Telecommunications Feasibility Study
East Liberty Neighborhood Network
Phase Two

Information Renaissance
425 Sixth Avenue, Suite 1880
Pittsburgh, PA 15219
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I. Executive Summary & Introduction. The Phase One Feasibility Study evaluated the infrastructure, organization and service provider options to bring high-bandwidth Internet services to the tenants of the soon-to-be-renovated Bell Atlantic, Highland and Liberty Buildings. The Phase One study observed that commercial service providers do not provide the desired services at prices affordable to the small business tenants likely to occupy the buildings. As a result, the study recommended the creation of an Internet cooperative that would build a Neighborhood Area Network (NAN). The NAN would link the buildings into a unified telecommunications network and aggregate the demands of the tenants to purchase a shared Internet connection and hire a network-wide technical support staff. The high-bandwidth services could be provided at cost-based prices, and the prices could be affordable if the number of subscribers were sufficient to reduce the average cost of the service per user to $100 to $300 per month.

Given the unclear schedule for the Highland Building renovation, Info Ren recommended, as a short-term alternative, the use of a high-bandwidth wireless connection from the WQED Tower Project (which has since been renamed the Wireless Neighborhoods Project) that would be transported to the Bell Atlantic and Liberty Buildings from a wireless hub to be installed on the roof of the Highland Building. This short-term plan could have been implemented prior to the renovation of the Highland Building. Organizationally, the study recommended that the East Liberty users purchase services as customers of the WQED Tower Project until the number of users grows to a level sufficient to sustain an independent Internet connection and user support staff.

Phase Two builds upon the recommendations in Phase One. Phase Two evaluates the infrastructure, organization and service provider options that can be used to extend the inter-building NAN recommended in Phase One into the community.

The Phase Two process started with East Liberty Development, Inc. (ELDI) providing names of community groups to be evaluated for inclusion in such a network. Info Ren visited the sites, interviewed the groups' technical staff and evaluated the sites' physical characteristics and locations to assess the groups' needs, resources and potential connection options. Info Ren then researched and evaluated infrastructure, organization and service provider options to connect the groups.

Also, in the interim between Phase One and Phase Two, the Heinz Endowments awarded a grant to ELDI to fund, in part, the preparation of a business plan for the Internet cooperative proposed in Phase One to build the NAN. In the course of preparing the business plan for the coop, Info Ren has, therefore, also reviewed the potential for serving the desired customers through the coop.

Further, the delay in the renovation of the Highland Building prompted the review of the East Liberty Presbyterian Church as an alternative neighborhood hub site. With funds provided by the Heinz Endowments, a neighborhood hub has been installed in the steeple of the Church. The hub can serve customers in a 360 degree range from the steeple.

The recommendation outlined below is that the community groups can be connected most feasibly in the short-term through a network consisting primarily of wireless connections -- stemming from the WQED Tower and the neighborhood hub in the steeple of the East Liberty Presbyterian Church, and from additional strategically located neighborhood hubs on community group roofs. This same network can also serve the tenants of the Liberty and Bell Atlantic buildings.

The study recommends the use initially of wireless infrastructure in view of its substantially lower costs compared to fiber optic infrastructure and its greater performance compared to copper connections. Fiber and copper cabling might still be used in locations where their specific strengths are needed -- where the greater capacity of fiber is needed or to physically interconnect sites sharing the same or contiguous buildings.

In the longer-term (i.e., over the next three to five years), the study recommends that the Penn Avenue and East Liberty Circle neighborhoods advocate for the installation of publicly-owned or accessible conduit banks and/or fiber optic cables when the City reconstructs Penn Avenue and the East Liberty Circle. The use of fiber optic infrastructure is a preferable long-term option to serve both as a high-bandwidth backbone and to deliver services directly to end users located along the fiber runs.

In terms of organization, the study proposes the expansion of the group purchasing structure (i.e., the Internet cooperative) recommended in Phase One and currently being developed as the Wireless Neighborhoods Project. The group purchasing structure, however, requires a customer base sufficient to distribute the costs of the high-bandwidth upstream Internet connection among its members at affordable prices. Until the cooperative is fully operational, the study recommends individual purchases from the organization serving the rest of the wireless users.[1]

Finally, in terms of service providers, the study recommends that the cooperative purchase its upstream Internet connection from the lowest priced source with terms (i.e., pricing structures, upstream resources and service options) appropriate for the coop's needs. This source could be a traditional service provider, a commercial high-bandwidth provider or a non-profit provider. The Internet cooperative itself would provide Internet service to its members by distributing the upstream Internet purchase over the NAN. In addition, the cooperative would provide technical assistance to its members as a service. Technical assistance would be provided by cooperative employees after the cooperative achieves a necessary scale and by contract until the scale is achieved.

[1] This same purchasing structure could include the Liberty and Bell Atlantic buildings in the short-term. As the Highland Building is renovated and the number of users grows, the East Liberty group could decide to stay in the cooperative or form an independent group.

II. The Community Organizations.
ELDI contracted with the Bloomfield Garfield Corporation (BGC) to help identify the community sites to be evaluated in the Phase Two feasibility study. BGC organized a series of meetings to introduce community groups to the Neighborhood Area Network concept. In the course of the meetings, Info Ren explained the project and issued survey forms to determine interested sites and to obtain initial information about the feasibility of connecting them. The survey forms were also distributed by email and by direct mail. BGC collected the survey responses and submitted them to Info Ren along with a further list of groups developed through BGC's direct contacts.

Info Ren conducted site surveys to further investigate the physical and organizational feasibility of connecting the sites (i.e., evaluating external sight lines to the WQED Tower, the Highland Building and East Liberty Presbyterian Church and internal wiring pathways), the groups' likely uses of the connections and the readiness of the groups (in terms of internal networks and in-house technical expertise) to maintain them.

The sites generally fall into two geographic clusters -- a group along the Penn Avenue corridor and a second group within the East Liberty Circle. The groups are separated by a hill running along Penn Avenue west of its intersection with Negley Avenue and by buildings on West end of circle.

The list, which includes names, addresses and sight lines, is attached as Table 1. The locations are all within two miles of the potential neighborhood hubs in the Highland Building or East Liberty Presbyterian Church and within 2.5 miles of each other.

III. Infrastructure Options.
A. Fiber optic extensions.
1. Advantages of fiber optic infrastructure. Apart from the issue of costs, fiber optic cabling would be the optimal physical means to extend the East Liberty Neighborhood Area Network from its three-building core to neighboring community sites. Fiber optic cable can carry data at extremely high data rates, providing an infrastructure sufficient for current and future needs. The data rate that the fiber does carry at any time is determined by the electronics that are attached to either end. With currently-available electronics, fiber optic cabling can carry data up to the rate of 10 Gigabits per second (10 Gbps) or 10,000 Mbps. Fiber optic cable is also durable with low maintenance costs and a long service life. It is not subject to interference from other media.

The cost of fiber installations is not cheap, but much of the cost lies in installation. The fiber optic cable itself is relatively inexpensive, but the total cost of an installation (materials and installation) ranges from $7 to $10 per foot for aerial installations and $100 to $120 per foot for underground installations. If fiber installations are coordinated with municipal schedules for street reconstruction (avoiding the need for underground trenching), the incremental costs of installing the fiber can be reduced substantially.

2. Aerial installations. The least expensive installation option is aerial -- using existing telephone or electric poles. The costs include the initial installation costs of

approximately $7 to $10 per foot and recurring maintenance (which is usually budgeted at 10% per year of the cost of the facilities).

However, aerial installations also include costs to occupy poles and to satisfy municipal regulatory programs. One-time costs will include engineering, inspections and administrative fees to gain the approval of the owners of the poles, "make-ready work" to raise and lower the facilities of other pole occupants to make room for the new installations, and municipal license fees. Recurring costs include pole rental charges (approximately $17 per pole per year) and municipal right of way fees ($1.90 to $2.25 per linear foot per year within the right of way) assessed by the City of Pittsburgh.[2]

Aerial installations can also be limited by municipal regulations requiring the underground installation of utilities, by limited space on poles (an increasingly prevalent condition in urban areas) and the pole owners' unwillingness to allow others, including potential competitors, to use them. Telecommunications companies are required by federal law to make unused space available to other public utility companies for a fee. For other companies, the right to use pole space depends upon the charges the users are willing to pay and the pole owners' willingness to provide the space. Examples of fees charged by Duquesne Light Company are set forth in Table 4. These include fees for engineering, field reviews, inspections, annual pole attachment fees and relocation costs incurred by other occupants of the poles.

3. Installation in Vacant Conduit. A further installation option involves pulling fiber cables through existing underground vacant conduit of phone and other utility companies. Many utility companies -- telecommunications, gas, electric, water, sewers and steam -- use underground facilities to provide service, and they may have vacant space that can be leased to others. The upfront costs include the costs of the materials and the labor to pull the fiber through the conduit. The recurring costs include rental fees paid to the owner of the conduit, right of way fees paid to the municipality and maintenance and relocation costs -- in the event of street reconstruction or work by other utilities.[3] A relatively new company, CityNet, for example, uses robots to install fiber optic cable through active sewer lines. CityNet states that it charges approximately $80 per foot.

4. Underground Trenching. The most expensive installation option is by underground trenching. This involves excavation of streets, traffic controls and restoration to the municipality's standards. The installation costs can approximate $110 per foot. Underground trenching also involves municipal permits and, in cities such as Pittsburgh, annual right-of-way fees.

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[2] These costs translate into fees of $10,000 to $11,880 per mile. The costs -- which represent the City's projection of the costs it incurs from the occupation of its streets by third parties -- are imposed through an ordinance governing the use of rights of way by public utilities and the public. The City of Pittsburgh, for example, requires the issuance of a telecommunications license and permits for any lines that cross or occupy City rights of way. The City's requirements, which also apply to underground installations, are outlined in section 7 below.

[3] Public utilities generally have the right to occupy public rights of way at no charge except for reasonable fees to cover the municipalities' costs of regulation, but the utilities must relocate their facilities at their sole cost when necessary to accommodate street work.

5. Rental of Existing Fiber. Companies such as DQE Communications install fiber optic cable in strategically deployed rings throughout the city and rent the cable to utilities and other interested parties. These rings are deployed most extensively in central business districts. The rings are more difficult to access in other locations. The rental costs, in any event, are expensive, ranging from $25,000 to $30,000 per month for an entire two-fiber ring. Dark fiber companies will also lease point-to-point fiber runs, but the pricing is established on a case-by-case basis.

6. Special Installations. Given the high cost of installing fiber, municipalities and others interested in promoting public deployment of fiber optic cable try to promote the installation of cable in the course of other installations. It has become common, for example, for municipalities to require cable television companies seeking franchises or franchise renewals to provide fiber optic-based institutional networks for the benefit of the municipal government, schools and libraries. Indeed, a number of Pittsburgh community groups joined with the Pittsburgh Public School District and the Electronic Information Network of the Carnegie to seek such a network in Pittsburgh.[4]

Some cities also install conduit banks and/or fiber optic cable themselves when they reconstruct streets. Some require utilities to install additional conduit to be dedicated to the City when the utilities open the streets for their own installations. The cities rent the facilities to service providers to promote competition and the broad dispersion of telecommunications infrastructure. They hope competition will lead to better services and lower prices and that the broad dispersion of infrastructure will cause high-bandwidth services to be made widely available throughout their neighborhoods. Pittsburgh does not have a policy in this area.

Penn Avenue and the East Liberty Circle are both scheduled for reconstruction in the next five years. The reconstruction presents an opportunity for the relatively inexpensive installation of fiber optic cables or conduit. As the City excavates the streets, conduit can be laid before the new street is built, reducing the costs of installation. The fiber optic cable can be pulled though the conduit at the same time or later after the reconstruction is completed. In either event, the costs of installation are minimized.

In the short-term, the community groups might try to pursue the fiber that Comcast is installing through the East End. The City included provisions in its renewed cable television Franchise Agreement with Comcast for the development of a Community Institutional Network (I-Net). Under the agreement, City Council would designate 45 community sites for fiber optic connections, and the sites would be entitled to purchase

[4] The groups submitted a proposal to the City of Pittsburgh in the course of the recent franchise renewal with AT&T (prior to its purchase by Comcast) seeking the installation of a dedicated fiber optic Institutional Network (I-Net). The I-Net Working Group asked that the City require AT&T to install the fiber as AT&T was going to install the fiber optic cable for AT&T's cable television upgrade. The City of Pittsburgh, however, did not require such an I-Net. Instead, the City required AT&T to sell high-bandwidth services to 88 sites designated by City Council members and to make the connections available at the company's direct, incremental costs.

high-bandwidth services from Comcast at the company's direct incremental cost of providing the service. Community groups, to date, have not been able to take advantage of these provisions given the high costs quoted by Comcast and the City's reluctance to press the company on the issue. However, under a recent revision to the agreement based upon Comcast's failure to meet the original deadline for completing the upgrade of its system, Comcast has been required to deposit its penalties for being late into a fund to assist with the connections. This might be an alternative for sites lacking external sight lines to a wireless hub or for hub sites requiring a high-bandwidth uplink.

7. Other Factors: The City's Street Fees. The City of Pittsburgh regulates the use and occupancy of public rights of way by telecommunications facilities. The Pittsburgh Code requires a Private Communications License as a condition to the installation and occupancy of telecommunications facilities for all parties except Verizon and the issuance of permits for the performance of each installation. See Pittsburgh Code, Chapters 412 and 427.

The major requirements for the license are the preparation of plans showing the intended work, the purchase of a bond and insurance and the payment of an annual license fee to the City. The fees vary depending upon the location of the installation (i.e., inside and outside the Central Business District) and whether the system of facilities "serves no customers other than itself" or whether the system will serve customers within the City. If the system is only intended to serve oneself, the annual fee is established on a per linear foot basis of conduit or wire (i.e., $1.90 per linear foot for each .250 diameter or less of aerial wire and $1.90 per linear foot for each diameter inch or less of underground conduit or wire) with a $500 minimum annual fee. If the facilities will serve customers, the fee is 5% of gross revenues. See Table 4.

The requirements for the work-specific permits are the preparation of plans, the purchase of a separate bond and insurance and the payment of a one-time permit fee. The permit fees vary in amount from "machinery in the right of way" permits at $75.00 and up to excavation permits calculated on the square footage excavated.

An interesting issue here is whether the cooperative would be considered a company serving itself or serving customers. A cooperative is owned by its members and provides service mostly to its members. Therefore, it is arguable that the facilities that serve the coop's members represent service to the coop itself. Those facilities would be licensed at the per linear foot fees. Facilities that serve non-members, however, would probably be subject to the 5% of gross revenues fee.

Of course, the cooperative could request the City to waive these fees, which the City is not, however, required to do. The City considers the fees to represent reimbursement for the cost of regulation and the decreased life of the streets caused by the presence of the facilities.

B. Copper extensions. Community groups can also be connected with copper cable, and the connections can be over existing copper cable or newly-installed copper cable.

Telephone companies do not rent specific pairs of copper cable to customers interested in connecting specific locations, but they do provide a service called Local Area Data Service (LADS) that accomplishes the same purpose. The service establishes a dedicated connection between two locations (routed through the companies' central office) over copper wire, and the customer is responsible for the electronics on either end required to transport data. The service is relatively inexpensive (approximately $60 to $100 per connection per month). The cost of the equipment to drive the data over the lines has been dropping, and the performance (up to 1.5 Mbps a few years ago) has been increased to 4.6, 10 and 15 Mbps (rates that are limited by end-to-end distances[5]). These connections may be cost-effective for organizations located close to a Verizon central office (for example, in East Liberty), since any connection will go first from the user site to the Verizon central office and second to the neighborhood hub. The limiting distance is the sum of the end-to-end connection through the central office. Estimated costs and limiting distances are outlined in Table 6.

New copper cables can also be installed in the same ways as fiber optic installations, and the issues and costs for copper installations are essentially the same as for fiber optic installations. The difference in materials costs, however, between the fiber optic and copper cables themselves is relatively small, such that a user able to afford the installation costs would normally choose a fiber optic connection over a copper connection.

C. Wireless Extensions.

1. Generally. In view of the high cost of installing fiber optic cables, service providers interested in providing high-bandwidth services have been exploring wireless technologies, and equipment manufacturers have been rapidly developing improvements. Wireless equipment can be installed quickly on rooftops and towers without the cost and time required to dig up streets and deal with pole owners and companies already occupying the poles. The capacities are higher than copper but lower than the ultimate capacity of fiber optic cable. Furthermore, higher-capacity wireless technologies are being developed all the time.

Limits include the limited availability of spectrum. Reserved frequencies are auctioned and can be expensive. Several non-licensed frequencies also exist; but as the number of users grows, interference may occur and service quality may be degraded. To address the potential for degradation as the popularity of wireless technologies grows, the Federal Communications Commission has been implementing proposals to increase the availability of frequencies for this purpose.[6]

Additional, potential limits may include aesthetic backlash from the public against communications towers or the placement of antennas on the tops of buildings. These complaints, however, can often be addressed with the less conspicuous equipment sizes

[5] A 15 Mbps link is currently limited to approximately 2,000 feet.

[6] Directional antennas with more focused beams can also address interference and allow the use of lower power radios.

and shapes. Aesthetic concerns can also be addressed, in some cases, with constructed disguises -- pseudo-trees or architectural extensions.

2. Classes of Wireless Technologies.
Equipment is being developed around standardized industry specifications and proprietary specifications; and both are being designed to operate at a variety of data transport rates. The standards are developed by the participants in the Institute of Electrical and Electronics Engineers (IEEE). Equipment based on standardized specifications is usually interoperable with the standards-based equipment of other manufacturers, and the competition within a standards-based market drives frequent technological improvements and decreasing prices. Equipment based on proprietary specifications can have special capabilities, but it is also generally more expensive than equipment based on industry standards. Different data rates are engineered to satisfy the marketing and service requirements of service providers and to meet customer needs.

The following section describes the general classes of standards-based and proprietary wireless technologies and highlights how they compare on the key issues of speed, configuration options, frequency, range and cost.

a. The 802.11 standards.
-- 802.11 & 802.11b ("Wi-Fi"). The IEEE has been developing standards for wireless technologies under the general category called 802.11. The most popular standard is called 802.11b. It is often referred to as "Wi-Fi." This is the technology used for the initial three wireless connections from the Regional Enterprise Tower to serve Community House, Hill House and the Pittsburgh Council on Public Education. These three initial connections entailed point-to-point connections using a dedicated set of antennas and radio electronics on each end of the connection, i.e., 3 installations at the RET and 1 installation at each of the three sites. The 802.11b technology is also being deployed on a broad scale in wireless indoor LANs that serve laptop and desktop computers and in informal neighborhood wireless projects where users share a single DSL or cable modem connection to the Internet. Competition is flourishing for products based on the 802.11b standard, generating new applications and equipment options and falling prices. New increasingly innovative uses, such as wireless access for laptop users, personal digital assistants (PDAs), public Internet kiosks and mobile point of sale terminals, are being developed beyond the applications.

-- 802.11a and 802.11g. Additional industry standards, 802.11a and 802.11g, are also being developed with data rates of 54 Mbps in the 2.4 and 5.6 GHz frequencies respectively. The advantages of these new technologies are their relatively high data rates and the prospect of improved, lower cost equipment resulting from competition among providers within the new standards. The disadvantages are the relatively few products currently in the market to date and the resulting lack of operating experience to judge the equipment's performance and reliability. Nevertheless, recent 802.11b equipment is being designed to be capable of being upgraded to the capacities of 802.11a and g.

-- Configuration options. The 802.11 equipment can be configured in point-to-point connections or as point-to-multi-point connections. Point-to-point connections require equipment on each end of the connection dedicated solely to that connection. Point-to-multi-point connections involve a single hub unit connecting to multiple end-points. A point to multi-point configuration is feasible for a neighborhood hub/distribution point.

-- Frequencies, Data Rates & Ranges. The 802.11b and 802.11g technologies operate in the unlicensed 2.4 GHz spectrum. The 802.11a technology operates in the unlicensed 5.6 GHz spectrum. The 5.6 GHz band has less traffic currently than does the 2.4 GHz band. The 2.4 GHz band has many sources of potential interference, including wireless video security cameras, cordless phones, wireless instrumentation and microwave ovens.

The 802.11b equipment operates at 11 Mbps. The 802.11a and 802.11g equipment operate at 54 Mbps. Despite the apparent size of the differences in speeds, an 11 Mbps connection (versus the 54 Mbps or higher connection) should be adequate for most small organizations. The purpose of the Wireless Neighborhoods project -- in terms of bandwidth -- is to create a Wide Area Network (WAN) infrastructure connecting non-profit and other users that has data rates equivalent to those of an office LAN and thereby to make possible the same kinds of sharing of resources among the Coop's participants as is commonly done by individuals within an office. The 11 Mbps data rate of 801.11b technology is consistent with the lower end of the data rates of an office LAN. Sites with good reception can also conduct high-bandwidth applications such as streaming video and video-conferencing.

The 11 Mbps technology, with its generally less expensive subscriber installations, is more attuned to the connection of individual subscriber sites. The higher-bandwidth technologies are better-suited for service to larger institutions and for the higher capacity requirements for the network's backbone (which aggregates and transports the traffic to and from end users and to the Internet).

The range of the 802.11b equipment depends upon the antenna chosen. Some manufacturers produce 802.11b equipment in packaged units consisting of a radio/access point and antenna. Others produce the radios and antennas as components giving the service provider the flexibility to mix and match the most appropriate antennas for each connection. Focused directional antennas transmit the greatest distances. When configured in point-to-multi-point connections, the strength of the signal and the potential distances covered can be reduced. Point to point connections can transmit up to 11 miles. Point to multi-point connections can serve ranges of 3 to 5 miles, given suitable sightlines and appropriate antennas.

-- Costs. The costs include equipment prices and installation costs. The equipment prices are relatively inexpensive. Prices have approximated $1,200 to $1,300 for the radio and antenna components of an installation, with installation costs on roofs ranging from $1,000 to $1,300. The difference in installation costs is based upon the difficulty of installations at particular locations and the ability to run wire from the roof to the user's network. A router is also required at each site at a cost of approximately $500.

Equipment costs are declining rapidly, however, and manufacturers are designing packaged units intended to be capable of being installed without a contractor. The equipment cost for a connection that does not require a rooftop installation (i.e., for a nearby user with a direct line of sight to the hub equipment through a window) can run as low as $350 per unit (i.e., antenna and radio electronics). For mobile computing use (i.e., laptop computers, personal digital assistants, etc.), the equipment price per subscriber connection can be as low as the $120 price of a PCMCIA Network Interface Card.

b. 802.16 (Wi-Max) Standards. The IEEE is also developing a series of technology standards called 802.16. While the 802.11 standards were originally designed for indoor use (i.e., office LANs) and were later adapted for outdoor use, the 802.16 standards are being designed specifically for outdoor use (i.e., as "last-mile" connections to provide Internet and data services through fixed wireless access points). These standards and the equipment designed to implement them are also intended to address the limitations of the 802.11 family of standards. These standards go by the name of Wi-Max. There has been a lot of discussion about the products but few have actually begun production and shipment. More activity is expected in 2004.

-- Configuration Options. Like 802.11 equipment, 802.16 equipment is being designed for point-to-point and point-to-multi-point configurations. They are also being designed to serve customers that lack clear sight lines between themselves and upstream access points. Designers are also pursuing equipment that can be installed by users -- without the more expensive contractor installations.

-- Frequencies, Data Rates & Ranges. Like the 802.11 standards, the 802.16 equipment is being designed to operate in a range of unlicensed frequencies and at data rates as high and higher than 802.11 equipment. Distances are expected to be about the same as for Wi-Fi, however, given the limited power allowed by the Federal Communications Commission for equipment operating in the unlicensed spectrum.

-- Costs. Given the limited introduction of 802.16 products into the market, prices have not been well established. As with 802.11 equipment, however, manufacturers are expected to charge relatively higher prices for base station units and lower prices for subscriber units -- to realize profits on the centrally-located base station units while encouraging widespread proliferation of subscriber units.

c. Proprietary Technologies. We chose to evaluate three proprietary technologies -- a high-bandwidth Proxim technology, a lower-bandwidth technology manufactured by Proxim and a relatively low-bandwidth technology (Motorola's Canopy).[7]

(i) High-Bandwidth Proxim Tsunami Technology. The Proxim Tsunami equipment is the technology used for the initial phase of the WQED Tower project. This is the equipment installed by Info Ren for the core backbone of the wireless network. The equipment is installed on the WQED Tower and at the first five end user sites. The

[7] Other notable manufacturers of proprietary products include Trango and Redline.

technology is based upon the company's proprietary specifications. The product was designed to be sufficiently reliable for carrier-class, outdoors applications and capable of serving a large number of users.

-- Configuration Options. This technology is point to multi-point technology -- meaning that a central "base station" unit can serve many "subscriber units" installed at individual user sites. The technology includes (i) a multi-sectored set of "base stations" installed on the tower that serve as point to multi-point antennas, in this case, a 60 degree range of coverage per antenna and (ii) "subscriber units" installed at user sites to communicate with the base stations. Both the base stations and subscriber units are manufactured as packaged units, with the antenna and radio combined into a single piece of equipment.

Configured to operate in its highest-bandwidth mode, this technology functions as a high-bandwidth backbone connecting the WQED Tower to neighborhood hubs (which could use lower-bandwidth technology to connect end users); or it can provide direct end-to-end connections with very high bandwidth. The base stations and backbones use the higher data rates to transport the combined traffic of the individual users.

-- Data Rates, Frequencies and Ranges. The Proxim technology operates in the 5.6 GHz unlicensed frequency band (which is used less by other current services and is consequently subject to less interference than the popular 2.4 GHz frequency band). It transports data at aggregated rates of 20, 40 or 60 Mbps. Its range is 6 miles at 20 Mbps to 3 miles at 60 Mbps.

-- Costs. The base stations are more expensive than the subscriber units. Base stations cost approximately $12,000 each. Subscriber units cost approximately $1,200. Both prices exclude the cost of mounting equipment and installation.

(ii) Lower-Bandwidth Proxim MP.11 Technology. In addition to Proxim's high-bandwidth equipment, the company has recently announced a new product line, MP.11, that is intended to compete with the popular 802.11b technology.

-- Configuration Options. The technology operates as point-to-multi-point technology, although it is not clear whether the base stations are configurable in six sectors or more. The products are packaged as units, although it appears that customers can choose and change antennas.

-- Data Rates, Frequencies and Ranges. Like the 802.11b technology, the MP.11 technology operates in the 2.4 GHz unlicensed frequency band and transports data at the rate of 11 Mbps. At 11 Mbps, the range can extend from 2.5 to 12 miles, depending upon the antennas chosen for the base station and subscriber units.

The press release accompanying the product suggests that the equipment is upgradeable to the higher 54 Mbps data rates of 802.11a and 802.11g. It is not clear, however, how easy the upgrade will be.

-- Costs. The base stations are priced at $995 each. An "enterprise subscriber unit" is priced at $595, while a "residential subscriber unit" is priced at $395. The product information does not describe in detail the differences between the two subscriber units. The subscriber units are designed to be capable of installation without a contractor.

(iii) Motorola Canopy. A further proprietary standard is adopted in the Motorola Canopy equipment.

-- Configuration Options. The Canopy technology is point-to-multi-point technology that also uses a six-sectored set of base station units that communicate with subscriber units serving individual sites. There is also a point-to-point backhaul component at 20 Mbps.

-- Data Rates, Frequencies and Ranges. The data rate is a total of 6.2 Mbps divided between upstream and downstream traffic between each base station and the subscriber units it serves. This means, for example, that the units can be set to transport data downstream from a base station to a subscriber unit at 4.7 Mbps, leaving 1.5 Mbps available for upstream data traffic.[8] The technology operates in the 5.2 and 5.7 Ghz frequencies. Its disadvantage is its relatively low bandwidth (i.e., designed for T1 or 1.5 Mbps data rates), shorter ranges (2 miles versus the 4-6 miles of 802.11b).

-- Costs. Canopy's main advantage is its price (i.e., $1,000 for a base station and $515 for a subscriber unit) and its reported reliability. The Canopy prices are comparable to the lower prices of the newer 802.11b equipment. Motorola also claims that the Canopy equipment is simple enough to be installed by the end user, eliminating installation costs. Like the other technologies, each site continues to require a router, which adds approximately $500 to the setup costs.

D. Options for the East Liberty NAN.

1. Fiber optic networks. In view of the imminent reconstruction of Penn Avenue and the East Liberty Circle, Info Ren evaluated the possibility of installing a fiber optic backbone during the reconstruction work. Installing the fiber at this time would save substantial costs for street excavation, traffic control and restoration. Exact costs are difficult to estimate due to the site-specific nature of the costs to connect individual buildings. We did obtain a budgetary estimate, however, from a fiber optic installer. The budget estimate showed a cost of approximately $600,000 to run fiber optic cable over the three miles of the opened streets. Additional costs include the installation of one or more pedestals (approximately $12,000 each) in each block where customers are served and $5 to $10,000 for the cost of entering each building. With a group of approximately 20 customers, this translates into an overall cost of approximately $1.2 million, including engineering costs and customer premises equipment. Table 8 also shows general estimates of the costs of this option.

[8] The 802.11b units, by contrast, can operate at the full 11 Mbps in either direction but not simultaneously.

2. Wireless networks. We also estimated costs of seven wireless options -- one involving the exclusive use of the 60 Mbps Proxim technology, two using a combination of 60 Mbps technology and the 11 Mbps 802.11b technology, two using a combination of 60 Mbps technology and the 11 Mbps MP.11 technology and two involving the Motorola Canopy technology.

The first option would include two 60 Mbps base stations in the Church steeple. This would provide a connection to the WQED Tower and two 60 degree areas of coverage from the roof of the neighborhood hub location. These 60 degree coverages could be contiguous or targeted to more disparate areas. End users and additional neighborhood hubs would connect with 60 Mbps subscriber units. The advantage of this option is the relatively high 60 Mbps of capacity and a technology designed to deal with outdoor interference.

The second wireless option involves a mix of 60 and 11 Mbps units -- a 60 Mbps connection to the WQED Tower located on the Church steeple and a 11 Mbps 802.11b wireless hub to the neighborhood also installed in the steeple. It would include a single 60 Mbps subscriber unit to connect to the 60 Mbps Proxim equipment on the WQED Tower and a series of 11 Mbps 802.11b units to distribute the upstream bandwidth to end users. Each 802.11b unit would be configured to service multiple end user locations with base station units pointed to serve the desired ranges of coverage. The advantage of this option is the relatively lower cost of the 802.11b equipment, the sufficiency of the bandwidth for streaming video and video-conferencing, and the broader variety of subscriber equipment (LANs, PDAs, laptop computers, etc.) from a variety of manufacturers that can connect to the 802.11b equipment. The 802.11b equipment is also interoperable with "hot spots" and wireless office LANs.

The third wireless option includes the installations in the second option plus four additional 11 Mbps base station units of 802.11b equipment at one to four strategically located neighborhood sites. This third option would make it possible to connect end users that lack lines of sight to either the WQED Tower or the Church.

Options 4 and 5 are identical to Options 2 and 3 but use the Proxim MP.11 equipment instead of the 802.11b technology.

Options 6 and 7 are identical to Options 2 and 3 but use the Motorola Canopy technology.

The estimated costs of the wireless options are outlined in Table 9.

3. Supplemental Fiber & Copper Connections. Even if the primary means to connect sites is with wireless technology, supplemental fiber and copper connections will have value for two reasons -- (i) to connect sites that lack sight lines to wireless hubs and (ii) to provide high-bandwidth uplinks from strategically-selected wireless hubs.

The connections to sites lacking sight lines can be done with fiber or copper connections. The fiber connections will involve the installation of the fiber from the community site to the neighborhood hub, the negotiation of a pole attachment agreement with the company owning the utility poles used for the connection, the issuance of a private communications license and utility work permit from the City, and the installation of electronics at the community site. The costs of a typical installation are outlined in Table No. 10.

A copper connection would be provided using the existing copper phone lines of Verizon.[9] The cooperative would purchase the LADS service from Verizon for a monthly fee and install electronics at the community site and the neighborhood hub. The lower costs of this option are outlined in Table No. 6.

A fiber connection has the potential to carry far higher data rates (1 to 10 Gigabits per second) compared to the 10 Mbps rates of the copper connections. A new fiber connection, however, is considerably more expensive than an existing copper connection. The current state of affordable electronics also limits the use of the copper connections to a distance of 10,000 feet from the community site, into the Verizon central office and out to the neighborhood hub site. Accordingly, a fiber connection is appropriate where the need for performance exceeds 10 Mbps and where the relatively-higher cost of the connection can be justified and funded. A copper connection can be provided more affordably but at a lesser performance rate.

Of the sites surveyed, a LADS connection may be the best connection option for the Garfield Jubilee Association. The Garfield Jubilee Association lacks sight lines to the WQED Tower, the East Liberty Presbyterian Church. It does have a sight line to Champion Commons, and it is approximately 1.1 miles from the East Liberty central office of Verizon. The maximum distance for a LADS/DSL connection at 10 Mbps is currently slightly less than one mile (4,000 feet) (See Table 5). A 4.6 Mbps connection, however, can be established at a range of 11,300 feet.

IV. Organizational and Service Provider Options. The organizational and service provider options for Phase Two build upon physical infrastructure that includes (i) a unified multi-building network, (ii) an organizational structure that permits multiple, competing service providers alongside a special provider with whom the building owner works actively to obtain specially desired services at affordable prices, and (iii) a service provider (i.e., possibly an Internet cooperative) to aggregate customer demands, conduct

[9] A copper connection can also be installed and owned by the cooperative from the community site directly to the neighborhood hub as an alternative to a fiber optic connection. There are relatively few savings with this approach, however, compared to the fiber optic installation. The primary costs with the installation of either a fiber or copper line are in the installation and recurring fees for pole attachments and City licenses and permits. If one were to opt for a direct physical connection installed and owned by the cooperative, the generally-preferred approach would be to use fiber. The alternative, however, that does promise savings is the use of Verizon's already-installed copper lines with the LADS service. This alternative avoids the installation costs of the copper and the recurring pole attachment and license fees in exchange for a relatively low monthly rental fee to Verizon.

bulk purchases of upstream services and operate and maintain the infrastructure required to deliver the services to the end users.

The simplest option is for Phase Two customers to purchase from the service provider in Phase One. It is conceivable that the Phase Two organizations could form their own purchasing unit, independent of the Phase One tenants. Indeed, an independent arrangement might be advisable if the interests of the Phase One and Phase Two end users were substantially different. Without such differences, however, the economies of scale made possible by a combined purchasing unit suggests that the Phase One and Two organizations should combine into a common purchasing unit.

As under the recommendations of Phase One, the combined purchasing unit would make its upstream purchases of Internet access and technical services from the provider (traditional service provider, commercial high bandwidth provider or non-profit provider) offering the best service at the best price.

Also, as was the case with Phase One, an interim ramp-up period would be undertaken in which the end users will purchase service directly from an upstream provider until a sufficient number of users is assembled to sustain an independent, local organization.

V. Recommendations.

A. Short-Term

1. Infrastructure -- Wireless & Supplemental Fiber

In the short-term (i.e., before the reconstruction of Penn Avenue and the East Liberty Circle), we recommend the deployment of a hybrid infrastructure that uses wireless technology for the network backbone and as a distribution technology but uses fiber optic cable where feasible. The wireless backbone would consist of the existing infrastructure linking the RET to the WQED Tower and a neighborhood hub on the East Liberty Presbyterian Church. Individual sites would be connected with wireless equipment linking either to the WQED Tower or the Church -- depending upon their sight lines, their bandwidth needs and the availability of resources to fund the connection costs. The wireless technology used for the last mile to the subscriber will be either the 802.11b or the Proxim MP.11 equipment (depending on the ease of upgrading the equipment to the higher speeds of 802.11a and 802.11g). As 802.16 becomes available, this technology, which addresses many of the limitations of the 802.11 family of equipment, should also be used. Fiber optic connections might be used as an uplink to the Internet (if feasible) and to connect sites adjacent to sites already served with a network connection. Copper connections might also be used where sight lines preclude wireless connections and the magnitude of installation costs precludes fiber optic connections.

2. Organization.

In the short-term (i.e., before the start-up of the proposed Internet cooperative), we recommend that the end users purchase Internet and network services though the WQED Tower Project. After the start-up of the cooperative, we recommend purchases from the cooperative.

B. Longer-Term.

1. Infrastructure -- Fiber & Supplemental Wireless

In the longer-term, we recommend the transition of the infrastructure to a hybrid system based primarily on fiber. The network should attempt to secure a fiber-based uplink to the Internet and fiber to each of the network's hub points.

We also recommend the installation of cooperatively-owned fiber in the course of the reconstruction of Penn Avenue and the East Liberty Circle. This could be used as a primary distribution system. Organizations fronting on or immediately adjacent to the streets containing the fiber can be connected to the network for the cost of installing a lateral run into the building, the necessary internal wiring and the electronics to light the fiber.

Other organizations will be connected through the redeployment of the existing wireless equipment and the deployment of new equipment. One of the attractive features of the wireless equipment recommended for the short-term is its mobility. If the cooperative is successful in obtaining fiber optic infrastructure to serve all or most of a neighborhood, the wireless infrastructure that formerly served the neighborhood can be re-deployed to serve new neighborhoods. This would most likely be done by installing the wireless equipment on strategically located points at the edge of the fiber network, using the wireless equipment to extend the effective reach of the fiber. This pattern can be repeated over and over as the cooperative gains access to additional fiber infrastructure.

2. Organization

In the longer-term, the cooperative will aggregate end user demands, solicit bulk purchases of resources and provide service to its members at cost-based prices. With the enrollment of a sufficient number of customers, the cooperative's services can be sustainable with prices affordable to small business and non-profit users.

Tables

Table 1
Community Organizations & Sight Lines

Names	Addresses	Lines of Sight
Initial Five Connections		
Bloomfield Garfield Corporation	113 North Pacific	WQED Tower
Eastside Neighborhood Employment Center	Champion Commons 5231 Penn Avenue	WQED Tower & Church
FamilyLinks	250 Shady Avenue	WQED Tower & Church
Kingsley Association	6118 Penn Cir. West	WQED Tower & Church
Pittsburgh Glass Center	5472 Penn Avenue	WQED Tower & Church
Other Sites with Clear Sight Lines		
Addison Behavioral , Inc.	5937 Broad Street	WQED Tower & Church
A Second Chance, Inc. [3 sites]	204 N. Highland Ave	Church
Big Brothers, Big Sisters & buildings adjacent to Bell Atlantic Bldg	5989 Penn Circle South	WQED Tower & Church (can link to Bell bldg with fiber)
Community Service Providers Network (shared office with Addison Behavioral)	5937 Broad Street	WQED Tower & Church
Competitive Employment Oppurtunities/Neighborhood Academy	Champion Commons	WQED Tower & Church
East Liberty Presbyterian Church	116 S. Highland Ave.	WQED Tower
Family Resources	141 S. Highland Ave.	WQED Tower & Church
Friendship Development Associates	5530 Penn Avenue	Church
Greater Pittsburgh Literacy Council	100 Sheridan Square	Church
Parental Stress Center	5877 Commerce St.	Church
Sojurner House	5460 Penn Ave.	WQED Tower & Church
Vintage	401 N. Highland Ave.	WQED Tower & Church
No Sight Lines to WQED Tower, Highland Bldg or East Liberty Presbyterian Church		
Garfield Jubilee Association	5424 Penn Avenue	Champion Commons & Persad Building
Hunger Services Network	204 37th St 15201	No

Table 2
Infrastructure Options

Fiber Optic Options: Aerial installation of new fiber Installation in vacant conduit Underground trenching Rental of existing fiber Special installations
Fiber & Copper Cable Extensions: Fiber and copper runs to sites adjacent to buildings with wireless equipment LADS/DSL equipment
Wireless Extensions: Proxim (60 Mbps) 802.11b (10 Mbps connections) Motorola Canopy (6.2 Mbps divided between upstream & downstream paths)

Table 3
City of Pittsburgh License & Permit Fees

	Annual Fees
1. Private Communications Systems License Fees: **(Pgh Code, Section 427.11)** **a. For a system "which serves no customers other than itself"**	
For facilities outside the CBD:	
Underground	$1.90 per linear foot for each diameter inch or less of underground conduit or wire
Aerial	$1.90 per linear foot for each .250 diameter inch or less of aerial wire
For facilities inside the CBD:	
Underground	$2.25 per linear foot for each diameter inch or less of underground conduit or wire
Aerial	$2.25 per linear foot for each .250 diameter inch or less of aerial wire
	$500 minimum
b. For a system that serves customers within the City.	5% of gross revenues
2. Other fees:	
Annual registration fee per provider	$100
Machinery in right of way permits	$75 & up
Street opening permits	$77.25 & up
Traffic obstruction permits	no charge
3. Other Requirements:	
Registration & annual renewals (Section 412.03)	
Street work permits (per event)(Section 412.02)	
Filing of a bond for license & for underground work (Pgh Code, Sections 412.02 & 427.10)	
Insurance	
Plans submitted for City review & approval.	
Agreement to relocate or remove at own expense at City's request. (Pittsburgh Code, Section 412.02)	

Table 4
Pole Attachment Costs

	Non-Recurring	Recurring
Paid to contractors:		
Engineering & drawings	$500 per pole	
Paid to pole owner:		
Administration fee (per project)	$455 per installation	
Field review		
Per pole	$93 per pole	
Additional per pole charge if company work required	$120 per pole	
Inspection	$10 per pole	
Pole attachment fee		$17 per attachment per pole per year
Paid to others on poles:		
Make-ready work	Site-specific costs per pole	

Notes:
1. Pole owner costs are from Duquesne Light Company (based upon FCC-approved rates).

Table 5
Copper DSL/LADS Options

LADS Connections	Data Rate	Maximum Distance	Equipment Costs	Recurring Costs
Tut				
Equipment (Tut XL4000)	10 Mbps	4,000 feet	$1,100	
(2 units)			$1,100	
Router			$500	
Verizon setup			$600	
Info Ren setup			$500	
Verizon recurring				$62
Total			**$3,800**	**$62**
Net to Net				
Equipment (SNE 2000 Network Extender)	2.3 Mbps	11,300 ft	$1,048	
(2 units)			$1,048	
Router			$500	
Verizon setup			$600	
Info Ren setup			$500	
Verizon recurring				$62
Total			**$3,696.00**	**$62**
Equipment (SNE 2020 Network Extender)	4.6 Mbps	11,300 ft	$1,363	
(2 units)			$1,363	
Router			$500	
Verizon setup			$600	
Info Ren setup			$500	
Verizon recurring				$124
Total			**$4,326.00**	**$124**

Table 6
Wireless Technologies Summary

	Unit Prices
60 Mbps Proxim units	
Base station units	
Panels	$12,000
Additional equipment & installation (typical)	$6,500
Total per base station (note 1)	$18,500
Subscriber units	
Radio/Antenna units	$1,200
Installation (typical)	$1,200
Router	$500
Total per subscriber unit	**$2,900**
10 Mbps 802.11b units	
Base station units	
Access points	$1,200
Antennas, masts & brackets	$561
Other equipment	$400
Installation (typical)	$1,850
Total per base station (note 1) (w/o cabinet)	$4,011
Subscriber units	
Radio/Antenna units	$650
Installation (typical)	$1,000
Router	$500
Total per subscriber unit	**$2,150**
Motorola Canopy units	
Base station units	
Panels	$995
Installation (typical)	$1,500
Total per base station (note 1)	$2,495
Subscriber units	
Radio/Antenna units	$515
Installation (typical)(note 2)	$1,000
Router	$500
Total per subscriber unit	**$2,015**
Total excluding installation	**$1,015**

Notes:

1. One switch/router ranging from $700 to $4,000 (approximate) is also needed for the collection of base station units at each neighborhood hub.
2. 802.11b subscriber units may run as low as $500 per site (access point & antenna).
3. Motorola claims that the Canopy subscriber units can be installed by customers without the need of a professional installation contractor, thereby eliminating the installation charge for many customers.

Table 7
Capital Cost Options -- Fiber Optic Technology

Installation During Street Reconstruction	Unit Prices	Units	Estimates
Fiber Optic Backbone:			
Fiber optic cable (288 strands, 3 miles) & Conduit			$597,605
Pedestals ($12,000 each)		20	$240,000
Building entrances (Approx. $7,500 per site)			$150,000
Electronics & Internal Wiring:			
Media converters	$500	20	$10,000
Wiring	$500	20	$10,000
Router	$700	20	$14,000
Capital Cost Subtotal:			$1,021,605
Other costs: Design & Engineering	20% of capital costs		$153,241
Total			**$1,174,846**

Notes:
1. Costs for fiber runs along Penn Avenue and around Penn Circle include materials & labor costs but no street excavation, restoration or traffic control.
2. Customer laterals are underground.

Table 8
Capital Cost Options -- Wireless Technologies

	Units	Unit Prices	Totals
Option 1			
All 60 Mbps Proxim Equipment			
(60 Mbps E. Liberty hub &			
20 60 Mbps connections)			
4 60 Mbps base station units	4	$16,000	$64,000
20 60 Mbps subscriber units	20	$2,900	$58,000
Base station switching equipment	1	$4,000	$4,000
End user site switching equipment	20	$500	$10,000
Subtotal			$136,000
Design & engineering (15% of capital costs)			$20,400
Total			**$156,400**
Option 2			
All 10 Mbps 802.11b subscriber units			
(802.11b E. Liberty hub (4 base station units),			
20 802.11b units)			
1 60 Mbps Subscriber unit			
Radio/Antenna units	1	$1,200	$1,200
Installation	1	$1,200	$1,200
Router	1	$500	$500
Subtotal			$2,900
3 802.11b neighborhood hub base stations			
Access points	4	$900	$3,600
Antennas, masts & brackets	4	$561	$2,244
Other equipment	4	$400	$1,600
Installation	4	$1,000	$4,000
Switch/router	4	$500	$2,000
Subtotal		$3,361	$13,444
(w/o env. cabinets)			
20 802.11b subscriber units			
Radio/Antenna units	20	$650	$13,000
Installation	20	$1,000	$20,000
Router	20	$500	$10,000
Subtotal		$2,150	$43,000
Subtotal Capital Costs			$59,344
Design & engineering			$8,902
Total			**$68,246**
Total (excluding neighborhood hub costs at church;			**$52,785**
funded by other sources)			
Option 3			
All 10 Mbps 802.11b subscriber units			
(802.11b E. Liberty hub (4 base station units),			
4 neighborhood base stations &			
20 802.11b units)			
1 60 Mbps Subscriber unit			
Radio/Antenna units	1	$1,200	$1,200
Installation	1	$1,200	$1,200
Router	1	$700	$700
Subtotal			$3,100
7 802.11b neighborhood hub base stations			
Access points	8	$900	$7,200
Antennas, masts & brackets	8	$561	$4,488
Other equipment	8	$400	$3,200
Installation	8	$1,000	$8,000
Switch/router	8	$700	$5,600
Subtotal		$3,561	$28,488
(w/o env. cabinets)			
20 802.11b subscriber units			
Radio/Antenna units	20	$650	$13,000
Installation	20	$1,000	$20,000
Router	20	$500	$10,000
Subtotal		$2,150	$43,000
Subtotal Capital Costs			$74,588
Design & engineering			$11,188
Total			**$85,776**
Total (excluding neighborhood hub costs at church;			**$67,056**
funded by other sources)			

Table 8-A
Capital Costs -- Wireless Technologies (cont.)

	Units	Unit Prices	Totals
Option 4			
All Proxim MP.11 technology			
(MP.11 E. Liberty hub (with 4 base station units),			
20 MP.11 subscriber units)			
1 60 Mbps Subscriber unit			
Panel	1	$1,200	$1,200
Additional equipment & installation	1	$1,200	$1,200
Switch/router	1	$700	$700
Subtotal			$3,100
4 Proxim MP.11 neighborhood hub base stations			
Access points	4	$995	$3,980
Antennas, masts & brackets	4	$561	$2,244
Other equipment	4	$400	$1,600
Installation	4	$1,000	$4,000
Switch/router	4	$700	$2,800
Cluster Management Software	1	$2,195	$2,195
Subtotal			$16,819
(w/o env. cabinets)			
20 Proxim MP.11 subscriber units			
Radio/Antenna units	20	$600	$12,000
Installation	20	$1,000	$20,000
Router	20	$500	$10,000
Subtotal		$2,100	$42,000
Subtotal Capital Costs			$61,919
Design & engineering			$6,300
Total			**$68,219**
Total (excluding neighborhood hub costs at church)			**$48,877**
Total (excluding neighborhood hub costs at church & subscriber unit installations)			**$25,877**
Option 5			
All Proxim MP.11 technology			
(MP.11 E. Liberty hub (with 4 base station units),			
4 neighborhood hubs &			
20 MP.11 units)			
1 60 Mbps Subscriber unit			
Panel	1	$1,200	$1,200
Additional equipment & installation	1	$1,200	$1,200
Switch/router	1	$700	$700
Subtotal		$3,100	$3,100
8 Proxim MP.11 neighborhood hub base stations			
Access points	8	$995	$7,960
Antennas, masts & brackets	8	$561	$4,488
Other equipment	8	$400	$3,200
Installation	8	$1,000	$8,000
Switch/router	8	$700	$5,600
Cluster Management Software	1	$2,195	$2,195
Subtotal			$31,443
(w/o env. cabinets)			
20 Proxim MP.11 subscriber units			
Radio/Antenna units	20	$650	$13,000
Installation	20	$1,000	$20,000
Router	20	$500	$10,000
Subtotal	20	$2,150	$43,000
Subtotal Capital Costs			$77,543
Design & engineering			$11,631
Total			**$89,174**
Total (excluding neighborhood hub costs at church)			**$68,512**
Total (excluding neighborhood hub costs at church & subscriber unit installations)			**$45,512**

Notes:
1. Proxim claims the MP.11 subscriber untis are simple enough to be installed without a professional contractor.
2. Design & engineering = 15% of capital costs.

Table 8-B
Capital Costs -- Wireless Technologies (cont.)

	Units	Unit Prices	Totals
Option 6			
All Motorola Canopy technology			
(Canopy E. Liberty hub (with 4 base station units),			
20 Canopy units)			
1 60 Mbps Subscriber unit			
Panel	1	$1,200	$1,200
Additional equipment & installation	1	$1,200	$1,200
Switch/router	1	$700	$700
Subtotal			$3,100
4 Motorola Canopy neighborhood hub base stations			
Access points	4	$995	$3,980
Antennas, masts & brackets	4	$561	$2,244
Other equipment	4	$400	$1,600
Installation	4	$1,000	$4,000
Switch/router	4	$700	$2,800
Cluster Management Software	1	$2,195	$2,195
Subtotal			$16,819
(w/o env. cabinets)			
20 Motorola Canopy subscriber units			
Radio/Antenna units	20	$1,030	$20,600
Installation	20	$1,000	$20,000
Router	20	$500	$10,000
Subtotal		$2,530	$50,600
Subtotal Capital Costs			$70,519
Design & engineering			$7,590
Total			**$78,109**
Total (excluding neighborhood hub costs at church)			**$58,767**
Total (excluding neighborhood hub costs at church & subscriber unit installations)			**$35,767**
Option 7			
All Motorola Canopy technology			
(Canopy E. Liberty hub (with 4 base station units),			
4 neighborhood hubs &			
20 Canopy units)			
1 60 Mbps Subscriber unit			
Panel	1	$1,200	$1,200
Additional equipment & installation	1	$1,200	$1,200
Switch/router	1	$700	$700
Subtotal		$3,100	$3,100
8 Motorola Canopy neighborhood hub base stations			
Access points	8	$995	$7,960
Antennas, masts & brackets	8	$561	$4,488
Other equipment	8	$400	$3,200
Installation	8	$1,000	$8,000
Switch/router	8	$700	$5,600
Cluster Management Software	1	$2,195	$2,195
Subtotal			$31,443
(w/o env. cabinets)			
20 Motorola Canopy subscriber units			
Radio/Antenna units	20	$1,030	$20,600
Installation	20	$1,000	$20,000
Router	20	$500	$10,000
Subtotal	20	$2,530	$50,600
Subtotal Capital Costs			$85,143
Design & engineering			$12,771
Total			**$97,914**
Total (excluding neighborhood hub costs at church)			**$77,252**
Total (excluding neighborhood hub costs at church & subscriber unit installations)			**$54,252**

Notes:
1. Motorola claims the Canopy subscriber untis are simple enough to be installed without a professional contractor.
2. Design & engineering = 15% of capital costs.

Table 9
Fiber Links Between Adjacent Buildings

Option 1: **Using utility poles**	**Unit Prices**	**Total for** **Typical Install** **(200 feet)**
Pole to Pole Aerial installations	$7-$10 per foot	$1,400 to $2,000 $2,000 (approx.)
Pole to Building (Laterals) Aerial installations	$2,500 to $5,000	$5,000
Electronics & Internal Wiring: Media converters Wiring Router	 $500 $500 $700	 $500 $500 $700
Other: Design & engineering	15% of capital costs	$1,305
Total:		**$10,005**
Notes: 1. Costs of underground installations are site-specific.		

Option 2: **Building to Building (w/o utility poles)**	**Unit Prices**	**Total for** **Typical Install** **(200 feet)**
Building to Building Aerial installations	$2,500 to $5,000	$5,000
Electronics & Internal Wiring: Media converters Wiring Router	 $500 $500 $700	 $500 $500 $700
Other: Design & engineering	15% of capital costs	$1,305
Total:		**$8,005**
Notes: 1. Costs of underground installations are site-specific.		

Table 10
Recommended Infrastructure & Organization

Short-Term

Infrastructure -- Wireless & Supplemental Fiber

- 60 Mbps Proxim connection between WQED Tower & East Liberty Presbyterian Church
- 11 Mbps 802.11b neighborhood hub on East Liberty Presbyterian Church
- 11 Mbps subscriber units for typical user
- Fiber connections where feasible for upstream Internet access
- Fiber connections to allow multiple connections to adjacent buildings from a single access point
- LADS copper connections for end users lacking sight lines to WQED Tower & neighborhood hubs

Organization

- Purchase from WQED Tower Project
- Purchase from Internet Cooperative

Longer-Term

Infrastructure -- Fiber & Supplemental Wireless

- Fiber along Penn Avenue & East Liberty circle
- Fiber connections to users where feasible
- Wireless connections where most feasible for end users

Organization

- Purchase from Internet Cooperative

Table 11
Recommended Connections by Community Site

Names	Addresses	Connection Point	Equipment
Anchor Buildings			
Highland	121 South Highland Ave.	WQED Tower or Church	60 Mbps Proxim
Liberty	6101 Penn Avenue	Church	Proxim MP11
Former Bell Atlantic	134 South Highland Ave.	WQED Tower or Church	60 Mbps Proxim (Family Resources)
Initial Five Connections			
Bloomfield Garfield Corporation	113 North Pacific	WQED Tower	60 Mbps Proxim
Eastside Neighborhood Employment Center	Champion Commons 5231 Penn Avenue	WQED Tower	60 Mbps Proxim
FamilyLinks	250 Shady Avenue	WQED Tower	60 Mbps Proxim
Kingsley Association	6118 Penn Cir. West	WQED Tower	60 Mbps Proxim
Pittsburgh Glass Center	5472 Penn Avenue	WQED Tower	60 Mbps Proxim
Other Sites with Clear Sight Lines			
Addison Behavioral , Inc.	5937 Broad Street	Church	Proxim MP11
A Second Chance, Inc.	204 N. Highland Ave	Church	Proxim MP11
Big Brothers, Big Sisters Buildings next to Bell Atlantic Bldg	5989 Penn Circle South	WQED Tower or Church (can link to Bell bldg with fiber)	Proxim MP11 or by cable from Family Resources hub
Community Service Providers Network	5937 Broad Street	Church	Proxim MP11
Competitive Employment Oppurtunities/Neighborhood Academy	Champion Commons	Existing connection in Chamption Commons	Champion Commons connection
East Liberty Presbyterian Church	116 S. Highland Ave.	WQED Tower	Neighborhood hub
Family Resources	141 S. Highland Ave.	WQED Tower	60 Mbps Proxim
Friendship Development Associates	5530 Penn Avenue	Church	Proxim MP11
Greater Pittsburgh Literacy Council	100 Sheridan Square	Church	Proxim MP11
Parental Stress Center	5877 Commerce St.	Church	Proxim MP11
Sojurner House	5460 Penn Ave.	WQED Tower or Church	Proxim MP11 (potential hub site)
Vintage	401 N. Highland Ave.	WQED Tower or Church	60 Mbps Proxim
No Sight Lines to WQED Tower, Highland Bldg or East Liberty Presbyterian Church			
Garfield Jubilee Association	5424 Penn Avenue	Champion Commons & Persad Building	10 Mbps LADS/DSL or Motorola Canopy Proxim MP11
Hunger Services Network	204 37th St 15201	No	10 Mbps LADS/DSL depending on location of CO

Note:
The Proxim MP11 units will soon be upgradable to 54 Mbps.