cbg communications, inc.

MEMORANDUM

TO: PAUL BERLANT

             EXECUTIVE OFFICER, MARIN GENERAL SERVICES AUTHORITY

FROM: DICK NIELSEN, SR. ENGINEER, CBG COMMUNICATIONS, INC.

SUBJECT: EVALUATION OF THE GOLDEN GATE TRANSIT WIRELESS BROADBAND PILOT

             PROJECT

DATE: 9/3/08

CC: TOM ROBINSON, EXECUTIVE VICE PRESIDENT, CBG COMMUNICATIONS, INC.

CBG Communications, Inc. (CBG), on behalf of the Marin General Services Authority (MGSA) has been involved in a project over a number of months to determine how a wireless broadband network might benefit the citizens of Marin County while creating new, and enhancing existing, connectivity for governmental agencies, including those employees working remotely in the County. As part of this project, CBG has been working with Golden Gate Transit (GGT, part of the Golden Gate Bridge District) on a wireless broadband on busses pilot project. Specifically, GGT has developed a wireless broadband system for two of its longer bus routes to determine if internet access aboard its busses may increase ridership: specifically on these longer routes and potentially aboard all of its busses serving all of its routes (and potentially Marin Transit routes as well) if the pilot is successful. It was determined that cooperation between the MGSA and the GGT may be fruitful for both entities in determining the value to riders, citizens and agencies of mobile internet access outside of more traditional wired access.

Goals of the Initial Evaluation

CBG has met with GGT staff several times, both on site and via telephone conference, in the past few months to better understand the functionality of the network that has been installed on busses operating on the 72 Express (72X) and 75 routes. The 72X route begins in San Francisco, winds through the City and enters Marin County via the Golden Gate Bridge. The 72X then travels to Santa Rosa on Highway 101 with limited stops beginning in Rohnert Park. The 75 route begins at the GGT's 1011 Andersen Drive facility and the route ends in Santa Rosa with stops in Marin County 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.

The busses utilized for the 72X and 75 routes are outfitted with cellular-based equipment which utilizes Sprint's cellular network for backhaul from the busses to the internet. The busses are then equipped with a Wi-Fi gateway providing network accessibility to riders on the bus.

One of the purposes of the evaluation was to determine the speeds that are achieved aboard the busses for access to and from the internet. In addition, applications that may be commonly utilized by riders on GGT busses were utilized to determine the practical functionality of the network. Although speeds and applications were tested, the ultimate goal was to determine if the network can operate in a manner that would satisfy rider's expectations once they access the network. Some of the applications that would be enabled if the bus network were functional both from a speed and reliability standpoint might include:

- Accessing work e-mail including attached files;
- Accessing web sites for research;
- Other types of telework activities;
- Banking and other financial tasks;
- Shopping and entertainment;
- Listening to streaming audio for news, sports and entertainment;
- Watching You Tube quality video and web-based videoconferencing.

Testing and Findings

CBG first performed throughput tests on Bus 695 while parked in the GGT's 1011 Anderson Drive facility to gain a baseline understanding of the speeds that could be realized in a stationary position. Our available time for testing at this location was limited by GGT schedules, but we were able to benchmark the network's basic capabilities and functionality prior to boarding a bus for mobile testing. While performing these stationary tests we achieved throughputs ranging from 703 Kbps (Kilobits or 1,000 bits per second) to as high as 1,033 Kbps (1.033 Mbps or million bits per second) in the forward direction and speeds ranging from 187 Kbps to 475 Kbps in the return direction. We walked around the bus and had minimal reduction in performance while moving 25 to 30 feet away from the bus. We watched You Tube video, pulled up highly graphic intensive web sites we were familiar with and listened to streaming audio. The short You Tube video loaded quickly and played seamlessly within several seconds. The live audio played flawlessly without drop-out and our experience with accessing familiar websites was also successful.

With this baseline information in hand, we then performed throughput testing on busses while traveling route 72X beginning in San Francisco at Folsom St. & 7th St. and traveling through sections of the City, across the Golden Gate Bridge, then through Marin County to Santa Rosa on Highway 101.

While traveling through San Francisco, the documented speeds achieved ranged from 296 Kbps in the forward direction around Folsom St. & 7th St. to as high as 1,684 Kbps (1.684 Mbps) around Northport St. and Mason St. The average speed in the forward direction was approximately 1 Mbps throughout San Francisco. The return speeds varied from 128 Kbps around Northport St. and Mason St. and were as high as 304 Kbps in the Sansome St. and California St. area with average return speeds in the City of 260 Kbps.

As we traveled across the Golden Gate Bridge and up Highway 101 through Marin County, we downloaded a 48.3 megabit file which took approximately 15 minutes to complete. We then

performed speed tests showing forward speeds ranging from 398 Kbps to 1,178 Kbps (1.178 Mbps) and return speeds of between 163 Kbps to 199 Kbps from Paradise Drive in Corte Madera up to San Marin Drive on the north side of Novato. Just north of San Marin Drive our documented return speeds dropped significantly to between 66 Kbps to 93 Kbps. This area has poor cell phone coverage (and thus also poor cellular data coverage) as noted by the driver of the bus. Furthermore, in the area just south of the Sonoma/Marin County border north to Highway 116 we experienced spotty coverage and no internet access was available in most of this area. As we approached the East Washington exit we experienced download speeds of 923 Kbps to 1,187 Kbps (1.187 Mbps) and return speeds of between 326 Kbps to 417 Kbps. While around the Railroad Avenue exit we downloaded 2 files, one of which was 560 Kb (Kilobytes) and the other was 250 kb. These downloads took 30 seconds and 18 seconds respectively.

From the Railroad Avenue area to the bus terminal at Piner Road and Industrial Drive in Santa Rosa we experienced speeds ranging from 385 Kbps up to 1,034 Kbps (1.034 Mbps) in the forward direction with the average being approximately 700 Kbps. The return speeds through this area ranged from 127 Kbps to 585 Kbps with the average being approximately 415 Kbps. CBG performed similar testing on a Route 75 bus between the GGT's 1011 Anderson Drive facility to the Santa Rosa bus terminal. In addition to the testing outlined below, we listened to a radio station streaming live audio during this trip. With the exception of drop out along Highway 101 between the Marin/Sonoma border and Highway 116, the audio worked very well with only a few minor interruptions during the entire trip.

We began testing at the GGT's 1011 Andersen Drive facility and then proceeded through the Marin County Civic Center campus. During this portion of the trip we achieved forward speeds of between 688 Kbps to 1,161 Kbps (1.161 Mbps) and return speeds of 328 Kbps to 595 Kbps. The average speeds were just below 1 Mbps forward and approximately 550 Kbps return.

As the bus proceeded northbound from the Civic Center and then onto Highway 101, we continued to listen to the radio station while downloading 3 separate files one at a time. The first

file was 800 Kb and took slightly more than one minute to download while the second file was 750 Kb and took 30 seconds to download. The third file took approximately 25 seconds to download and was approximately 650 Kb.

We then performed speed tests and had results ranging from 620 Kbps to 1,363 Kbps (1.363 Mbps) forward and 311 Kbps to 600 Kbps in the return direction. These tests occurred between the St. Vincent exit and the De Long Avenue exit in Novato. As we left Novato, we began a download of a 4.1 Mb (Megabyte) file which took just over two minutes, again while listening to the radio station. From just north of the Marin/Sonoma County line to the bus terminal in Santa Rosa we achieved speeds of 1,108 Kbps (1.108 Mbps) to 1,516 Kbps (1.516 Mbps) forward and 317 to 420 Kbps in the return.

Key Benefits of Broadband Internet Access to Mobile Users on the Bus

Based on our findings, users are able to perform work related tasks and access files from the employer's network, search the web for research needing to be completed for work, perform information gathering and transactional functions such as reading e-mail, banking, shopping and research as well as reading and listening to real time news and information.

Conclusions Concerning Initial Testing

The goal of this evaluation was to determine if riders on the equipped busses could practically utilize the network to allow them to be fully productive mobile internet users while spending as much as 2 hours going to work and 2 hours commuting home on the bus (4 hours total out of a 24 hour day). By means of our throughput tests, downloading of files, listening to live radio via the internet and downloading video, we found that indeed riders could perform many internet based duties while on the bus, therefore increasing their productivity and minimizing time needed for these tasks while not riding the bus. We successfully downloaded files in a reasonable amount of time demonstrating that riders can download files, including large files attached to e-mails and turn time on the bus into productive time for work related tasks as well as personal based internet access. As mentioned above, we accessed live streaming audio via the

internet which allows riders to keep up to date on current events and receive emergency information from all over the country and beyond, as well as by accessing news sites via the internet.

The functionality of this network demonstrates how a Wi-Fi enabled network, utilizing a cellular based network for backhaul, could be utilized by MGSA member agencies in both a mobile environment as well as for remote stationary applications. Mobile applications could include setting up a cellular connection at a disaster site or during a major event and then utilizing Wi-Fi technology to offer connectivity to critical employees located in the area. Some of the remote applications could include network access for Public Works employees working in areas that do not have ubiquitous internet access options today, such as Western portions of the County. Remote sites could be established at facilities such as pump stations, stream gauging stations and precipitation gauge stations. These remote locations, such as the gauges located in Dillon Beach and Point Reyes Station, could be served by a cellular network connection for monitoring purposes while providing the backhaul for a Wi-Fi wireless network.   This application would allow County and other agencies' employees access to their networks for upload and download of information while on site rather than having to travel to a location miles away for access. These and other potential applications will be studied further in tandem with the next steps described below.

Next Steps

To better understand specific applications, including to County and other public agency employees, that would be most useful to the MGSA's member agencies (and Marin constituencies as a whole) CBG is currently working with GGT and Marin County's Information Services and Technology Director, David Hill, to develop and implement a survey for GGT network users. The goal of the survey related to the GGT is to determine the level of value to its riders and if the network might help promote ridership among persons not currently utilizing mass transit. The goal of the survey related to the MGSA is to help establish user profiles as well as applications utilized by these users that are enabled by the wireless network. The survey

will help to determine the network's ability to run applications of various sizes as well as give an indication of what cannot be achieved in a practical manner on the network. Determining applications that function in a satisfactory manner on a network such as the GGT's network will provide the MGSA with a template for going forward with expansion to provide new or additional remote access and mobility to existing MGSA member networks.   This will help the MGSA determine who within the County would benefit from additional remote and mobile network connectivity. Some such beneficiaries of applications availed via augmented MGSA member run networks, such as the GGT's network, might include: Citizens in remote areas where Internet access would be offered for the first time, Public Safety and Public Works employees who would realize additional network access or improved performance over what is available today, employees who may see opportunities for mobile internet access as an additional prompt to utilize mass transit and become involved in the Green Commute program and many others. This effort will be implemented in mid-September and then evaluated near the end of 2008.

Please don't hesitate to contact me if you have any questions or need additional information.