# Enhancing the Rider Experience: The Impact of Real-Time Information On Transit Ridership

## Progress Report

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# 1. Introduction

The document is an expanded progress report that summarizes work completed under FDOT Project BD549#13. According to the scope of the project, Task 1 was the Literature and Existing Systems Review and Task 2 was Needs and Technology Assessments. The attached report documents the completion of both tasks in full. Task 3 was to implement the Wi-Ride system. The initial subtask in Task 3 was to select equipment based on Tasks 1 and 2. The attached report also documents that portion of Task 3 in full.

Additionally, the report describes efforts invested in securing a replacement wireless network to accomplish the same purposes and objectives of the original scope without compromising the integrity of the project. These efforts included negotiations and collaborations between CUTR and each entity involved; Parking and Transportation Services at USF, Computer Science and Engineering Department at the College of Engineering, Verizon, Hillsborough Area Regional Transit (HARTline), and Pinellas Suncoast Transit Authority (PSTA).

## 1.1 Study Objectives and Benefits

The objective for this project was to evaluate how ready access to wireless networks and real-time information affects transit system ridership as well as the rider's experiences. The Wi-Ride project hypothesizes that ridership would increase if productivity and security in buses could be increased. The project contemplated the installation of network and video devices in all buses so that Internet access and video surveillance services could be provided.

The potential benefit of this project is the increased understanding of the potential opportunities and limitations of wireless communication systems that might affect transit system ridership, including data integration, coverage issues, bandwidth, security, etc.

## 1.2 Study Progress

Over the course of the project, numerous factors outside the control of the project team resulted in changes in the direction of the project. As proposed, the project was dependent upon the successful implementation of a high-speed wireless "meshnetwork" that was in the process of being installed on the University of South Florida's campus by the university's Parking and Transportation Services (PATS) department. However, for reasons described later in this document, the University stopped installation of the meshnetwork. In the meantime, new wireless high-speed cellular services were being introduced. The project team, in consultation with the FDOT project manager, had been working on switching from on-board cameras and traveler information on a single campus shuttle bus using the USF meshnetwork to the use of a high speed cellular network to provide Internet access to riders on a couple of express routes (multiple buses serve each route) operated by two Tampa Bay area transit agencies. Though the project team felt that the proposed changes in the research implementation plan were consistent with the overall objective, FDOT determined that the scope was sufficiently different that the project should stop and a new scope should be developed.

## 1.3 Report Organization

The purpose of this expanded progress report is to document the extensive effort that was made to carry out this project. The identification of equipment, conceptual design, and benchmark survey should benefit others who seek to develop a similar project. The first section provides an overview of the uses of traveler information and other potential technology applications that might enhance ridership. The literature review is the second section and focuses on wireless applications, and real-time information impacts on riders and non-riders. The third section assesses the need for such a system by summarizing the results of the survey of the USF community. The existing systems review section summarizes USF's wireless communication system, highlights the capabilities of the proposed meshnetwork, and assesses the availability of other wireless communication services in the area. Major subtasks included the review of the video and/or voice devices that could be used for transit wireless applications and the identification of the communication profiles and loads for network design. The fifth section, Technology Assessment – PATS Wireless Meshnetwork, summarizes what happened that resulted in the decision of USF to halt the installation of the meshnetwork. The final section of this report is the technology assessment of broadband wireless networks for transit that became available during the course of the project.

# 2. Real-Time Information in Transit – An Overview

## 2.1 Background

Perceiving the potential of technology for increasing ridership and/or decreasing operating costs, the public transportation industry continues to expand its use of a growing range of applications. Advanced Public Transportation Systems (APTS) are technologies used to improve the efficiency and effectiveness of public transportation operations, vehicle maintenance, and administration. These technologies include a wide range of computer databases, software, and hardware, as well as vehicle devices such as mobile data terminals (MDTs) and global positioning satellites sensors, and automatic vehicle location (AVL) systems. Another set of applications geared towards information dissemination, Advanced Traveler Information Systems (ATIS), plays an important role in improving the convenience, safety and efficiency of travel by assisting travelers with pre-trip and en-route travel information.

Another form of technology being used by transit agencies is the provision of real-time transit information systems to provide better customer service by disseminating timely and accurate information. Real-time information is accessed through a variety of media including dynamic message signs (DMS) at stops and stations, kiosks (at bus shelters, office buildings, shopping centers, and other locations), cable television, personal digital assistants (PDAs), the Internet, and telephones. Riders use this information to make various decisions about modes of travel, travel routes, and travel times. The availability of real-time transit information helps travelers make efficient use of their time by allowing them to pursue other activities while waiting for a bus or train. It also has been shown to help reduce anxiety by letting travelers know when the next bus or train will arrive or depart.

Table 1 provides an overview of currently available technologies of APTS in the transit industry. These applications are implemented to improve the operations management aspect of the transit industry, in turn positively influencing the other vitally important aspect which is customer service. Although Table 1 lists current APTS applications, for the purposes of this study, only applications that provide real-time information impacting ridership and/or customer satisfaction will be further discussed (marked by ✓).

**Table 1: Advanced Public Transportation Systems**

| Service Bundle | Applications in Transit |
| --- | --- |
| Traveler Information | • Pre-trip Transit Information Systems ✓<br>• In-terminal/Wayside Transit Information ✓<br>• In-vehicle Transit Information Systems ✓<br>• Personal Information Systems✓<br>• Multimodal Traveler Information Systems ✓ |
| Transit Safety and Security | • On-vehicle Surveillence ✓<br>• Station/Facility Surveillence ✓<br>• Incident Response ✓ |
| Fleet Management | • Communications Systems ✓<br>• Geographic Information Systems (GIS) ✓<br>• Transportation Management Centers ✓<br>• Traffic Signal Priority Systems✓<br>• Automatic Vehicle Location Systems ✓<br>• Transit Operations Software<br>• Automatic Passenger Counters (APCs)<br>• Maintenance Information Systems<br>• Data Management for Decision Making |
| Electronic Fare Payment | • Closed System<br>• Open System<br>• Fare Payment Media |
| Transportation Demand Management | • Dynamic Ridesharing<br>• Dynamic Routing and Scheduling<br>• Automated Service Coordination<br>• Transportation Management Centers<br>• HOV facility Monitoring |

| Service Bundle | Applications in Transit |
|---|---|
| Transit Intelligent Vehicle Initiative | ♦ Collision Avoidance<br>♦ Obstacle Detection<br>♦ Guidance/Steering Assistance<br>♦ Coupling/Decoupling |
| Other | ♦ Guided Busways<br>♦ Communications Based Train Control |

The following sections review the selected types of APTS that are pertinent to the scope of this study and briefly describe national and international case studies demonstrating the effectiveness of the application on ridership and customer satisfaction. The information provided in this section is based on or excerpted from the Federal Transit Administration (FTA) Transit ITS Impacts Matrix available at http://web.mitretek.org/its/aptsmatrix.nsf/framemain?OpenFrameSet

## 2.2 Traveler Information

Transportation information provided to travelers prior to and during a trip includes static and/or real-time information accessed at home, at work, at transit stops, in transit vehicles, and for several modes. Types of information provided via multiple devices/media are described in the following sections.

### *Pre-trip Information*

Transit information that is obtained before departing on a trip can be static and/or real time, and may include transit routes, maps, schedules, fares, park-and-ride lot locations, transit trip itineraries, etc. Media supporting pre-trip information include the telephone, Internet, electronic kiosks, fax machines, television, etc.

This application should increase ridership because transit systems are easier to use and more attractive as evident by these quantitative examples:

- London, England - A survey of users of London Transport's ROUTES computerized route planning system revealed that 80 percent of callers made the trip about which they inquired, 30.4 percent changed their route based on information received, and 10.4 percent made a trip they would not otherwise have made via transit.

- Ventura County, CA – When users of TranStar, the automated transit trip itinerary planning web service, were surveyed, 56 percent of respondents would not have made a transit trip without pre-trip information.
- Acadia National Park, ME - Island Explorer bus system implemented numerous ITS technologies, including AVL and vehicle communication systems. The system also recorded the number of vehicles entering and exiting parking lots at national parks and disseminated the information to visitors via the web, phone and parking lot status signs. Island Explorer ridership increased 17 percent from 2001 to 2002, and the average number of excess parked cars per day decreased from 325 to 274 during the same period.

With pre-trip information customer convenience is increased by reducing uncertainty and anxiety and also by providing a venue for public service announcements. Documented examples of quantitative impacts include:

- Newark, NJ - New Jersey Transit's automated telephone information system reduced caller wait time from an average of 85 seconds to that of 27 seconds.
- Minneapolis, MN - In a survey of Metro Transit's Orion Transit Itinerary Planner System, an automated transit trip itinerary planning system used by customer service call center agents, 19 percent of customers felt the service was "much improved," 18 percent perceived that the service was "somewhat improved," 59 percent felt that the service was "about the same," and 2 percent believed that the system was "somewhat worse" compared to the former manual process that was used.

### *In-terminal/Wayside Transit Information Systems (Non-interactive)*

Non-interactive systems provide arrival/departure information of buses/trains at bus stops or terminals, and train stations or platforms. Information is displayed on monitors, variable message signs, sign boards, passenger information displays, and/or electronic kiosks. They may provide static (scheduled) or real-time information.

Ridership should increase because the transit system is more attractive and easier to use as shown by the examples listed below:

- Helsinki, Finland - In a customer survey regarding a real-time transit vehicle arrival display system implemented on one tram line and one bus route, 16 percent of tram passengers and 25 percent of bus passengers reported that they increased their use of the line/route because of the displays.

- Brussels, Belgium - The ridership of bus lines equipped with real-time wayside information displays about waiting times has increased by 6 percent.
- Liverpool, England - Ridership reportedly increased between 5 percent and 6 percent in a trial on lines equipped with at-stop displays of real-time information.
- Southampton, England - Surveys of the users of bus arrival time information via variable message signs indicated that about 3 percent of riders would use the bus system more often as a result of having this information.

Some quantitative examples of impacts on customer satisfaction include:

- Helsinki, Finland - A customer survey regarding a real-time transit vehicle arrival display system revealed that 95 percent of respondents found the system useful, and 68 percent felt that the system increased their level of comfort. The most frequently reported benefits were being informed of the remaining waiting time and knowing whether the vehicle expected had already arrived.
- London, England - In a survey of the London Transport Countdown System (real-time bus arrival information), 82 percent said information displayed was acceptably accurate, 64 percent believed service reliability improved, 83 percent said time passed more quickly knowing that the bus was coming, and 68 percent said their general attitude toward bus travel improved.
- Turin, Italy - An opinion survey regarding the provision of forecasted arrival time of vehicles at bus/tram stops revealed that 75 percent of customers found the system useful.
- Connecticut - A survey of the Connecticut DOT and Amtrak coordinated automated announcement system revealed that, when compared to the old system, the mean rating of the quality of announcements increased 18 percent, and the above average rating of the quality of announcements increased 23.5 percent.

### *In-vehicle Transit Information Systems*

These systems automatically provide visual and/or audio announcements on transit vehicles. Typically, announcements include next stop, major cross-roads, transfer point, landmark, and destination information. Additional information, such as public service announcements, news and weather, and advertisements, may be provided at other times. This very feature adds to ADA compliance.

Although some increase in ridership may be expected because of the added comfort level, there are no documented quantitative examples.

For customer satisfaction, very high responses were documented as comfort level increased and anxiety about using the system was reduced. In Turin, Italy; an opinion survey regarding the provision of next-stop information on board transit vehicles revealed that 75 percent of customers found the system useful.

### *Personal Information Systems*

Traveler information that is subscriber based or tailored to meet an individual's needs (e.g., travel profile) may include incident notification, transit vehicle arrival alert, or other information. Information is received via e-mail, PDAs, pagers, etc. Although no quantitative examples are available to show impacts on ridership and customer service, this kind of practical application is expected to reduce wait time for transit vehicles by notifying customers of incidents and major delays. This application also has the potential of increasing the perception of transit reliability.

### *Multi-modal Traveler Information Systems*

The use of any type of traveler information media (monitors, kiosks, Internet, telephone, etc.) to provide real-time and static information on both transit and traffic enables travelers to make fully informed mode choice decisions, both pre-trip and en-route. The information about a trip or knowing when a bus or train is due to arrive alleviates anxiety about "Have I missed it?" or “Will I get to my appointment on time?”

Those that have been installed to date and are accurate are very well received. Examples of impacts on ridership include:

- Seattle, WA - A survey conducted of Smart-Traveler users indicated that, based on improved information, 5 percent to 10 percent change modes.
- Los Angeles, CA - Over half of the accesses to Smart Traveler kiosks included requests for Los Angeles County Metropolitan Transportation Authority (MTA) bus and train information.
- San Francisco, CA - A survey of commuters revealed that, of those aware of traffic congestion prior to their departure, 7.1 percent changed mode. However, 39.3 percent did not change behavior because they did not believe it would help.
- Minneapolis, MN - One third (33 percent) of the accesses to the Minnesota GuideStar TravLink system requested bus schedule adherence information while another 31 percent examined bus schedules.

## 2.3 Transit Safety and Security Applications

These are systems and technologies that deal with transit personnel and customer safety and security. The expected impacts of these technologies should be high due to increased feelings of safety. If riders feel safer, this could contribute to better customer satisfaction and can also encourage ridership by removing a real or perceived barrier about public transportation. However, not enough research has been done to measure how perceived feeling of security would impact ridership. Three technologies can be applied to enhance safety:

### *On-vehicle Surveillance*

This application provides remote monitoring/recording of the passenger safety environment on board transit vehicles and includes cameras, silent alarms, covert microphones, and/or intercoms.

In Denver, CO, assaults on bus operators and passengers dropped by 20 percent after the Denver RTD implemented its AVL/CAD system, which contained a silent alarm and covert microphone feature.

### *Station/Facility Surveillance*

This application provides remote monitoring/recording of the passenger safety environment in stations, parking lots, and at transit stops. It includes cameras and passenger activated emergency systems and also allows customers to request assistance in case of an emergency.

### *Incident Response*

Using technologies to provide a timely and informed response to incidents helps riders know that response is quicker so there may be less fear about using public transportation.

## 2.4 Fleet Management

Fleet management may implement a variety of APTS technologies such as computer software, communications systems, and AVL for more effective planning, scheduling, and operations of transit vehicle fleets.

### *Communications Systems*

These systems are media equipment used for voice communications and/or data transfer for transit operations and may include mobile data terminals (MDTs). The most critical link is between the transit vehicle and management center, where a digital and/or analog radio system is typically employed.

### *Geographic Information Systems (GIS)*

GIS is a database management system in which geographic databases are related to one another via a common set of location coordinates. This relationship allows users to make queries and selections of database records based on both geographic proximity and attributes. GIS provides base maps for AVL, service planning, and trip itinerary planning.

### *Transportation Management Centers (TMCs)*

TMCs are centralized location (either physically or virtually) for monitoring and controlling transit fleet operations.

### *Traffic Priority Treatment*

This application gives transit vehicles priority over other vehicles at signalized intersections. The traffic signal is held on green, or turns green earlier than scheduled, to provide right-of-way to the transit vehicle. The benefit to transit users may be the reduction in trip time.

### *Automatic Vehicle Location (AVL) Systems*

AVL systems automatically determine and track the real-time geospatial location of a vehicle. Several different technologies may be used to perform AVL, such as GPS, ground-based radio, signpost and odometer, dead-reckoning, and combinations of these. Some increase in ridership is expected as evaluated in these quantitative examples:

- Toronto, Canada - The Toronto Transit Commission estimates that service improvements, from its AVL system, will conservatively result in a 0.5 percent to 1.0 percent increase in ridership.

- Portland, OR - From fall 1999 to fall 2000, weekday ridership increased by 450 for one route after Tri-Met used AVL data to adjust the route's headways and run times.
- Denver, CO – The Regional Transportation District (RTD) in Denver observed a 5.1 percent increase in ridership between 1995 and 1996 and attributes the increase to its CAD/AVL system.
- Milwaukee, WI - Total revenue ridership increased 4.8 percent between 1993 and 1997 for the Milwaukee County Transit System. The agency attributes the improvement to its CAD/AVL system.

AVL provides better customer satisfaction by increasing service reliability, facilitating passenger information including knowledge of bus position, thus reducing anxiety. Examples of impacts on customer satisfaction include:

- Milwaukee, WI - Schedule related public complaints decreased 24 percent between 1993 and 1997 for the Milwaukee County Transit System. The agency attributes the improvement to its CAD/AVL system.
- Denver, CO - Customer complaints have fallen by 26 percent since Denver RTD installed AVL.
- Portland, OR - Customer complaints fell from 60 in the fall of 1999 to 28 in the fall of 2000 (53 percent decrease) for one route after Tri-Met used AVL data to adjust the route's headways and run times.

The above snapshot shows how transit agencies are utilizing advanced technologies to enhance systems performance and where these applications have paid off in terms of customer satisfaction and retention. Also evident by this brief review is that providing real-time information helps riders make better decisions about their trips and helps agencies make better decisions on operation management issues.

# 3. Literature Review

As previously mentioned in the introductory section of this report, applications in APTS have proven to impact ridership and customer satisfaction. With new technologies emerging every day, new applications are tested and evaluated as they impact operations management invariable efforts to improve ridership and customer satisfaction. Emerging APTS applications utilize wireless networks to enhance transit operations, maintain existing ridership and attract non-riders. This literature review covers wireless applications in the transit industry, describes some of the new transit “amenities” and presents previous research findings on impacts of real-time information on riders and non-riders experiences.

## 3.1 Wireless Applications

Wireless applications are being used to improve operations in the transportation service industry. The Los Angeles County MTA is using wireless communication systems to speed up the public transit system with the use of bus-mounted transponders. It gives priority to transit vehicles at traffic signals while relaying bus arrival information to bus-stop message boards.

Wireless applications also are being used to monitor passenger loadings and provide additional in-vehicle or at-stop security. For example, the application of a wireless local area network could enhance the application of infrared motion analyzer (IRMA) automatic passenger counting systems. IRMA discerns the differences between boarding and exiting passengers at each door of transit vehicles *(2)*.

Interest in expanding wireless technologies to increase transit ridership is on the rise. Research conducted by the ITS research group at the University of Washington (ITS/UW) reports on a transit vehicle information system, *MyBus*, that delivers estimated departure times for buses at user-selectable geographic locations to Internet-enabled mobile devices *(3).* The system uses real-time vehicle position reports to predict travel times to future locations. Although the physical restrictions of mobile devices (e.g., screen size and input options) affect user interaction and data presentation, a Wireless Application Protocol (WAP) enabled cell phone is a suitable device for receiving real-time transit information. The nature of the information delivered by the *MyBus* prediction system is ideally suited to mobile users such as bus riders.

In Korea, research was conducted on how to provide en-route transit service information to passengers over ubiquitously available cellular phone devices while conforming to the emerging Korean ITS architecture *(4).*

The Transportation Research Board Transit Cooperative Research Program, TCRP report 92, "Strategies for Improved Traveler Information," published in 2003 provides a summary of existing practices in the area of improved traveler information in terms of traveler information needs, assessment of the state-of-the-art in information technologies, and preparation of a number of case studies in the area of improved traveler information *(5).*

In effect, wireless applications can be seen as another feature or "amenity" to help build transit ridership. TCRP Report 46, "The Role of Transit Amenities and Vehicle Characteristics in Building Transit Ridership: Amenities for Transit Handbook and the Transit Design Game Workbook," identified passenger amenities and transit vehicle characteristics that attract ridership, evaluated their relative impact on ridership, determined their relative cost-effectiveness, and provided the industry with practical tools that will assist transit professionals and policy makers in analyzing investment decisions *(6)* . This project will examine how various other "amenities" are assessed.

## 3.2 Real-time information impacts on riders and non-riders

In Washington, an evaluation of customer satisfaction with King County Department of Transportation's (Metro) bus station video monitors, known as Transit Watch®, concluded that it is widely used and found useful by most of the transit riders *(7).* The evaluation reported the results of a survey of a representative sample of transit riders at two transit centers in the Seattle metropolitan region. Telephone surveys were conducted between January and March 1999, resulting in a total of 505 completed questionnaires. While most respondents to the survey found the information displayed about bus schedules and real-time departure status comprehensive and accurate, they also offered many useful suggestions for improvements to the system. Transit Watch® was perceived to be of real benefit by its users. While passengers did not think that it altered their overall satisfaction with their transit experience, new frequent riders, who are likely to be most at risk of leaving public transportation when given the opportunity, reported the highest levels of satisfaction with Transit Watch®, (additional information on is at a web site maintained by the University of Washington, at the following URL, accessed May 20, 2004: http://www.its.washington.edu/transitwatch/).

In conjunction with Transit Watch® demonstration, the Busview-X project was deployed to show the viability of providing real-time transit information to transit riders *(8).* This project designed an advanced graphical transit information system using data from King County Metro Transit's existing AVL system and the Puget Sound's regional intelligent transportation backbone. The project managers created a World Wide Web page to launch the application; and demonstrated the system's viability by providing real-time transit coach locations to personal workstations on the University of Washington campus. As a precursor for the Puget Sound region, Busview-X was designed to:

- provide real-time coach location information to the test group,
- enhance King County Metro's existing investment in AVL technology without disrupting existing operations,
- evaluate AVL accuracy,
- encourage increased ridership, modal change, and productivity, and
- be compatible with federal efforts to develop a national ITS architecture.

Busview-X was used 2,490 times over a period of 670 days from November 1995 to September 1997.

During the Seattle Smart Trek Model Deployment Initiative, the ideas developed in the campus-based version of Busview-X were used to create a new version, Busview that could be widely supported on the Internet and allowed graphic user interface. Although the evaluation survey was very insightful, there remains to be an accurate measure for concluding whether ridership actually increased due to the availability of real-time information. The response of non-riders and the likelihood that they might decide to use transit as a result of the monitors was not confirmed by the evaluation. Also, bus information such as that provided by Transit Watch® is only one factor out of many that can impact ridership.

The FTA is particularly interested in what transit riders prefer regarding high technology types of information services. The August 2003 research report, "Customer Preferences for Transit ATIS" *(9),* presents findings from 12 workshops in 4 metropolitan areas with 284 transit customers conducted in November 2002. The results indicate riders prefer traditional forms of paper-based information and traditional wayside signage (e.g., schedules, maps, and fares). Inaccurate information was perceived as worse than no information, and high-quality traditional forms of information were considered more important than high technology approaches. Awareness of advanced transit information services was low, even in areas where they are available, suggesting that transit agencies need to promote their existing information services more.

Improved information received from public and private media can help travelers make more informed decisions, shorten times spent in traffic congestion and reduce anxiety/stress *(10).* The San-Francisco Bay Area TravInfo Project study analyzes the behavioral response of automobile and transit commuters as well as non-commuters to travel information received from radio, television and telephone. The data were collected through a computer-aided telephone interview conducted in the San Francisco Bay Area (N=947). Random-digit-dialing was used to reduce potential biases. The influence of information has seldom been studied in terms of these different users. The study analyzed impacts of socioeconomic, context and information variables on individuals' decisions to adjust 1) travel before beginning their trips, 2) given adjustment, the frequency of trip changes, and 3) the type of trip decision changed most recently including route, departure time, mode and no change. Travel time uncertainty and travel information received from the electronic media increased the pre-trip adjustment propensity. Furthermore, the most widely available and accessed medium, the radio, was highly likely to result in behavioral adjustments. Non-commuters had a high receptivity to canceling their trips in response to travel information. This has important implications for congestion relief in transportation networks.

The impact of emerging wireless technology that extends customer service on-board buses has not yet been explored. Wireless systems offer the opportunity for enhancing the experience of actually riding transit. Wireless "mesh" networks can use every client device (e.g., cell phone, PDA, laptop) as relay points or routers for network traffic to increase the speed and connectivity to the Internet of those devices. By pushing intelligence and decision making to the edge of the network, highly mobile and scalable broadband networks can be built at very low cost. With high speeds and wireless connections, time on the transit vehicle can be spent working on the Internet, checking email, etc.

# 4. Needs Assessment

USF is the second largest university in the southeast and among the top 20 largest in the nation. Founded in 1956, USF is located in the thriving Tampa Bay area. It has campuses in Tampa, St. Petersburg, Sarasota-Manatee and Lakeland, as well as its centers in downtown Tampa, New Port Richey, and Northern Pinellas County. USF's total enrollment in fall 2004 was 42,950 with 32,442 undergraduates and 7,366 graduate students. Tampa campus enrollment was 35,081 students in 2004.

Operated by USF, the Bull-Runner is a shuttle service that transports students in and around campus. The shuttle is free for all USF students, faculty, visitors and staff. The shuttles circulate on the USF Tampa campus, between the colleges and facilities, on and off-campus dormitories, and the University Mall. The Bull-Runner provides year-round reliable, safe and friendly transportation, (est. 800,000+ passenger trips per year).

In 2004, a USF Parking and Transportation Services (PATS) survey was administered to staff, faculty, and students at the University of South Florida. The survey was conducted to assess attitudes about and usage of parking and transportation services on the Tampa Campus of the University of South Florida and also to address which services and facilities would be most useful to students, staff, and faculty.

In addition to participant's work status (full-time, part time) and work location (on or off campus), trip origin and mode, the survey collected data on:

- Familiarity with shuttle and transit systems (Bull Runner and HARTline)
- Frequency of use of those systems
- Willingness to ride based on access to home and the availability of night and weekend service
- Willingness to ride without the need to transfer
- Willingness to ride if one knew where services went
- Estimation of what constitutes a "reasonable wait time" at a bus stop
- Experience using the USF PATS website

In addition to collecting the above data, CUTR added questions to the PATS survey to assist the research team in better understanding the attitudes and perceptions of riders and non-riders to enhancements to the USF Bull Runner System. The survey was conducted online and included skip patterns to ask only the pertinent follow-up questions.

The entire survey was converted from web format into text format to be included in Appendix A of this report. The first portion of the survey (questions 1-19 are those of PATS. The last 26 questions are those added by the Wi-Ride research team for the purposes of this project.

USF's InfoMart[1] numbers show that 76 percent of the USF Tampa campus population is students, 16 percent are staff and 8 percent are faculty and administrative positions for the Tampa campus. The response rate for this particular survey was approximately 5 percent of the Tampa Campus population of approximately 45,000 students, staff, and faculty, (2,165 respondents). This breaks down to 390 faculty members, 866 staff members, and 909 students who completed the parking survey. These percentages (18 percent faculty, 40 percent staff, and 42 percent students) of respondents show an overrepresentation of staff and faculty. This information indicates that faculty and staff are overrepresented in this particular sample and students are underrepresented. Weighting was used to adjust for this discrepancy in the sample.

The Wi-Ride portion of the survey consisted of 26 questions. The first question was designed to assess the familiarity of participants with the USF Bull Runner Shuttle. One third of the participants were familiar with at least one route on the system while almost one fourth did not go where the shuttle goes. The answers to the first question can be summarized as follows:

- I know it runs on campus, but I don't know where it goes (16.59 percent)
- I know it runs on and off campus, but I don't know where it goes (22.39 percent)
- I am familiar with at least one route, but don't know the whole system (34.06 percent)
- I am familiar with the whole system (14.65 percent)
- I don't know anything about it (14.21 percent)

The remaining 25 answers from the questionnaire are listed in Table 2. Two-thirds of participants indicated they do not use the shuttle at all, while nearly one in five participants used the shuttle few times in a semester. A little over seven percent of participants indicated daily or weekly use.

A ranked sums analysis was performed to define the most important factors affecting participants' decision to ride the Bull Runner shuttle. The factors are listed in Table 2 in descending order of importance in the decision-making

[1] The USF InfoMart is a web-based application intended to provide management information, in summary and detail, to interested users in the campus and general community. Data include a spectrum of University resources: including student headcount, enrollment, courses, credit hours, degrees, employees, and more.

process to use the shuttle. It was concluded that, if time and/or money savings were realized in riding the shuttle instead of driving, more people will choose the shuttle more often. The next group of characteristics affecting the stated preference to ride the shuttle involved aspects of dynamic convenience and timing. People will ride the Bull Runner if they know that they do not have to wait for a long time for the shuttle to come, if they know when the next shuttle is coming, if they know how long it takes to complete their journey on the shuttle, and if they can walk to the stops in five minutes or less. The third set of factors that influence using the shuttle were parking prices and availability, safety and security perceptions, and real-time information availability. The availability of evening services did not seem to affect the decision to ride the shuttle. Also, shuttle transfer was not an issue in the decision to ride the shuttle more often.

The findings of the survey indicate that the major factor in encouraging participants to ride the shuttle more would be saving time and money. The survey also suggests that if the actual arrival times of shuttles at stops were known and if actual arrival times of shuttles at stops can be accessed on-line and by phone, the shuttle use would increase. The original scope of this research project would test if and by how much shuttle use increases when these services become available. Other services in the top ranks include knowing when the shuttle will arrive before the passenger walks to a stop and how long the trip takes prior to boarding.

According to stated choices of UFS faculty, staff, and students, the proposed services would have provided them with incentives to ride the shuttles more frequently. Had the meshnetwork been installed, an “after” survey would have been conducted to measure the changes in ridership and the levels of customer satisfaction with the newly installed services.

As explained in a subsequent section, the meshnetwork installation was suspended by USF. CUTR was not able to develop the proposed system to develop, test and validate wireless access strategies on enhancing transit ridership on the university’s shuttle system. The task of combining strategically placed video and other sensors to collect and process data on the effect of such services on ridership was not able to be tested.

**Table 2: Attitudes of USF Faculty, Staff, and Students Towards Shuttle Services**

| n=2,165 before weigh | Daily (%) | Frequently (few times per week) (%) | Occasionally (few times per month) (%) | Rarely (few times per semester) (%) | Not at all (%) |
|---|---|---|---|---|---|
| ***How often do you use the USF shuttle*** | ***3.55*** | ***3.62*** | ***7.88*** | ***22.70*** | ***62.25*** |
| If I knew that riding the shuttle would save time compared to driving and parking, I would use it... | 17.11 | 19.87 | 19.51 | 15.08 | 28.43 |
| If I can save money using the shuttle compared to driving and parking, I would probably ride the shuttle... | 15.90 | 16.49 | 17.28 | 19.03 | 31.30 |
| If I know the actual arrival times of shuttles at stops, I would ride the shuttle... | 10.05 | 15.21 | 22.34 | 21.13 | 31.27 |
| If I can get actual arrival times of shuttles at stops on-line and by phone, I would probably ride the shuttle... | 9.08 | 11.23 | 21.12 | 23.56 | 35.01 |
| If the shuttle runs frequently, I would probably ride it... | 7.82 | 14.44 | 22.33 | 23.84 | 31.57 |
| If I know the exact duration of my trip on the shuttle, I would ride it... | 5.56 | 8.24 | 12.85 | 11.76 | 61.59 |
| If I know how long the trip takes prior to boarding, I would probably ride the shuttle... | 8.83 | 14.31 | 22.32 | 20.77 | 33.77 |
| If I can walk to a shuttle stop in less than 5 minutes, I would ride the shuttle... | 10.49 | 14.16 | 20.37 | 22.81 | 32.17 |
| Knowing when the shuttle will arrive before I walk to a stop would make me use the shuttle... | 8.52 | 13.43 | 22.02 | 22.25 | 33.78 |
| If it takes too long to find a parking space, I would probably ride the shuttle... | 9.15 | 14.39 | 20.05 | 22.06 | 34.35 |
| If I feel that shuttle stops are safe places to wait, I would probably ride the shuttle... | 8.53 | 12.53 | 23.85 | 21.32 | 33.77 |
| If I can get route information on-line and by phone, I would probably ride the shuttle... | 6.30 | 10.22 | 22.60 | 26.59 | 34.29 |
| If parking fees were increased, I would probably ride the shuttle... | 8.92 | 9.72 | 17.03 | 28.73 | 35.90 |
| If shuttles were less crowded, I would use the shuttle... | 8.07 | 11.79 | 21.54 | 23.94 | 34.66 |
| Knowing that shuttle drivers have 2-way communications for use in case of emergency would make me feel safe and I would ride the shuttle... | 7.35 | 10.88 | 22.04 | 24.42 | 35.31 |
| If I know where the shuttle goes, I would probably ride it... | 4.96 | 7.64 | 19.32 | 35.03 | 33.05 |

| n=2,165 before weigh | Daily (%) | Frequently (few times per week) (%) | Occasionally (few times per month) (%) | Rarely (few times per semester) (%) | Not at all (%) |
|---|---|---|---|---|---|
| If I know where the shuttle stops are, I would probably ride the shuttle… | 5.17 | 7.33 | 19.25 | 32.83 | 35.42 |
| If weather permits walking, I would ride the shuttle… | 8.18 | 11.70 | 19.88 | 23.75 | 36.50 |
| Seeing surveillance cameras on-board the shuttle would make me feel safe and I would ride the shuttle… | 6.02 | 10.01 | 20.64 | 24.09 | 39.24 |
| If I know how to get to a shuttle stop from a PNR facility, I would probably ride the shuttle… | 5.96 | 10.94 | 17.35 | 25.53 | 40.22 |
| Seeing emergency call boxes at shuttle stops would make me feel safe and I would ride the shuttle… | 5.30 | 7.34 | 17.10 | 24.74 | 45.52 |
| If I have to switch over to another shuttle to get to where I want to go, I would probably ride it… | 2.58 | 3.80 | 10.93 | 27.64 | 55.05 |
| If I know when the next shuttle is arriving if the one I want is full, I would ride the shuttle… | 8.98 | 12.85 | 18.75 | 24.91 | 34.51 |
| If the shuttle ran in the evenings, I would probably ride it… | 4.19 | 6.43 | 9.75 | 18.14 | 61.49 |

# 5. Existing Systems Review

In 2002, USF's Parking and Transportation Services (PATS) contracted to install a meshnetwork wireless communications system and provide the necessary software to improve fleet operations and improve the university's public transportation service.

The following summarizes the task to identify the types of video, voice, and/or data information, storage requirements (e.g. on-board vs. central location), and location options (e.g., onboard vs. at bus stops) that could be collected and distributed by Wi-Ride.

## 5.1 USF's meshnetwork wireless communication system

The primary purpose of PATS effort was to improve management and operations of the Bull-Runner system. According to USF's contract with the meshnetwork vendor, the installed system must meet USF's objective of locating and obtaining specific data from the shuttle buses on route, with the purpose of storing and redirecting this continuously transmitted information. The specifications for the vehicle information to be transmitted and recorded included:

- Information in real time at a minimum data rate of 1.5 Mbs.
- Vehicle location within a minimum of 5 meters, updated a minimum of every two seconds.
- Unique automatic vehicle identification code.
- Vehicle velocity (directly measured or derived from location change /time.)
- Driver identification system: keypad, touchscreen, card swiper, or equivalent driver input method.
- Route identification system: keypad, touchscreen, card swiper, or equivalent driver input method.
- Emergency distress alarm unobtrusively driver activated.
- Automatic route deviation alarm.

As part of this project, the meshnetwork for USF was to be installed as a campus-wide, wireless multi-hop communication network so that information could be exchanged among the buses, the control center and select bus stops. Further, this wireless network was to be connected to USF's network and the Internet so that users on campus and outside campus could have access to bus-related information. Figure 1 shows the wireless network and its scope and connectivity to other USF's networks.

The wireless communication network was based on MeshNetworks' Mesh Enabled Architecture (MEA) technology, which provides broadband and multi-hop wireless connectivity. The provider' was contracted to deliver the following:

1) The installation of several intelligent routers on the USF campus and on public electric poles. Combined routers would provide coverage to the entire campus and to the two bus routes outside USF's campus
2) One mobile unit for each bus
3) One control center where the fleet of buses and the entire application and network was going to be managed

The bus units where equipped with GPS units in order to have absolute location information of the units at any time. In addition, this network had other bandwidth management capabilities by which the available channel capacity of 2 Mbps could be managed more efficiently for specific applications. For instance, certain priority and quality of service mechanisms were available to better service some more critical applications or different types of streams, such as voice and video.

Even though this communication network was meant to be used by PATS, it represented a major investment that could be leveraged to provide additional benefits to USF and the community at large. Conversations with PATS concluded with the idea of using this communication network as a platform for developing and supporting more services and research activities. Part of the PATS planned project with the meshnetwork vendor was to connect each bus to the central controller which would enable PATS and riders to connect to the wireless network via a wireless box installed in each bus. Such a system would allow the vehicle to transmit its location in real-time as well as provide access to the Internet. The control center was physically located in the PATS office on campus. The information received from each bus would instantly be displayed on electronic boards located in all bus stops, so riders would know where the buses are and how much time it will take the next bus to reach the specific bus stop. The Wi-Ride project was designed to complement PATS's effort. The expectation by all parties was that CUTR would use this meshnetwork once fully installed to test the Wi-Ride concept. Given the substantial investment by USF and the vendor in the infrastructure, there was no way to predict the problems that contributed to the suspension of the meshnetwork installation at USF.

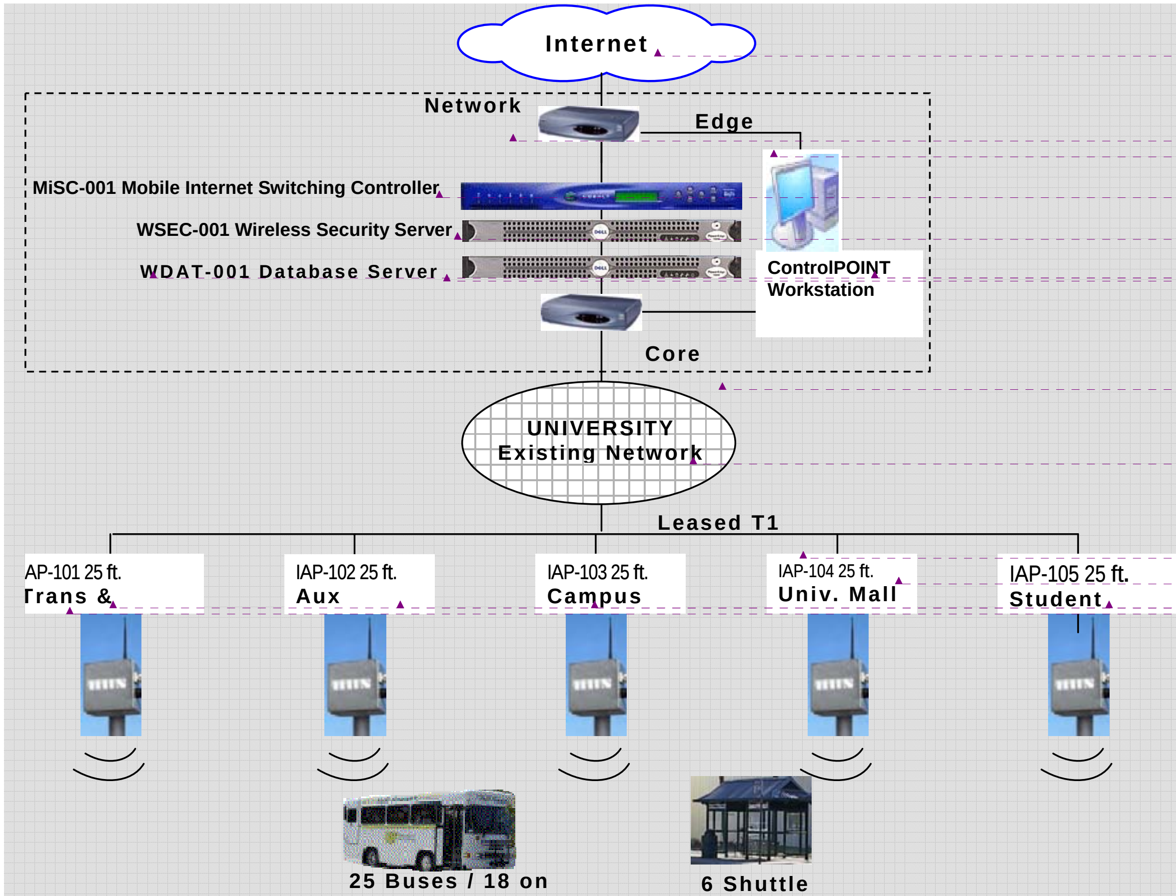


**Figure 1: Wireless Network**

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Based on this infrastructure, the Wi-Ride project hypothesizes that ridership would increase if productivity and security in buses could be increased. The project contemplated the installation of network and video devices in all buses so that Internet access and video surveillance services could be provided. Figure 2 shows the entire concept of the Wi -Ride project.

The Wi-Ride project had to study different aspects of these new services. For example, the wireless network provided a maximum capacity of 2 Mbps, therefore, the new services should be provided so that they did not affect the operations of the transportation management application. This is particularly important in the case of the video surveillance service, as video transmissions usually require large amounts of bandwidth. Therefore, as part of the project, different transmission options, equipment and location of the equipment were going to be studied and evaluated to engineer the system properly. Other considerations were the strengths and weaknesses of the alternative methods of providing the service, particularly through wireless networks such as 802.11(b) and cell phone service. The project team reviewed such options.

Another aspect was how to determine the effect of such systems on rider and potential rider attitudes and behavior. The following sections will summarize the findings from designing the system and locating hardware that would satisfy system requirements. With the focus of such a system on enhancing ridership, the project team needed to establish a baseline from which to assess changes in attitudes and/or behaviors. A subsequent section of this report will summarize the results of a comprehensive survey of USF students, staff and faculty to establish baseline attitudes and behaviors (i.e., before the system was deployed).

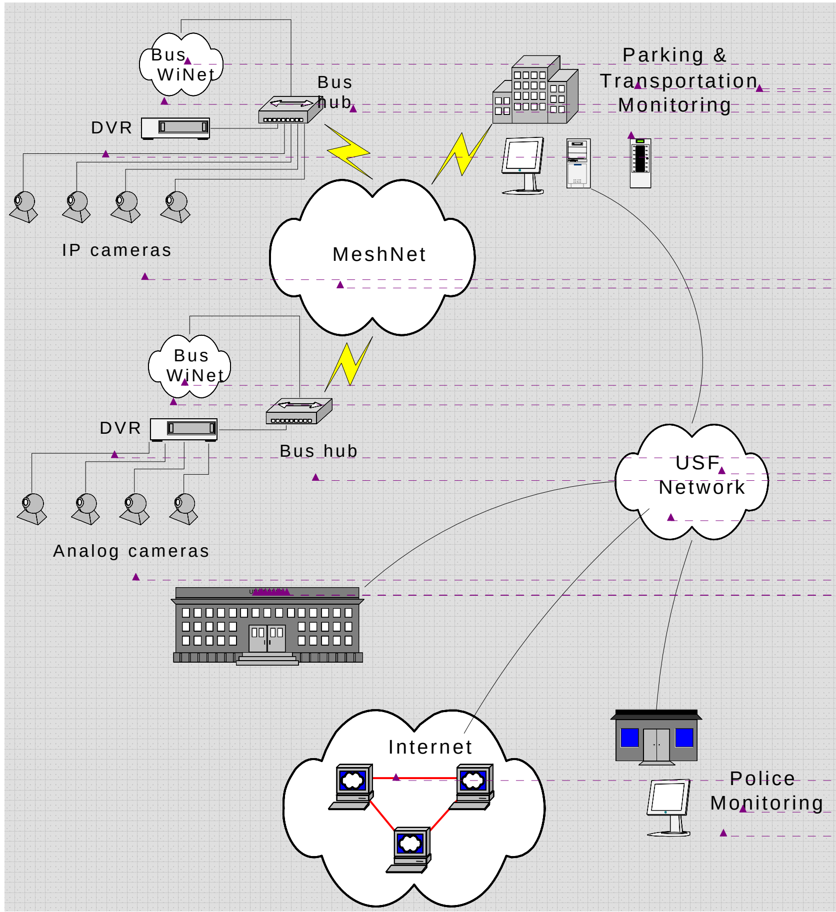


**Figure 2: The Wi-Ride Concept**

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## 5.2 Capabilities of proposed meshnetwork

Figure 3 shows how the new PATS meshnetwork would provide connectivity to the USF main wired network and the Internet. Through the wireless network, shuttle riders would have access to all current applications and services already available through USF and Internet access. Riders could be using their portable devices on-board as if they were seated in their respective office seats within USF, and therefore, they could be checking their email accounts, writing reports, etc. or browsing the Internet while riding from home to work.

To achieve this connectivity within the bus, an additional device must be installed and connected to the main bus "box" that actually connects the bus to the wireless network. This internal device must provide connectivity using a popular technology so that most riders can actually connect their devices to the network. A wireless local area network (WLAN) access point of the IEEE 802.11b type, the most widely used wireless technology was selected for this purpose. Most users now have 802.11b interfaces or can buy them for approximately 30 dollars. Also, newer computers are equipped with this wireless interface already integrated into the motherboard. These WLANs cover the bus area completely and can simultaneously accommodate all riders aboard the shuttle.

Figure 3 shows the necessary equipment within each bus to provide Internet access and video surveillance and how all these internal devices are interconnected to the wireless network, the USF network, and the Internet. A high speed switch is utilized as a device integrator. The wireless access point and the video recorder both are connected to the main switch. Wireless portable devices, such as laptops and PDAs, connect directly to the wireless access point and then to USF's network through the main modem or "box" that connects the bus to the exterior wireless network. Similarly, video streams from the cameras are either stored on the bus in the minicomputer or sent to PATS's main controller where the video streams are monitored and stored as well.

Figure 4 shows the physical location of the different devices in a typical bus.

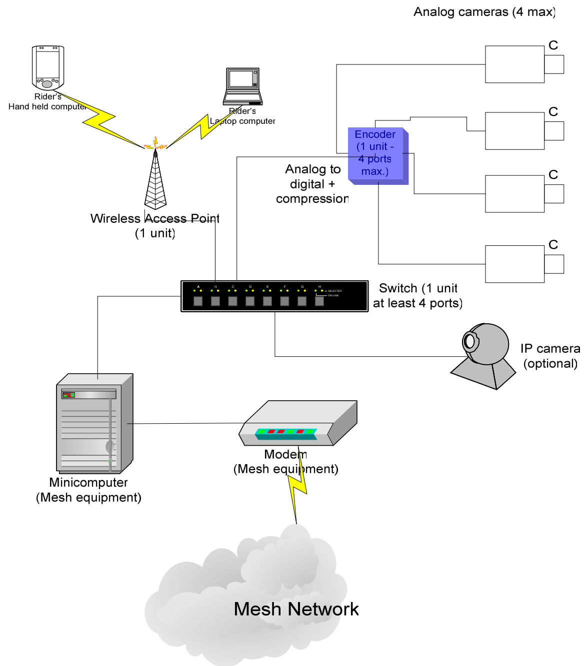



**Figure 3: Necessary Equipment Within Each Bus to Provide Internet Access and Video Surveillance**

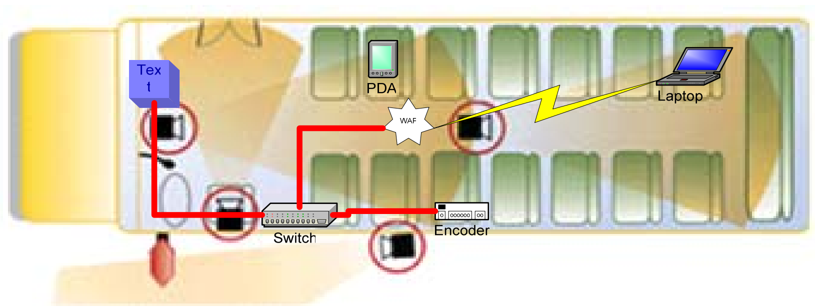



**Figure 4: Physical Location of the Different Devices in a Typical Bus**

## 5.3 Available wireless communication services in the area

While the PATS wireless network seemed to be the ideal network to use for the Wi-Ride project, the capabilities of other wireless networks available in the Tampa Bay area were investigated to determine if they were suitable to serve as a backup or supplemental network for this project. The identified potential solutions fit into two categories:

- USF's 802.11b "Wi-Fi" network
- Commercial cellular networks

The first potential solution is USF's 802.11b "Wi-Fi" wireless network. IEEE 802.11b or "Wi-Fi" hotspots are areas in which anyone with a "Wi-Fi"-enabled device can connect to the Internet. These devices can be laptops, desktop PCs, Personal Digital Assistants (PDAs), or any other portable device that has either build-in support for a Wi-Fi connection or has been outfitted with a Wi-Fi connection card that can be purchased at most electronic stores. These cards must support the Wi-Fi standard in order to be compatible with the network *(11)*. 802.11b connections support data transfer speeds up to 11 Megabits per second (Mbps) which would be sufficient bandwidth to support multimedia applications such as streaming video as well as multiple web-browser connections by riders with laptops on the transit vehicle *(17).* A Wi-Fi hotspot is created by the installation of a router that is wired to the campus network and has antennas to support wireless connections to nearby client devices in a radius of approximately 50-250ft (range can vary depending on signal strength, interference, and nearby physical obstacles). In order for a transit vehicle to connect to this network, a wireless router and access point would have to be installed on the vehicle. This system would function as both a client device to USF's network and provide an extension of the USF wireless network to compatible devices such as riders' laptops on the bus or an on-board computer used to record and transfer digital video. Additionally, for a stable connection to USF's 802.11b network coverage over the transit routes would have to be complete and without gaps that could interrupt service.

USF's Information Technology (IT) department was contacted to determine the locations and amount of 802.11b on-campus coverage. A map of USF campus coverage is available at http://help.acomp.usf.edu/wireless/map.html. It was determined that coverage was focused on buildings and nearby outside common areas and did not extend to roads or parking lots where transit vehicles would travel. The cost associated with extending the on-campus Wi-Fi network to the roads traveled by transit is outside the scope of this project, and USF IT does not currently have plans to provide such coverage in the near future. Additionally, since a significant percentage of the shuttle routes are off-campus to serve the nearby living communities and University Mall, even an expansion of the USF Wi-Fi network would not be able to cover these extended areas on the PATS service routes. Therefore, USF's 802.11 network was eliminated as a potential alternate solution for the Wi-Ride project.

A second potential solution is the wide variety of commercial cellular networks that are available to the public. The networks available in the Tampa Bay area include those owned by the companies Alltel, Cingular / AT&T Wireless, Sprint-Nextel, T-Mobile, and Verizon Wireless. Each of these companies has deployed a particular type of cellular data network implemented using varying types of technology, each of which has a different data transfer rate. All cellular networks can be classified as a particular "generation" according to the networks data speed *(18)*. A list of networks classified by generations is shown in Table 3, along with services that can be provided to a single user of that connection. It should be noted that demands on the cellular data network are dramatically increased by multiple simultaneous users, so for the Wi-Ride project the listed services in the 2.5G category cannot be provided to multiple transit riders simultaneously. A list of the cellular carriers, data networks, network classification, costs, and network technologies and specifications are shown in Table 4 *(19).*

**Table 3: Cellular Data Networks Classified by Generation**

| Cellular Data Networks - Services and Speeds | | | | | | |
|---|---|---|---|---|---|---|
| | **1G** | **2G** | **2.5G** | **3G** | **3.5G** | **4G and Beyond** |
| Technology | AMPS | GSM, CDMA, iDEN | GPRS, 1xRTT, EDGE | UMTS, 1xEV-DO | HSDPA (upgrade for UMTS), 1xEV-DV | WiMax |
| Speeds | n/a | Less than 20Kbps | 30Kbps to 90Kbps | 144Kbps to 2Mbps | 384Kbps to 14.4Mbps | 100Mbps to 1Gbps |
| Features for single user | Analog (voice only) | Voice; SMS; conference calls; caller ID; push to talk | MMS; image; Web browsing; short audio/video clips; games, applications, and ring tone downloads | Full-motion video; streaming music, 3D gaming; faster Web browsing | On-demand video; video conferencing | High-quality streaming video; high-quality video conferencing; Voice-over-IP telephony |
| Source: "CNET's Quick Guide to 3G Cell phone Service," *Digital Living*. June, 2005. | | | | | | |

To connect to these networks, the user must subscribe to the cellular service for a monthly fee. Activation of a subscription account is usually associated with a required service contract, either one or two years in length. The user must also purchase a connection card that is compatible with both the cellular network and the user's device. These cards are sold by the cellular carriers and usually feature a PCMCIA-type connection, which is commonly found on laptops, although a few do have a Compact Flash-type (CF) connection which can be found on some PDAs and other smaller profile devices. For a transit vehicle to connect to this network, some kind of onboard computer equipped with a cellular connection card would have to be located on the bus. This computer could be connected to an on-board wireless router to allow riders to access the Internet or digital video cameras to record and transfer video.

**Table 4: Alternatives to MeshNetwork**

| Cellular Data Networks | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Cellular Carrier | Network Type | Network Classification | Avg. Download Speed | Burst Download Speed | Avg. Upload Speed | Burst Upload Speed | Available in Tampa as of 4/1/2004? | Monthly Cost | ETA for nationwide rollout | Website |
| Alltel | CDMA (1xRTT) | 2G | 40-70Kbps | 144Kbps | ~40-70Kbps | ~144Kbps | Yes | $70, Unlimited | n/a | http://www.alltel.com/business/enhanced/mobilelink.html |
| | EV-DO | 3G | 300-500Kbps | 2MB | ~40-60Kbps | 100Kbps | No, launched May 2005 | $70, Unlimited | Early 2006 | http://www.alltel.com/business/enhanced/mobilelink.html |
| Cingular / AT&T Wireless | GPRS | 2.5G | ~25-35Kbps | ~90Kbps | ~25-35Kbps | ~90Kbps | Yes | $80, Unlimited | n/a | http://www.cingular.com/sbusiness/data_connect |
| | EDGE | 2.5G | 70-135Kbps | 200Kbps | ~70-135Kbps | ~200Kbps | No, launched Q4 2004 | $80, Unlimited | Late 2004 | http://www.cingular.com/sbusiness/data_connect |
| | UMTS | 3G | 220-320Kbps | 384Kbps | ~220-320Kbps | ~384Kbps | No | $80, Unlimited | End of 2006 | http://www.cingular.com/midtolarge/umts?awredirect=awspecificpage |
| Nextel | iDEN, CDPD | 2G | 56Kbps | 56Kbps | 56Kbps | 56Kbps | Yes | $44.99, Unlimited | n/a | http://www.nextel.com/en/solutions/dataaccess/unlimited_access_plan.shtml |
| Sprint (now Sprint-Nextel) | CDMA (1xRTT) | 2G | 60-80Kbps | 144Kbps | ~60-80Kbps | ~144Kbps | Yes | $80 for 300MB | n/a | http://www.sprint.com/business/products/categories/wirelessData.jsp |
| | EV-DO | 3G | 300-500Kbps | 2MB | ~40-60Kbps | ~100Kbps | No | Unknown | Early 2006 | http://www.sprint.com/business/products/products/wirelessHighSpeedData.jsp |
| T-Mobile | GPRS | 2.5G | 20-35Kbps | ~56Kbps | ~20-35Kbps | ~56Kbps | Yes | $30, Unlimited | n/a | http://www.t-mobile.com/plans/default.asp?tab=Internet |
| | UMTS/HSDPA | 3G | Unknown | Unknown | Unknown | Unknown | No | Unknown | 2007 | n/a |
| Verizon Wireless | CDMA (1xRTT) | 2G | 60-80Kbps | 144Kbps | ~60-80Kbps | ~144Kbps | Yes | $60, Unlimited | n/a | http://www.verizonwireless.com/b2c/mobileoptions/nationalaccess/index.jsp |
| | EV-DO | 3G | 400-700Kbps | 2MB | 40-60Kbps | 100Kbps | No, launched Sept. 2004 | $80, Unlimited | End of 2006 | http://www.verizonwireless.com/b2c/mobileoptions/broadband/index.jsp |
| ~ = Approximate speed based on network technology (actual speed not documented by carrier) | | | | | | | | | | |

Cell phone data networks are currently implemented using two basic types of data networks: those based on Global System for Mobile Communications (GSM) technology and those based on Code-Division Multiple Access (CDMA) technology. Nextel, having a network based on the proprietary Integrated Digital Enhanced Network (iDEN) technology is one exception (13). When first deployed in the mid-1990s, each of these networks supported basic second-generation (2G) data speeds which averaged usually less than 20 Kbps. Enhancements for these networks

(General Packet Radio Service [GPRS] for GSM and 1xRadio Transmission Technology [RTT]) were deployed in the late 1990s and early 2000s, enabling data speeds on the order of 30Kbps-80Kbps. At the time of the initial evaluation of potential alternative networks in the Tampa Bay area in July 2004, the fastest cellular data network was either Sprint or Verizon Wireless' 1xRTT network with average download speeds of 60-80Kbps and bursts up to 144Kbps. A list of all services, including services that would become available later in the project as discussed in Section 6 – "Technology Assessment – Broadband Wireless Networks for Public Transit," is shown in Table 4. Averaging slightly greater than dial-up speeds, existing networks would not have been able to sustain streaming video or web access for multiple simultaneous users. Additionally, the monthly fee associated with cellular networks made it significantly more expensive than the meshnetwork, which was a private infrastructure owned by PATS and therefore free to use on this project. Therefore, cellular data networks were initially eliminated as a potential alternate solution for the Wi-Ride project.

## 5.4 Review of video and/or voice devices that could be used for transit wireless applications

In addition to Internet access to increase productivity, the Wi-Ride project would also include video equipment to increase security. As part of the project, different video surveillance vendors and equipment were evaluated in order to choose the equipment that best suited the project needs. Since the channel capacity of the network was unknown at the time, and since the video application would consume a portion of the 2 Mbps, very flexible equipment in terms of compression schemes and storage capabilities were needed. Compression schemes were important to study the tradeoffs among channel capacity consumption, clarity and usefulness of the video for security purposes. Flexible storage devices were also needed to determine what would be the most appropriate place to store the video; on the bus, in a central location at the control center or at both locations. This aspect is related to the channel capacity consumption issue as previously described.

Different vendors were contacted for the technical assessment of equipment suited for the project. Examples of equipment assessed included Internet Protocol (IP) cameras, analog cameras, Digital Video Recorders (DVR), encoders and video software. Information was gathered from 10 vendors: NCDCS, Verint, Axcess, Axis Communications, AccuTech, DVTel, GE Interlogix, SerVision USA, Vaguard Managed Solutions, and VCS. After the initial analysis, Verint, Axcess and NCDCS remained of interest. Verint and Axcess could provide the entire video solution, and NCDCS could provide IP cameras only. In addition to these and other technical aspects, costs and company characteristics were also considered factors. The support of these decisions is documented in the following tables, taken from the project's main evaluation matrix.

Table 5 includes general information about the companies, the type of product they offer, prices and some important conclusions/observations for our project, such as use of standards, provision of multiple video streams, flexibility, and technical and commercial support.

**Table 5: Vendor and Product Information**

| Vendor | Contact Information | Product Offered | Product Components | Total Solution Price | Conclusions |
|---|---|---|---|---|---|
| NCDCS, Inc. | http://www.ncdcs.com/<br>info@ncdcs.com<br>sales@ncdcs.com<br>(360) 666-3443<br>P.O. Box 2902<br>Battle Ground, WA 98604 | MPEG4 Camera System | 4 port Web Server / Encoder lo or hi speed | $2100.00 - $2700.00 | Have a MPEG4 based IP camera solution. Will test their equipment and software as an alternative to expand number of cameras in buses. |
| | | | 4 analog cameras: enclosed bullet or dome | $380.00 - $540.00 | |
| | | | Webcam / encoder | $1,750.00 | |
| | | | WebVR 200 for 4 video streams | $500.00 | |
| | | | WebVR Pro for 4 video streams | $600.00 | |
| | | | Digital Video Storage | Cust. PC | |
| Verint | http://www.verint.com/<br>Martin Bolduc:<br>martin.bolduc@verint.com<br>Bill at COAXIAL:<br>bill@coaxialsystems.com<br><br>1800 Berlier St. Suit 200<br>Laval, Quebec H7L 4S4<br>CANADA<br>(450)686-9000<br>(450)686-0198 | Custom Design | S1504e-T Ethernet video server wo/power supply | $2,000.00 | Utilizes a proprietary compression algorithm (based on the widely used MPEG4 standard). So far, their equipment provides speed and adaptability. Software can work in the three live scenarios considered: monitoring central station, bus recording and monitoring |
| | | | nDVR-PRO 3.0 option - Remote archive server for 1-8 cameras w/ one failover dir server | $750.00 | |
| | | | nDVR-PRO 3.0 CD - Video management/storage PRO software w/ Internet connectivity and maps/procedures functions for 8 encoder/decoder and 2 client licenses | $5,000.00 | |
| | | | Digital Video Storage | Cust. PC | |
| | | | Does not inc S&H | | |
| Axcess, Inc. | http://www.axcessinc.com/<br>Tom Pacey:<br>tpacey@axcessinc.com<br>Phone: 1-800-588-6080 Ext. 224<br>Fax: 972-407-9085<br>3208 Commander Drive<br>Carrollton, TX 75006 | Networked Digital Video Solution | PV-LCT-2000 LANConnect | $679.00 ea. | Utilizes a proprietary based codec for compression (straying away from the widely used MPEG4 standard). Future scalability issues: 16 cameras max are supported per LANCorder software, whereupon a new package would need to be purchased to support more came |
| | | | LANCorder software | $840.00 | |
| | | | Total (w/4 LANConnects, 1 per cam): | $3,556.00 | |

| Vendor | Contact Information | Product Offered | Product Components | Total Solution Price | Conclusions |
|---|---|---|---|---|---|
| Axis Commun-ication | http://www.axis.com/<br>info@axis.com<br>kyle.sadlock@axis.com<br>SAN DIEGO<br>Phone: +1 858 458 0471<br>1-800-444-AXIS | AXIS IP Surveillance Solution | AXIS 2130 Pan Tilt Zoom Network Camera | $1,699.00 | Top of the line provider for IP cameras and an IP-based solution. Supports only JPEG solutions which consume lots of bandwidth when compared to MPEG. |
| | | | AXIS 2120 Network Camera | $949.00 | |
| | | | AXIS Milestone Software for Camera Management and Recording (4 camera license) | $1,195.00 | |
| AccuTech<br><br>(Pelco distributor) | http://www.accutech.com/<br>1-800-493-8328 Ext. 113<br>(Mike Harron) | Pelco Digital Video Recorder | DX 3108-240 | N/A | Product did not support simultaneous viewing of multiple cameras. No capability of recording continuously at central location, only locally. Vendor suggested another product but there were no follow-ups on it, even after reminding them, and felt that their |
| DVTel, Inc. | http://www.dvtel.com/<br>Phone: 201-368-9700<br>Fax: 201-368-2615<br>52 Forest Ave.<br>Paramus, NJ 07652 | SecureLink Network Video Recording System | NVRS Elite NVR Software | N/A | Numerous efforts to contact vendor via telephone and email. When they finally did reply to an email they told me that they felt their application wouldn't suit our needs since they did not see how it would fit and that it was not ruggadized. So they did n |
| | | | NVR Elite Remote Archiver | N/A | |
| | | | User License (2 pack) | N/A | |
| | | | Camera Licenses (1-9) | N/A | |
| GE Interlogix | www.geindustrial.com/ge-interlogix<br>Gulf Atlanta Marketing<br>(407)359-0525<br>Gatlantic@aol.com<br>Roberta Bandenburg | BusSecure | Mobile Vehicle Digital Video Recorder | $10,186.00 | Product does not support transmission of live video over a WAN. Only still snapshots can be accessed via an antenna and cellular transmission. Storage is local only. |
| | | | Wave Reader Software | | |
| | | | camera color 2.9mm lens | | |
| | | | camera color 4.0mm lens | | |
| | | | camera color 6.0mm lens | | |
| | | | camera housing aluminum | | |
| | | | Microphone | | |
| | | | Tag alarm | | |
| | | | Review station w/o drive | | |
| | | | 110 VAC to 12 VDC power supply | | |

| Vendor | Contact Information | Product Offered | Product Components | Total Solution Price | Conclusions |
|---|---|---|---|---|---|
| SerVision USA | http://www.servision.net/<br>nickb@servision.net,<br>info@servision.net<br>Tel: +1 925 323 3847<br>Fax: +925-323-3847<br>2759 Grande Camino<br>Walnut Creek, CA 94598 | Video Surveillance Solutions | SVG-400 | N/A | Last minute suggestion from U.S.-based VCS partner. Several attempts to contact vendor, but no reply. Seemed to offer a possible solution, but it required a bulky pc that would probably take up a lot of space. |
| | | | Client Software | | |
| | | | Control Center Software | | |
| Vanguard Managed Solutions | Mansfield; MA - 508-261-4000<br>www.vanguardms.com | Equipment required 120v AC power | | | Unsuitable power source. |
| VCS | http://www.vcs.com/english/index.shtml<br>info@vcs.com<br>Phone: +49-911-93 456-0<br>Forchheimer Strasse 4<br>90425<br>Nuremberg/Germany<br>USA-based Partners:<br>http://www.vcs.com/english/bezugsquellen/partner/usa.shtml | VCS Surveillance Solution | Toshiba IK-DF01A | $275.00 | Germany based company. Contact established via a U.S.-based partner who said that the products I selected were currently in production, despite being advertised on their website. Suggested solution only supported 1 camera at a time. |
| | | | VCS VideoJet 10 | $650.00 | |
| | | | VCS VIDOS 16 Channel Licence Software | $1,100.00 | |
| | | | VCS VIDOS 16 Channel Licence Recording Software | $2,250.00 | |
| | | | Total (w/4 cameras & VideoJets): | $7,050.00 | |

Table 6 includes the technical information collected to analyze the Digital Video Recorders (VDRs). Again, in addition to general and technical information, the table contains important aspects of the project, such as communication protocols utilized, network interfaces supported, compression schemes, data rates, and prices, among the most important ones.

## Table 6: Digital Video Recorders

| Product | Vendor | Price | Dimensions HxWxD | Video inputs | Drive size | Frames per second | Compression | Server Functions Highlights | Video Data Rate | Network Protocols | Software/Update | Configuration | Content of Delivery | Network port |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Digital Web Server w/o storage capabilities Lo – Hi (for Q2) | NCDCS, Inc | $2100.00 - $2700.00 | 212x45x 143 (mm) | 4 analog BNC | available thru external network based device | Aggregate throughput of 20 fps shared between 4 ports at 10 max per port | MPEG4 200:1 -500:1 | PTZ controls | 56 Kbps - 1 Mbs | TCP/IP, ping, HTTP, ARP, FTP, DHCP, SMTP, and PPPoE | | | | 1 RJ-45 10-BaseT 10Mbps Ethernet |
| Digital Video Storage 1u | NCDCS, Inc | N/A | | | 480-1000 GB | | | Monitor sensors<br>Trigger alarms<br>Control lights<br>Browser-based GUI management | | | RAID 0,1,5, and 5 w/hot-spare | | | 2 10/100 and 1 GB Ethernet interfaces w/failover & trunking support<br>Local SCSI external port (optional) |
| Network Digital Video Recorder Axis 2460 | Axis Communic ation | N/A | | | 2X 40 GB Disks | | | | | | | | | |
| S1504e-T Ethernet video server | Verint | $2,000.00 | | 4 composites, 1 vpp into 75 ohms (NTSC/PAL) | available thru external network based device | 1-30 fps programmable (full motional) claims 30 fps per analog port | MPEG4 based 176 x 120 to 704 x 480 | | 30 Kbps - 4Mbps | TCP/IP, UDP/IP, RTP/IP | Firmware upgrade: flash memory for video codec upgrade, and application firmware over the network | Remote: via nDVR,S configurator, or telnet<br>Local: via serial port using any ASCII terminal | | 1 RJ-45 10/100Mbps Ethernet |

| Product | Vendor | Price | Dimensions HxWxD | Video inputs | Drive size | Frames per second | Compression | Server Functions Highlights | Video Data Rate | Network Protocols | Software/Update | Configuration | Content of Delivery | Network port |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| LANConnect | Axcess, Inc. | $679.00 | | 1 analog BNC | N/A - Stored on network pc | 15-30 fps | Proprietary CODEC | Alarm connection and Intelligent Alarm Trigger Detection | 128Kbps-256Kbps refresh rate | TCP/IP | N/A | Via LANConnect receiver software | | 1 RJ-45 10/100Mbps Ethernet |
| | | | | | | | 263 CIF | Bandwidth throttling | Bandwidth approx.: 100kbps/10 fps | | | | | |
| | | | | | | | | Dual video display modes (color/mono-chrome) | | | | | | |
| | | | | | | | | Addressable by 2 simultaneous receivers | | | | | | |
| SVG-400 | SerVision USA | N/A | 206mm x 90.5mm x 240mm | 1-8 camera inputs | 2.5 inch: 20GB - 80GB | 60 fps | MPEG-4, DSP based | Simultaneous video recording and playback on all channels, continuous and cyclic recording - disk never full | | LAN, WAN | | Built-in web-server | | 1 RJ-45 10/100Mbps Ethernet |
| | | | | | 3.5inch: 20GB - 250GB | | 320x240, 160x120 | High security encryption (192 bit) of the video stream | | PSTN, ISDN, ADSL | | Supports 15 concurrent users | | Optional: PSTN (phone) modem (SVG400-P) |
| | | | | | | | Data rates: 15 Kbps - 2 Mbps | Adjustable bit rates to support the full range of network bandwidths (15 KBits/sec to 1 MBits/sec, 5-30 fps live) | | GSM, GPRS, CDMA, HSCSD | | | | Optional: PCMCIA slot for external modems (SVG400-M) |
| | | | | | | | | Software generated Motion Detection with adjustable threshold and Region-of-Interest | | | | | | |
| | | | | | | | | Event-driven user notification | | | | | | |
| SecureLink 7501E Encoder | DVTel, Inc. | N/A | 4.52" x 5.6" x 1.25" | 1 analog BNC | N/A | 1-30 fps | MPEG4 | 3 alarm inputs, 1 relay output | 30 Kbps - 4Mbps | TCP/IP | Firmware upgrades via network | Configuration via Telnet or SecureLink Configurator | | 1 RJ-45 10/100Mbps Ethernet |
| | | | | | Stored on network pc | | 176x120 to 720x480 | Firmware upgrades via network | | RTP/IP | | | | |
| | | | | | | | | SSL-based user authentication | | UDP/IP | | | | |

| Product | Vendor | Price | Dimensions HxWxD | Video inputs | Drive size | Frames per second | Compression | Server Functions Highlights | Video Data Rate | Network Protocols | Software/Update | Configuration | Content of Delivery | Network port |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| DX 3108-240 | AccuTech | N/A | 3.5" x 17.3" x 18.3" | 8 analog BNC | 240 GB | 30 fps | MPEG<br>640 x 240<br>352 x 240 | 4 alarm inputs<br>2 relay inputs<br>Live and recorded video viewing | | TCP/IP | Remote Site software | | Rack ears<br>Rubber feet<br>IR Remote controller<br>DB15 to 8-BNC cables for DX3116, RS-232C to RS422/485 converter | RJ-45 10/100 Ethernet |
| VideoJet 400 | VCS | N/A | Desktop (mm): 260x37.02x184.96 Cabinet (mm): 435.6x44 x184.97 | 4 BNC PAL/NTSC compatible | Opt. 20 GB | | MPEG-4 / H.323<br>704x288 2CIF<br>352x288 CIF<br>176x144 QCIF | 4 alarm inputs & Master Alarm<br>4 relay outputs<br>DHCP - auto-IP assignment<br>Multicasting & Internet streaming<br>Motion detection & comprehensive security features | 10 kB/s - 1 MB/s | RTP, RTCP<br>UDP, TCP, IP<br>HTTP, IGMP, ICMP<br>ARP, DHCP, SNMP | Flash ROM<br>Remote Programmable<br>Local RS232 port | Via web browser<br>Built-in Web server<br>Quick Install Guide<br>CD w/manual and VCS software (PROVLite) | VideoJet 400 Encoder/Codec w/power supply<br>RS323 null modem | 10/100 Base-T FastEthernet |
| VideoJet 8000 | VCS | N/A | 446.3 x44.6 x351.52 mm | 8 BNC PAL/NTSC compatible | USB interface for WLAN or local storage | 480 fps | MPEG-2 / MPEG-4<br>720x576 full D1, 352x288 CIF<br>704x288 4CIF/2CIF<br>352x288 CIF<br>176x144 QCIF | 8 alarm inputs<br>8 relay outputs<br>Integrated video scene analysis<br>Multicasting & Internet streaming<br>Motion detection & comprehensive security features | 1 MB/s - 8 MB/s<br>9.6 kB/s - 1.5 MB/s | RTP, RTCP<br>UDP, TCP, IP<br>HTTP, IGMP, ICMP<br>ARP, DHCP, SNMP | Flash ROM<br>Remote Programmable<br>OSD, built-in LCD | Via web browser<br>Built-in Web server<br>Quick Install Guide<br>CD w/manual and VCS software (PROVLite) | VideoJet 8000 Video Server incl. main cables<br>RS323 null modem, cable, 1 HU rack mount kit | 10/100/1000 Base-T GB Ethernet |

| Product | Vendor | Price | Dimensions HxWxD | Video inputs | Drive size | Frames per second | Compression | Server Functions Highlights | Video Data Rate | Network Protocols | Software/Update | Configuration | Content of Delivery | Network port |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Mobile Vehicle Digital Video Recorder | GE-Interlogix | $5,100.00 | 4x7x10 (inches) | 4 BNC PAL/NTSC compatible | | 1 to 30 programmable | Wavelet | | | | | | | 1 Ethernet 10/100 |
| RemoteVU Guardian | Vanguard Managed Solutions | N/A | 1.75X12. 5X15.5 | | 1x80 GB | | H.263 | FTP, Web | | | | | | 1 Ethernet 10/100 |
| External USF proprietary storage | OEM | | | | | | | | | | | | | |

Table 7 provides the specifications of the recommended product that facilitates the transfer of video to and from the bus. The product is the VIP 100 and the vendor, VCS, information can be found at http://www.vcs.com/english.

**Table 7: Original Equipment Manufacturer (OEM) Specifications for VCS VIP 10 Video Sender/Receiver Module**

| | Compression | Frames/sec | Image Quality | Network Port | Video Data Rate | Audio Data Rate | Audio Encoder | Software Update |
|---|---|---|---|---|---|---|---|---|
| **Specs** | MPEG-4 | 30 fps | 720x576 | 10/100 Base-T FastEthernet | 9.6 kB/s - 4MB/s | 64 kB/s Bidirectional audio | Sampling rate: 8kHz | Flash ROM Remote Programmable |

| **Other Specifications** | | | | | |
|---|---|---|---|---|---|
| **Video Encoder** | **Network Protocols** | **Configuration** | **USB Interface** | **Misc. Functions** | **Video Encoder** |
| 704x576 4CIF | RTP, RTCP | | One 1.1 ext. interface | Remote PTZ camera control | 704x576 4CIF |
| 704x288 2CIF | UDP, TCP, IP | Via web browser | Usage: WLAN or local storage | Dome & multiplexer control | 704x288 2CIF |
| 352x288 CIF | HTTP, IGMP, ICMP | | WLAN (opt.) RF-Interface 802.11b | Motion detection | 352x288 CIF |
| 176x144 QCIF | | Built-in Web server | Storage Media (opt.): | Alarm management | 176x144 QCIF |
| Low latency mode < 150ms | ARP, DHCP, SNMP | Local RS232 port | CompactFlash card, micro-drive | Alarm input | Low latency mode < 150ms |

Table 8 contains the information pertaining network cameras. These are also known as IP cameras, intelligent cameras or Web cameras. The main feature of these cameras is that they can be remotely accessed and controlled through a network connection. Communication protocols supported, frame rates, compression schemes, audio support, and price were among the most important considerations.

**Table 8: Web-Network Cameras**

| Product | Vendor | Price | Dimensions HxWxD | Highlights/ Functions | Video Inputs | Frame Rate / sec | | Resolution | Compression | | | Video Data Rate | Network Protocols | Configuration | Image Sensor | S/N Ratio | Sensitivity | | Power | Operating System |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| AXIS 2130 Pan Tilt Zoom Network Camera | Axis Communication | $1,699.00 | 4.4"x5.4"x5.6" | | | up to 30 | | 704x480 max | Motion JPEG | | | | TCP/IP, HTTP, ARP, FTP, DHCP, SMTP, PPP, CHAP, PAP, and more | Remote conf and status | 1/4" Sony EXView HAD intelaced CCD HxV: 768x494; Resolution (pixels): 704c480 | | Illumination range: min 2 lux | | 13V DC | |
| AXIS 2120 Network Camera | Axis Communication | $949.00 | 2.24" x 3.39" x 7.21" | Password/ user name protection for restricted camera access<br>Event triggered remote image storage via email and FTP | | Up to 30 fps @ 352x240 | Up to 12 fps @ 704x480 | 704x480 | MJPEG | 352x240: 10 Kb (Low), 7 Kb, (Med), 3 Kb (Hi) | 704x480: 43 Kb (Low), 28 Kb, (Med), 13 Kb (Hi) | | TCP/IP, HTTP, ARP, FTP, DHCP, SMTP, PPP, CHAP, PAP, and more | Firmware updates via flash memory | | | 1-200,000 LUX @ F1.0 | 1-5,000 LUX w/fixed iris lens | | Linux OS |

| Product | Vendor | Price | Dimensions HxWxD | Highlights/ Functions | Video Inputs | Frame Rate / sec | Resolution | Compression | Video Data Rate | Network Protocols | Configuration | Image Sensor | S/N Ratio | Sensitivity | Power | Operating System |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| WebCam / encoder | NCDCS, Inc | $1,750.00 | 59x69x115 mm | Bidirectional Audio Voice over IP | | 5 to 30 | QVGA 320 x 200 Horizontal resolution 380 TV lines | MPEG4 200:1 to 500:1 | Scalable bandwidth 56kbs to 1Mbs | TCP/IP, ping, HTTP, ARP, FTP, DHCP, SMTP, and PPPoE | | | 1/3" Interling SONY super HAD CCD | | 12 VDC x 250 mA | |
| LANCam | Axcess Inc. | $849.00 | | Alarm input<br>Video loop through<br>1 RJ-45 10/100 Ethernet<br>Motion video and snapshots<br>Bandwidth throttling - min. 9.6 kbps | | 15 to 30 | 330 TVL (H)<br>350 TVL (V) | Proprietary CODEC<br>30 fps max | | TCP/IP | Via software<br>User authentication - login and password<br>Mini-firewall built-in | CCD Iris, video driving auto iris | > 46dB | 2 LUX @ F1.4 | 12V DC x 1.5 A | |

| Product | Vendor | Price | Dimensions HxWxD | Highlights/ Functions | Video Inputs | Frame Rate / sec | Resolution | Compression | Video Data Rate | Network Protocols | Configuration | Image Sensor | S/N Ratio | Sensitivity | Power | Operating System |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| C 100 | VCS (and others; search web for good deals) | | 175x68.5x71 mm | | Multicasting / Live Video over Network<br>Comprehensive Security Functions<br>Integrated Motion Detector | Simultaneous Analog/Digital (PAL/NTSC) | 30 fps | NTSC: 480 (h) x 350 (v) TV lines<br>PAL: 470 (h) x 410 (v) TV Lines | H.261 / H.263 / H.323<br>MPEG-4 / M-JPEG | RTP, RTCP<br>UDP, TCP, IP<br>HTTP, IGMP, ICMP | Flash ROM<br>Remote Programmable | Via web browser<br>Built-in Web server | 1/3" color CCD | 48 dB (AGC off) | | |

Analog cameras were also analyzed. These are the cameras that would be connected in different places around the bus and to the DVR. These cameras can be either black and white or color. In most cases they come included with the entire video solution and the project team found that there was not much difference among them.

A second evaluation matrix was also built to study Verint and Axcess in more detail. Although all the necessary information to make a decision was collected, final recommendations were not made due to the unavailability of USF's meshnetwork. Nonetheless, the second evaluation matrix is also included below as Tables 9, 10, and 11.

## Table 9: Vendors

| Vendors | Product Offered | Product Components | Equipment Pricing | Total Solution Price (1 bus) | Total Solution Price (10 buses) | Total Solution Price (50 buses) | Conclusions |
|---|---|---|---|---|---|---|---|
| Verint<br>http://www.verint.com/<br>Martin Bolduc:<br>martin.bolduc@verint.com<br>Bill at COAXIAL:<br>bill@coaxialsystems.com<br><br>1800 Berlier St. Suit 200<br><br>Laval, Quebec H7L 4S4<br>CANADA<br>(450)686-9000<br>(450)686-0198 | Custom Design | S1504e-T Ethernet video server wo/power supply | $2,000.00 | Equipment needed:<br>1 nDVR-PRO-3.0 (8 cam, 2 user video management sw)<br>1 nDVR-PRO-8RAS-3.0 remote archive server for 8 cams & (1) failover.<br>1 S1504e-T Video Server<br>Item 2 discount - 10 percent<br>PC for Central Station at least $2,000.00<br><br>Total: $8,975.00<br><br>Note: One license for user video management at Central Station, and one license for user video management at the bus. | $8,975.00 previous column<br>Plus equipment needed:<br>9 nDVR-PRO-8RAS-3.0 remote archive server for 8 cams & (1) failover.<br>9 S1504e-T Video Server<br>Above discount - 15 percent<br>16 nDVR-Pro3.0 (2) additional cam licenses<br>5 nDVR-PRO-3.0 (2) additional clients for user video management at the bus.<br><br>Total: $36,755.00 | $36,755.00 previous column<br>Plus equipment needed:<br>40 nDVR-PRO-8RAS-3.0 remote archive server for 8 cams & (1) failover.<br>40 S1504e-T Video Server<br>Above discount - 20 percent<br>80 nDVR-Pro3.0 (2) additional cam licenses<br>20 nDVR-PRO-3.0 (2) additional clients for user video management at the bus.<br><br>Total: $163,555.00 | Utilizes a MPEG4 standard based proprietary compression algorithm. |
| | | nDVR-PRO 3.0 option - Remote archive server for 1-8 cameras w/ one failover dir server | $750.00 | | | | |
| | | nDVR-PRO 3.0 CD - Video management/storage PRO software w/ Internet connectivity and maps/procedures functions for 8 encoder/decoder and 2 client licenses | $5,000.00 | | | | |
| | | Digital Video Storage | Cust. PC | | | | |
| | | Does not inc S&H | | | | | |
| Axcess, Inc.<br><br>http://www.axcessinc.com/<br>Tom Pacey:<br>tpacey@axcessinc.com<br>Phone: 1-800-588-6080 Ext. 224<br>Fax: 972-407-9085<br>3208 Commander Drive<br>Carrollton, TX 75006 | Networked Digital Video Solution | PV-LCT-2000 LANConnect | $679.00 ea. | Equipment needed:<br>4 LANConnects (1 per cam)<br>1 LANCorder Software<br>1 PC Server (approx $2,000)<br><br>Total: $5,556.00 | Equipment needed:<br>40 LANConnects (discounted @ $611.00 ea.)<br>3 LANCorders<br>3 PC Servers (approx. $6,000.00)<br><br>Total: $32,960.00 | Equipment needed:<br>200 LANConnects (discounted @ $559.00 ea.)<br>13 LANCorders (discounted @ $768.00 ea.)<br>13 PC Servers (approx. $26,000.00)<br><br>Total: $147,784.00 | Utilizes a proprietary based codec for compression (straying away from the widely used MPEG4 standard). |

| Vendors | Product Offered | Product Components | Equipment Pricing | Total Solution Price (1 bus) | Total Solution Price (10 buses) | Total Solution Price (50 buses) | Conclusions |
|---|---|---|---|---|---|---|---|
| | | LANCorder software | $840.00 | Including local storage:<br><br>Scenario 1 (purchase additional LANCorder per bus):<br>1 LANCorder Software<br>1 PC Server<br>(approx. $2,000.00)<br><br>Total: $8,396.00 | Including local storage:<br><br>Scenario 1:<br>3 LANCorders<br>3 PC Servers<br>(approx. $6,000.00)<br><br>Total: $41,480.00 | Including local storage:<br><br>Scenario 1:<br>13 LANCorder Software<br>13 PC Servers<br>(approx. $26,000.00)<br><br>Total: $183,768.00 | Future scalability issues: 16 cameras max are supported per LANCorder software, whereupon a new package would need to be purchased to support more cameras. Software needs its own server instead of having multiple copies on the same pc. |
| | | Total (w/4 LANConnects, 1 per cam): | $3,556.00 | Scenario 2 (use existing LANCorder copy on bus, w/Axcess' permission):<br>1 PC Server (approx. $2,000.00)<br><br>Total: $7,556.00 | Scenario 2:<br>3 PC Servers (approx. $6,000.00)<br><br>Total: $38,960.00 | Scenario 2:<br>13 PC Servers (approx. $26,000.00)<br><br>Total: $173,784.00 | |

## Table 10: Digital Video Recorders

| Product | Vendor | Price | Video inputs | Drive size | Frames per second | Compression | Server Functions/Highlights | Video Data Rate | Network Protocols | Software/Update | Configuration | Network port | Security |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| S1504e-T Ethernet video server | Verint | $2,000.00 | 4 composites, 1 vpp into 75 ohms (NTSC/PAL) | available thru external network based device | 1-30 fps programmable (full motiona) claims 30 fps per analog port | MPEG4 based 176 x 120 to 704 x 480 | | 30 Kbps - 4Mbps | TCP/IP, UDP/IP, RTP/IP | Firmware upgrade: flash memory for video codec upgrade, and application firmware over the network | Remote: via nDVR, Sconfigurator, or telnet Local: via serial port using any ASCII terminal | 1 RJ-45 10/100Mbps Ethernet | SSL-based authentication |
| LANConnect | Axcess, Inc. | $679.00 | 1 analog BNC | N/A<br>Stored on network pc | 15-30 fps | Proprietary CODEC<br>263 CIF | Alarm connection and Intelligent Alarm Trigger Detection<br>Bandwidth throttling<br>Dual video display modes (color/monochrome)<br>Addressable by 2 simultaneous receivers | 128Kbps-256Kbps refresh rate<br>Bandwidth approx.: 100kbps/10fps | TCP/IP | N/A | Via LANConnect receiver software | 1 RJ-45 10/100Mbps Ethernet | Login via username and password<br>Mini-firewall built-in |

## Table 11: Software

| Product | Vendor | Price | Function | O/S | H/W | Real-time | Video Viewing | Display | Scan Network | Configuration | Trigger & Alarm | Recording | Email | Security |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| nDVR-PRO 3.0 option - Remote archive server for 1-8 cameras w/ one failover dir server | Verint | $750.00 | | Windows NT MSQL | Server (Archiver and directory) only Minimum Requirements – for system up to 16 cameras* Intel(r) Celeron(tm) 1 GHz Processor* 512 MB of RAM for Server only* 20 GB hard drive configured in Raid 1 (for OS/nDVR/SQL)* Required GB hard disk for video storage* 10/100 Ethernet Network Interface Card* Microsoft(r) Windows 2000 Service Pack 4, or Windows XP Service Pack 1 | | | | | | | | | end to end SSL 248 bit RSA digital video signature |
| nDVR-PRO 3.0 CD - Video management/storage PRO software w/ Internet connectivity and maps/procedures functions for 8 encoder/decoder and 2 client licenses | Verint | $5,000.00 | | Windows NT MSQL | Monitoring station only (viewing 16 cameras full motion)Recommended Requirements* Intel(r) Pentium(r) 4, 2.2 GHz Processor or higher* 384 MB of RAM or higher* 32 MB graphics card1* CD-WR2* 10/100 Ethernet Network Interface Card* Microsoft(r) Windows 2000 Service Pack 4, or Windows XP Service Pack 1 | | | | | | | | | end to end SSL 248 bit RSA digital video signature |

| Product | Vendor | Price | Function | O/S | H/W | Real-time | Video Viewing | Display | Scan Network | Configuration | Trigger & Alarm | Recording | Email | Security |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| LANCorder | Axcess, Inc. | $840.00 | Network Video Recorder | Win 2000/XP | PC | Yes | 1-16 simultaneous streams | Local player with time/date search engine | IP addressable to retrieve specific camera feeds | Via a web browser | Triggered alarm notification | Video device selection | Yes - alarm event triggered | Security login features |
| | | | | | | | Simultaneous viewers | Playback in 4x4 (16 images) format of all videos | Automatic detection of cameras on network connected to LANConnect device | Up to 30 fps for single stream, up to 4 fps for multiple streams - dynamically adjusted or manually selected | Alarm event email feature | Frame rate selection | | |
| | | | | | | | | De-multiplexed viewing of a single video stream | | | | | | |
| | | | | | | | | Disk capacity status | | | | | | |

## 5.5 Review communication profiles and loads for network design

Since PATS wireless network never became available, this task was not performed. If the research project was to be carried out using Verizon's wireless network, determined to be the best option available as a substitute of USF's meshnetwork, this task would be completed. The main task to perform here would be the study of the network performance with regards to the number of users and type of network traffic.

# 6. Technology Assessment

## 6.1 PATS Meshnetwork

Several performance tests were initially envisioned before putting the new services in place. Since the meshnetwork was a shared infrastructure with the main objective being the management of the fleet of USF buses, it was important to determine the impact that these new services would have on the network. In particular, PATS people were concerned about the amount of channel capacity that the video streams would take and the impact on the management application. Also of concern was the performance of the users and the quality of the video. The response time of the applications being run within the buses using the new Internet access service had to be reasonable. Also the video that would be transmitted and stored would need to be of sufficient quality for PATS risk management needs Obviously, these objectives pointed toward different directions, as, for example, a high quality video needs more channel capacity and more storage.

As a result, performance tests were established to determine the minimum acceptable rate for the video streams, the compression mechanism, the location where to store the video and for how long, the maximum number of concurrent video streams, the blockage of video streaming and voice over IP applications from inside the buses, etc. For these reasons, one important decision variable in the acquisition of the video equipment was the flexibility to change and use different compression schemes, transmission rates, storage options, etc. All these tests were going to be performed with the real equipment and the real meshnetwork once in place.

Unfortunately, while the project team worked on these and other aspects of the project, internal (USF) and external problems slowed down the progress of the PATS's project and finally, in late 2004, PATS revealed that the project was at a complete standstill due to lack of funding, turnover at PATS, and disputes with the vendor. Despite the fact that PATS had possession of many of the routing devices, the system cannot function as a whole due to lack of on-board bus computers that were never delivered to PATS. In consultation with the FDOT project manager and FDOT Research Office, a decision was made to look for alternatives to the meshnetwork and revise the scope of the project.

Beginning in September 2004, the status of the PATS meshnetwork became questionable. Conversations with PATS officials shortly after revealed that due to internal (USF) and external situations, the installation of the meshnetwork was at a stand-still with no further available funding. With the meshnetwork no longer an option, the issue of potential alternative broadband wireless networks was revisited. USF IT was again contacted, and it was determined that there had not been sufficient changes to USF's 802.11b network. The only remaining alternative would be cellular data networks. Since the reason that cellular networks were initially dismissed as an option related to the low data speeds of available networks, a potential solution for the Wi-Ride project must be a new third generation (3G) high-speed network that was not available during the initial evaluation. The original list of specifications for all available networks was appended and is shown in its entirety in Table 4, section 5.3 of this report.

## 6.2 Technology Assessment - Broadband Wireless Networks for Transit

On September 28, 2004, Verizon Wireless launched their "Broadband Access" service, an EV-DO cellular data network with download data rates averaging broadband speeds of 400-700Kbps, and bursts up to 2MB *(14)*. Although upload speeds of 60-80Kbps with bursts up to 144Kbps would prevent the streaming upload of video from the bus to the Internet, the high speeds of the download connection would make it feasible to provide Internet access to riders with laptops on the transit vehicles and potentially stream video to the bus from a central video server. These services would retain the intent of the original project and still allow the impact of real-time data services on transit riders to be evaluated. Additionally, this new network is available wherever a cellular signal that supports EV-DO is transmitted, which includes the entire Tampa Bay area. Therefore, this network extends the potential cooperating transit agencies to include PSTA with locations in Clearwater, Largo, and St. Petersburg and the HARTline in Tampa.

Since a replacement network was now available, potential on-board equipment was evaluated. To provide Internet access to the bus and to transit riders, a device with the following specifications was needed:

1) Total equipment cost < $1200
2) Wi-Fi compatible router
3) Supports cellular modem compatible with Verizon Wireless EV-DO network (Audiovox PC5220 or Novatel v620 PCMCIA cards)
4) Usage tracking mechanism so an accurate history of device usage, including the number of users, can be reported

Table 12 shows all evaluated devices, referred to as "cellular gateways." While a full scale, ruggedized, on-board computer could provide the needed functions, these devices cost several thousand dollars and therefore were outside of the budget's scope. It was discovered that there are very few ruggedized, low-cost "cellular gateway" devices that have a reduced function set (when compared to an full-scale on-board computer) that brings the cost of the device into the range of the project budget but still meet the project requirements. The first device that was found to meet the specifications was Alliant Network's CGW103-RG. However, it was later discovered that the device was discontinued upon the purchase of Alliant Networks by BroadCom in February 2005. A new device, Omniwav's MH1100, became available shortly afterwards and provides all necessary features that the CGW103-RG exhibited.

**Table 12: Cellular Gateway Devices**

| Company | Product | Cost | Built-in Wi-Fi router | Cellular modem | Provides Usage History | Global Positioning System | Allows 3rd party software to be installed on device | Ruggedized | Notes/ Conclusion | Website |
|---|---|---|---|---|---|---|---|---|---|---|
| Alliant Networks | CGW103-RG | $850.00 | Yes | Can connect to any supported PCMCIA modem (including Verizon EV-DO card) | Yes | Yes, satellite-based GPS | | Yes | Product is no longer available (Discontinued when Alliant Networks was purchased by BroadCom 2/4/2005)<br><br>*Does not fit system specs* | http://www.alliantnetworks.com |
| Junxion | JB-110b | $699.00 | Yes | Can connect any supported PCMCIA modem (including Verizon EV-DO card) | | No | | Yes | Provides all needed functions except for usage history of network activity. No 3rd party software can be installed on device, which prevents creation of custom software to record usage history. While this device allows will allow transit riders to connect to the Internet, the study would be prevented from successfully tracking the usage of the device down to the user level. Only data usage available would be the count of transferred kilobytes from the Internet to the transit vehicle from Verizon's monthly service statement.<br><br>*Partially fits system specs and provides service, but not usage history needed for study* | http://www.junxion.com/product/ |
| Possio | PX40 | Un-known | Yes | Built-in UMTS/GPRS modem | Yes | No | | Yes | Only supports UMTS cellular service which is only available in select U.S. cities, not Tampa<br><br>*Does not fit system specs* | http://www.possio.com/scripts/split.asp?cat=3&prod=wireless&dynfile=px40_overview&id=english&dh=3 |

| Company | Product | Cost | Built-in Wi-Fi router | Cellular modem | Provides Usage History | Global Positioning System | Allows 3rd party software to be installed on device | Ruggedized | Notes/ Conclusion | Website |
|---|---|---|---|---|---|---|---|---|---|---|
| Telepath Wireless | C-WAN2XW | > $1200 | | Connects to internal cellular modem via serial port. | Yes | No | | Yes | Very expensive system due to configuration. Open PCMCIA slot for Wi-Fi card. Does not currently support PCMCIA connections for cellular modems, so a stand-alone cellular modem is connected to the router via a serial port. Stand-alone cellular modems for 3G networks are currently scarce and expensive, which prevents this solution from being viable. This system is actually several devices connected together and integrated into one box and "suitcase". *Does not fit system specs* | http://www.telepathwireless.com/ |
| InMotion Technology , Inc. | oMG 1000 | $1,800. 00 | Yes | Can connect to any supported PCMCIA modem | Yes | Yes, satellite-based GPS | Yes | Yes | Very expensive system, but does includes on-board computer with linux-based system. *Does not fit system specs* | http://www.inmotiontechnology.com/gateway.htm |
| OmniWav Mobility | MH1100 | $929.00 | Yes | Can connect to any supported PCMCIA modem (including Verizon EV-DO card) | Yes | Yes, satellite-based GPS | Yes | Yes | $979 if ordering 4 or less. Supports all needed functions. Comes with external cellular antenna, Wi-Fi antenna, & power adaptors. Vendor will allow custom scripts and applications to be installed on the embedded-linux device. *Fits system specs* | http://omniwav.com/ |
| Global Net Commerce Inc. | Data modem | > $1200 | | Built-in CDMA modem | Yes | No | | | No built in Wi-Fi, so additional router needed. Not ruggedized or mountable. Must order 100 or more for $1200 pricing. Largely untested in vehicle applications. *Does not fit system specs* | info@globalnetcommerceinc.com |

After a device was selected to provide access to Verizon's broadband network and the Internet from the bus, secondary devices that could display video to riders who didn't have laptops were investigated. Since the low-cost "cellular gateway" devices do not support direct video connections to a regular video device, an IP monitor that had its own network-addressable connection was needed. Table 13 shows a list of these devices.

**Table 13: IP monitors**

| Company | Product | Cost | Advantage | Disadvantage | Link |
|---|---|---|---|---|---|
| Digital Systems Engineering | IPC6/215 | $4,432.00 | Full fledged computer size of monitor. 15" monitor | Very expensive | http://www.digitalsys.com/html/computers.html |
| Sony | LocationFree TV LF-X5 | $1,100.00 | Simple device, fairly low price. | 7" monitor. Not ruggedized. New technology. Cannot be charged and used at same time. No mounting equipment | http://www.sony.com |
| Sony | LocationFree TV LF-X1 | $1,500.00 | 12.1" monitor, simple device, fairly low price. Can be recharged during use. Picture-in-Picture is supported for TV and other images. | Not ruggedized. New technology. No mounting equipment | http://www.sony.com |
| ViewSonic | Airpanel V110p | $804.95 | Low cost. 10" monitor. | Low processing power. Meant to be used on local WLAN with computer. Unsure if device will work on bus. No mounting equipment. | http://www.viewsonic.com/support/mobilewireless/airpanelsmartdisplays/airpanelv110p/ |

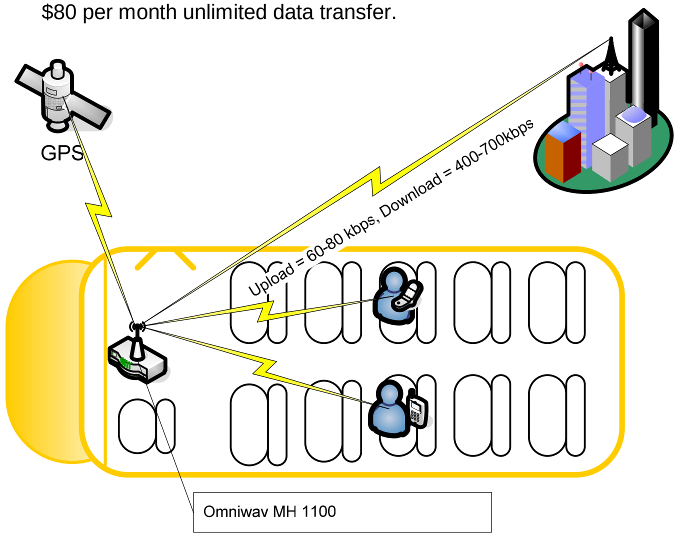
An additional GPS feature is included, which adds the potential for location-based services that could be delivered to the riders. Another device, the Junxion JB-110b, fit all requirements except for capability to record network usage down to a user level. While this device would provide users with a Wi-Fi connection, it would not allow the study to record accurate history information per user. Therefore, the number of simultaneous users accessing the network would not be determined and the time it was accessed would also not be determined. The only usage information available would be a count of the amount of data transfer to and from the cellular gateway from the EV-DO network from Verizon, expressed in kilobytes. This information would not be useful for the scope of this study, which is to determine whether ridership is affected by access to real-time information. To determine how many users accessed the service and whether the same user accessed the service multiple times, which can be determined by the unique Media Access Control (MAC) address of the Wi-Fi card in each user's laptop, more precise usage history is needed. MAC address recording and usage timestamps are supported by the MH1100.

System cost is estimated at $1068, which includes the MH1100, the Audiovox PC5220, and all necessary antennas, connectors, and mounting equipment. Additional costs include the service for Verizon's EV-DO Broadband Access plan, which is $80 with a contract required for at least one year of service. If service is terminated during the contract period, an early-termination fee of $175 is charged to the account. Figure 5 shows a diagram of the network structure.

# Verizon Wireless

*EV-DO/CDMA Network*

EV-DO = Average download speeds of 400-700 kilobits per second (Kbps) with burst speeds up to 2 Mbps. Average upload speeds expected to be between 60-80kbps with burst speeds up to 144kbps. $80 per month unlimited data transfer.




This cellular gateway is meant to serve many people via a wired or wireless connection (Wi-Fi). Wireless card for EV-DO network is required ($100). External Antenna is included to increase WAN and Wi-Fi signals.
Supports GPS, so cellular gateway can also act as an AVL.

**Omniwav MH1100 Cellular Gateway - $929**
**Audiovox PC5220 -EV-DO card - $100**

Contact:
www.omniwav.com

**Figure 5: Network Structure Using Verizon EV-DO Broadband Access Service and Omniwav MH1100 Cellular Gateway**

It was determined that IP monitors are fairly new technology, and the most appropriate device would be the Sony LocationFree TV LF-X1. However, due to the high price, it will not be possible to include this device with the current project budget.

After the equipment was selected, PSTA and HARTline were contacted to see if their cooperation could be secured for the study in replacement of USF PATS. The research team attended meetings with both agencies, and came to a tentative agreement. PSTA was still evaluating and troubleshooting a newly installed AVL system and could not participate in the project until that task was completed. They estimated that they would be able to participate around June or July 2005. HARTline is planning to deploy new buses and routes in January 2006. The HARTline team has committed to install and test a Wi-Ride system on the new buses. Both agencies agreed to advertise the Wi-Fi service to transit riders, keep track of ridership counts while the devices were deployed, and install the necessary equipment on their buses. Therefore, cooperation of two new transit agencies has been secured.

Various PSTA and HARTline bus routes have been discussed as targets for the broadband wireless service. Several Express Bus routes, including the 100X, 200X, and 300X, are routes that cross Tampa Bay and travel from Clearwater to Downtown Tampa and back. These routes are approximately 45 minutes in length, which would allow the riders a sufficient amount of time to open their laptops and take advantage of the Wi-Fi connection. Additionally, these express routes target business-class travelers, who would also be an excellent target market for the Wi-Fi service. A final decision on selected routes will be made closer to the time of deployment when further ridership data is available for the new express bus routes and other newly established routes.

Since the initial equipment evaluation of cellular gateways, there have been further developments that increase the number of options for high-speed cellular data networks. Over the last year, mergers between major cell phone carriers, including the merging Sprint and Nextel into “Sprint-Nextel” on 12/15/2004 and the acquisition of AT&T Wireless by Cingular on 2/17/2004 have allowed the companies to pool their assets and invest in the creation of faster data networks *(15), (16),* and *(17).* Additionally, increased customer interest in data applications for cell phones has encouraged cellular carriers to provide faster access to the Internet. As a result, almost all cellular companies are currently testing broadband wireless solutions or have already launched a broadband service in several major markets. On March 28, 2005, Alltel unveiled its Axcess Broadband service, another EV-DO service very similar to Verizon’s, in select cities, including Tampa. Sprint is also testing EV-DO service in cities other than Tampa, but plans to launch nation-wide service in early 2006. Cingular/AT&T Wireless launched its Enhanced Data rates for GSM Evolution (EDGE) network (a 2.5G service) in late 2004 and is currently testing its UMTS network in various cities other than Tampa, but plans to launch the UMTS service nationwide as early as the end of 2006.

Fortunately, manufacturers of the low-cost cellular gateway devices that support PCMCIA cards only have to install drivers for the 3G compatible cards on their existing device in order for their device to be compatible with the new emerging networks. This “plug-and-play” system will allow owners of these devices to choose the best network that is available for their location without being locked into a particular cellular carrier or network type.

The emergence of multiple competing broadband networks should reduce the price that is charged to access them. The average monthly fee for unlimited access is currently around $80 per month. However, once this technology becomes established and services such as streaming music and video to mobile devices become more common, prices will drop significantly. Cingular/AT&T Wireless and Verizon Wireless have already introduced consumer-level plans at $25 and $15 per month (respectively) that provides access to certain streaming music, 3D games, and videos from a broadband-enabled mobile phone.

## 6.3 Project Status

In discussions with the FDOT project manager in early 2005, it was recommended that the broadband wireless service option (e.g., Verizon) be pursued and tested with a couple of transit systems, include a vanpool. Both the FDOT project manager and FDOT Research Office personnel recommended submitting the revised scope once the transit systems were on-board. In addition, the costs would be determined by the routes selected by the agencies and the number of cellular gateways and service plans required CUTR was preparing a new scope once the cooperation of the transit agencies was obtained and budget updated to reflect the expanded tests when, in June 2004, the FDOT Research Office issued a “cease work” order. In consultation with FDOT project manager, it was determined that the new direction appeared to deviate from the original scope and that the new direction would be best handled as an entirely new project. It also was noted that the circumstances requiring these changes were outside control of the project team. This report was prepared to summarize the findings to date and document the extensive effort of the research team on this project such that others will benefit from the information and lessons learned.

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# Appendices

## Appendix A: USF Parking and Transportation Services Web Survey – 2004

1) Please select your status:

- Student
- Faculty
- Staff

2) Work status:

- full-time
- part-time
- not applicable

3) Work location:

- on-campus
- off-campus
- not applicable

4) Student status:

- full-time
- part-time

5) I live:

- on-campus
- off-campus

6) What is your ZIP code?

- 33612
- 33613
- 33617
- 33637
- 33549 south of I-275
- Other :
- If you answered other, please explain.

7) Please select where you live from the list (locations A-N)
Select Answer

- Adagio Apt Homes
- 3600 E. Fletcher Ave Andover Club
- 4824 E. Busch Blvd Arbors @ Fletcher Island
- 13400 Arbor Isle Dr Ascott Place
- 14003 Saulk Ct Ashley Gables

- 2225 E. 131st Ave Ashley Oaks
- 1701 131 st E. Ave Avalon Heights
- 4314 E. Fletcher Ave Boardwalk
- 8800 Boardwalk Trail Drive Breckenridge
- 14502 Valor Circle Brentwood Place
- 8741 Grove Terrace Brittany Oaks
- 2827 Americana Ave. Broadmoor
- 4939 E. Busch Blvd. Burlington Green
- 14608 43rd St Cambridge Woods
- 14240 N 42nd St Camden Live Oaks
- 5100 Live Oaks Blvd. Campus Lodge
- 15115 Livingston Avenue Campus Walk
- 4102 Quixote Blvd. Carlton Arms North
- 6400 Markstown Dr. Carrington Park
- 16801 W. Tampa Palms Blvd. Cedar Trace
- 2200 Cedar Trace Circle Club at Woodland Pond
- 13801 N. 37th Street Club Mirage
- 3600 E. Fletcher Ave. Collegiate Hall
- 2919 Network Place Colonial Grand @ River Hills
- 6900 Aruba Ave. Courtyard Apts
- 5105 Mission Hills Ave. Courtyard Palms
- 1401 Moonlight Ct. Courtyard Suites
- 13106 N. Florida Ave. Cypress Pointe
- 5119 E. Fletcher Ave. Cypress Run
- 15501 Bruce B. Downs Blvd. Deerpath on the Lake
- 10200 North Armenia Doral Oaks
- 105 Sunnyside Rd. Eagles Point @ Tampa Palms
- 15501 BB Downs Blvd. Excellence Apartments
- 5005 Excellence Blvd Fairway Oaks
- 14306 N. 46th St. Suite 200 Fisherman's Landing
- 8900 Fishermans Pointe Dr. Fontana Hall
- 4200 E. Fletcher Avenue Forest Place
- 12202 N. 22nd Street Fredericksburg
- 13142 N 22nd Hidden Palms
- 14555 Bruce B Downs Jefferson Commons
- 3424 Jefferson Commons Dr. La Place
- 13408 Grand Prix Way Lakeside North @ Carrollwood
- 3339 Handy Road Lakeview Oaks - 14201 Cyber Place Lenox Place
- 11311 N. 22nd St. Livingston Place
- 15215 Livingston Ave. Marbella
- 12406 n 15th St. Apt A Mark Place
- 103 145th Ave. E Meridian
- 8501 N 50th St Other

Please select where you live from the list (locations O-Z):
Select Answer

- Oak Manor
- 5105 Mission Hills Ave. Oak Ramble

- 14621 Grenadine Dr. Palm Grove Apts
- 5039 Chalet Court Palm Island Club
- 13800 Bruce B. Downs Blvd Palm Lake
- 13401 N. 50th St. Palms @ Livingston
- 15420 Livingston Park Avenue
- 11325 N. 50th St. Pine Lake
- 1924 Pine Loch Terrace Plantation
- 10605 N. 56th St. Preserve @ Temple Terrace
- 7855 E. Fletcher Ave. Regency Palms
- 4113 E Linebaugh Ave. Regent
- 4131 E Busch Blvd Regents Place
- 2588 Seafood Circle Regents Walk
- 13016 Leeds Court Remington
- 10610 N. 30th St Sherwood Lake Apt
- 1811 Tinsley Circle Sierra Point
- 8412 Rio Bravo Court Southern Oaks
- 13533 Gragston Circle Springwood Apts.
- 4201 Woodspring Lane Square Plaza
- 12708 Bruce B Downs St. Croix Apts
- 14535 Bruce B. Downs St. James Place
- 12614 Crescent Oaks Pl. Summit West
- 11500 Summit West Blvd. Sun Pointe Lake
- 14200 Bruce B. Downs Sunscape Apt.
- 13617 Fletcher Regency Dr. Sussex Manor
- 12205 N. 58th St. Terrace Palms
- 5200 Rochelle Lane Terrace Pointe
- 11305 N. 51st Street The Hamptons at Tampa Palms
- 15350 Amberly Dr. The Oak @Temple Terrace
- 5518 Terrace Ct The Palms at Livingston Phase I The Palms at Livingston Phase II Timber Falls
- 2600 E 113th st University Oakwoods
- 1250 E. 113th Ave. University Square II Apts.
- 2810 University Square Dr Villages @ Turtle Creek
- 14620 Turtle Creek Circle Wildwood Acres
- 13418 Dottie Dr. Windridge
- 14301 Bruce B Downs Windsor @ Ashton Park
- 2020 Beares Ave. E. Winridge
- 14301 Bruce B Downs Woodland Pond Townhomes
- 13801 N. 37th St. Worthing Square
- 2225 E. 131st Ave.
- Other/Not Listed
    - If you selected other or your location was not listed in either of the two menus above, please specify either an address or major intersection near your home:

Please select where you live from the list:
Select Answer

- Beta Hall

- Castor Hall
- Delta Hall Epsilon Hall
- Eta Hall
- Holly Apts
- Iota Hall
- Kappa Hall
- Kosove Apts
- Lambda Hall
- Magnolia Apts
- Mu Hall
- Theta Hall
- Village Apts
- Zeta Hall

8) How do you typically travel to and from USF?

- Drive alone
- Drive alone and use Park N Ride Lot
- Motorcycle
- Bicycle
- Walk
- Carpool with USF person
- Carpool with non-USF person
- Ride USF Shuttle
- Ride HART Line (public transportation)
- Other
- If you answered Other, please explain.

9) USF Parking Services is considering offering special parking privileges to those who carpool. Please answer the following questions, considering your willingness to carpool to campus. In order for me to CARPOOL to campus, the following changes would have to be made:

- I need to be able to easily find USF students, faculty, or staff that I could carpool with, even if my schedule changes daily or each semester
- If I carpool some days, I need to also be allowed to have my car on campus on days when I need to drive alone to campus.
- Special carpool parking spaces that are convenient to my classes/work building
- I need access to trans. home from USF campus if I or my carpool partner has an emergency and need to adjust hours.
- None of the above
- Other
- If you answered Other, please explain.
- If the above changes were made, would you carpool to campus at least once per week?

10) Have you ever accessed the USF Parking and Transportation Services web site?

- If yes, did you find the information you needed?

11) Are you aware the HARTline offers free bus service for ALL USF faculty, staff and students?

- Have you used HARTline since they began offering free bus service to USF faculty, staff and students?
- I am satisfied with Hartline service and use it.
- USF Students, Faculty, and Staff can now ride HARTline buses fare-free (on non-express routes) by showing a valid USF ID card to bus driver.
- In order for me to ride a HARTline BUS to campus, the following changes would have to be made:

    - Bus stops closer to my residence.
    - Bus shelters at more stops.
    - I would like for buses to come every ___ minutes. (Explain in Other box.)
    - None of the above
    - If you answered Other, please explain.
    - If the above changes were made, would you take HARTline to campus at least once per week?

12) If I did not drive to campus, I would most likely come to campus by

- Getting a ride from someone else
- Ride HART Line (public transportation)
- Biking
- Walking
- Using USF Shuttle
- I would not consider any other option

13) Please indicate the time you usually arrive on campus each day of the week.

- Before 8AM
- 8:00 - 8:59 AM
- 9:00 - 9:59 AM
- 10:00 - 11:59 AM
- 12:00 - 2:00 PM
- After 2pm
- Don't come to campus
- Monday
- Tuesday
- Wednesday
- Thursday
- Friday
- Saturday
- Sunday

14) Do you currently own a USF parking permit?

- Yes
- No

14 a) In a typical weekday, how many minutes does it take you to locate a parking space? Select Answer

- Under 5 Minutes
- 5 - 10 Minutes
- 11-15 Minutes
- 16-20 Minutes

- 21-25 Minutes
- 26-30 Minutes
- 31-35 Minutes
- Over 35 Minutes

14 b) Typically, how many parking facilities/lots do you drive until you find a parking space?

- One
- Two
- Three
- Four or more

14 c) Generally, how many times do you drive out of the campus AND return during a typical weekday?

- None
- One
- Two
- Three
- Four or more

15) Please indicate the time you usually leave from campus each day:

- Before 8AM
- 8:00 - 8:59 AM
- 9:00 - 9:59 AM
- 10:00 - 11:59 AM
- 12:00 - 2:00 PM
- After 2pm
- Don't come to campus

    - Monday
    - Tuesday
    - Wednesday
    - Thursday
    - Friday
    - Saturday
    - Sunday

15a) Where do you park during weekdays?

- Medical/Clinics
- Engineering/Sciences
- Fine Arts
- Business/Sun Dome
- Administration/Library
- Credit Union/Facilities
- Residence Halls
- Park n Ride Lots
- PCD/Moffitt

- Other :
    - Mon
    - Tue
    - Wed
    - Thurs
    - Fri
    - Sat
    - Sun

15b ) What is the primary reason for NOT using Park n Ride?

- Able to find parking close to my destination
- The inconvenience does not justify the cost savings
- Waiting time for shuttle service is too long
- Not familiar with Park N Ride and it's costs
- Other :
- If you answered Other, please explain.

16) In order for me to BIKE to campus, the following changes would have to be made:

- Bike paths/lanes would need to connect the edge of campus to the core of campus
- Crossing perimeter streets (Fletcher, Fowler, BBD, 50th) would need to be made safer
- There would need to be improved lighting on bike paths/lanes Install more secure bicycle locking facilities
- Install covered bicycle locking facilities Bicycles would need to have their own facilities, separate from the sidewalks
- None of the above Other :
- If you answered Other, please explain.
- If all of the changes you marked above were made, would you ride a bike to campus at least once per week? Yes No

17) I would take the USF shuttle to campus at least once per week if it came within a 5-minute walk of my home.

- I would take the USF shuttle to campus at least once per week if it ran later than 9:30pm.
- If yes, how late?
- I would take the USF shuttle to campus at least once per week if it ran on weekends.
- I would take the USF shuttle to campus at least once per week if I knew where it went.
- I would take the USF shuttle to campus at least once per week if I did not have to transfer shuttles to get where I am going.
- Which of the following additional stops on USF shuttle routes would be of most use to you?
    - Kash-n-Karry Plaza
    - Publix Plaza (Pro-Copy)
    - Target/U-Save Plaza
    - Other :
- If you answered Other, please explain.
- If the USF shuttle went to the location selected above, I would take it there at least once per month.

18) What is a reasonable amount of time to wait for the USF shuttle? (answer in minutes)

19) Please provide your ideas and suggestions for improving parking on the USF campus (optional)

Portion of the survey designed by the CUTR Team for the WI-RIDE project

1) What best describes your familiarity with the USF shuttle service? Select Answer

- I don't know anything about it
- I know it runs on campus, but don't know where it goes
- I know it runs on and off campus, but don't know where it goes
- I am familiar with, at least, 1 route, but don't know the whole system
- I am familiar with the whole system

2) How often do you use the USF shuttle?
Select Answer

- Daily
- Frequently (few times per week)
- Occasionally (few times per month)
- Rarely (few times per semester)
- Not at all

3) If I know where the shuttle goes, I would probably ride it
Select Answer

- Daily
- Frequently (few times per week)
- Occasionally (few times per month)
- Rarely (few times per semester)

4) If I know where the shuttle stops are, I would probably ride the shuttle
Select Answer

- Daily
- Frequently (few times per week)
- Occasionally (few times per month)
- Rarely (few times per semester)
- Not at all

5) If the shuttle runs in the evenings, I would probably ride it
Select Answer

- Daily
- Frequently (few times per week)
- Occasionally (few times per month)
- Rarely (few times per semester)
- Not at all

6) Seeing emergency call boxes at shuttle stops would make me feel safe, I would ride the shuttle
Select Answer

- Daily
- Frequently (few times per week)
- Occasionally (few times per month)
- Rarely (few times per semester)
- Not at all

7) Knowing when the shuttle will arrive before I walk to a stop would make me use the shuttle
Select Answer

- Daily
- Frequently (few times per week)
- Occasionally (few times per month)
- Rarely (few times per semester)
- Not at all

8) If I have to switch over to another shuttle to get where I want to go, I would probably ride it
Select Answer

- Daily
- Frequently (few times per week)
- Occasionally (few times per month)
- Rarely (few times per semester)
- Not at all

9) If the shuttle runs frequently, I would probably ride it
Select Answer

- Daily
- Frequently (few times per week)
- Occasionally (few times per month)
- Rarely (few times per semester)
- Not at all

10) If I can get route information on-line and by phone, I would probably ride the shuttle
Select Answer

- Daily
- Frequently (few times per week)
- Occasionally (few times per month)
- Rarely (few times per semester)
- Not at all

11) If I can get actual arrival times of shuttles at stops on-line and by phone, I would probably ride the shuttle
Select Answer

- Daily
- Frequently (few times per week)
- Occasionally (few times per month)
- Rarely (few times per semester)

- Not at all

12) If I know that riding the shuttle saved time compared to driving and parking, I would use it

- Daily
- Frequently (few times per week)
- Occasionally (few times per month)
- Rarely (few times per semester)
- Not at all

13) If I can save money using the shuttle compared to driving and parking, I would probably ride the shuttle
Select Answer

- Daily
- Frequently (few times per week)
- Occasionally (few times per month)
- Rarely (few times per semester)
- Not at all

14) If I know how long the trip takes (before boarding), I would probably ride the shuttle
Select Answer

- Daily
- Frequently (few times per week)
- Occasionally (few times per month)
- Rarely (few times per semester)
- Not at all

15) If I know the actual arrival time of shuttle at stops, I would ride the shuttle
Select Answer

- Daily
- Frequently (few times per week)
- Occasionally (few times per month)
- Rarely (few times per semester)
- Not at all

16) If I feel shuttle stops are safe places to wait, I would probably ride the shuttle
Select Answer

- Daily
- Frequently (few times per week)
- Occasionally (few times per month)
- Rarely (few times per semester)
- Not at all

17) If parking fees were increased, I would probably ride the shuttle
Select Answer

- Daily
- Frequently (few times per week)
- Occasionally (few times per month)
- Rarely (few times per semester)
- Not at all

18) If it takes too long to find a parking space, I would probably ride the shuttle
Select Answer

- Daily
- Frequently (few times per week)
- Occasionally (few times per month)
- Rarely (few times per semester)
- Not at all

19) If I know how to get to a shuttle stop from a park and ride facility, I would probably ride the shuttle
Select Answer

- Daily
- Frequently (few times per week)
- Occasionally (few times per month)
- Rarely (few times per semester)
- Not at all

20) If I can walk to a shuttle stop in less than 5 minutes, I would ride the shuttle

- Daily
- Frequently (few times per week)
- Occasionally (few times per month)
- Rarely (few times per semester)
- Not at all

21) If I know the exact duration of my trip on the shuttle I would ride it
Select Answer

- Daily
- Frequently (few times per week)
- Occasionally (few times per month)
- Rarely (few times per semester)
- Not at all

22) If weather permits walking, I would ride the shuttle
Select Answer

- Daily
- Frequently (few times per week)

- Occasionally (few times per month)
- Rarely (few times per semester)
- Not at all

23) Seeing surveillance cameras on-board the shuttle would make me feel safe, I would ride the shuttle
Select Answer

- Daily
- Frequently (few times per week)
- Occasionally (few times per month)
- Rarely (few times per semester)
- Not at all

24) Knowing that shuttle drivers have two-way communications for use in case of emergency would make me feel safe, so I would ride the shuttle
Select Answer

- Daily
- Frequently (few times per week)
- Occasionally (few times per month)
- Rarely (few times per semester)
- Not at all

25) If shuttles were less crowded, I would use them
Select Answer

- Daily
- Frequently (few times per week)
- Occasionally (few times per month)
- Rarely (few times per semester)
- Not at all

26) If I know when the next shuttle is arriving if the one I want is full, I would use shuttles
Select Answer

- Daily
- Frequently (few times per week)
- Occasionally (few times per month)
- Rarely (few times per semester)
- Not at all