC-NET systems are documented and under the end-to-end control of DC-NET. Electronics at the site are locked and only accessible to DC-NET. All hub sites and the associated fiber terminations and electronics are under the control of DC-NET. In the event of a security alert or regulatory change (such as more strenuous HIPAA requirements), the District can rapidly increase its level of physical security at DC-NET facilities and efficiently make necessary changes.

- **Reliability.** Densely constructed fiber optic rings and more than 30 redundant hub sites throughout the District provide the basis for a highly reliable service. DC-NET offers the District demonstrably higher uptime than does Verizon because DC-NET's multiple layers of redundant architecture improve system availability. DC-NET connects all of its customers using fiber rings to the premises. Almost all of DC-NET's fiber travels through physically redundant cable pathways. Network electronics have redundant optical electronics, redundant processors, and redundant power supplies at the customer premises. At all DC-NET backbone locations, electronics are powered by UPS hardware that provide battery backup. Where available, DC-NET electronics are also powered by backup generators at user premises. In 2007, its first full year of operation, DC-NET demonstrated an almost perfect record of availability. In fact, over the course of the year, the backbone experienced no outages, and only four sites lost their connection to the network in a total of three data outages. By way of comparison, Verizon commits to no more than an average of seven hours outage per site per year. But DC-NET delivered an average of only 15 minutes outage per site per year in 2007. In 2007, of the 135 lit sites (i.e., those with active electronics), 114 were connected with redundant electronics, redundantly routed fiber paths or both, enabling fail-safe operation in the event of an electronic or fiber outage. For these reasons, DC-NET is uniquely positioned to meet redundancy and reliability requirements set by many Homeland Security initiatives.

- **Sustainability.** As a facilities-based fiber optic service provider, DC-NET has significant resources to maintain and repair the network and to add facilities to the network. Because the District owns the fiber optic capable, it retains control to restore disrupted services, flexibility to design its network to minimize risks, and capability to cost-effectively offer customized services. Its resources include:
  - Three full-time engineers and six technicians on staff dedicated to outside plant;
  - Outside contractors to handle construction of new routes and repair of fiber damage in the public right of way;
  - An outside contractor for fiber maintenance;
  - The right to add overhead aerial cables by lashing its cables to Comcast cable strand;

- The right to add underground cables by using capacity in Verizon conduit or in conduit used by the District of Columbia;[2]
- Comprehensive as-built documentation of all existing DC-NET physical plant; and
- Documentation of DC-NET, District of Columbia Department of Transportation (DDOT), Comcast, and Verizon pole lines and conduit.

DC-NET pricing is designed to result in neutral operating income, thereby minimizing the cost of maintaining the network. In fact, DC-NET's annual revenues meet or exceed costs, in part because of concerted efforts over the past year to reduce operation and maintenance expenses. DC-NET's expenses are at or slightly below projected revenues collected from the District Agencies. For FY2008, the realized operational revenue was $10.6 million and the operations and maintenance costs were $7.6 million. For FY2009, revenue is estimated at $12 million and operational and maintenance costs are estimated at $8.3 million.

- **Scalability.** DC-NET represents an infrastructure asset with a lifetime of decades that is almost endlessly upgradeable and capable of supporting any number of District applications and innovative communications initiatives. Because DC-NET currently uses only a small fraction of its potential network capacity, it can readily scale with the District's needs simply by upgrading electronics. Its benefit to the District will increase with time as the District's communications needs increase. Moreover, increased demand can be accommodated rapidly; because of its broad reach, DC-NET can add service to a new District facility within five days if the facility is near fiber and within 15 to 20 days if it is not near fiber.

  DC-NET offers tremendous flexibility and security owing to its control of fiber optics. DC-NET selects the quantity of fiber and route for each cable and constructs spare fiber for future use. It has detailed as-built documentation of each fiber route. With available staff and contractors, it can quickly extend fiber to new sites and has the flexibility of selecting a route that is optimized for adding new District facilities as needed. It can optimize its routes and hub site selection for the survivability of District sites in an emergency, particularly those sites most critical for emergency response.

- **Technological Configuration and Architecture.** The DC-NET cable plant is 100 percent fiber optic. It extends to approximately 310 miles across the District connecting more than 200 buildings and serving approximately 76 District agencies. DC-NET manages a 10 Gbps core fiber ring connecting three data centers and OC-48 SONET MPLS city-wide backbone of 7 metro rings (including a public safety wireless ring), 16 hub sites, and 25 distribution rings with an average of 20 sites per ring. Every location in the District is within one mile of existing DC-NET fiber rings, and most locations are no more than a few blocks from existing DC-NET fiber.

[2] DC-NET Staff reports the terms of using Verizon conduit is in District of Columbia Code 34-1921.05

Standard site design provides 1 Gbps (Gigabit Ethernet)[3] symmetrical connectivity with the capability to increase data speed to 10 Gbps using standard off-the-shelf electronics. Further, minor customization and re-configuration of fiber plant can provide hundreds of Gbps to any given location, making it possible for any location in the District to become a data center, public safety center, technology center, or media facility.

- **Future Plans.** DC-NET has opportunities to expand, not only by serving more entities, but also by expanding the services and customer service it offers existing customers. Many DC-NET subscribers view DC-NET as an alternative to private voice and T1 data services. DC-NET must educate its partners about the total breadth of its capabilities, services, features and benefits in order to fully leverage its potential. DC-NET is in the midst of an aggressive expansion to the District's schools. Once expansion is complete, DC-NET may seek to expand its footprint to federal agencies, non-profits, hospitals, libraries, or other institutions that may not violate commercial use restrictions.

  A substantial portion of DC-NET's fiber conduit and utility pole attachments was obtained through agreements with Comcast, RCN, and Verizon,[4] which include use restrictions. Because of these restrictions, DC-NET is used to meet public, educational and governmental communications needs, but the District does not currently lease fiber to the private sector.

Network Efficiencies

DC-NET connects all of its customers using fiber rings to the premises.[5] Almost all of DC-NET's fiber travels through physically redundant cable pathways.[6] Network electronics have redundant optical electronics, redundant processors, and redundant power supplies at the customer premises. At all DC-NET backbone locations, electronics are powered by UPS hardware that provide battery backup. Where available, DC-NET electronics are also powered by backup generators at user premises. Such physical redundancy would be cost-prohibitive with a private vendor.

The density of DC-NET fiber rings and their location is a key technical advantage. No location in the District is more than one mile from existing DC-NET fiber rings, and 267 locations already fully functioning sites. Most unserved locations are within a few blocks of DC-NET

[3] One gigabit per second equals approximately one billion (1,000,000,000) bits per second. The capacity is greater than 600 T1 circuits, 15,000 standard telephone circuits, or the service currently provided by 80 cable modem connections or 60 Verizon FiOS connections.
[4] Fiber obtained through the Comcast cable franchise agreement is used to create a portion of the DC-Net backbone.
[5] Some of the auxiliary FEMS or MPD locations are connected over fiber spurs rather than rings. Some DCPS sites are temporarily connected over fiber spurs while ring construction is completed.
[6] Some DCPS locations are temporarily connected over rings that travel over collapsed routes for the last few blocks to the location. Locations served by underground fiber routes have collapsed routes from the street into the premises.

fiber. Because of this density, there is relatively low incremental construction cost to connect a new site to a ring and configure it with redundant electronics.
Indeed, DC-NET can cost-effectively and efficiently add new sites to diversely routed fiber optic rings because of widespread existing fiber infrastructure, business processes, and singular focus on District government and public school customers. It can connect a new facility within three to four days if there is fiber in proximity and within 15 to 20 days if fiber is not nearby. By contrast, Verizon indicated in discussions with the District that it can add services within 30 to 60 days for sites with fiber on premises and where TLS service exists at the local wire center (CO or POP). For other locations, Verizon requires that a site survey be performed, with time (and cost) to implement the service dependent on fiber availability to the site and determined on a case-by-case basis.

Costs of DC-NET construction are $15,000 to $25,000 per mile for aerial construction and $40,000 to $50,000 per mile for underground construction. The agency is simply responsible for the cost of purchasing and installing the equipment and the ongoing operational cost. In contrast to private vendors, there is no external monthly recurring charge for the service.

In order to obtain a comparable service to DC-NET from a private vendor, a District agency would need to purchase a customized service of two separate MPLS connections of the required speed to each site, plus pay the cost of construction of two separate fiber routes, with one of the two routes traveling to a second more-distant central office. Depending on fiber availability, the District would likely need to pay tens or hundreds of thousands of dollars per site for construction, in addition to the monthly recurring service charge for the service.

By avoiding these costs, the District realizes annual savings from DC-NET of $5.25 million, based on current usage. This savings will grow as the communications needs of District agencies grow. The savings arise from a combination of voice and data services, along with avoided costs for the operation of the public safety radio network, data center interconnection, and other critical communications.

DC-NET not only provides cost-effective, rapid expansion, but it also allows partners to select the appropriate bandwidth for their needs. For instance, Verizon TLS only provides basic TLS at speeds of 10 Mbps or higher. More significantly, the TLS EVPL comparable to DC-NET is currently only available at 100 Mbps. This capacity exceeds the demand at most DC-NET sites. By contrast, DC-NET provides data service with tunnels and QoS at data speeds from 2 Mbps to 1000 Mbps. A lower speed data service enables the agency to purchase a more economical service and expand to higher speeds as needed. Because it controls both ends of the fiber, DC–NET can use any equipment and immediately upgrade capacity or add new services. With a modular upgrade, DC-NET can upgrade any one of its backbone fiber pairs to 320 Gbps -- over a hundred times faster than widely available commercial service offerings.

DC-NET can work with its clients to customize their service. It can configure sites with specialized electronics or fiber routing – or potentially to simply provide dedicated dark fiber. In this way, DC-NET saves customers money by allowing them to purchase the bandwidth they need – and easily upgrade service as demand grows. One example of customization is the establishment of the Wireless Ring to interconnect District public safety wireless operations. The Wireless Ring enables public safety agencies to operate a dedicated infrastructure that is in many ways operationally separate from other agencies, and is tailored to meet the mission critical needs of public safety communications.

In short, DC-NET enables not only long-term savings relative to leased commercial services, but also enables the District to avoid the limitations of leased services with respect to performance, availability and capacity. The demands of public safety applications alone weigh strongly against the use of leased services, regardless of cost. Taking cost into account, however, a District-owned fiber infrastructure is the most cost-effective approach for meeting internal District networking needs in the long-term.

OneCommunity: Stakeholder-Owned, Public-Private Middle/Last-Mile Community Broadband

OneCommunity[1] is a 501(c)(3) nonprofit owner/operator of a community fiber/wireless network. The OneCommunity model is based on leveraging, investing and capitalizing local fiber/network assets on behalf of the community with the intended purpose of providing community subscribers access to high capacity fiber/wireless network services enabling local innovation while lowering subscriber operational expenses. OneCommunity is focused on using broadband technologies to address the community's top social priorities.

Our governance represents a broad cross section of public and private regional stakeholders and partners:

Our core principles include:

- **Co-investment** to address top social priorities
- **Broad community governance** model
- **Open, neutral network** that:
  - Aggregates demand;
  - Creates public/private partnership opportunities;
  - Enables sharing of public and private assets;
  - Facilitates carrier exchange and community Intranet;
  - Delivers high capacity, best of breed solutions;
- **Highest quality infrastructure** that enables access to leading edge services and applications
- **Capital-creation ability** of shared stakeholders public assets/service contracts

As a result OneCommunity has attracted more than $50 million in new stakeholder and private investment for community based projects; $15 million in network savings; and $18 million for broadband social and economic development programs directly impacting our community partners.

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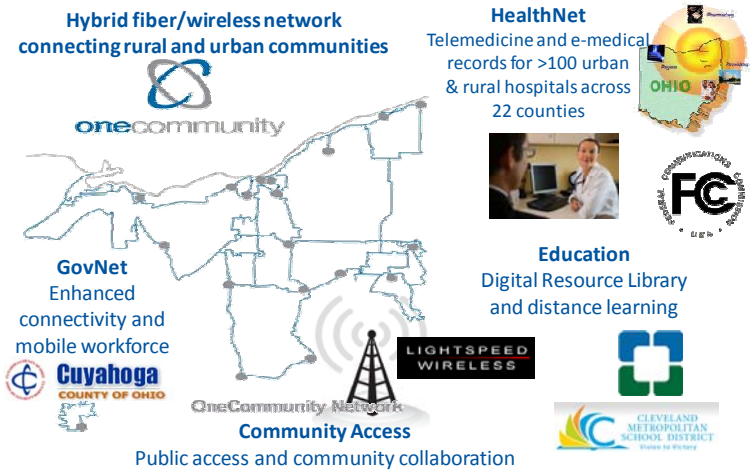
[1] NATOA thanks Mark Ansboury, the Chief Technology Officer of OneCommunity, for this case study.

OneCommunity works with local broadband partners and community stakeholders to create a financially sustainable economic environment that creates jobs. We garner support from:

- **global technology companies** in fiber, equipment, software and in-kind services for innovation and transformation
- **private and federal funds** for local community infrastructure and broadband innovation including funds that directly impacted local community interests such as schools and hospitals
- **foundation funds** for local programming that leverages the broadband to improve society, plus millions from outside of Ohio aimed at innovation i.e. Knight Center of Digital Excellence

Building Community Collaboration and Developing Regional Strategies
OneCommunity has successfully been working with communities interested in developing long-term commitments as subscribers for the purpose of co-investing, developing and adopting a shared community broadband network. Education, health care – and most recently, local government – have begun to work with OneCommunity on regional strategies for development of big broadband services. These efforts have also led to successful awards from the FCC and regional economic development grants. By obtaining resources (such as the FCC grant and funding from the Cleveland Clinic), and establishing open communications with interested communities, OneCommunity is in a position to expand the reach of its network while providing unique value to these subscribers and community stakeholders. Together, we are accelerating the progress of their industries, and hence the community.



Community Shared Technology Development
OneCommunity will build its own broadband facilities if necessary, but it would prefer not to do so. It typically tries to work cooperatively with the providers that own or control facilities that OneCommunity can incorporate into its regional network. For example, in Northern Ohio, OneCommunity has received donations of fiber from private-sector providers such as Cavalier Telecom, First Telecommunications, and CityNet. OneCommunity has also acquired abandoned or underutilized assets that could be repurposed to facilitate revitalization of distressed communities and serve the needs of public interest institutions. OneCommunity has worked cooperatively with private-

sector entities such as AT&T, Cavalier Telecommunications, CityNet, Cox Cable, First Telecommunications, Level 3, Global Crossing, Qwest, XO Communications and Time Warner Cable. OneCommunity has also worked closely with public-sector and community providers such as the Department of Education and Instructional Technology Centers that serve the needs of the region's schools, colleges, municipal wireless projects, county and municipal fiber networks, the statewide academic and research network (OARNet), and various other university and health networks.

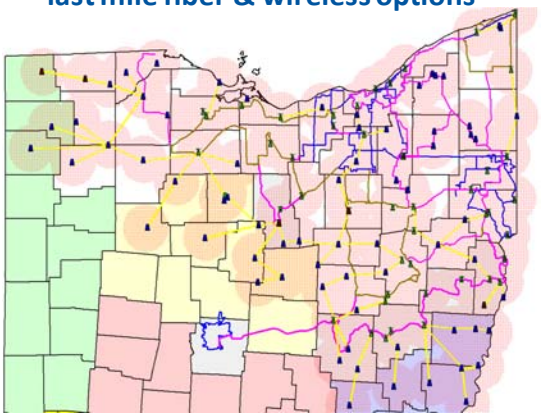
OneCommunity is not attached to any particular ownership model for broadband infrastructure, believing that the more important questions are whether the broadband infrastructure is available and whether it is being used most effectively. As long as broadband infrastructure is available on reasonable terms and conditions, broadband infrastructure is an asset to every community in the region, regardless of who owns it. When the value of the asset is increased (through effective and efficient use), it is increased for all concerned, including the community as well as the public or private asset owner. As a result, for OneCommunity and its partners, whether the network is "public" or "private" has little, if any, practical significance. OneCommunity's experience in Northern Ohio proves that, under the right conditions, public-sector and private-sector network assets can creatively be made to work for the community, to the benefit of all concerned.

Convergence: OneCommunity is in an increasingly strong position to facilitate collaboration, convergence and sharing among local, regional and statewide projects that consolidate the investment in tech services and applications. The scalability and transformation potential of our **tech platform and its associated broad collaborative aimed at social innovation is a very attractive investment and operating** model:

- **Improves collaboration and sharing of resources**
  - Convergence of local, regional and state interests
  - Creates options for development of new services
  - Creates opportunities co-invest existing operation dollars for greater capacity and services
- **Improved digital infrastructure creates social and economic return on investment**
  - Virtualization, aggregation and distribution of community resources across region
  - Attracts talent, businesses and outside investment with jobs
  - Increases commerce and hence taxes
  - Innovation is a media magnet for the region and its leaders
- **Increased adoption of technology drives enhanced community services, enabling innovation and reduces costs**
  - Improved health, education, workforce development
  - Innovation in both the public and private sector
  - Enhances civic pride and fosters culture of change and innovation
- **Enhanced economic development**
  - Attracting investment/grants
  - Creating sustainable funding
  - Attracting and retaining talent
  - Attracting and retaining technology intensive businesses

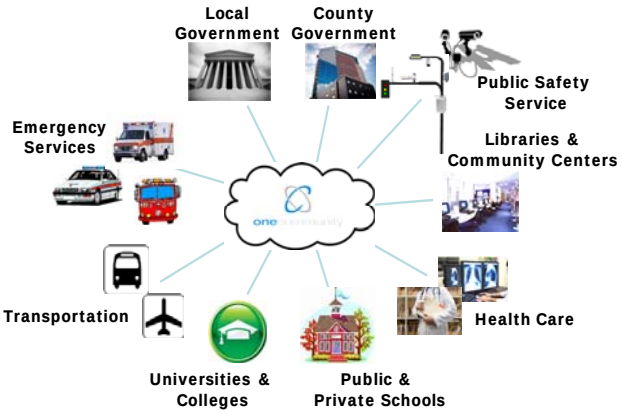
Impact in our Rural and Urban Communities

Solving middle mile in rural America creates last mile fiber & wireless options



- Regional/local meet-me points
- Public/Private partnerships
- Access to shared infrastructure
- Co-investment in local communities
- Consumer choice

Public interest users Anchor last mile community broadband in rural America



- Creating Public/Private partnerships
- Aggregating demand
- Sharing infrastructure and services
- Collaborative community programs
- Co-investment in community infrastructure

Guiding Principles: Creating the Core Value Proposition in Terms of Return on Investment (ROI)

OneCommunity's guiding principles are designed to help make technology invisible, removing all the barriers and providing support to our community stakeholders as needed. Our community objectives focus on scale, impact, and sustainability. The OneCommunity Broadband Coalition serves as the community's managed services partner and provides the following key differentiators' and core value proposition in terms of ROI that are realized through:

- **An Innovative Business Model**

An ***open, carrier-neutral and multi-stakeholder community network aggregates and leverages our community's investments*** to increase availability, capacity, value added services. This ***lowers overall total cost of ownership (TCO) while increasing the social value of the communities' investment.*** In addition, the community network approach can provide additional value to both the public and private sector by;

- **Reducing the burden of government** and improving health and education services;
- Helping communities leverage ultra broadband to prompt **economic development;**
- **Aggregating demand** across stakeholders and industries for **sharp collective cost reductions;**

- Leveraging the sharing of public and private assets and competencies (including phone, cable and utility) **to facilitate the delivery of the highest capacities, lowering capital and operating costs,** while helping attract additional investment
- **Providing an open, facilities-based neutral network** that serves as a gateway for all network and service providers for both physical and logical network services;
- Using strong existing partnerships and agreements with key local, state and national providers to **rapidly deliver high capacity, best of breed solutions, for sharply lower costs;**
- **Leveraging the capital creation ability** of shared infrastructure and aggregating services to invest and advance the needs for broadband infrastructure throughout the region;
- **Investing in the highest quality infrastructure, available for community use.**

- **Leveraging of Public and Private Investment to Resolve Market Inefficiencies**

Collaborative public and private investment:

- necessitates a role for the government, and community non-profit partnerships in part because benefits often accrue to society as a whole, where they are not an active part of the investment strategy of publicly traded broadband providers;
- creates community driven strategies that invest in broadband infrastructure to meet the needs of the underserved urban and rural communities through collaborative multi-stakeholder investment;
- has the potential to contribute to long-term community broadband projects that impact economic growth based on costs and benefits accrued to government, education, health and workforce programs; and
- raises the standard of living of all if the adverse market inefficiencies -promoting policies are offset, and if efforts are made to expand infrastructure access.

Examples and Impact

Community and Economic Impact: The project provides direct fiber and wireless interconnectivity between thousands of government agencies, K-12 schools, health care facilities, universities, community colleges, libraries and civic organizations. The project spurs the roll-out of next-generation, last-mile broadband solutions with speeds of 10 Mb/s to 10 Gb/s by commercial carriers leveraging this investment in middle-mile capacity to extend enhanced service offerings to their last-mile commercial and residential customers. This will create one of the largest and fastest regional broadband networks in the world, placing the State of Ohio on the global map for business attraction, innovation, investment and retention.

Partnering to Expand Infrastructure: A shared broadband communications network allows community stakeholders to leverage the community's broadband fiber and service partnerships (along with their own enterprise infrastructure and resources) for the benefit of the entire region. Some examples of elevating the community infrastructure to that of a shared broadband communications resource involves the:

- **Cleveland Clinic Foundation's** investment of $10 million in the CMSD Broadband E-Rate project brought $8.7 million in additional federal funds for multi-gigabit broadband while

providing seed funding for OneClassroom. OneClassroom is a broadband content delivery program that facilitates the collaboration and interconnection of up to 1,500 schools through partnerships with the region's Instructional Technology Centers (ITCs) peering with the State eTech network.

- **FCC RHCPP awarded OneCommunity/NEO RHIO $11.3MM over three years** to implement HealthNet, an expansion of our fiber-optic network to accommodate the connection of rural health care facilities. This investment will expand OneCommunity's broadband fiber network to 22 counties.
- **Cuyahoga County awarded OneCommunity $14 million** to provide "Best of Breed" broadband technology services to attract additional investment and development in key innovation zones throughout the county, saving the county $10 million over five years. In addition, aggregating over 17 municipalities' data and voice service demands, further lessoning the burden of government while increasing capacity to everyone.
- **City of Akron's sharing of facilities, conduit and fiber** to support the deployment of the city's public safety network and creating the opportunity to share the physical fiber and wireless assets to provide public safety wireless enabling OneCommunity to use the fiber to support public interest access to health care and schools, along with public community Imax and WiFi wireless access.

NATOA/Palm Beach County, FL Case Study 1
Palm Beach County coordinates statewide interconnection to Florida LambdaRail ultra high-speed network

Overview

Since its inception, the data network owned and operated by Palm Beach County, Florida has grown from several hundred devices connected in ten buildings to its current state of over 13,000 devices interconnected in 300 plus buildings, including the delivery of public wi-fi in libraries, courthouses and the County-owned Airport, among others, and covering some 600 miles of plant.

In recent years, the County has taken the lead in leveraging its network to interconnect schools, colleges, municipal governments, public safety, healthcare and non-profit organizations, which helps drive down costs for all the agencies involved and reduces the burden on taxpayers. The logical next step was to expand this idea to the state level.

After becoming the first county in the State of Florida to have a direct fiber interconnect to the Florida LambdaRail (the Sunshine State's leg of the national "wideband" network of the same name) for Internet and Internet2 access, Palm Beach County has become the aggregator for FLR service to all government, education, and non-profit entities both within the County as well as to neighboring counties. This design is now referred to as the "Palm Beach County Model".

By assisting other local and regional entities with interconnection to the FLR, Palm Beach County is providing the means for substantial savings on telecom costs for these entities. As a result, this statewide network is growing, connecting more and more local governments, universities and other institutions and realizing even more of its potential.

Key Considerations

Benefit – Increased ultra high-speed connectivity at a reduced cost to all participating agencies.

Partners – The Palm Beach Broadband consortium, including Palm Beach County, South Florida Water Management District and The School District of Palm Beach County, among others, The PBC League of Cities, Martin County, St. Lucie County, several Palm Beach County municipalities and the state universities already on the FL LambdaRail network

Viability – This project takes available connectivity to a whole new level for participating partners at a reasonable cost through the leveraging of existing resources among the partners.

Scalability – The basic concept, now known as the "Palm Beach Model," can be easily applied to add on additional partners across the state. As the County expands its network, as it is looking to do for the remote Glades area pending federal funding, interconnection to the FLR is an extremely valuable added benefit to any location where fiber can be routed.

Financial/Economic Analysis

1. **Capital expenditures: $250,000**
   - Physical connection of County fiber to Level 3 (FLR) Point-of-Presence
   - Installation of Routers/ Switching Equipment in POP facility
2. **Annual operating expenditures: $90,000 year**
3. **Greater capacity offered:**
   - Redundant Internet Access

- Access to Internet 2
- Direct Access to Disaster Recovery Facilities
- Dramatic Cost per Mbps savings over traditional carriers

4. **Annual revenues; and/or cost savings realized through shared construction, demand aggregation, and so on**:
   - Palm Beach County realizes **$30,000** annual savings in internet access alone
   - FLR provides Aggregator Model which allows the County to connect non-County anchor institutions and provide them the service access for **$100/month pass thru to the Florida Lambda Rail**
   - County provides non-County anchor institutions and municipalities 100MB connections for $700/month (includes the $100 FLR fee)

NATOA/Palm Beach County, FL Case Study 2
Palm Beach County plans to expand its network out to the Glades communities

Overview

Pending BTOP funding, Palm Beach County, FL plans to extend its data network westward to the Glades, an area that has been desperate for improved broadband service.

Palm Beach County is the largest county east of the Mississippi River and covers more than 2200 square miles. The "Glades Region" of Palm Beach County refers to the westernmost communities of Belle Glade, Pahokee, and South Bay situated on the shores of Lake Okeechobee—isolated from the coastal areas by more than 20 miles of sugar cane fields and agricultural farmland as far as the eye can see. Nearby Clewiston, in Hendry County, is also part of this region. The area in question covers about 54 square miles with a combined population of 161,102, and it has been nationally recognized as one of the most impoverished areas in the nation.

Residents of the Glades are a diverse mixture of whites, blacks, and Latinos. Statistics from the 2000 census showed the median household income in Belle Glade was $22,715 with almost 33% of the population below the poverty line. More than one fifth of households earn less than $10,000 annually. There is a shortage of doctors, dentists and other basic services and not a single large grocery store serving Belle Glade and surrounding communities. School age children have fallen behind in education based on statewide test scores. These are all challenges presented by the large presence of a non-English speaking population who live in this historically economically depressed region.

Sugar is the legacy and the lifeblood of the Glades Region. Reclaimed land bordering on the south and east of Lake Okeechobee is surfaced with a rich black soil known as "muck" that produces some of the nation's most bountiful harvests, including sugar cane and winter vegetable crops.

As the largest employer in the Glades region, the sugar industry's proposed decision to reduce operations in the area will have a severe economic impact across the commercial spectrum of the Glades region. Job losses resulting from a pull-out of U.S. Sugar Corporation would wreak havoc upon the already stressed economic conditions of the region. The current unemployment rate is projected for Belle Glade is estimated to be 12-13%,

In spite of the poverty that has plagued this area for generations, there are signs of hope. Substantial infrastructure investments have begun to benefit the Glades region in some areas. A new 70-bed hospital ("Lakes General Hospital") is being built by the Palm Beach County Health Care District, a separate taxing district in Palm Beach County, and is scheduled to open in 2010. In 2008, a badly needed water treatment facility came online to serve the communities of Belle Glade, Pahokee, and South Bay. The U.S. Corps of Engineers has invested in levee improvements after tests several years ago found structural deficiencies. A new middle school is under construction and Palm Beach Community College (PBCC) is building a new technical education training facility. Palm Beach County is currently constructing its largest ever public building project – a $300 million expansion of the Sheriff's West County Detention Facility. Additionally, Florida Power & Light is constructing a new biomass generating plant in western Palm Beach County which will be fueled chiefly by sugar cane stalks and other solid wastes. But beyond the short term employment created by these proposals, they all need sufficient, reliable, low-cost broadband connectivity to succeed over the long term.

With the distance and resulting isolation of the Glades communities, it is more important than ever to "be connected" to the coastal cities and the rest of the world. The County, along with the other member agencies of the Palm Beach Broadband (PBB) regional consortium, has made a

commitment to provide the missing piece to the Glades equation--broadband service—by extending the county fiber optic network to include a new local fiber loop in the Glades region, connecting public community anchor agencies in three cities, and expand the successful Digital Inclusion initiative in qualifying rural and urban neighborhoods.

Key Considerations

Benefit – The project brings affordable high-speed connectivity to a blighted rural area. Our fiber will interconnect critical community anchor institutions in the identified communities, including 46 public PreK-12 schools, Palm Beach Community College, Lakes General Hospital, 48 municipal government buildings, 38 county buildings, 18 public safety buildings, and 5 public libraries.

The increased bandwidth provided to public anchor and support institutions will enable state and local economic development and workforce agencies to dramatically improve assistance to low-income, unemployed and under-employed citizens. Palm Beach County's Economic Development Office currently coordinates with the Workforce Alliance, Business Development Board of Palm Beach County, Inc., local Community Redevelopment Agencies, Enterprise Florida, Inc., Office of Tourism, Trade & Economic Development (State), Small Business Administration (USDC), Rural Development (USDA), and Economic Development Administration (Federal). Communication and coordination between all public agencies and services will be enhanced as their broadband services improve. Anchor institutions will receive increased bandwidth at reduced cost, allowing libraries, schools, hospital, public safety, the Colleges, County and city offices to improve service to their communities.

A significant benefit of the project is the ability to co-leverage the fiber to support multiple uses including: public safety, transportation, education, healthcare and digital inclusion to our high poverty communities. Additional connectivity will also enhance critical off site data storage, interagency communication, and coordination with public safety agencies, particularly for hurricane preparedness and disaster recovery.

In addition, Lakes General Hospital will work with families to utilize technology to improve primary healthcare and medical services through the use of telemedicine by medical specialists in other parts of the County.

The project will also allow for an expansion of our Digital Inclusion project, and provide free connectivity, computers and training to the 23,173 eligible students and their families who would not have Internet access in their home otherwise. While heavily focusing on educational opportunities for students, families will be encouraged to utilize this resource to improve their quality of life--by obtaining GED and workforce training, applying for jobs, for social security, Medicaid, food stamps, emergency assistance and additional local state and government services—and doing so online anytime, 24/7.

We estimate the number of direct jobs estimated to be created by the infrastructure project to be 140. The estimated number of indirect jobs created is anticipated to be in excess of 1,800.

Partners – Palm Beach Broadband (PBB) is a consortium of six agencies: Palm Beach County government, the School District of Palm Beach County, Palm Beach Community College, Florida Atlantic University, South Florida Water Management District and the Palm Beach County Education Commission. Our Agreement for Interagency Cooperation was executed in 2007. In this agreement, the agencies agree to leverage the infrastructure and talent of the collective group for the benefit of the citizens of Palm Beach County. To guarantee success, the agencies co-fund a project

manager to direct and coordinate our work. PBB has a track record of successfully implementing multiple interagency broadband connectivity and digital inclusion related projects.

Viability – Realizing the great need for connectivity in this remote area, the PBB partner agencies are working together to link the Glades region with the world—and in the process provide the means for substantial savings in telecom expenses for the entities involved.

Sustainability - Once completed, the maintenance of the Glades loop would be shared by the anchor tenants, and likely offset by the aforementioned savings.

Scalability – PBB projects and planning could easily be replicated by other public consortiums, and PBB has reached out to both the Heartland Consortium, on the west side of the Lake, and to the Research Coast area, to the north of Palm Beach County. We also anticipate Lakes General Hospital becoming a model site for using broadband-generated resources to improve patient care in a rural and economically challenged area. Additionally, the Digital Inclusion projects are designed to be easily replicated by other agencies and community groups to assist low-income families.

Financial/Economic Analysis

1. **Capital expenditures: $6,400,000**
   - Physical expansion of fiber 31 miles to remote area - $1,900,000
   - Creation of a Regional fiber loop - $3,000,000
   - No-cost Wireless Broadband to all residents - $1,500,000
2. **Annual operating expenditures: $50,000 year**
3. **Greater capacity offered:**
   - Redundant Internet Access
   - Access to Internet 2
   - Direct Access to Disaster Recovery Facilities
   - Dramatic Cost per Mbps savings over traditional carriers
4. **Annual revenues; and/or cost savings realized through shared construction, demand aggregation, and so on**:
   - County provides non-County anchor institutions and municipalities 100MB connections for $700/month (includes the $100 FLR fee)

NATOA/Palm Beach County, FL Case Study 3
Palm Beach Broadband's Digital Inclusion Project

Overview

Through an extensive collaborative effort between a number of public agencies, dozens of low-income families have been provided wireless high-speed Internet service and a refurbished computer to access it—all at no cost to them.

Palm Beach Broadband was formed in 2006 by six Florida charter organizations – Palm Beach County government, Palm Beach County School District, Florida Atlantic University, Palm Beach Community College, South Florida Water Management District, and Palm Beach County Education Commission. Since then, additional taxpayer-supported organizations have begun to participate, including the local health care district and multiple municipalities located in Palm Beach County.

Among the coalition's first initiatives were two successful Digital Inclusion Projects, which were completed in the cities of West Palm Beach (Pleasant City school neighborhood) and Delray Beach (S.D. Spady/Village Academy neighborhood). Both of these projects targeted families with school age children who participated in the subsidized school lunch program, who could not afford the luxury of Internet service or, in most cases, a computer at all. A plan was developed by the coalition to install a wi-fi antenna on the roof of the closest neighborhood school building to serve these families and provide computers for their use at no cost.

The real success of this project is found not only in the end result, but in the collaborative effort that helped to achieve it. The PBC Education Commission provided overall project management; the School District supplied the hardware, taking older-model computers marked for elimination and recycling them—with vocational students doing the refurbishing work as part of their training; Palm Beach County government supplied technical support and the use of its extensive data network; two social agencies, The Mentoring Center and the Urban League, provided user training for program participants; and Palm Beach Community College and Florida Atlantic University offered help desk services to guide the novice net surfers through any troubled waters.

Key Considerations

Benefit – The project brings free high-speed connectivity to those who cannot afford it, providing free connectivity, computers and training to families who would not otherwise have Internet access in their home. While heavily focusing on educational opportunities for students, families will be encouraged to utilize this resource to improve their quality of life--by obtaining GED and workforce training, applying for jobs, for social security, Medicaid, food stamps, emergency assistance and additional local state and government services—and doing so online anytime, 24/7.

Partners – Palm Beach Broadband (PBB) is a consortium of six agencies: Palm Beach County government, the School District of Palm Beach County, Palm Beach Community College, Florida Atlantic University, South Florida Water Management District and the Palm Beach County Education Commission. Our Agreement for Interagency Cooperation was executed in 2006. In this agreement, the agencies commit to leverage the infrastructure and talent of the collective group for the benefit of the citizens of Palm Beach County. To guarantee success, the agencies co-fund a project manager to direct and coordinate our work. PBB has a track record of successfully implementing multiple interagency broadband connectivity and digital inclusion related projects.

Viability – The success of this project has made a real difference in the lives of the participating children and families, who can now experience the infinite educational and cultural advantages of

the Internet from the comfort of their home--at any time of day, even outside of school hours--at absolutely no cost for the service or the computer.
Sustainability –The commitment of the PBB partner agencies is ongoing, with new partners coming onboard, allowing support for the project to continue for the foreseeable future.

Scalability – Through this project, Palm Beach Broadband has created a proven model by which local government and other public agencies can successfully deliver broadband service to low-income families--by pooling resources, sharing strengths and working together to the considerable benefit of the participating families. The success of this project has prompted PBB to explore expanding the program to seven additional target areas, pending federal stimulus (BTOP) funding.

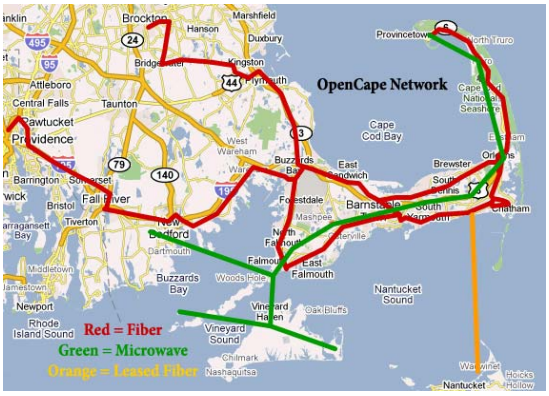
Financial/Economic Analysis

1. **Capital expenditures: $250,000**
   - Physical expansion of fiber to 4 local schools and 100' school TV towers
   - Installation of 36 Tropos Antenna of Street Light Poles
   - WiFi modems for residential computers
   - No-cost Wireless Broadband to all residents in 2.5 square miles
2. **Annual operating expenditures: $5,000 year**
3. **Greater capacity offered:**
   - 100 Mbps to Schools
   - Access to Internet 2
   - No cost internet access to high poverty residents (combined with existing School District program providing free refurbished computers and training)
   - Dramatic Cost per Mbps savings over traditional carriers
4. **Annual revenues; and/or cost savings realized through shared construction, demand aggregation, and so on**:
   - Wireless broadband network is multi-use that provide public safety services in addition to the no-cost broadband

OpenCape: Regional Public and Commercial Middle-Mile Network

The OpenCape project[1] in southeast Massachusetts presents a model that combines public interest, ownership, and control with licensed private operation. This model is well suited to regions where some broadband services are available, but broadband is not ubiquitous, and anchor institution needs are not met due to a lack of capacity or high cost.

The non-profit 501(c)(3) OpenCape Corporation represents the interests of the region and will own the network. Its board is composed of anchor stake holders from the county, towns, public safety, healthcare, K-12 and higher education, research institutions, and economic development interests. The for-profit RCN Metro Optical Networks (RCN) will be licensed to operate the OpenCape network under a 25 year indefeasible right to use (IRU). RCN will pay OpenCape both a flat fee and a percentage of RCN's gross revenues. OpenCape will use the revenues it receives from RCN to address its operating costs, to replace, repair, and expand the network over time, and to aid anchor institutions in developing applications that will benefit the region.



OpenCape will consist of a core fiber backbone on Cape Cod with extensions to two major regional network connection centers in Providence and Brockton, numerous fiber optic laterals extending off of the backbone, a high capacity optical transport system, a microwave radio overlay, and a regional collocation center. All of these elements combine to provide a robust, high capacity communications infrastructure. Fiber optic based services will range from traditional bandwidth based offerings to dedicated wavelengths of light to dark fiber leases. The OpenCape collocation center will serve as the focal point of network operations and provide leased collocation space for public and private organizations in the region.

The cost to construct the OpenCape system is $40 million. OpenCape Corporation has applied to the National Telecommunications and Information Administration (NTIA) under its authority to grant funds under the "Broadband Technology Opportunities Program" (BTOP) for $32 million. OpenCape has secured commitments for $8 million in matching funds from the Massachusetts Broadband Institute ($5 million), RCN Metro Optical Networks ($2 million), and Barnstable County ($1 million).

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[1] NATOA thanks Dan Gallagher of OpenCape for this case study.

Benefit – The OpenCape network will reduce the barriers to entry for last mile providers by providing a middle mile solution that delivers multiple points of interconnection, at speeds suited to the specific provider, at rates that allow them to operate in a competitive market place over time across the entire region.

OpenCape also provides the technologies, speeds and redundancy required of a varied anchor institution community and other enterprises at costs significantly lower than are available today at commercial rates, with a further 15% discount for non-profits, and 25% discount for government anchor institutions.

OpenCape will connect over 70 anchor institutions to the network using laterals as part of its initial build-out. The OpenCape path was specifically selected to permit many additional anchor institutions the ability to rapidly obtain service from the network. In addition, the OpenCape network will support expansion of services into the communities of the South Coast where unemployment in Fall River and New Bedford is nearly 15 percent.

Partners – The many anchor institutions of the region, such as the world-class research institutes of Woods Hole, regional medical facilities, public colleges, school districts, municipalities, and libraries have participated fully in the definition of need and the development of solutions. Barnstable County has partnered with OpenCape and identified the network's construction as a top priority for meeting goals such as the creation of a regional umbrella service model for towns and school districts in the region. OpenCape's ongoing interactions with executive departments of the state government are also ensuring that the Commonwealth's direct interest in building a statewide network are addressed.

Viability – Comprehensive support across a broad spectrum of stake holders, three years of extensive work on the project, and financial analysis, clearly indicate the viability of this model. It is widely supported throughout the region and the state. One hundred percent of the towns and school districts on Cape Cod and the Islands have submitted letters of support for the effort. Seed funding was provided by Barnstable County, the John Adams Innovation Institute, the Massachusetts Broadband Institute, Woods Hole Oceanographic Institution, and Cape Cod Community College. The Cape legislative delegation successfully increased the Broadband Bill Incentive Fund by $5 million in the Massachusetts legislature that will be used as a portion of the match in the BTOP application. The federal legislative delegation has provided letters of support, as well as essential liaison with federal agencies such as the Army Corps of Engineers.

Sustainability – A comprehensive market analysis, business plan, and financials have been developed by professionals that clearly indicate the long term viability of OpenCape. Essential to the long term sustainability of the system is the inclusion of a profit driven operating partner, a capital replenishment plan, and mechanisms to ensure an open access competitive network. OpenCape, and in turn its operating partner, RCN Metro Optical Networks (RCN), recognize that a sustainable business model for

OpenCape is in large part dependent on expanding market. Attracting new last mile providers and aiding incumbents in the expansion of services, across a broad range of technology options, is key to OpenCape's sustainability.

Scalability – The OpenCape network is designed to be easily upgraded and expanded. Fiber optic based services will range from traditional bandwidth based offerings to dedicated wavelengths of light to dark fiber leases. The core equipment can be in-service upgraded to support both a larger number of wavelengths and higher data rates. By building laterals using fiber optic cable instead of copper lines the project is ensuring that there is ample expansion capability at every location served. The microwave backup system for public safety is also rapidly upgradeable with the swap of end point equipment. The regional collocation center is integral to the network and is designed to provide services in a modular manner with the quick swap of equipment and rapid patching to create wide area networks and aggregated services.

Capital Costs – OpenCape specifically selected its operating partner, RCN Metro Optical Networks (RCN), in advance of submitting its BTOP application because there is great advantage to planning the network with an experienced builder and operator of middle mile networks. This proved essential in designing and estimating the cost of building and operating the network. Prices were determined by canvassing several vendors with whom RCN has had experience with in the past.

Financials – OpenCape developed a business plan that included financials for both the non-profit OpenCape Corporation and its licensed operating partner. In this model the non-profit owner must understand the financials of the licensed partner as well as its own financials. A third party professional firm was contracted to develop these financials for both capital and operating budgets.

Efficiencies – The creation of a regional middle mile open access network offers efficiencies in both capital outlay and operating costs for anchor institutions and private last mile providers. OpenCape's extensive long term contact with regional stake holders has ensured their needs were included in the network design. None of these stake holders alone could build the infrastructure they need, but their needs can be addressed within a comprehensive regional middle mile project. For example:

- The Commonwealth of Massachusetts is planning to create a state-wide network for all government services it provides. OpenCape will provide the southeast Massachusetts portion of that network.
- The regional power provider, NSTAR, seeks to develop and expand smart grid applications. OpenCape is negotiating pole rights with NSTAR in exchange for fiber strands.

Operating costs are also reduced significantly for both commercial and public entities. A simple two tiered pricing model for middle mile broadband services - on-Cape and off-Cape - was developed. The pricing is approximately 50% less than the currently available middle mile services offered on Cape Cod. These prices will attract last mile

providers to Cape Cod and allow them to develop a sustainable, long term business model. Anchor institutions and other enterprises will also benefit substantially from these lower rates. In addition to these highly reduced commercial prices, there is a 15 percent discount for non-profit organizations, and a 25% discount for government anchor institutions.

Building Blocks – A large capacity middle mile network in the region offers opportunities for continued growth and expansion. For example, OpenCape is analyzing undersea fiber to Martha's Vineyard as a follow on expansion of the OpenCape network.

EXHIBIT 3

"Community Anchor Institution Connection Costs – Case Study: Prince George's County, Maryland"

Community Anchor Institution Connection Costs – Case Study

Prince George's County, Maryland

Prepared by Andrew Afflerbach, Ph.D., P.E.

for the

National Association of Telecommunications Officers and Advisors (NATOA)

Case study

- New fiber optic cable added to existing community anchor network
- Medium-density suburban area near Washington, DC
- Seven miles built to nine community anchor institutions
  - Fire stations
  - Schools
  - Government buildings

Case Study

- Portion of NTIA BTOP application
- Extension of successful community anchor fiber optic network constructed by cable operator as part of franchise agreement
  - Elementary schools and fire stations not currently served
  - Internet and broadband services will extend to currently underserved population

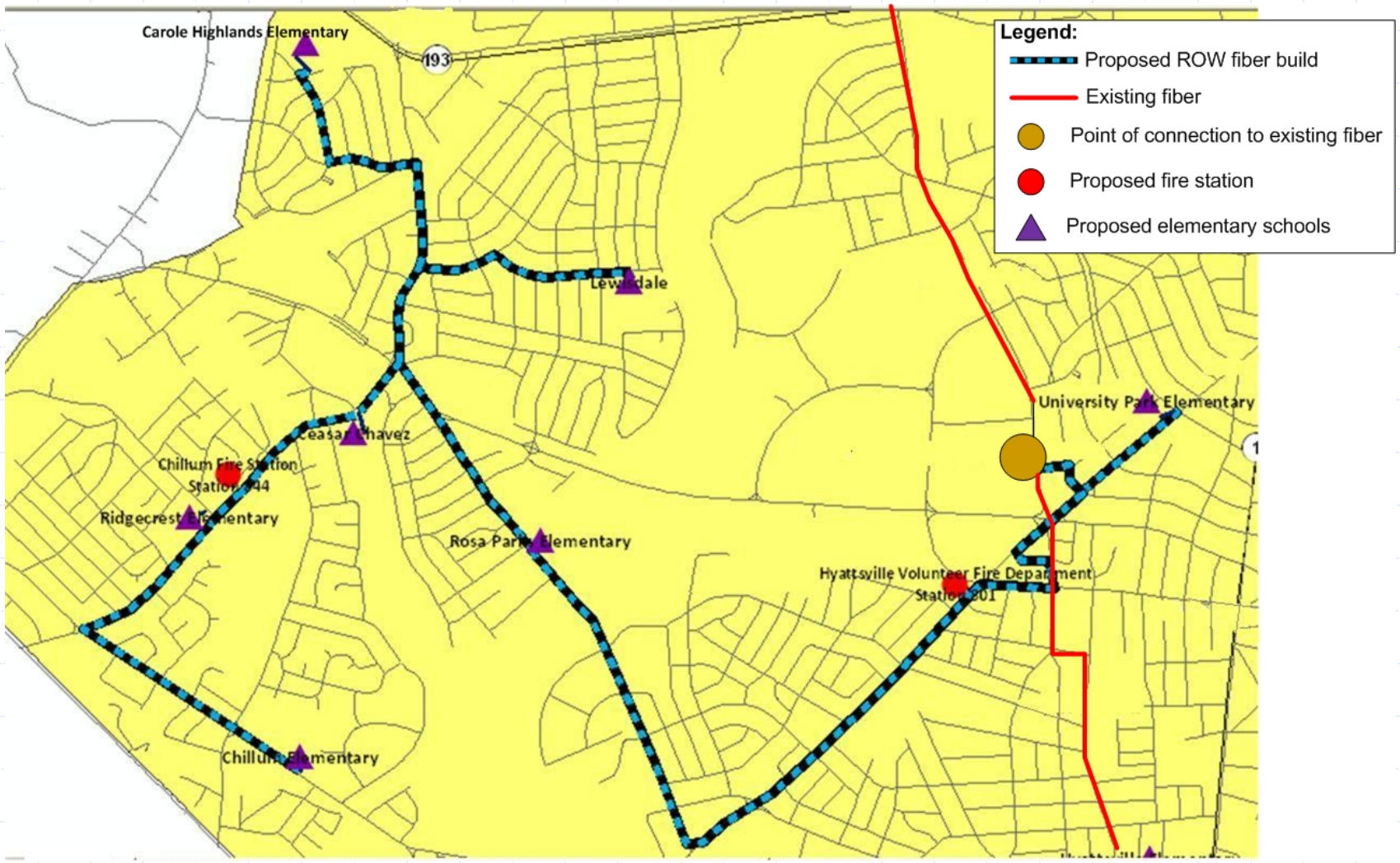
Construction technique

- Underground
  - Selected due to uncertainty of access to poles
  - One 2” conduit
  - Represents “worst case scenario” —costs may be lower if aerial utilities are available
- 144-count single-mode fiber in right of way
- 12-count fiber dedicated to each institution
- Dozens of spare fibers for future use or open access
- Star topology

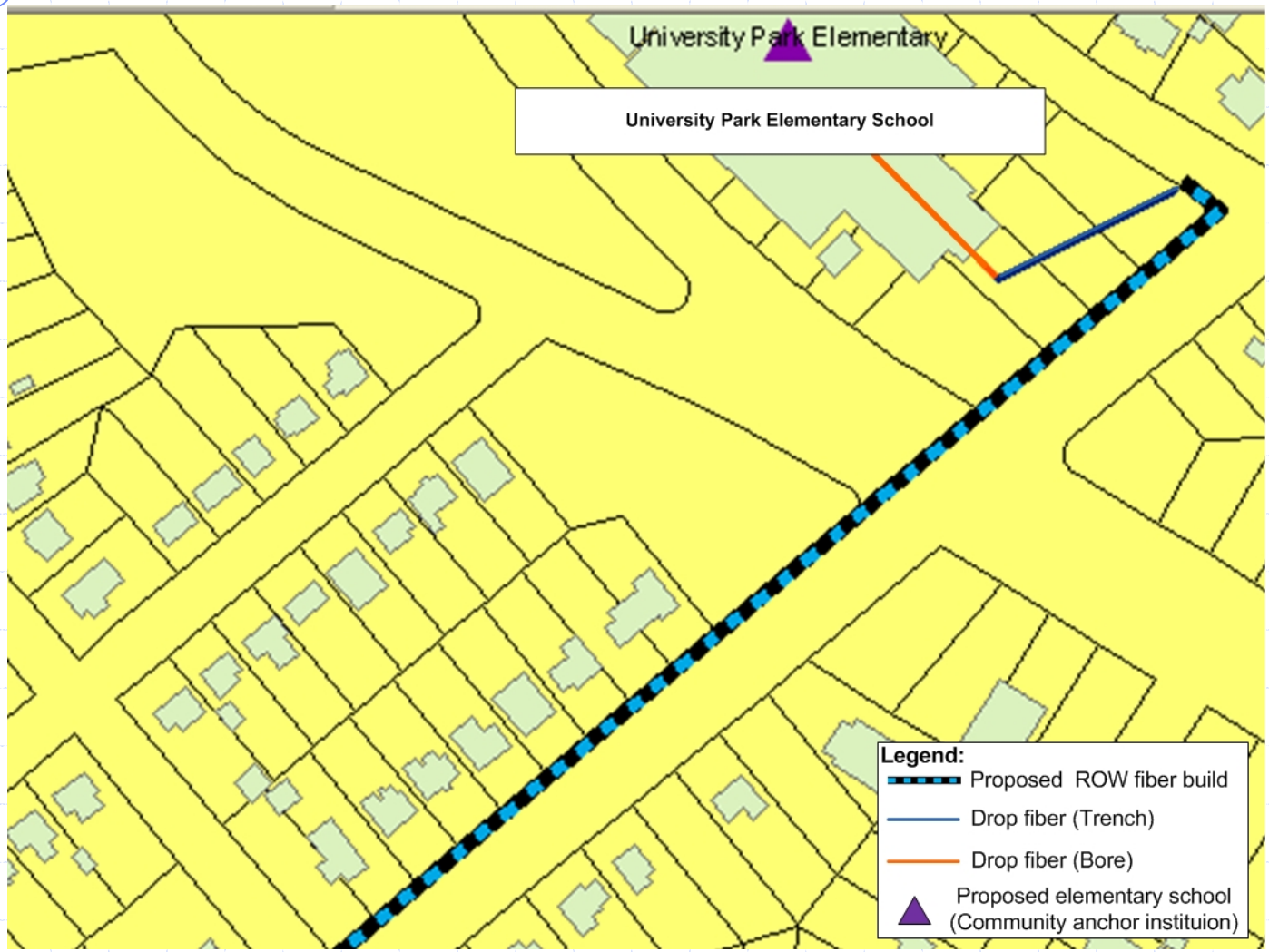
Electronics

- Gigabit Ethernet IP technology
- Dedicated fiber links from each site to switch at meet point on existing network
- CWDM technology provides dedicated light path to network core from each site (not needed in all networks—$9,000 extra cost provides needed security in this shared school/pubic safety network)
- Cisco 2811 and CWDM optics at each new site
- Additional CWDM equipment at NOC

Case study area



Drop fiber to community anchor institution



Cost estimate overview

Case study area	Cost
ROW fiber build	$915,770
Drop fiber	$60,300
Electronics and Installation	$157,000
Project Management	$72,910
Total	**$1,205,980**
Average cost/site	**$134,000**

Detailed estimate for ROW fiber build

Materials

Description	Quantity	Unit	Cost/Unit	Total Cost
Fiber 144 Count	42504	Feet	$1.30	$55,255
2" Conduit, Sweeps, Couplings	36960	Feet	$1.75	$64,680
Inner Duct	36960	Feet	$0.65	$24,024
Pedestal/ Vault	77	Each	$300.00	$23,100
144 Patch Panel	1	EACH	$5,000.00	$5,000
Splice cases and trays	10	Each	$300.00	$3,000
Tax and Freight				$17,510
TOTAL MATERIALS				**$192,570**

Labor

Description	Quantity	Unit	Cost/Unit	Total Cost
Permitting	36960	Feet	$0.25	$9,240
Trenching	20790	Feet	$12.00	$249,480
Boring	16170	Feet	$12.00	$194,040
Pedestal/Vault Placement	77	Each	$300.00	$23,100
Place Conduit	36960	Each	$2.50	$92,400
Place Innerduct	36960	Feet	$2.50	$92,400
Place Fiber	42504	Feet	$1.25	$53,130
Mount Patch Panel	1	Each	$750.00	$750
Fiber Splicing	288	Each	$30.00	$8,640
TOTAL LABOR				**$723,200**
COST OF BUILD FOR AREA UNDER CASE STUDY				**$915,770**
AVERAGE COST/SITE				**$101,760**

Detailed estimate for drop fiber to site

Materials

Description	Quantity	Unit	Cost/Unit	Total Cost
Patch Panel (12 Count)	1	Each	$300.00	$300
Drop Fiber (12 Count)	380	Feet	$0.30	$120
Drop Rolled Duct ($1^1/_4$")	280	Feet	$0.40	$112
Pedestal/ Vault	2	Each	$40.00	$80
Splice Case With Trays	1	Each	$100.00	$100
Tax and Freight				$80
TOTAL MATERIALS				**$800**

Labor

Description	Quantity	Unit	Cost/Unit	Total Cost
Site Visit	1	Each	$200.00	$200
Trenching	220	Feet	$8.00	$1,760
Boring	60	Feet	$12.00	$720
Place Conduit	280	Feet	$1.10	$310
Pedestal/Vault Placement	2	Each	$50.00	$100
Building Entrance & Internal Wiring	1	Each	$1,400.00	$1,400
Place Cable	280	Feet	$0.20	$60
Mount Patch Panel	1	Each	$50.00	$50
Fiber Splicing	24	Each	$30.00	$720
Fiber Testing	12	Each	$45.00	$540
TOTAL LABOR				**$5,860**
AVERAGE DROP COST PER INSTITUTION				**$6,700**
DROP COSTS FOR ALL 9 INSTITUTIONS				**$60,300**

Detailed estimate for electronics

Community anchor institution (new site) electronics			
Description	**Cost/Unit**	**Quantity**	**Total**
Cisco 2811 Router	$3,510	9	$31,590.00
Cisco IOS Advanced Security	$803.25	9	$7,229.25
SFP CWDM GBIC	$4,012.20	9	$36,109.80
HWIC-1GE-SFP	$1,512.00	9	$13,608.00
APC Back-UPS RS 1500LCD 120V Black	$285.47	9	$2,569.24
APC Extended Warranty	$53.99	9	$485.88
TOTAL	**10176.91**		**$91,600.00**
Meet point electronics			
Description	**Cost/Unit**	**Quantity**	**Total**
CWDM 2-slot Chassis	$401.63	1	$401.63
CWDM 8-port MUX Module	$6,426.00	2	$12,852.00
TOTAL	**6827.63**		**$13,300.00**
Network operations center electronics			
Description	**Cost/Unit**	**Quantity**	**Total**
CWDM 2-slot Chassis	$401.63	1	$402
8-port MUX Module	$6,426.00	1	$6,426
SFP CWDM GBIC	$4,012.24	9	$36,110
TOTAL	**10839.87**		**$42,536**
MISCELLANEOUS	$1,000	9	**$9,000**
TOTAL ELECTRONICS COST			**$157,000**
AVERAGE COST/SITE			**$17,500.00**

Construction labor costs are largest component

- 70% of construction cost
- 60% of total
- Highly variable depending on local demand at time of project
- Large projects provide an opportunity for competitive bulk or long-term pricing

Electronics must take specific network needs into account

- Different technologies depending on number of fibers available to each site
- Capacity (Mbps) requirement
- Need for scalability
- Security standard must reflect use
  - Public safety
  - HIPAA
  - Separate service providers sharing open access
  - Open public internet