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Report on the Wireless Broadband Pilot Project to the MGSA Board

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Introduction and Overview

As part of Phase II of its contract with the Marin General Services Authority (MGSA), CBG Communications, Inc. (CBG) has been working with Golden Gate Transit (GGT) on a Pilot Project involving wireless broadband on buses. During Phase I of the Project, CBG worked with the MGSA to identify a number of wireless broadband efforts occurring in Marin, their status and projections for their development in the future. As part of this effort, a Wireless Marin Advisory Committee was developed that incorporated representatives from the MGSA, the Marin Telecommunications Agency (MTA), the Marin Emergency Radio Authority (MERA), and the JPA Oversight Committee, to review and discuss the findings in Phase I and assist in projecting a wireless broadband development path for the future that could derive benefits for the MGSA and its members, as well as, allied agencies. It was determined that working with GGT on a wireless broadband project would help determine a variety of elements that could point to beneficial outcomes for all interested parties, including the best technologies to employ, individual and agency user applications, and the viability of various system concepts.

Accordingly, in the spring of 2008, CBG, building on discussions that began in 2007 during Phase I of the Project, began working with GGT to design facets of the pilot that would provide critical information to the MGSA related to the goals of Phase II of the Project. This initially included activities like working with Marin County (County) to determine whether the wireless broadband on buses Pilot could be incorporated into the County's Green Commute program. The initial concept was that a certain number of those in the grogram would participate in the Pilot as a control group (being chosen based on group members having diverse demographics). These commuters would receive incentives from either GGT or the County, or from both, to participate in detailed survey gathering efforts. Under the County's Green Commute rules, though, it was indicated to CBG and GGT that a specific group could not be chosen out of the entire Green Commute population to participate. It was further indicated to us by those running the Green Commute program that members could also not be solicited by the County as

volunteers, under the rules of the program. It was thought that they could be solicited by GGT employees to complete surveys through personal interviews or survey intercepts at bus stops outside of the Civic Center, but ultimately CBG and GGT determined that it would be more fruitful to open up the survey to the entire GGT ridership population on the routes designated for the pilot and not try to establish a County control group.

As discussed in greater detail in the next Section, CBG also worked with GGT and its vendor for the project, Wandering Wi-Fi, on a variety of elements related to how broadband access would be implemented on the buses and how users would access the system while riding. CBG's Senior Engineer also rode buses installed with the pilot system, performed a variety of technical testing and employed a variety of applications to compare his experiences with those ultimately reported by riders later in the Pilot. The outcomes of both CBG's testing and the ridership surveys are detailed further below and have also been provided in previous memorandums and updates to the Board in September, 2008, November, 2008 and January, 2009. Ultimately, the Pilot was deemed a success and GGT plans to expand the current deployment on 7 buses to its entire fleet of approximately 200 buses in a phased approach to be completed in the 3rd quarter of 2010. GGT is currently attempting to determine how the expansion will be funded and the deployment schedule will be dependent on available funding.

Also, as detailed below, a review of the Pilot's technology, applications and outcomes has demonstrated a number of potential uses for MGSA members and considerations for the future.

A detailed discussion on the project's findings is found in the next Section.

Discussion and Findings

A planning meeting was held with the GGT early in 2008 to discuss the elements desired for a successful pilot project aboard GGT buses and the desire of GGT to determine if internet access aboard its buses may increase its ridership. These findings would then be applied to Marin in a broader manner by determining the perceived value of mobile,

remote internet access by its residents and local government agencies. Following on this, it was discussed that the pilot be designed in such a way that the subsequent findings could be applied to a larger scale wireless deployment in Marin including additional bus deployment.

A. Design of Pilot – Overall Purpose

In an effort to get the most feedback from both bus riders and Marin residents on the value of broadband internet access in-transit, the pilot consisted of outfitting seven Motor Coach Industries (MCI) buses with wireless broadband that are utilized primarily for longer routes, including the 72X that travels between downtown San Francisco, through Marin County on Highway 101, with limited stops along its route, and the Santa Rosa transit hub. Route 75 buses were also outfitted with the wireless network. This route begins in downtown San Francisco, and travels across the Golden Gate Bridge and up Highway 101 to Santa Rosa. Route 75 stops at the San Rafael Transit Center, the Marin Civic Center, Redwood Frontage Road and Mitchell Boulevard, The Smith Ranch Park and Ride, Enfrente Road and Salvatore Drive and the Atherton Avenue bus pad.

B. Technology Utilized

The seven buses were outfitted with cellular based equipment utilizing Sprint's cellular network for backhaul to and from the buses to the internet. This equipment is then connected to a Wi-Fi gateway installed by Wandering Wi-Fi, which provides accessibility to riders on the buses.

C. Testing of Pilot

The pilot project was formally initiated in June 2008. In July, 2008 CBG met with GGT staff to discuss the level of success to that point in time. It was noted that use of the network had been increasing since its inception. It was further determined that testing of the network would now produce a good understanding of the technological abilities of the network to provide a service capable of

allowing various applications to run smoothly, therefore satisfying riders' needs and desires.

Initially, CBG ran speed tests on a bus while stationed at GGT's 1011 Anderson Drive facility to gain a baseline understanding of the network's forward and return speeds while in a stationary position. We achieved speeds ranging from 703 Kbps (Kilobits per second) to 1,033 Kbps (1.033 Mbps or million bits per second) in the forward or download direction and speeds ranging from 187 Kbps to 475 Kbps in the return or upload direction. We were able to watch a You Tube video, access highly graphic-intensive websites, read e-mail and listen to streaming audio, all with no experience of drop-out or slowdown.

With this baseline understanding of the network's abilities, we then performed speed tests, downloads of large files, listening to live streaming audio, watching a video from You Tube and accessing e-mail while riding on both the 72X and 75 bus routes from downtown San Francisco, through Marin County and terminating at the Santa Rosa bus terminal. Our measured speeds varied along the routes with speeds ranging from 385 Kbps to 1.516 Mbps, with an average speed of slightly below 1 Mbps in the forward direction. The return speeds varied between 127 Kbps to 600 Kbps, with the average speed approximately 400 Kbps in the return direction. There is one area along the routes where signal is not available. This is within a mile or two in both directions from the border of Marin and Sonoma Counties. Other than when we were in this area, we were able to run all of the applications we attempted with very satisfactory results.

D. Users' Profile and experiences

With the positive findings during the above detailed testing, CBG assisted GGT in developing surveys to ascertain the opinions of riders utilizing the network. Two surveys were developed; the first was a demographics-based survey to determine who is utilizing the network. The second survey was designed to glean the

perceived effectiveness of the network and riders' perception of value. The key findings of the surveys include:

Demographics

- 70.4% of respondents were male with 29.6% being female
- 48.1% were between the ages of 46 and 64 with 37% between 31 and 45 years old.
- 88.9% were employed full time with a small percentage of self-employed persons and students
- 84% had a 4 year degree or post graduate
- 37% had incomes greater than $120,000 per year, 25.9% had incomes of between $81,000 and $120,000, with 18.5% declining to answer this question

Perception of the Network

- 52.6% stated the network is moderately fast with 39.5% saying the network is fast and 2.6% saying it is extremely fast
- 2.6% said the network is slow and 2.6% said the network is extremely slow
- 42.5% said the network is very important to them with 37.5% saying important, 12.5% somewhat important and 7.5% not important

E. Applications Enabled by the Pilot

Applications enabled for and utilized by riders included most uses of internet access. The two most commonly utilized applications were to read news and access e-mail. Applications utilized by riders, in order of number of riders using each, included:

- News
- E-Mail
- Research
- Business-to-business functions

- Keep in touch with family and friends

- Website applications

- Contribute to blogs

- E-business

- Watch TV or video

- Video games

- Banking

- Online purchases

- Monitoring functions

- Access government services

- File sharing

- Education

- Find local information

GGT has been monitoring the usage of the network since its inception. Utilization has increased from slightly below 300 sessions during the month of August 2008 to nearly 550 sessions in January 2009.

The surveys allowed users to write in comments and the majority of these comments were positive toward the network and its value to them. Some comments included:

- What an unexpected and wonderful surprise to get Wi-Fi this morning

- Very reliable and fast enough

- A little slow for things like video, but works well for e-mail and basic web surfing

- I appreciate having the access. Thanks!

- If this were offered fleet wide, MANY people would ride the bus more often. It's great.

- I've had drop out problems between the southern end of Golden Gate Bridge and well into the city.

- I love it! It's definitely an incentive to ride for me.

A few riders used the service when one of the buses was rerouted from the 72X and 75 routes. One commented "I would think this is something most of the riders would really like to see become permanent; I know I would".

F. Overall Results

Overall GGT staff believes that the pilot project has been a significant success. Rider comments on the surveys were overwhelmingly positive with only a few comments indicating drop outs or slow speeds. GGT staff has indicated the desire to further deploy Wi-Fi on all of the buses used for longer commutes in mid 2009 with the remainder of the fleet being outfitted with Wi-Fi before the 4th Quarter of 2010. This schedule may be impacted if funding for the project is delayed.

Applications for MGSA Members

The functionality of the network determined during the pilot project demonstrates how a Wi-Fi enabled network, utilizing a cellular based network for backhaul, could be used by MGSA member agencies in both a mobile environment, and for remote, stationary applications. Specifically we have determined the following potential applications:

A. Marin Transit

A direct application would be for riders and employees on Marin Transit routes. Although many of these routes are shorter than those chosen for the pilot, the survey responses demonstrated that while access to the internet on buses has significant benefits for long-haul riders (for example, those with commutes from Sonoma into San Francisco), it also has benefits for those who want to access their, or send a quick, e-mail only for a duration of 5-10 minutes. Consistent with this finding, GGT is planning to potentially install network access on all of its bus

routes, regardless of their duration. Further, with GGT operating all of Marin Transit's routes, except the Stagecoach and Community Shuttle routes, deployment on the majority of Marin Transit routes could piggyback on GGT working to fully equip its fleet.

Additionally, Marin Transit facilitates Para transit ridership. Persons with disabilities often rely on electronic forms of communication for a variety of activities when they have limited mobility. This is another area where placement of network access on these vehicles could have a significantly beneficial effect.

B. Public Safety

Many MGSA member public safety agencies (County Sheriff, municipal Police Departments, Fire Districts, etc.) already have mobile data access through either air-card equipped mobile data terminals (direct to cellular access) or mobile access routers, which allow the choice between Wi-Fi access or cellular data access. Where the type of system demonstrated in the Pilot would be beneficial for public safety, is where multiple public safety entities may be converging on a specific event, emergency or disaster location, all trying to potentially access limited cellular facilities in potentially an uncoordinated, sporadic fashion. In these cases, a high-capacity Wi-Fi connection could aggregate all the data traffic and deliver it in a priority stream to the nearest cellular facility, thus consolidating and coordinating emergency communications. Additionally, the Wi-Fi system could allow data communications between those on site without going through the cellular system if properly configured. Therefore, local data communications (perhaps even voice in a Voice over IP format) could be effectively communicated at high-speed without ever competing for access to the cellular system.

It also would allow those entities arriving on-scene without currently installed mobile access terminals to use laptops and, by entering the proper security code, participate in the data transfer both between on-site units and, through the

internet, back to other critical officials or agencies that are not on-site. This concept may be further augmented by working with a specific cellular provider to establish an affordable portable, cellular antenna reception and transmission system that could be implemented as needed, if the reach of the closest permanently installed facilities is beyond necessary transmission and reception range.

The same concept works also in non-emergency, large event situations, such as a Fair, outdoor rally, etc. Because of the nature of the cellular backhaul, an important, critical element is that the access can be used in both a stationary and a mobile manner, allowing communications to begin and then continue in transit as needed.

C. **Public Works**

Use of this type of system by Public Works and other similar employees would be similar to the uses by Public Safety employees, but would typically focus on necessary wireless broadband access at a large construction site or where multiple inspections are being coordinated at one location. Another important use would be aggregated access for monitoring and control facilities in remote areas, such as in the Western portions of the County.

Regarding Public Works employee access, there first would need to be Wi-Fi or cellular air-card enabled data access devices, handhelds such as laptop PCs or tablet PCs, or vehicle-equipped devices such as mobile data terminals and mobile access routers. Then, similar to the scenario discussed above for Public Safety employees, data access for multiple parties at one large site (such as rebuilding a bridge, redeveloping a stream or riverbed after a flood, restoring and repairing a hillside after a mudslide, etc.), would be facilitated by the local Wi-Fi system which would aggregate and route local data traffic. Then, traffic to the internet would also be aggregated and sent to the cellular connection.

Regarding remote monitoring and control facilities, such as pump stations, stream gauging stations and precipitation gauge stations, depending upon their proximity, the data traffic again can be aggregated over a Wi-Fi connection and if no wire line facilities are available to backhaul the monitoring and control data, it could be done through a Wi-Fi to cellular broadband connection. This may be especially critical in the Western portion of the County where broadband access, either wireline or wireless, is concentrated in certain locations such as Dillon Beach and Point Reyes Station.

D. Community and Social Services

There are a variety of applications for Community and Social Services agencies. Many of their applications may involve specific individuals needing to either download or upload data related to client visits. In these cases, if the social or community service employee is within cellular broadband range, an individual air-card enabled laptop may be the most beneficial, unless the employee is able to access a secure Wi-Fi connection and already has a Wi-Fi enabled laptop or tablet PC. However, these agencies often serve groups of clients where public access to the internet is beneficial, such as at Community Centers, and at locations where public and community forums are held, such as medical screening locations. In these cases, including outdoor locations such as the outside area of Community Centers and other public facilities, public parks and open spaces, setting up a Wi-Fi system can be extremely beneficial to Marin citizens for a variety of applications. In some cases, such as those profiled below, there is already wire line (including fiber optics) backhaul connectivity available and in use today. In other cases, it would be relatively easy to set up a Wi-Fi aggregation point, but there is no wire line backhaul available. In these instances, having the Wi-Fi to cellular connection would be beneficial. Such installations would also help begin to develop more of a ubiquitous broadband capability across Marin. For example, broadband mapping done by the State of California and research work that CBG has done to date, indicates that many areas of Marin have broadband access from both wireless and wireline providers, including multiple choices in a number of

areas, but there are significant gaps, especially in western Marin, as you move farther away from the 101 corridor and in public spaces that are surrounded by a variety of forms of access but with no or limited access within those spaces. Accordingly, using the concepts successfully demonstrated by GGT, targeted Wi-Fi/cellular implementations could be developed in these areas to increase the ability of the public to access broadband wherever and whenever it needs to in Marin.

Considerations for the Future

A. GGT Decision to Move Forward

Based on the findings of the survey, GGT has determined the following "pros" offered by the pilot project: added customer value, relatively inexpensive, ease of installation and minimal hardware. The "cons" associated with the pilot and moving to a full deployment include; ongoing customer education, dropouts along certain segments of service (primarily at the border of Sonoma and Marin Counties) and fleet-wide installation costs. However, developing the system in conjunction with outfitting the buses with other necessary equipment may help to minimize the cost. One other problem experienced was periodic queuing and loading issues when riders signed onto the network, but this problem was resolved early in the pilot.

GGT staff has posed the following possibilities to their policy and decision-making Board concerning how to move forward:

- Continue the pilot project by installing equipment from other vendors
- Continue the pilot with the addition of a few more buses
- Move to Phase II, which would outfit 57 additional buses.
- Discontinue the program

All indications are that the project will move forward into phase II and ultimately outfit the entire fleet of buses. The perceived value to riders indicates significant potential to add additional riders now and into the future, especially since riders

can use the time on the bus to be productive as opposed to time spent driving a vehicle to and from work locations that are a significant distance from their homes.

In addition to further deployment on GGT's buses, they are exploring deployment on their ferry system. The first step will be for GGT to develop a RFP to secure a vendor to outfit the ferries and maintain the equipment. To this point, GGT has not decided on the technologies to be utilized on the ferries and they are exploring the networks deployed in other similar applications.

Another potential service being discussed by GGT is deployment of wireless service at its transit terminals and large bus stops. This would allow for seamless connectivity by riders while transferring from one bus route to another. This would further expand the functionality of the network for riders in that they would not be required to re-establish their network connection when changing buses.

B. Other Marin Explorations

Marin County and its municipalities have deployed significant wireless and wire line networking facilities to date. This includes deployment of a number of wireless hotspots in the County. For instance, all of the County's Free Library branches as well as all of the municipally-run libraries have wireless routers operating to allow their patrons to access the Internet by using their own laptop or PDA as well as through using library owned PCs. Mill Valley has deployed two remote hot spots for its police and other employees to access information from the network in remote locations, which minimizes the amount of time needed for them to upload and download files, and other information. The City of Novato had intended to deploy remote hot spots but, lack of available funding has limited them to a single hotspot in the police headquarters, as of the last conversation with City representatives.

The Marin Sheriff's department has shown interest in developing hotspots in the County but deployment has not yet begun.

Other police and fire departments have shown interest in deploying hotspots in strategic locations within the County. With a coordinated plan, these entities would be able to share financial, networking and other resources to realize a larger more efficient deployment that would provide a larger broadband network footprint throughout Marin.

C. National Explorations and Possibilities

Development of broadband systems, especially wireless broadband, have increased around the country despite the well publicized, failed efforts of some municipal networks developed in tandem with entities like EarthLink and MetroFi. Specifically, development continues to occur both with local government-sponsored networks and a number of evolving commercial roll-outs.

For example, Hollywood, Florida (population of 142,000) recently signed a contract with Johnson Controls (one of the entities interested in the MGSA's original RFI) to deploy a municipal wireless broadband network throughout the City. The key here, as it is for many successful local government-sponsored networks, is that the Hollywood network has underlying municipal communications purposes (in this case, wireless automated meter reading [AMR] and public safety communications) that provide the appropriate cost/benefit for implementing the initial network , regardless of its use by others (City residents will be able to utilize the network for free Wi-Fi access, up to 1Mbps symmetrical [upload and download]). Also, as in other successful local government implementations, a local WISP (wireless internet service provider) has been contracted to operate the system.

A similar implementation has occurred in Rock Hill, South Carolina. Here the City uses municipally-owned fiber for all of the communications backhaul from

the individual wireless devices and to the internet. In fact, many jurisdictions are using municipal Wi-Fi networks for monitoring and control functions, especially energy management and automated meter reading (for example, Santa Clara, CA utilizes the former MetroFi network assets that it assumed for automated meter reading).

Another big application is wireless video surveillance, which is utilized in such Cities as Dallas, Granbury, McAllen and Southlake Texas, Temple and Washington, Georgia and Reading, Pennsylvania. This and many other public safety uses are also part of some of the larger implementations in the country including Minneapolis, Minnesota and Oklahoma City, Oklahoma (which according to MuniWireless has the largest Wi-Fi public safety network in the world).

Wi-Fi networks that are part of mobile implementations such as GGT's Pilot and the Wi-Fi Rail service implemented by San Francisco's BART (Bay Area Rapid Transit) are also on the rise. In fact, equipment vendor Icomera, reports a 272% increase in Wi-Fi use on public transport over the last year (the biggest increases have been in Europe).

Overall then, the key characteristics of a successful implementation that involves local government are:

- Underlying public communications purposes and networks that are implemented largely with public and or grant funds (they all, though are implemented with the goal of improved service while saving and /or avoiding costs in either the short or long run).

- Networks that are part of the solution, not the whole solution. In other words, many successful wireless network implementations are part of hybrid wireless/wire line networks (usually involving fiber optic backhaul or node

interconnectivity) and they are part of a "network of networks" (where some applications may only be on the wireless part of the hybrid, other applications are only on the wire line part of the hybrid and some applications may cross both portions of the total network).

- They are implemented as part of a dynamic networking strategy that leverages implemented assets as long as possible, but understands that new technology must be integrated over time.

It is important to note here that there are a number of local government-sponsored projects, especially those that focus on the national goals of improving public safety communications and their interoperability and improving broadband accessibility and affordability for the greatest percentage of populations of users within any given area, in order to be able to access broadband stimulus funding as part of the BTOP (Broadband Technologies Opportunities Program) that is part of the National Recovery and Reinvestment act.

Some noted proposals in this regard in California already include funding for public safety communications interoperability enhancements in the Bay Area and additional communications and video surveillance technology for Oakland.

The MGSA and allied agencies, building on the success of the GGT Pilot, potential applications for its member Agencies and what is occurring nationally, should be able to leverage this funding if they or allied entities decide to move forward with a beneficial broadband application or concept. It is notable for example, that one of the top priorities in Utah is continuing to fund and expand UTOPIA, the Utah Telecommunications Open Infrastructure Agency, a fiber to the premises system being built in 2 and 3rd tier communities outside of Salt Lake City.

Much is also happening on the commercial wireless/wire line broadband provider front. For example, Verizon Wireless recently announced that, even with the economic downturn, it expects its 4G (4th generation) wireless network to be available in at least 25 to 30 markets by the end of 2010 and to blanket the US by 2015. This 4G network, known as LTE (Long Term Evolution), is expected to provide peak download speeds of 50-60 Mpbs. Average download speeds will be lower since the cellular broadband-based system is still a shared medium per cell. However, this is anywhere from 25 to 50 times faster than their current 3G, EVDO (Evolution, Data Optimized) network. 4G implementations like LTE will utilize the 700 MHz wireless spectrum, once it becomes available when broadcasters complete digital transition activities in June of this year.

The other commonly discussed 4G technology is mobile WiMAX (IEEE 802.16e). This technology in the US is primarily driven by Clearwire and Sprint and the other members of their consortium. Initial launches in areas like Baltimore have been termed successful, but growth has been slow based on the lack of capital available to support the multi-billion dollar roll-out. Even so, Clearwire is set to expand its footprint in Portland, Oregon.

On the wire line front, fiber to the home (FTTH) deployments have continued to increase, driven largely by Verizon's FIOS service in markets where it is also the ILEC (Incumbent Local Exchange Carrier). The important finding here, based on a Yankee Group study reported in Communications Technology magazine, is that the average revenue per unit (ARPU) is exceeding expectations and FTTH operations around the world have reached profitability after only a few years of operation. The study indicates that the high desire for HDTV services is the current key revenue driver and that two-way video communication will be the ultimate application that greatly increases economic success.

Regarding local government sponsored fiber to the home projects, implementations have largely been put on hold because of the significantly high

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cost of initial implementation and the lack of sufficient capital funding to support such implementations at this time.

D. Recommended Potential Directions and Next Steps

Based on the successful outcome of the Pilot, the activities on both regional and national fronts and the incorporation of broadband into the package of activities and functions that are anticipated to stimulate the economy, CBG recommends that the MGSA consider, in conjunction with allied agencies such as the MTA, MERA and others, the following next steps:

- Leverage the successful experience of the GGT Pilot, for the potential Wi-Fi-enabled and Wi-Fi/cellular broadband applications described above.

- Pursue a network of networks approach – the network development efforts of a variety of agencies and organizations within Marin have been well received and have provided a higher level of broadband access for both local government agency functions and general public use by the citizens of Marin. Where the cost benefit is positive, based on an underlying public purpose, these projects should continue to be implemented, maintained and integrated with other projects to continue to develop a "broadband quilt" of affordable and available access for local government agencies and citizens.

  Additionally, it is important to look at a hybrid approach because wireless technology by itself, even with 4G and other improvements, may not provide the high-capacity needed in some instances, while wire line technology (primarily fiber optics) may always prove too expensive to extend to the furthest reaches of Marin.

  It will also be important to remember that the private sector will likely never satisfy all of the broadband needs in Marin. While the private sector

continues to invest in new technology and provide higher levels of access to residents, businesses and government entities, their business model relies on deriving the highest return on investment, especially when capital markets, like those today, are difficult to access. Accordingly, those users that have multiple and various broadband options in Marin will likely get more in the future. Those that do not have multiple options, or may have no real viable options, will likely continue to be in this situation for a significant period of time to come without government intervention and involvement.

- Have telecommunications policy-makers in Marin move forward to determine an overall direction and help identify, oversee and implement activities and functions to achieve the overall direction. This includes:

  o Have a telecommunications policy-making organization, such as the MTA, take the lead on broadband development activities in Marin
  o Have the designated policy-making entities coordinate efforts to obtain grant funds to pursue broadband implementation that will stimulate the economy, enhance public safety and improve citizen access (such as funding from BTOP through the NTIA).
  o Place an emphasis on sharing information and developing shared applications and resources that will utilize the type of hybrid networks profiled herein.
  o Potentially pursue broader implementation of wireless and wire line networks and access as part of necessary communications system procurement and upgrade requirements, much the same way that the local governments profiled above developed systems that have multiple uses while fulfilling the underlying need to establish automated meter reading.

In short, it will be important for Marin to keep moving forward to build on the success that it has achieved to date and continue to enhance the broadband climate in Marin, even if enhancements are only incremental in the near term.