SIEMENS

Wireless Broadband Report

Houston County, Georgia

Presented to: The Wireless Houston County Committee

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Siemens Business Services, Inc.

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Project Background

Houston County (pronounced House'-ton), Georgia is located in the geographic center of the state and is often referred to as "Georgia's Most Progressive County". The county contains three incorporated cities; Centerville, Perry and Warner Robins, and is home to Robins Air Force Base (the largest industrial complex in the state), the Museum of Aviation (the fourth largest aviation museum in the country), the Georgia National Fairground and Agricenter (an 1,100 acre site for diverse activities in Central Georgia) and many other commercial, industrial, governmental, cultural and recreational points of interest.

The county is one of the fasted growing in the state of Georgia, with an estimated population of over 120,000[1], essentially having doubled every decade since 1940.

The county's rapid growth is due to a number of factors; ease of transportation (the area is often called the Crossroads of Georgia), a well-trained and highly-motivated workforce (nine post-secondary institutions within a 50 mile radius), a stable tax environment (operating under a tax cap since 1982) and an intense focus on education (eighteen Georgia Schools of Excellence and three National Blue Ribbon Schools).

Despite the strong outlook for the county's future, local government, education and business leaders perceived a gap in the region's advanced telecommunications, and recognized its impact on the county's ability to attract new businesses, increase the performance of its education system and improve its residents' quality of life.

In December 2003, the Wireless Houston County Committee (WHCC) was formed as an informal group of local government, education and business leaders, with the goal of fostering collaboration between local governments and the private sector, while acting as a catalyst to make Houston County one of the first and largest wireless broadband counties in the U.S.

In March 2004, The WHCC passed a unanimous resolution authorizing Siemens Business Services, Inc. to conduct a study and deliver a report to the committee, which was to include:

- An assessment of the county's existing broadband infrastructure.
- An evaluation of the feasibility and economic viability of using wireless technology to provide universal broadband access throughout the county.
- An analysis of business model scenarios and recommendations on how the WHCC can move forward to accomplish its objectives.

This document represents Siemens Business Services' findings and recommendations from this study.

[1] Source: Projected from 2002 Census estimate. http://quickfacts.census.gov/qfd/states/13/13153.html

Executive Summary

The WHCC's stated objective is make Houston County a completely wireless community, as part of an overall strategy promote and prepare the county for more rapid economic and social growth. We believe this can be broken down into a more basic objective; to make broadband service universally available to all businesses and residents in the county. In this context, wireless broadband technology is an enabler; an assumption; the means and not the end.

Though unintended, the WHCC has found itself at the center of two industry wide debates; what role local governments should and will play in making broadband services universally available within their communities; and whether, or to what extent, wireless broadband technology will be used to achieve universal availability. This project has become a common point of reference in these debates, with interest being shown in the project by individuals in San Francisco CA, Washington DC, Amsterdam Netherlands, Melbourne Australia and Munich Germany.

The impact of the WHCC's decisions going forward, both in terms of direct impact to the community, and in influencing the outcome of these debates, cannot be overstated. Further, we understand that the recommendations made in this report may be perceived as controversial, provocative, or counter in some ways to the political ideology of local government, however we have attempted to address these objections through our analysis.

Our findings from this study are summarized below:

- While the infrastructure for broadband connectivity within Houston County is advanced and mature, providing value for the majority of business and residential subscribers, these services are not *universally* available throughout the county.

- No telecommunications provider has publicly stated the intent to provide universal broadband service throughout the county.

- Wireless broadband technology *is* the most technically and economically viable method of universally extending the reach of broadband services within a geographic area such as Houston County.

- We estimate the first-year cost to deploy, operate and maintain a countywide wireless broadband network to be $720,000.

Based on these findings, we recommend two scenarios for the WHCC to consider:

- The WHCC can transition from acting as a *catalyst* to a more active role to ensure that its objective for universal broadband is met. This may be accomplished through the formation of a non-profit organization, an authority or any other legal

entity deemed appropriate by the committee and authorized by local government to act on these recommendations. Should the committee choose this option, the business model referred to as *Cooperative Wholesale*, which is described in detail in the Business Model Analysis section of this report, should be adopted.

Cooperative Wholesale combines tactics currently used in a variety of other public infrastructure projects, including public/private cooperation, anchor tenant, aggregate demand, and horizontal integration (sometimes referred to as wholesale or neutral host). We believe this unique set of tactics has yet to be combined in the market as an overall strategy and policy and the opportunity exists for the WHCC to create a *blueprint* for universal broadband service within other communities.

- Should the WHCC be adverse to having local governments, through a non-profit or other vehicle, finance, own and operate a communications network, the committee should engage in more active and focused discussions with the private sector (namely the incumbent telecommunications providers) to accomplish their objective. We have discovered during this study a strong commitment from incumbent providers to respond to the needs of the Houston County community, and the importance of their assets as "facilities based" providers cannot be overstated.

Regardless of the option chosen by the WHCC, we recommend that the following actions be taken:

- Continue the committee's role of acting as a catalyst to promote public and private sector cooperation and stimulate private-sector investment.

- Begin a focused effort working with local governments to evaluate their current policies with respect to zoning ordinances, right-of-way and franchise fees, access to government-owned assets (such as communications towers), and coordination with infrastructure projects (such as roads and conduits), with the goal of easing the investment burden of the private sector.

- Further evaluate federal and state grant funding opportunities that may be used to support either of the above options.

- Further evaluate the aggregate broadband demand created by local government and quasi-government organizations to validate the financial impact of the above options.

Study Methodology

- Interviews were conducted with more than fifty individuals from various local governments, education institutions, businesses, interested parties and industry experts. The objectives, topics and questions varied depending on the organization or individual being interviewed.

- Secondary research was performed to review the demographics of the county, the current state of its broadband infrastructure, prior research work and case studies for similar initiatives.

- A wireless broadband network was temporarily deployed within the county to evaluate its performance characteristics and feasibility as a technology pursuant to delivery of universal broadband access.

- Analysis was subsequently performed to generate various business model scenarios and to produce our recommendations.

- The results of the data collection, analysis and recommendations were incorporated into this report.

Broadband Analysis

Based on the objective of this study, it was necessary to consider the following two questions:

- What data exists to validate that universal, countywide broadband access will result in more rapid economic and social development?
- Is the county underserved by existing broadband alternatives such as digital subscriber line (DSL), hybrid-fiber-coax (HFC) or other broadband service alternatives?

Economic & Social Impact

Substantial research work has been performed relating to the impact of universally available broadband on economic development.

- Dataquest Inc., a division of Gartner Inc., estimates that the deployment of "true" universal broadband could result in an increase in the U.S. gross domestic product of $500 billion annually over the next ten years[2].
- Yankee Group predicts $223 billion in costs savings with universally available broadband in the U.S.[3]
- The New Millennium Council quantifies the benefits of nationwide deployment of broadband for employment, projecting that the expansion of broadband has the potential to promote an increase of 1.2 million U.S. jobs[4].

During interviews with the Houston County Development Authority, a comment was made that "corporations who consider relocation to the county increasingly evaluate the status of the region's telecommunications system, not only in industrial and commercial facilities, but also in the surrounding residential areas". This is likely due to the corporations' desire to attract more highly skilled or specialized workers from a broader geographic area. These factors suggest a direct connection between the universal availability of broadband and the ability for the county to attract and retain new businesses in the region.

[2] See http://www4.gartner.com/5_about/press_releases/2002_08/pr20020826a.jsp

[3] *The Collaborative Commerce Value Statement*, Yankee Group, Boston, MA.

[4] *Understanding Broadband Demand: A Review of Critical Issues*. Office of Technology Policy, U.S. Department of Commerce

In addition to the impact on economic growth, prior research work also demonstrates a direct correlation between broadband availability, social issues and the quality of citizens' lives[5]:

Despite the apparent connection between broadband and social benefit, our view is that the deployment of a universally available broadband network in the county will *not*, on its own, delivery substantial benefit to the community. The real value from this initiative will be based on the extent to which the following scenarios and applications are deployed to make use of this network.

Teleworking – The process of performing work-related duties while away from an office location, although not necessarily from home, has been shown to provide substantial benefit to corporations. Benefits can include reductions in office space fees and the ability to gain access to a broader base of skilled or more specialized workers. The potential social impact for employees is even more profound:

- Reduced time commuting results in more productive work hours and reduced road congestion.
- Fewer work distractions benefit employees who do not rely on a great deal of personal interaction with others.
- More opportunities are available to people with disabilities, who may have the right skills for a given job, but difficulty with transportation; and
- With more dual-income families, the ability to telework eases the process of mixing professional and personal/family responsibilities.

E-Government – The ability for citizens to more easily interact with government agencies results in many benefits. Citizens can elect to obtain services and support from various government agencies off-hours, without interrupting their work schedules.

Distance Learning – Citizens who seek to complete or continue their education after joining the work force can leverage a broadband service to access distance learning applications. Distance learning students can also interact with students and faculty, while balancing their work life, providing a direct benefit to their quality of life. With nine post-secondary educational institutions within a 50-mile radius of Houston County, the impact on the community can be substantial.

In addition to these examples, there are many other direct and indirect social benefits in areas such as public safety, telemedicine and agriculture.

[5] A report by the Telecommunications Industry Association (TIA) entitled *The Economical and Social Benefits of Broadband* provides a thorough analysis of these issues. The report can be referenced at http://www.tiaonline.org/policy/broadband/Broadbandpaperoct03.pdf

Broadband Availability and Pricing

To estimate the availability of broadband services in Houston County, a geographic and demographic analysis was first performed to define household and business density. The results of this analysis were then combined with an estimate of existing broadband coverage areas.

As the following diagram demonstrates, higher household and business density (indicated by darker shading) exists in areas surrounding the three incorporate cities of Centerville, Perry and Warner Robins.

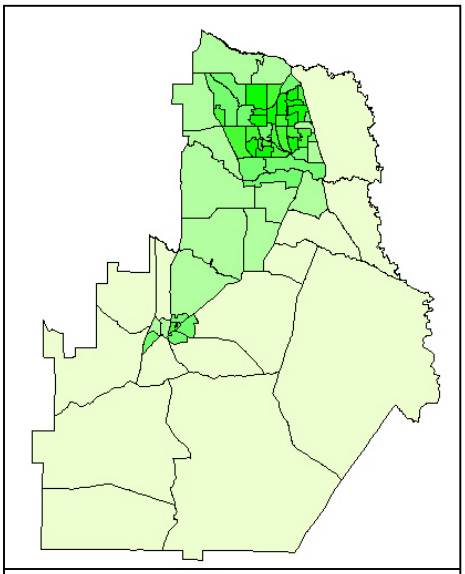

Figure 1
Household and Business Density

DSL Services

ALLTEL, BellSouth Corporation and ComSouth Corporation provide DSL service to business and residential subscribers in Houston County.

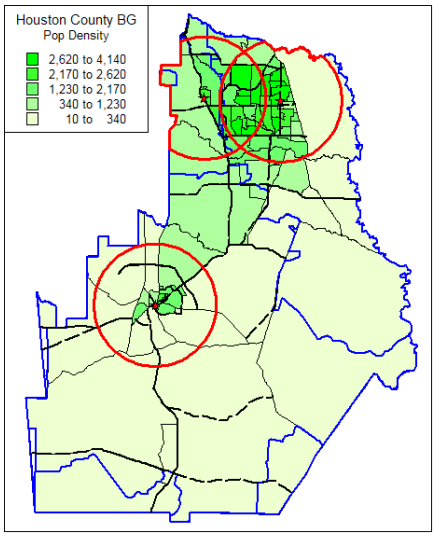

Figure 2
DSL Availability

The diagram above shows the DSL coverage areas serviced directly by the three central offices (COs) owned by ALLTEL and BellSouth, designated by the three red circles. These coverage areas extend to approximately three miles (18,000 feet) from each CO. Note that the red circles above do not represent the complete coverage area of ALLTELL and BellSouth due to both company's use of Digital Loop Carrier (DLC) equipment, which extends the reach of their DSL services to multiple points in adjacent areas.

- In addition to ALLTEL's two COs in Centerville and Perry, they have deployed 37 DLCs in various locations, which provide DSL availability to all but 117 households in their local exchange territory[6].

- In addition to BellSouth's one CO in Warner Robins, they have deployed 25 DLCs in various locations, which provide DSL availability to approximately 80% of all households in their local exchange territory[7].

ALLTEL provides DSL services to home and business subscribers in the cities of Centerville and Perry[8]. The price for ALLTEL's DSL home service is $34.95 per month, with promotional discounts for one or more months available at various times.

BellSouth Corporation provides BellSouth® FastAccess® DSL service in Warner Robins and the surrounding area. Three services are marketed to residential subscribers[9] (FastAccess DSL Lite, FastAccess DSL Ultra and FastAccess DSL Xtreme) and five

[6] Source: Interviews with ALLTEL representatives.
[7] Source: Interviews with BellSouth representatives.
[8] Source: http://www.alltel.com/dsl_internet/availability/georgia.html
[9] Source http://www.fastaccess.com/content/consumer/product_comparison.jsp

services are marketed to business subscribers[10] (FastAccess Business, FastAccess Business Static IP, FastAccess Business DSL Plus, FastAccess Business Speed 384 and FastAccess Business Speed 768).

BellSouth's DSL services have a variety of characteristics including upstream and downstream connection speeds, monthly price and other standard or optional features. Base prices for the residential services above range from $34.95 to $54.95 per month. Prices for the business services above range from $79.95 to $219.95 per month. Monthly prices for the home services may vary depending on whether the subscriber uses BellSouth's retail local voice service or other bundled service options such as long distance.

ComSouth Corporation provides their JetNet DSL service in certain southern parts of Houston County[11]. The JetNet service is marketed to both residential and business subscribers. These services have a variety of characteristics including upstream and downstream connection speeds, monthly price and other standard or optional services. Prices for the residential services range from $59.95 to $99.95 per month. Prices for the business services range from $99.95 to $139.95 per month.

Cable Services

Cable Internet services are provided in Houston County by Cox Communications Middle Georgia and Watson Cable Company.

Cox Communications provides their Cox High Speed Internet service in certain areas within Houston County. Two services are marketed to residential subscribers[12]; A Preferred Package (up to 3 Mbps download / up to 256 Kbps upload) priced at $49.95 per month and a Premiere Package (up to 4 Mbps download / up to 384 Kbps upload) priced at $89.95. Discounts off these monthly rates are available to customers who subscribe to other Cox services.

Cox Business Services also markets various services to business subscribers, including high-speed Internet (speeds up to 1.5 Mbps) as well as Fibernet, DS-1 and DS-3 level service (pricing not publicly disclosed).

Watson Cable Company provides their Watson Online Internet service in areas of Warner Robins and Centerville. Watson markets a residential service (approximately 500 Kbps)

[10] Source: http://www.fastaccess.com/content/product_comparison.jsp

[11] Source: http://www.cstel.net/ Secondary research could not be found to determine the location of ComSouth's central office or switching location.

[12] Source: http://www.cox.com/middlega/highspeedinternet/high%5Fspeed%5Finternet%5Fpricing.asp

priced at $34.99 per month and a business Internet service (bandwidth not publicly disclosed) priced at $99.99 per month[13].

Estimating the coverage area for cable internet service is difficult (relative to DSL providers) due to the HFC network architecture used by many cable operators. The following data from Warren Communications News, the leading publisher of news, analysis and research in the fields of telecom, broadcasting, the Internet, satellites, consumer electronics and related industries, does provide some insight to the coverage characteristics for Cox Communications Middle Georgia:

Counties Served	Bibb, Houston, Jones, Monroe, Peach
Miles of Plant	1,623 coax, 35.0 (planned); 176 fiber-optic, 159 (planned)
Homes passed	106,568

While this data does not state the percentage of land area, households or population covered within our focus area, it does suggest the following:

- 1,623 miles of coax and 106,568 homes passed suggests a deployment estimate of ~ 65 households per line mile of coax cable.

- With a combined estimate of 333,716 households in Bibb, Houston, Jones, Monroe and Peach Counties[14], this suggests that Cox Communication Middle Georgia covers ~32% of the households in the combined five-county territory.

Note that the estimates provided above were obtained from secondary sources only and likely do not reflect the actual coverage characteristics of Cox Communications Middle Georgia.

Broadband Availability & Pricing Summary

We estimate that the combination of DSL and cable broadband services currently provide availability to 80-90% of the households and businesses in the northern half of the county. Additional findings are provided below:

- Broadband availability tends to be deployed first and concentrated most in areas with the highest household and business density.

- Broadband availability in the southern and southeastern parts of the county could not be determined, but is assumed to be minimal.

- The degree to which DSL services overlap is minimal due to the regulation of local exchange areas.

[13] Source: http://www.watsononline.net/

[14] Source: 2000 Census

- The degree to which DSL and cable services overlap is higher, although the extent of overlap could not be calculated without coverage data from the cable operators.

- The providers' use of regional or national standard pricing seems to imply no direct link between local market competition and the price paid by subscribers. Pricing competition for these services seems to result more from the degree of overlap within the *total* area providers operate within. The relatively high price paid for ComSouth's DSL ($59.95/month) seems to validate this point.

Technology Analysis

Technology Overview

The term *broadband* is loosely defined and often varies depending on the timeframe (e.g. 2001, 2003, 2005) and the delivery method (wireline, fixed wireless, mobile wireless) being referenced. It is important to establish a working definition for this report; therefore we have chosen to refer to the term broadband as synonymous with the Federal Communications Commission's (FCC) definition for "advanced telecommunications"[15]. This definition is:

"Services and facilities with an upstream (customer-to-provider) and downstream (provider-to-customer) transmission speed of more than 200 kbps."

To address our assumption that wireless broadband technology may be, or may become, the most technologically feasible and economically viable method to extend universal broadband throughout Houston County, it is important to provide a baseline understanding of existing wireless broadband technologies and a review of how these technologies are expected to evolve over time.

Non-standard, non-interoperable (so-called proprietary) wireless broadband solutions have been available from a variety of equipment vendors for several years. More recently, there has been renewed interest in this technology, which is due to a number of industry developments, including:

- The IEEE[16] began development of a family of standards in the late 1990's for what is referred to as 802.16x wireless metropolitan area network (WMAN) specifications. The "x" refers to letters used to designate a variety of WMAN standards.

- The first version of this standard, referred to as 802.16, was published in April 2002 and addressed fixed (meaning that subscribers are not mobile), line of sight (meaning that the base station and subscriber antennas are within sight of each other) technology. The 802.16 standard focused on various licensed wireless

[15] Federal Communications Commission – Third Report - Deployment of Advanced Telecommunications Capability to All Americans in a Reasonable And Timely Fashion - Docket No.: CC 98-146 - http://hraunfoss.fcc.gov/edocs_public/attachmatch/FCC-02-33A1.pdf

[16] The Institute for Electrical and Electronics Engineers – An organization focused on the development of technical standards.

frequencies (meaning licensed and regulated by FCC policy) in the 10-66 GHz range.

- Wireless broadband equipment and component suppliers founded a non-profit organization called the WiMAX Forum™ in 2003, with a charter to facilitate the deployment of wireless broadband networks and ensure interoperability of the 802.16x-based products. The organization's membership has grown quickly to include leading companies such as Airspan Networks, Alvarion Ltd., Aperto Networks, Ensemble Communications Inc., Fujitsu Microelectronics America, Intel Corporation, Nokia, OFDM Forum, Proxim Corporation, Siemens ICM and Wi-LAN Inc.

- The 802.16a standard was ratified by the IEEE in January 2003, which built on the original 802.16 standard by adding non-line-of-site capability, operating in both licensed and unlicensed wireless frequencies in the 2-11 GHz range.

- The 802.16REVd standard, designed to consolidate features in 802.16 and 802.16a for improved performance, ease of deployment, and to replace incorrect, ambiguous, or incomplete material, is expected to be ratified June 2004.

- Work is also underway on the 802.16e standard, which is designed to support mobile subscribers, and is expected to be ratified late in 2004.

Once a technology become standardized and made interoperable, its market tends to grow dramatically, and the ratio of price to performance tends to decrease quickly[17]. This is due in large part to the interoperability that is created between vendors, the removal of the R&D burden for suppliers who previously had to invest in proprietary efforts and efficiencies gained through volume manufacturing. Further, Intel Corporation's initiative to produce WiMAX-based silicon (chips that power these communications components) will result in a further reduction of equipment costs, particularly in subscriber equipment.

It is important to note that, as of the date of this report, there are currently no products on the U.S. market that meet the definition of WiMAX, since the term is reserved for products which adhere to the 802.16 standards and have been tested and certified for interoperability by the WiMAX Forum. The first WiMAX certified products are expected to begin shipping in late 2004.

Despite this fact, numerous equipment providers, including Alvarion (the company whose equipment was used during our test deployment) provide solutions that are

[17] This phenomenon is often referred to as being a combination of *Moore's Law* and *Metcalfe's Law*. Moore's Law is based on the observation made in 1965 by Gordon Moore, co-founder of Intel, that the number of transistors (and therefore computing performance) per square inch on integrated circuits had doubled every year since the integrated circuit was invented. Moore predicted that this trend would continue for the foreseeable future.

Metcalfe's Law, based on Robert Metcalfe's (founder of 3Com Corporation and inventor of Ethernet), states that the usefulness, or utility [value], of a network equals the square of the number of its users.

commonly called "pre-WiMAX" (meaning they adhere to the majority of the ratified standards). These products are upgradeable in most cases, and are providing value in hundreds, if not thousands of networks today.

The initial, fixed versions of these standards, 802.16 and more importantly 802.16a, are ideally suited to provide backhaul (connectivity from a last-mile network or wireless hotspot to an Internet backbone) as well as a complement or alternative to traditional last-mile solutions such as DSL and cable. The following diagram illustrates this point:

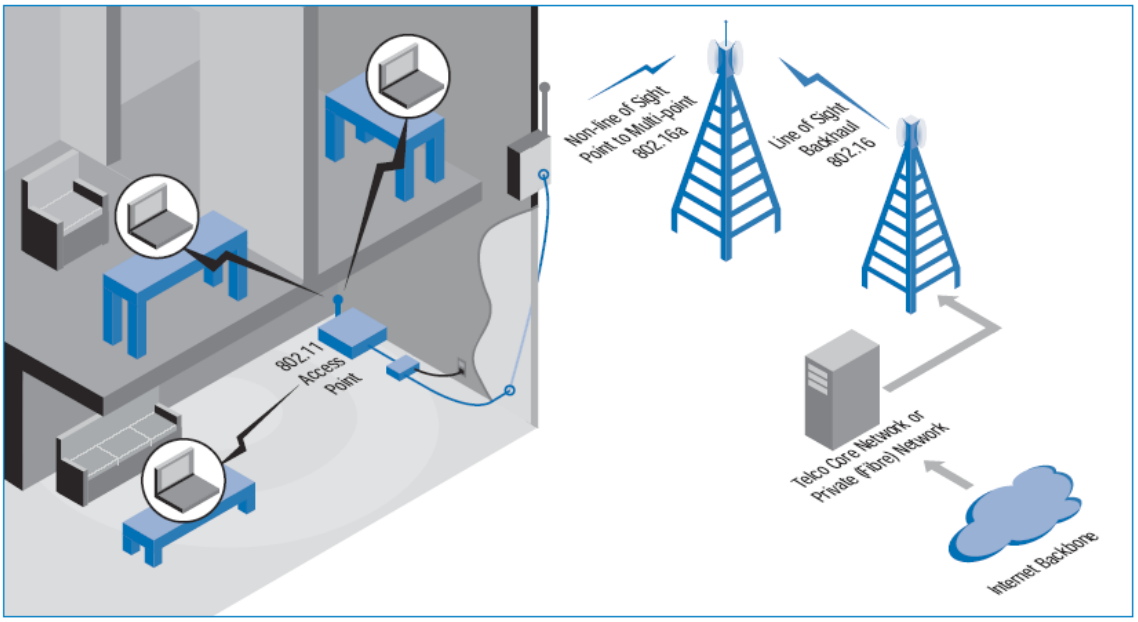

Figure x:
802.16 and 802.16a Deployment Scenarios

Source: Intel Corporation

802.16a solutions are designed to support:[18]:

- Non-line-of-site or near-line-of-sight operation (depending on the frequency used and configuration).
- Large "cell sizes" of 30 miles.
- Both licensed and unlicensed wireless frequencies in the 2-11 GHz range.
- 72 Mbps (megabits per second) of net available bandwidth per sector.

While the early 802.16x standards and implementations will be fixed, and will require outdoor-mounted antennas, the roadmap over the next few years will introduce indoor-mounted antennas, portability and vehicular-level mobility. The following chart provides an overview of how and when these evolving standards are expected to support different characteristics and usage models.

[18] Source: WiMAX Forum http://www.wimaxforum.org/news/press_releases/WiMAX_Forum_Overview/

	1st Half 2005	2nd Half 2005	2006-2007
Characteristics & Usage Models	• Outdoor install • Fixed wireless	• Indoor install • Fixed wireless • Portability for roaming within a service area	• Embedded in device • Mobile • Higher speed • Roaming across service providers
Standards	802.16REVd	802.16REVd & 802.16e	802.16e

Figure 3
802.16x Roadmap & Usage Models

We recommend that the WHCC consider this roadmap given their current objective for universal broadband. An initial deployment of wireless broadband technology, which may provide access to all fixed locations within the county, should also be considered an infrastructure that prepares the county to support usage models over time that require mobile broadband connectivity.

Feasibility Test Results

During this study, a test network was deployed in the county to evaluate the performance characteristics of available wireless broadband technology.

Note that a full, countywide radio frequency (RF) survey was not performed during this study, and the results provided below should be used only to validate rough estimates for the infrastructure and equipment requirements and capital expenditures for an eventual countywide deployment. Prior to moving forward with the deployment of a commercial network, a comprehensive countywide RF survey, network design and financial model should be created.

The following provides an overview of the process used to conduct the feasibility testing:

- Wireless broadband base station and antenna equipment from Alvarion, Inc., a worldwide leader in wireless broadband systems, was installed on a single communications tower located at Leverett Road in Warner Robins.

- The specific technology evaluated was based on Alvarion's BreezeAccess VL (5.8 GHz unlicensed), wireless broadband solution.

- Wireless broadband subscriber units and antennas, also from Alvarion, were deployed at five remote locations in the county, ranging from three to twelve

miles in distance from the communications tower. Further detail on these locations is shown below:

Location	Address	LAT	LONG	Distance From Base Station
The Park Complex	701 Park Drive, Warner Robins	N 32 35.7320	W 083 36.6993	3.03 Miles
GA Agricenter	401 Larry Walker Pkwy, Perry	N 32 26.4231	W 083 45.0347	12.27 Miles
Police Training Ctr	Stalnaker Ave Warner Robins	N 32 34.9678	W 083 35.7395	4.15 Miles
County Courthouse	201 Perry Pkwy Perry	N 32 28.1660	W 083 42.1406	9.43 Miles
Royal Oaks Subdivision	Royal Crest Circle, Kathleen	N 32 32.3683	W 083 42.6628	5.13 Miles

- RF scans were conducted at each test location to identify sources of interference.
- Readings were taken to evaluate the signal strength and net throughput (amount of upstream and downstream data sent during a time interval) between each test location and the base station.
- All testing was performed using a point-to-multipoint configuration, using the near-line-of-site capabilities of Alvarion's BreezeAccess VL solution.
- The base station antenna equipment was oriented in generally a South-Southeast direction, providing approximately a 120-degree span of coverage.

A two-dimensional diagram showing the location of the communications tower in relation to the five test locations and a three-dimensional diagram showing the topographical characteristics of the test area are provided below:

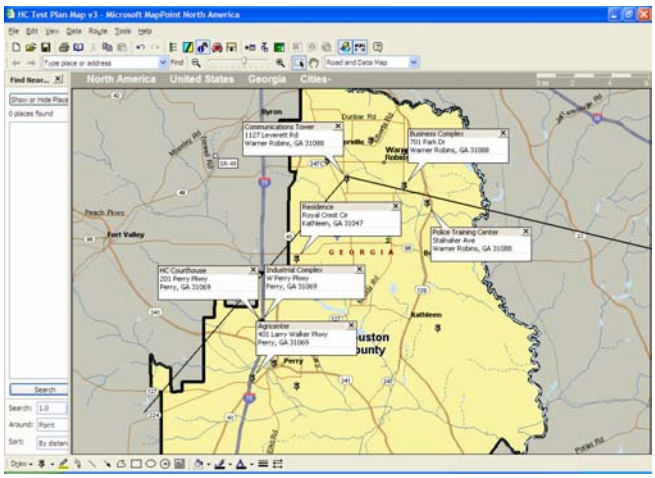

Figure 4
Tower and Test Site Locations

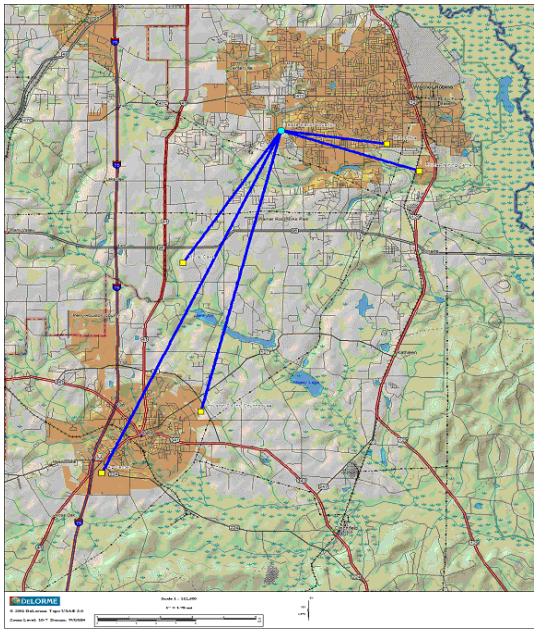

Figure 5
Topographical Map

In order to maintain a concise format for this report, we have chosen to provide the detailed test results from only one of the five test locations; the Georgia National Fairgrounds and Agricenter, which was the furthest distance tested. The test results from the other four locations were similar. The results of the passive RF scan at the Agricenter are shown below:

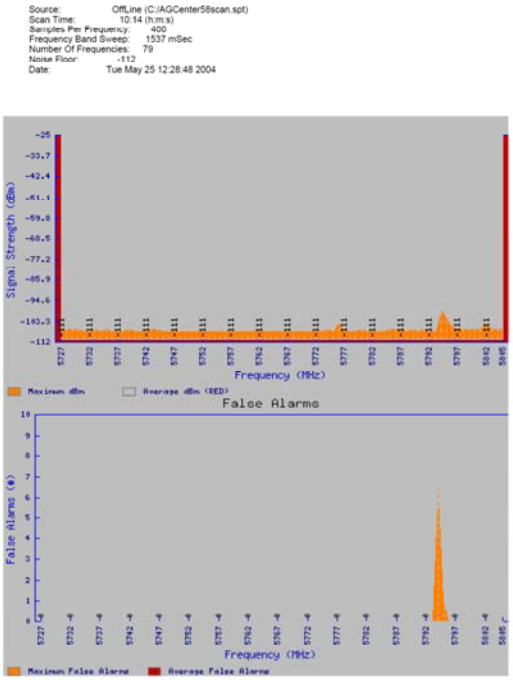

Figure 6
Agricenter RF Scan Results

The above spectrum analysis reveals minimal RF noise in the 5.725 to 5.850 GHz frequency band at the Agricenter. There was no substantial RF interference source in this area, an indication that any specified channel within the 5.8 GHz band should function well.

The link path analysis and link path photograph below demonstrates that the Agricenter site presented some RF path challenges. While the base station ground elevation was higher than the test location ground elevation, the average tree and foliage height was approximately 100 foot along the path and the RF path was not clear.

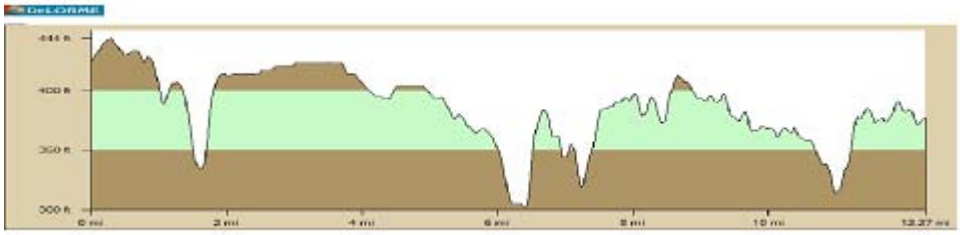

Figure 7
Agricenter Link Path Analysis

Figure 8
Link Path Photograph

Despite the 12-mile distance and the near-line-of-site conditions, the system provided a stable link, with a net throughput of 6.8 Mbps. Actual bandwidth tests were run to and from the Internet as well (limited by our fractional DS-3 Internet connection). These results are shown below:

- Downstream traffic from www.dslreports.com - 4.6 Mbps
- Upstream traffic to www.dslreports.com - 2.9 Mbps

Deployment Scenario

Based on the data collected during the feasibility testing, combined with Siemens Business Services, Intel and Alvarion's experience in similar deployment, we were able develop an example deployment scenario to demonstrate how a countywide wireless broadband solution might be implemented. Note that this deployment scenario should not be used as the *only* basis for an eventual deployment. A full, countywide RF survey and detailed design should be considered during a future phase of this project.

During the feasibility testing, a *sectorial-cell* architecture was used, whereby all customer premise equipment (CPEs) communicated directly with a single base station radio. A logical diagram showing this configuration is shown below:

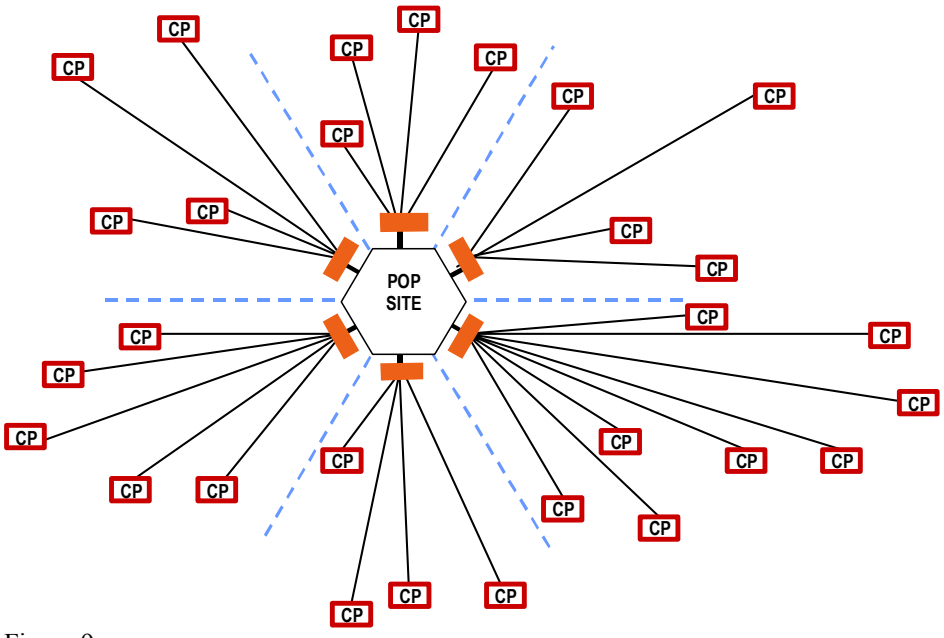

Figure 9
Sectorial Cell Architecture

An alternate approach is a distributed, m*icro-cell* architecture, which still uses a base station as a central point, but includes repeater sites strategically positioned within certain subscriber markets. A logical diagram showing this configuration is shown below:

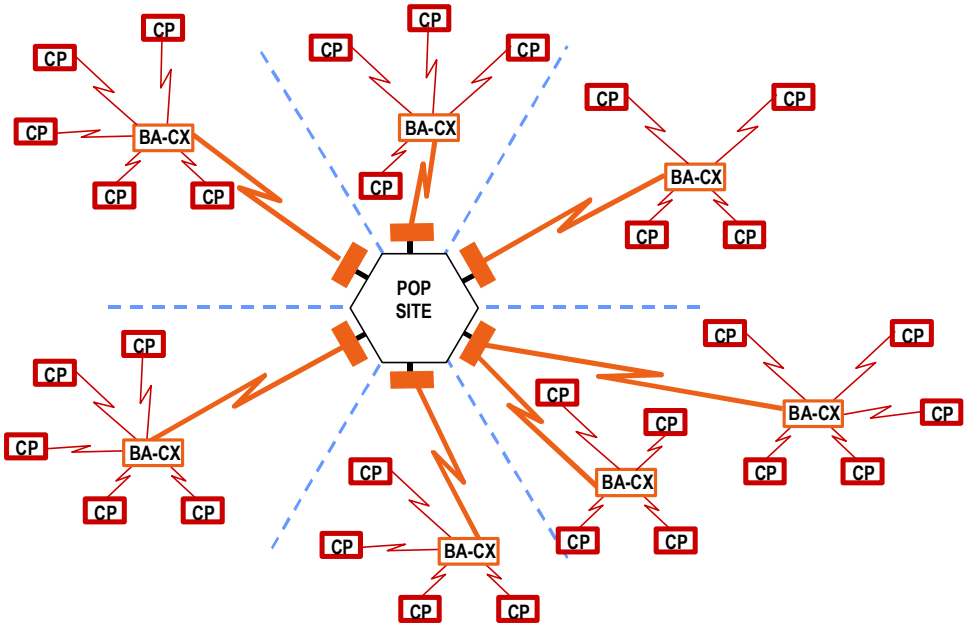

Figure 10
Micro-Cell Architecture

A combination of these two architectures is required for universal coverage within Houston County. The criteria used to make this determination include:

- The considerable change in elevation that exists throughout the county.
- Performance, while excellent, was hindered due to the lack of a clear RF path in some areas.
- The need to minimize the distance between a proposed subscriber and an *access point* radio in order to cover the more challenging areas of the county and optimize performance.
- Heavy foliage in certain areas that may prevent RF propagation unless a distributed model is implemented along with the base station infrastructure.

The following diagram shows the theoretical coverage area that could be provided from two communications towers in the county, using a combination of the two network architectures described above.

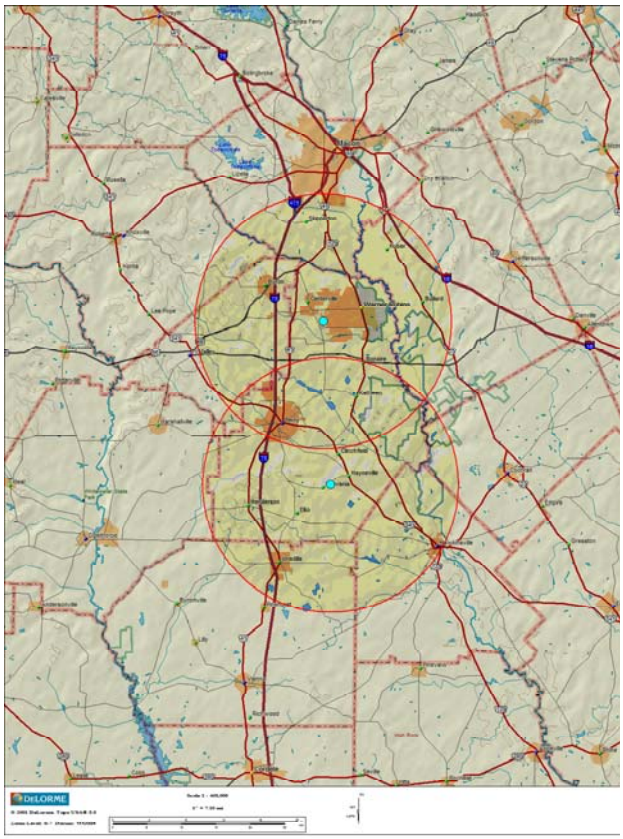

Figure 11
Theoretical Single-Tower Coverage Area

This theoretical coverage area demonstrates the ability to extend approximately 25 miles around the designated base stations. In order to provide universal coverage, the micro-cell architecture will also need to be deployed. Small markets should be targeted using repeater sites that will provide a wireless bridge from the potential subscriber locations to the designated base station. This will enable wireless maneuverability around the challenging terrain that presents itself throughout the county.

A single base station in this sectorized model will yield 72 Mbps of net distributable bandwidth (18 Mbps per 90-degree sector). This bandwidth can then be allocated throughout the coverage area and distributed to each individual geographic region as needed. The coverage areas can be targeted using the aforementioned coverage model and bandwidth can be allocated based on different subscriber requirements.

In summary, we estimate that two communications towers, one generally-located in Warner Robins and one in the Central-Southern half of the county, deployed using a combination sectorial and micro-cell architectures, can provide universal broadband access throughout the county. Additional details for this deployment scenario are provided below:

- Four 90-degree sectorial antennas are installed on each of the two communications towers. The antennas are cabled to access unit equipment, which are housed in equipment rooms at the base of the communications towers. This provides a 360-degree coverage around each base station.

- One of the base stations is designated to provide the backbone connection to the Internet. The other base station is connected via a point-to-point wireless broadband link.

- Sectorial antennas are mounted at government and large business subscriber locations, which provide business-class, guaranteed bandwidth by communicating directly to a base station.

- Repeater sites are deployed at a variety of locations where subscribers require a lower class *best effort* service, such as small business parks and residential neighborhoods.

- Outdoor antennas are installed at small business and residential subscriber locations and provide access to the network through the repeater sites.

- A network operations center (NOC) is deployed to provide the infrastructure needed for proactive monitoring and maintenance of the network.

Based on the above deployment scenario, which served as the basis for the initial deployment cost estimates presented in this report, the resulting network can be configured to provide various types and qualities of service, to a variety of target markets.

Should the WHCC choose to adopt the Cooperative Wholesale model, which would support anchor local government and quasi-government tenants, each of the eight sectors of the network could be configured to support 60 business-class, guaranteed 1.5 Mbps connections each (assumes 18 Mbps of net available bandwidth per sector, with an oversubscription rate of 5:1). Numerous other configurations could be combined depending on subscriber needs.

Risks

Concerns are often raised about the ability for wireless broadband technology to provide the robust security and quality of service (QoS) inherent in today's wireline networks. A brief overview of these issues is provided below:

Security

The 802.16x family of standards was built from the ground-up to support advanced levels of security. Authentication and registration are part of the core standard. Authentication is based on Public Key Infrastructure (PKI) based X.509; an international standard which defines the prevailing technology for digital certificates and other security measures. These certificates allow for unique authentication of a transmitting device back to a base station. This allows a base station to evaluate a transmitter to determine if it is authorized to receive service.

Current-generation wireless broadband solutions, such as those from Alvarion, also combine the Advanced Encryption Standard (AES), a Federal Information Processing Standard (FIPS) Publication that specifies cryptographic algorithms for use by U.S. Government organizations to protect sensitive information. These solutions are securely deployed within many U.S. and international government and public safety agencies today.

Quality of Service

The 802.16a standard includes Quality of Service (QOS) features that enable services such as voice and video that require a low-latency network. These features enable an operator to simultaneously provide premium, guaranteed levels of service to businesses, and high-volume "best-effort" service to homes, all within the same base station service area.

Unlike the 802.11 (wireless LAN) standards, which use "contention-based" access techniques, the 802.16a standard uses a "scheduling protocol" for controlling access and scheduling to the system and prioritizing latency-sensitive traffic.

Despite these built-in QoS mechanisms, the use of unlicensed wireless spectrum, like the 5.8 GHz equipment used during our testing, limits the ability of an operator to *guarantee* quality of service due to malicious of unintentional *self interference* (interference caused by other providers who choose to operate in an overlapping geographic area). Our view is that these risks can be mitigated through a disciplined architecture and design, cooperation amongst providers[19] and should be further reduced by technology innovation in this area[20].

[19] An example of unlicensed wireless broadband operator cooperation is the Wireless Broadband Access Network Coordination (BANC) group, fixed-wireless operators who are working together to minimize interference and maximize reliability and spectrum efficiency. http://www.wbanc.com/

[20] A groundbreaking report entitled *The Radio Revolution* by Kevin Werbach of the New America Foundation explores advances in radio technology that should result in more efficient use of wireless spectrum.
http://wireless.fcc.gov/outreach/2004broadbandforum/comments/NewAmericaPublicKnowledge.pdf

Cost of Subscriber Equipment

An important issue to consider with any communications business is the cost of customer premise equipment (CPEs) required to "provision" a new subscriber. While the cost of wireless broadband CPEs are currently high, relative to the cost of CPEs for more established technologies like cable and DSL, our view is that this risk may by minimal for Houston County based on the following:

- Government and business subscribers are less sensitive to higher CPE cost due to the relative cost of the CPE compared to their monthly telecommunications costs. Based on the assumption of a Cooperative Wholesale model, initial subscribers are likely to be local government and quasi-government tenants, with business and residential subscribers being serviced through commercial retail providers, this minimizes the risk.

- As mentioned earlier, standards efforts and volume manufacturing are expected to result in dramatic decreases in the cost of CPEs over the next two years, so this risk should be reduced over time.

Technology Summary

Our view is that wireless broadband technology may be, or may become the most technically and economically viable method to extend universal broadband service to a large geographic area such as Houston County. The following excerpt from a report entitled *The Market Structure of Broadband Telecommunications* established the baseline analysis and findings needed to support this case[21]. While detailed, this analysis is critical to understand our recommendation.

[21] *The Market Structure of Broadband Telecommunications*: Gerald R. Faulhaber and Christiaan Hogendorn: Copyright 2000 by Blackwell Publishing Ltd

> There are generally three types of costs associated with communications systems: (i) a cost per unit of usage (such as a minute or a packet); (ii) a cost per user (such as the cost of the access connection); and (iii) a cost per potential user of service availability (such as the cost to extend, say, a fiber optic line down a street).
>
> The latter two costs are somewhat different than might occur in other industries, although they are typical of infrastructure systems. For example, a provider of fiber services would have to construct its network of fiber lines underneath the streets (or on telephone poles), and its choice of which homes and businesses to pass with such lines would determine its target market. However, simply laying the cable does not connect the homes so passed.
>
> It is this network investment decision that makes broadband networks, indeed most network infrastructure, a unique problem. Once a network is built with a specific scope, then the network can be used to provide service to *everyone* within this market region, and *no one* outside this region. In order to serve a *single* customer in a neighborhood (say, a city block), a network service provider must provide a facility (say, a fiber optic cable passing under the street) that is capable of serving *all* the households in that neighborhood.
>
> Recently a great deal of attention has focused on what technology will be used to provide broadband access, with hybrid fiber-coax (also called cable modem) and DSL the leading contenders. At this time, HFC, which consists of a fiber-optic network connected to homes and businesses using coaxial cable, is the only contender which can provide true broadband (up to 10 Mbps) at reasonable cost.

The report referenced above, published in 2000, makes the case that HFC, commonly referred to as "cable", was the most economically viable technology to provide broadband access. Despite the fact that many other issues influence the success of one technology or another (regulatory, political, strength of providers, etc.), the transition that cable operators have made from being primarily a one-way media for transmission of broadcast video in the late 1990's to almost sharing the market for broadband connectivity with DSL operators, and their prospects for the "triple play" of voice, data and video bundled services, establishes the validity of the authors' findings.

When we consider the more detailed framework of the report referenced above, combined with developments in recent years with wireless broadband technology, our conclusion is that HFC, DSL, Fiber and other wireline business models are not as economically suited to reach the larger, more sparsely populated geographies required for universal broadband. The WHCC's ability to recognize this trend, and to react to it, can create substantial benefit for Houston County.

Business Model Analysis

Role of Local Government

While first-generation Internet access relied on the almost universal telephone network for dial-up connectivity, broadband service requires new infrastructure such as fiber, coaxial cabling and digital switching equipment. Given the relatively high capital investment needed to deploy and maintain this infrastructure, it is assumed that commercial broadband providers consider each community's business and household density, demographics, prospects for aggregate demand and other factors in deciding where and when to make these investments.

In many communities that have failed to attract the commercial investment required for universal broadband, local governments have begun to take a more active role. The policies adopted by local governments vary greatly[22], but are typically focused on either direct or indirect involvement in the supply-side (making broadband service universally available) or demand-side (stimulating demand for broadband service). A review of various policies used by local governments is provided below, along with our recommendations on options for the WHCC.

Supply Side

Municipal Ownership – refers to a model whereby local governments choose to finance, deploy, own and operate a broadband network. This model can refer to either a completely government-owned network or a cooperative network (similar to the EMC; an electrical utility company owned by its customers/members).

While the Municipal Ownership model has the advantage of ensuring universal broadband service for a community, it is often criticized due to the following potential disadvantages:

- It can and often does result in a tax burden for residents of the community.
- It can result in a perception that the public sector is "competing with" the private sector, a negative perception in more conservative political environments.
- In the cooperative model, it may require having utility (e.g. gas, electric, water) customers "subsidize" the capital costs for the deployment of the network.

[22] A report from the Organization for Economic Co-operation and Development (OECD) entitled *Broadband Infrastructure Deployment: The Role of Government Assistance* provides additional detail on the various policies in this area. The report can be referenced at http://www.olis.oecd.org/olis/2002doc.nsf/linkto/dsti-doc(2002)15

During interviews conducted with local officials in Houston County, we observed a conservative political viewpoint with respect to this issue. There was a consistent view among elected officials that "if the private sector was willing to provide universal broadband service, then local governments should not compete with them". There was also a strong commitment to maintain the tax cap that has been in existence in the county since 1982, and not to burden their taxpayers.

Financier – refers to a model whereby local governments provide financing for the private sector to promote investment in universal broadband. There are a variety of mechanisms that can be used to accomplish this including:

- Grants
- Guaranteed Loans
- Bonds
- Tax Incentives

There are a number of Federal funding options that the WHCC can leverage, or at a minimum promote, in their efforts going forward. A review of the most relevant programs is provided below:

Rural Utility Service (RUS) – The U.S. Department of Agriculture's Rural Broadband Access Loan and Loan Guarantee Program[23] made $1.4 billion in loans and loan guarantees available in 2003 to provide broadband services in rural communities. These loans can be used to facilitate deployment of technologies to provide two-way data transmission of 200 kbps or more, in communities with populations up to 20,000.

Technology Opportunities Program (TOP) – The U.S. Department of Commerce's TOP Program[24] gives grants to state, local and tribal governments, health care providers, schools, libraries, police departments, and community-based non-profit organizations. Projects must demonstrate how they can, through the use of technology, support lifelong learning, help public safety officials protect the public, assist in the delivery of health care and public health services, and foster communication, resource-sharing, and economic development within rural and urban communities.

To date, the TOP program has awarded 583 grants, totaling $218.9 million and leveraging $297 million in local matching funds.

SAFECOM Program – The U.S. Department of Homeland Security's SAFECOM Program[25] provides grant funding to improve the effectiveness of public safety communications systems and to resolve interoperability issues. The program was

[23] http://www.usda.gov/rus/telecom/broadband.htm

[24] http://www.ntia.doc.gov/top/

[25] http://www.pswn.gov/about.cfm

established in 2002 to address the wireless communication needs of public safety organizations. SAFECOM serves as the umbrella program within the Federal government to help local, tribal, state and Federal public safety agencies to improve public safety response through more effective and efficient interoperable wireless communications.

Enabler – refers to a model whereby local governments revise their policies to ease the investment burden of the private sector. This may include:

- Easing zoning policies and ordinances wherever possible (e.g. tower or facilities placement).
- Reducing right-of-way fees.
- Relaxing or re-negotiating franchise fees in exchange for infrastructure commitments.
- Discounting access to government-owned assets (e.g. communications towers).
- Coordinating infrastructure projects with providers (e.g. conduit during road construction).

We recommend that the WHCC begin a focused effort to work with local governments to evaluate their current policy in these areas and make recommendations to achieve the committee's objective for universal broadband.

Demand Side

Anchor Tenant – refers to a model whereby local governments agree to become a "customer" in exchange for a broadband provider's commitment to deploy universal broadband access within their community.

In a recent citywide wireless broadband deployment, Cerritos California allowed the use of city-owned mounting assets, and made a commitment to be the anchor tenant of a wireless broadband network run by a wireless Internet service provider (WISP)[26].

We recommend that the WHCC (working with local governments) consider the anchor tenant model as a tactic to stimulate private investment in wireless broadband. This will be addressed further in the business model summary below.

Demand Aggregation – refers to a model whereby local governments and businesses within a geographic region "pull together" and document sufficient demand to justify investment by a broadband provider. This could be referred to as a superset of the anchor tenant model above, with the addition of the business community.

[26] http://www.tropos.com/pdf/Cerritos_Casestudy.pdf

The concept emerged in the western Massachusetts county of Berkshire in the late 1990's[27] and appears to have seen modest success, despite their provider's (Global Crossing) difficulties in recent years.

A more recent study on the feasibility of this model was performed by Mercer University for the Georgia Department of Industry, Trade and Tourism in late 2003[28]. The study, *Connect One Georgia*, while making a credible case for the demand aggregation model's ability to stimulate economic development in Georgia, concluded that "there were no vendors willing to submit a positive response" and "their decision was based simply on economic reasons".

We recommend that the WHCC consider future developments in this area, however we do not believe that the geographic size, business density, and other demographics of Houston County would permit the WHCC to meet their objectives solely based on a demand aggregation model.

Business Model Components

Like the term *broadband*, the term b*usiness model* is often used loosely, and in different ways depending on the context. For the purpose of this report, the term *business model* will refer to the unique "assembly" of the following three characteristics of a telecommunications business:

- ***Value Chain Functions*** – refers to the various functions that must be performed for a viable, end-to-end telecommunications business.

- ***Degree of Provider Integration*** – refers to the number and type of public and/or private sector organizations who are involved in providing the value chain functions referenced above.

- ***Economic Model*** – refers to the financial characteristics of a telecommunications business. This may include issues such as "for free vs. for fee" or revenue sharing arrangements by the value chain providers.

[27] Berkshire Connect Assessment and Recommendations Report – Massachusetts Technology Collaborative http://www.bconnect.org/assess.htm

[28] *Connect One Georgia: An Economic Development Initiative of Mercer University* – Richard Goddard, Major General USAF (Ret), Senior Vice President for Administration

Value Chain Functions

For any viable telecommunications business, there exists a diverse set of functions that must be performed. The following diagram provides a high-level overview of the most common telecommunications value chain functions.

- ***Ownership*** – the functions required to finance the deployment and maintain ownership of a network.
- ***Operation and Maintenance*** – the functions required to design, build, operate and maintain a network and any backend systems for providing subscriber services (e.g. Web hosting, email and voice services).
- ***Service and Support*** – the functions required to provide customer service and end-user support for network subscribers.
- ***Settlement & Billing*** – the functions required for invoicing subscribers and coordinating financial transactions across the different value chain providers (e.g. revenue sharing arrangements and roaming).
- ***Marketing and Sales*** – the functions required to define, price, market and sell subscriber services within a target market.

Degree of Provider Integration

Historically, the telecommunications industry has consisted of "vertically integrated" providers that chose to deliver all or most of the five value chain functions described above in a direct, end-to-end way[29].

Due in large part to various federal policy changes[30], and more recently, the growth of unlicensed wireless deployments, the telecommunications industry has continued to

[29] *A Value Chain Perspective on the Economic Drivers of Competition in the Wireless Telecommunications Industry:* Alfred P. Sloan School of Management - Massachusetts Institute of Technology. This report provides a more detailed analysis of the impact of horizontal integration on the wireless telecommunications industry. mitsloan.mit.edu/research/clockspeed/ Wirelessthesisfinal.doc_1.doc

progress to a more horizontally integrated model; meaning that a variety of providers are involved in delivering an end-to-end telecommunications service.

We predict that this trend will continue to accelerate in the area of wireless broadband services. The relevance for Houston County is that this trend typically results in an increase in the number of commercial providers within a geographic region and an increase in the competitiveness of broadband pricing, both of which are critical for universal broadband service within the county.

Economic Models

There are two basic economic models that should be considered by the WHCC.

Commercial Service - refers to an economic model whereby telecommunications services are provided to subscribers in exchange for a fee. This of course represents the majority of broadband services today.

Community Service – refers to an economic model whereby telecommunications services are provided to subscribers within a community at no cost. This model is increasingly being used to provide wireless access in a number of cities around the U.S., with the main objective being "urban renewal". Many city governments are taking this step to attract more commerce into downtown, urban areas that have seen business decline due to residential migration to suburban areas[31].

We believe that, given the geographic size, and the estimated cost to provide universal coverage and capacity on a countywide basis, the Community Service model is not a viable approach for the WHCC to promote (except as a complement to the broader countywide deployment, in small downtown districts for example). Further, Community Service networks tend to be designed as *amenities* and subscribers are more tolerant of service outages and downtime than the government, education, industrial and commercial customers within the county are likely to be.

[30] This refers specifically to *the Cable Communications Act of 1984* and the *Telecommunications Act of 1996*, which are often credited with an increase in competition, lowering of prices and more rapid market growth.

[31] The city of Long Beach, Calif., announced that it would make free wireless Internet access available in its downtown area as part of an effort to attract visitors and companies to the business district. http://www.longbeachportals.com/press-clippings/nytimes/NYTimes-1-6-03.htm. In addition, many other cities have announced similar plans, including Austin, TX (www.austinwireless.net), the Greater San Francisco Bay Area (www.bawug.org), British Columbia (www.bcwireless.net), Atlanta, GA (www.atlantafreenet.org), and Houston, TX (www.houston-wireless.net)

Business Model Recommendations

Based on the breakdown and analysis of the value chain, provider integration and economic models provided above, there are several approaches the WHCC can take to meet their objectives. Should the WHCC adopt the more active role of owning the network, we recommend a *Cooperative Wholesale* model.

The Cooperative Wholesale model leverages the horizontally integrated approach, whereby the local governments (through a non-profit or other vehicle) finance, deploy, own and operate a wireless broadband network throughout the county, but do not sell access to the network directly to business or residential subscribers. Instead, access to the network would be sold to commercial operators, at discounted rates, allowing them to either extend the reach of their exiting subscriber networks or begin offering new services within the county.

We believe that this model has been validated through the much-publicized Allconet project, a countywide deployment in Allegany County, MD[32]. The Allconet project may represent a baseline strategy for a viable, universal broadband strategy within Houston County.

While it was outside the scope of this study to evaluate and aggregate existing telecommunications costs within the local governments, we believe that the aggregate cost savings for existing broadband services by county and city governments, schools, libraries, hospitals, non-profits, state agencies and regional agencies operating with the county may in fact result in a rapid payback and minimal taxpayer burden. The following quote references similar results with the Allconet project.

"Allconet saves [public sector] subscribers approximately $67,000 each month in carrier leased line services. We don't have any leased lines in our network. Our monthly telephone bill is basically zero, as far as the county is concerned. Without the wireless solution, it would be very difficult to afford Internet access in all of our schools."

Jeff Blank, Supervisor of Microcomputers and Networking

Allegany County Board Of Education

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[32] ALLCONET is the Intranet for Allegany County. Consisting of a partnership of government and non-profit entities. http://www.allconet.org/

Cost Estimates

Based on the deployment scenario described earlier, we were able to estimate the first-year costs to deploy a wireless broadband network throughout Houston County. These costs estimates are relevant only to the extent that the WHCC elects to take the more active role of endorsing the Cooperative Wholesale business model.

Note that the estimates provided are based only on the results of our preliminary testing and our knowledge of similar initiatives. A more detailed financial model to forecast capital and operating expenditures, subscriber and revenue projections, cash flow and payback should be developed after a business model has been selected and a complete countywide RF survey and final design has been completed.

Item	Qty	Total Est. Cost
Up-front Costs		
Base Station Antennas & AU Equipment	8	$47,000
Repeater Equipment (900 MHz)	10	$43,000
Point-to-Point Tower Backhaul Equipment	1	$14,000
Wholesale Customer CPE Equipment	40	$48,000
NOC Equipment and Software	1	$40,000
Design and Project Management Services	1	$75,000
Base Station Installation/Testing	1	$35,000
NOC Design and Deployment	1	$60,000
		$362,000
Recurring Costs (annual)		
Operation and Maintenance	1	$54,300
Spare Equipment Inventory	1	$15,200
Internet Backbone Connection	1	$144,000
Communications Tower Rental	1	$38,000
Repeater Site Access Rental (for 10 repeaters)	1	$24,000
Wholesale Billing, Settlement & Customer Services	1	$65,000
Total First Year Cost	1	**$702,000**
Total Annual Recurring Cost	1	$340,500

Based on these estimates, if the network were configured to provide 1.5 Mbps, business-class service to only 100 subscribers (using the anchor tenant model), at a rate of $300 per month, the payback for the upfront costs outlined above could occur within approximately 12 months. This also does not consider the wholesale revenue potential for the network in the event other retail providers choose to market the service to business and residential subscribers.

Appendix A – Fort Valley Case Study

During the interview process for this study, we spoke with numerous individuals who mentioned a recent deployment of wireless broadband technology in Fort Valley, GA, a small community in adjacent Peach County. The Fort Valley project was often referred to as "having been a failure" and had apparently received some negative publicity[33].

We felt it was important to conduct an interview with the Fort Valley Utility Commission (FVUTIL), the organization responsible for the system, and to provide an objective opinion on whether these perceptions were due to the "public utility" approach, the use of wireless broadband technology or some other factor(s).

It was reported that more than $2.5 million was spent by the FVUTIL over five years to build a communitywide fiber-optic and wireless telecommunications system. In addition to startup costs, operating losses for the system were estimated to be surpassing $1 million in the project's first four full years of operation.

During our interview with the FVUTIL, the following information was gathered.

- FVUTIL has deployed 900 MHz wireless broadband base station equipment on a water tower they own in Fort Valley.
- They are currently providing wireless broadband Internet services to approximately 100 subscribers; 80% business and 20% residential.
- The services range from 256 Kbps (Kilobits per second) to 1.5 Mbps, with four grades of service: College, Basic Residential, Premium Residential, and Business.
- They estimated that less than $200,000 has been spent on the wireless broadband deployment, and the balance of the telecommunication investment referenced above has actually been for a fifteen-mile redundant Synchronous Optical Network (SONET) fiber ring throughout the surrounding area.

Our opinion, after reviewing the project's background and interviewing FVUTIL is:

- The perceived failure of the "wireless broadband" project in Fort Valley seems to be based more on the negative publicity that the FVUTIL's fiber connectivity project has received than the relative success of their wireless service.
- An uptake rate of 80 business subscribers in this period, in a community with approximately 137 recorded business locations[34] is not a disappointing uptake rate for a broadband service.

[33] Source: http://www.macon.com/mld/macon/news/7853036.htm
[34] Source: City-data.com