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Application of Information Technology to Transportation Logistics and Security at Northern Kentucky University

FEBRUARY 2013

FTA Report No. 0036
Federal Transit Administration

PREPARED BY
Northern Kentucky University
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Emily Crawford
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Federal Transit Administration
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U.S. Department of Transportation
1200 New Jersey Avenue, SE
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Metric Conversion Table

SYMBOL	WHEN YOU KNOW	MULTIPLY BY	TO FIND	SYMBOL
		LENGTH		
in	inches	25.4	millimeters	mm
ft	feet	0.305	meters	m
yd	yards	0.914	meters	m
mi	miles	1.61	kilometers	km
		VOLUME		
fl oz	fluid ounces	29.57	milliliters	mL
gal	gallons	3.785	liters	L
ft^3	cubic feet	0.028	cubic meters	m^3
yd^3	cubic yards	0.765	cubic meters	m^3
		NOTE: volumes greater than 1000 L shall be shown in m^3		
		MASS		
oz	ounces	28.35	grams	g
lb	pounds	0.454	kilograms	kg
T	short tons (2000 lb)	0.907	megagrams (or "metric ton")	Mg (or "t")
		TEMPERATURE (exact degrees)		
^oF	Fahrenheit	5 (F-32)/9 or (F-32)/1.8	Celsius	^oC

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13. ABSTRACT

This research grant provided the opportunity to research and deploy beneficial transportation technologies to support transit needs. Working with the Transit Authority of Northern Kentucky (TANK), solutions were developed that can apply to transit agencies and emergency management across the country. As a result of this research, technologies were developed and deployed to Wi-Fi-enable buses, send video content to buses in transit, send riders service alerts via email and text, visualize the cost and environmental advantages of public transit, and provide location aware trip planning and other informational services via the Web, desktop gadgets, mobile apps, text messages, and kiosks.

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TABLE OF CONTENTS

LIST OF FIGURES

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ABSTRACT

This research grant challenged Northern Kentucky University (NKU) to use applied research to study and develop technologies to support the emerging needs of the transit community. Working with the Transit Authority of Northern Kentucky (TANK) as the platform for this research, solutions were developed that are applicable to transit agencies and emergency management across the country. As a result of this research, technologies were developed and deployed to Wi-Fi enable buses, send video content to buses in transit, send riders service alerts via email and text, visualize the cost and environmental advantages of public transit, and provide regional trip planning and other informational services via the Web, desktop gadgets, mobile apps, text messages, and kiosks. This report explores these applications and presents extended outcomes of this applied research.

EXECUTIVE SUMMARY

Technology advancements in our new digital society demands changes in both functional and social aspects of public transit. A recent study indicates that America's youth are decreasing the amount they drive (vehicle miles dropped by 23% from 2001 to 2009) and increasing their use of transportation alternatives.[1] This younger population (the "digital natives") seek a mode of transportation that is affordable, allows them to stay connected on the go, supports their environmentally-conscience lifestyle, and provides tools that will make it easy to use. On the other side of the coin, business professionals (the "digital immigrants") are seeking alternatives to the daily commute. This includes out-of-town travelers as well as daily commuters. As they sit in traffic, they also seek ways to be connected to work and access information during the commute and use tools to understand the transit environment if their work schedule varies.

Small- and medium-size transit agencies struggle to provide cutting-edge technologies to enhance rider and operational services. This is due to high cost barriers of entry, other priorities, and or the inability to internally support new systems.[2]

Additionally, as public transit vehicles can be commandeered by emergency management during regional disasters, transit authorities lack tools that would be critical to assisting these first responders and/or emergency management to stay in touch and stay informed.

Over the course of this research, several solutions were researched, piloted, and deployed that serve the needs of transit authorities, riders, and emergency management. We focused on tools and technologies that could be dual-purposed to provide benefit to riders and transit employees on a daily basis and could be repurposed during emergency situations. Moreover, solutions research has already impacted other transit agencies and other service providers such as the healthcare industry and education.

This report discusses the research and deployment of technologies that have brought value to transit providers and riders and, in most cases, are applicable to transit agencies across the nation. These technology advancements include enabling buses with Wi-Fi, sending video content to buses in transit, sending riders service alerts via email and text, visualizing the cost and environmental advantages of public transit, and providing location aware trip planning and other informational services via the Web, desktop gadgets, mobile apps, text messages, and kiosks.

[1] David, Benjamin, Tony Dutzik, and Phineas Baxandall, "Transportation and the New Generation: Why Young People Are Driving Less and What It Means for Transportation Policy," April 2012.

[2] Knapick, Randy J., and Anne O'Neil, *Passenger Transport*, 2008, http://newsmanager.commpartners.com/adapt/issues/2011-02-11/19.html.

SECTION 1

Introduction

The Center for Applied Informatics (CAI) at Northern Kentucky University (NKU), partnering with the Transportation Authority of Northern Kentucky (TANK), researched, developed, and implemented technology-based solutions for the purpose of enhancing TANK's effectiveness and operational efficiency in the areas of logistics and security. For this project, logistics is defined as the process of planning, implementing, and controlling the efficient flow of mass transit bus services, including the buses and passengers, through available routes. Security is defined as encompassing not only community protection related to Emergency First Response and Local Disaster Preparedness, but also to passenger safety and awareness. The effort spanned a five-year period, with specific deliverables each year.

As background, TANK has provided bus transportation services to Boone, Campbell, and Kenton counties in Kentucky, as well as to downtown Cincinnati, Ohio, since 1973. TANK consistently has been an important partner in the economic growth of the region and has worked closely with community leaders and organizations, such as the local Chambers of Commerce, to develop a comprehensive transportation network. In addition to managing its daily transportation service, TANK takes part in a wide array of community activities including emergency disaster assistance, school field trips, and neighborhood festivals. TANK coordinates its service with Cincinnati's Metro bus line (the Southwest Ohio Regional Transportation Authority, SORTA). The combination of TANK and Metro provides mass transit within the northern Kentucky and Greater Cincinnati areas, spanning the International Airport in Hebron, Kentucky, to Kings Mill, Ohio. TANK and Metro operate in total about 500 buses servicing 100 routes that cover 994 square miles. In 2011, TANK carried over 3.67 million passengers. In 2011, Metro provided about 17 million passenger trips.

SECTION 2

Defined Needs

NKU and TANK collaborated around several transportation technology initiatives. At a high level, technologies produced through these efforts are meant to address the following needs:

- TANK's current technology was insufficient for timely response and participation in Emergency First Response and Local Disaster initiatives. TANK is an active partner in the community's First Response efforts that respond to public emergencies (terrorist threats) or natural disasters (floods or tornadoes). There was an identified need to provide a technology solution that could fulfill a dual role: to be used by riders on a daily basis and to have the capacity to be an asset to first responders during emergency situations.
- TANK currently has limited technology on its buses to support increased driver and passenger security. The identified need was to provide riders with both proactive and reactive tools that would support communication and information dissemination.
- TANK lacks state-of-the-art tools that could positively impact its passenger logistics. TANK riders are a key component of its logistics process, and as such, TANK's objective is to transport the riders from one destination to the next in the most efficient way. Currently, TANK offers no timely broadcast method by which to notify passengers of a bus delay or a route change. TANK's bus schedule information, which is available in printed form, is often outdated. This bus schedule information is also available via its website (www.tankbus.org) but is difficult to read. Collectively, these logistics issues impede the efficient flow of riders through the mass transit process, causing them to spend needless time waiting for a bus that is stuck in traffic or that will not arrive at all because of a changed schedule. Finally, there are several barriers to ridership that need to be addressed. The lack of available, up-to-date information, a learning curve that is needed to navigate the system as a new rider, and a lack of tools to justify the advantages of using the system contribute to transit challenges. These are all common challenges for transit agencies of similar sizes. The need was identified to produce better logistical and decision making tools that were based around technology to better empower riders.

These goals were expanded during the course of the project to include the following extended needs:

- Transit across regions is segmented. Currently, systems and transit information is not consistent across different regional transit authorities. For example, TANK and METRO/SORTA could leverage each other's resources and data to improve transit operations within both agencies. Research and development are needed in this area, resulting in a better end-user experience through enhancement of operational efficiencies.

- TANK has much data regarding its carbon footprint but does not have the "informatics" needed to use these data to adequately communicate the "green" benefits and/or make adjustments based on these data system. Analysis of the data, coupled with best practice informatics methodology, can make currently unused data available for consumption, allowing presentation of green impact information in a clear, understandable format.
- As riders become more tech-savvy, there are increased expectations for TANK to offer more anytime/anywhere services. Web-based tools, mobile tools, and alternative technology platforms are the easiest to use and most cost-efficient for exchanging transit data between the agency and their users. Additional platforms to information availability need to be researched and solutions that are compatible with modern riders' expectations need to be developed. This will ensure sufficient information exchange regarding rider/bus logistics for anytime/anywhere service.

SECTION 3

Strategies

NKU has a strong regional partnership with TANK, partnering on several initiatives over the years, including the UPASS program in 2007. The UPASS program allows NKU students, faculty, and staff to ride all regular TANK bus routes and university shuttles for free. This successful program, which continues today, saves students and employees money, has a positive impact on the environment, and reduces historic traffic and parking concerns on the NKU campus.

CAI, the engagement arm of NKU's College of Informatics, uses students, staff, and faculty to impact the region by engaging in innovative applied research projects with organizations to drive real-world solutions. CAI is housed in the new state-of-the-art Griffin Hall facility. This facility is the embodiment of everything digital, providing a unique resource to the NKU campus and the region.

NKU approached TANK to partner on these informatics-based research projects to ultimately impact TANK and similar metropolitan regions in the level of technology and quality of public transportation that are provided to the communities they serve. During this partnership, NKU and TANK engaged Cincinnati's Metro bus line. This line, operated SORTA, was determined to be a key in providing regional transit between Northern Kentucky and Cincinnati.

Other strategic partnerships and collaborations were forged as the research progressed. Examples of such partnerships included:

- Federal Transit Administration (FTA) – The project is being administered by FTA. Funding was made possible through a four-year, $1.6 million Congressionally Directed Appropriation secured by U.S. Senator Jim Bunning (R-Ky.) for NKU's College of Informatics.
- WCPO-TV – WCPO-TV is an ABC affiliate located in Cincinnati. It is owned by the E.W. Scripps Company, a diverse media company with interests in newspaper publishing, broadcast television, national television networks, interactive media, and television retailing.
- Lily Pad – Project Lily Pad brings free wireless Internet access to public spots, business districts, and common areas throughout the Cincinnati region. The project is a volunteer-driven initiative organized by Give Back Cincinnati, a non-profit organization comprising more than 3,000 members and representing 400 companies.

Our overall strategy in determining and researching solution sets was to focus on the overall sustainability and scalability of the solution. Sustainability was important because public funding cuts have made innovative initiatives impossible, as there was not the potential of new funding and/or new personnel to support these initiatives after initial development. Scalability of the solution was also a strategic driver. We understand that TANK was being used as the platform of this research but, ultimately, this research would be applied to both smaller and larger agencies and transit systems.

Throughout the research and development, we also were very strategic about ensuring that all riders would see benefit through different portions of the project. Although some research may provide benefit to technology possessing and/or technology literate riders, other dimensions work to assist riders without their own technology and even without technical acumen.

As part of this strategy, key "Foundational Technology Areas" were defined. From each of these areas, technology was researched and relevant rider tools and/or transit tools were developed. Moreover, the research performed has already spawned extended regional outcomes to provide even more value to riders, the transit authorities, and the community.

The Foundational Technology Areas are as follows:

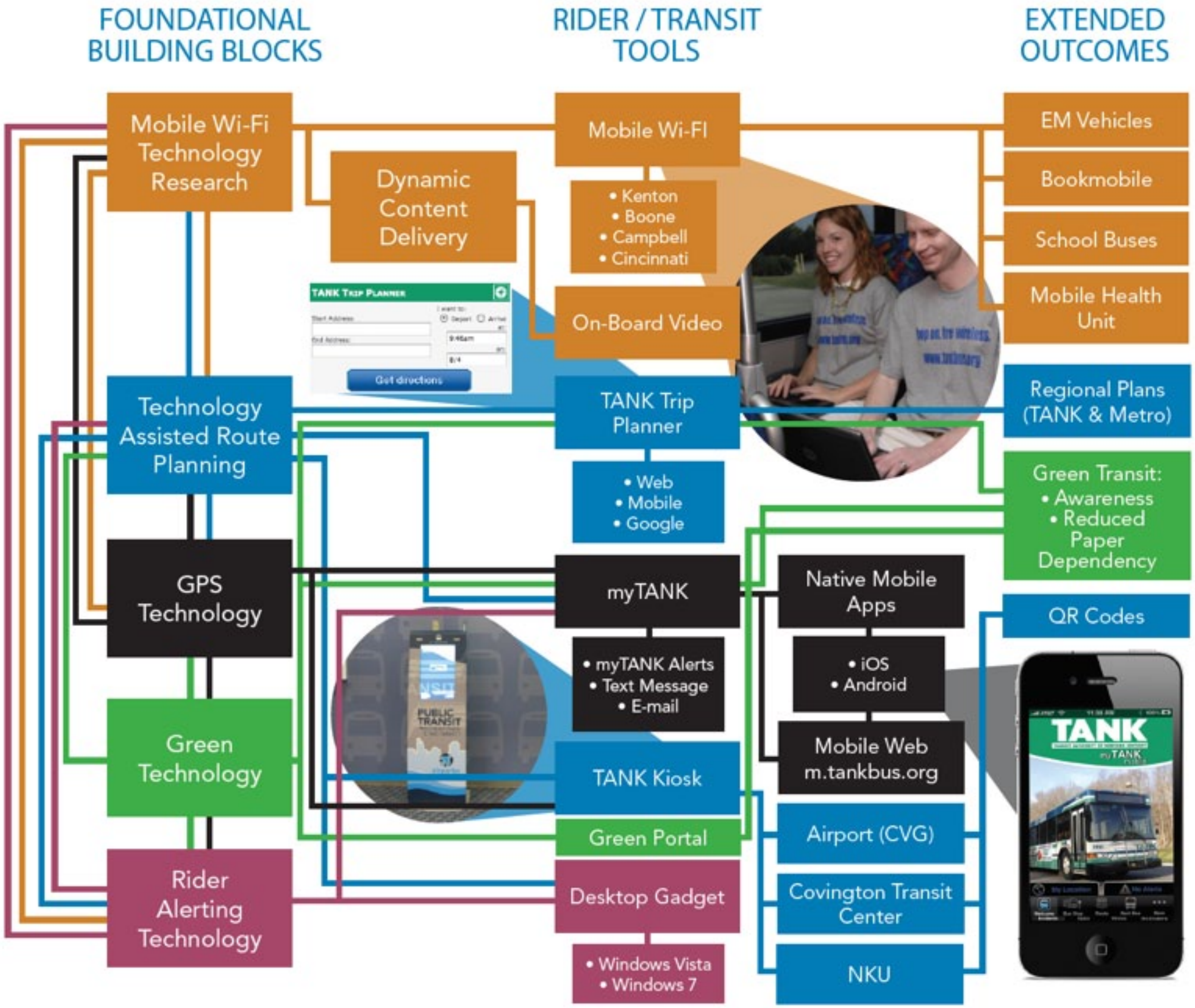
- **Mobile Wi-Fi Technology** – "Wi-Fi" is a foundational technology that allows an electronic device to exchange data wirelessly (using radio waves) over a computer network, including the Internet. A device that can use Wi-Fi (such as a personal laptop computer, video game console, smart-phone, or tablet) can connect to the Internet via a wireless network access point. Such an access point (or "hotspot") has a range of about 65 feet. Typically, Wi-Fi access points are fixed to a certain position/radius (i.e., a Panera Bread location) and provide a back-haul data flow via connection to a wired router. The unique aspect of this technology research area is that there is no wired connection to a backhaul and the hotspot is on rolling stock. This infrastructure offered potential for security, logistics, and other forms of communication with the outside world during a commute.
- **Assisted Route Planning** – Planning a route for riders was a big challenge. Besides using multiple paper schedules or cross-referencing multiple online PDF versions of those same paper schedules, there was no easy way to plan a trip. This was a barrier of entry for a new or novice rider. Even for experienced riders, taking out-of-the-ordinary trips or recovering from a missed bus could prove time-consuming and confusing. A few online Web solutions were being offered with high cost of ownership that made it impossible for a small- to medium-size transit authority to realize a return on investment.
- **GPS Technology** – As logistics was a critical component of the research, focus was applied to this area, not only in the sense of bus locations, but also taking into account rider location. Rider location is accomplished by either

using GPS data on rider smart phones or from the physical location of the fixed-position kiosk that riders are accessing.

- **Green Technology** – Environmental and financial benefits of taking the bus (in terms that riders can understand and appreciate) were not available. Much cost and environmental data were available that were not being used. Additionally, a heavily paper-based system was impacting another facet of green initiatives, as most riders picked up multiple copies of multiple schedules. As we kept green initiatives in mind, we have extended our definition of "green" in all contexts to be both realized environmental savings as well as cost savings.
- **Rider Alerting** – Keeping riders informed of both logistical and security issues was an important focal point for this research. As it stood, alerts could only be communicated via the transit authority's website. Riders would have to check the website often (a "pull" model) to ensure they did not miss information that may impact their trip. Additionally, normal communication from the transit authority was a separate email system that did not have alerting functionality. We wanted to ensure that riders received "pushed" information relevant to them in a timely manner and in a mode that was easily-available to them regardless of their location.

Figure 3-1

Research areas: Foundational building blocks, transit tools, and extended outcomes



SECTION

4

Implementation: Case Studies

The applied research areas that support the foundational building blocks are effectively characterized in a variety of case studies. Each case study below used one or more building blocks to produce technology solutions to support the transit system. Additionally, for some of these case studies, extended outcomes are documented as either deep or wide extensions of the researched technologies. The following four cases document both the research and realized successes for the transit agency, riders, and region.

Case Study 1

A Connected Bus – Mobile Wi-Fi Connectivity

Background on MTA

Building a BAN (Bus Area Network) is an interesting challenge compared to building a classic Wi-Fi network. With a typical Wi-Fi LAN (Local Area Network), one is not faced with the additional challenges that a mobile BAN introduces: specialized equipment, multiple backhaul options, access point security, and vehicle-based power options. Understanding the available options, designing a lights-out solution, testing in the lab and on the road, piloting in real scenarios, deploying to desired routes, and monitoring connection statistics were all parts of the foundational research. As is seen later in this case study, the solution lent itself to extended solutions using this platform.

TANK collaborated with CAI to determine the bus routes to be used for the pilot program. It was determined that fixed routes—those using a set schedule and routing—would need to be used for the pilot program to not only ensure guaranteed wireless access for passengers expecting to use the service, but also to maximize rider satisfaction. Among all fixed bus routes, demographics were analyzed to determine which specific routes served riders most likely to use Wi-Fi service and should be chosen for the initial launch. Business commuters, students, and airport routes were the main factors taken into consideration.

Research

The solution was researched, developed, tested, and evaluated using vendor-neutral and unbiased research of existing wireless technology. CAI built and evaluated solution sets, architected and enhanced solutions, performed software development, tested, benchmarked and configured solutions, and monitored system performance based on the following criteria:

- Costs (Initial and TCO [Total Cost of Ownership])
- Speed
- Security
- Coverage of area
- Functionality
- Flexibility
- Durability
- Usability (by passengers connected to LAN via laptops, tablets, and smart phones)

Research efforts also included collaboration with the Kentucky Office of Homeland Security and local county officials to ensure integration with Emergency First Response efforts.

Networks

The network to provide connectivity for the buses along their routes was one of the most important decisions to getting this solution correct. High-level options that were available to provide the backhaul were to use the following:

- *Satellite* – Companies such as HughesNet[3] provide solutions in which satellite technology is used to deliver broadband connectivity, historically in locations where hardwired solutions were not an option. This option seemed reasonable, but there were several factors that eliminated this as a viable solution:
  - Monthly cost of solution—for 10+ users, the cost was near $350 per month per bus.
  - Daily download allowances were strictly enforced.
  - Although transfer speeds were good, latency was a known issue.
- *Wi-Fi mesh along the route corridors* – This methodology would use only off-bus technology to create a Wi-Fi mesh along the proposed routes that the buses would be taking. Wi-Fi mesh technology essentially provides a chained cluster of hotspots that are linked together to blanket a given area with a Wi-Fi signal and a classic "wired" experience. Each node must not only capture and disseminate its own data, but also serve as a relay for other nodes.[4] Although this would have given the fastest speeds, it was eliminated as a realistic solution for the following reasons:

[3] *HughesNet*, 2011, http://www.hughesnet.com/.

[4] Sichitui, Mihail L., "Wireless Mesh Networks: Opportunities and Challenges."

- A costly, detailed study would need to be done to assess the routes and determine locations for the hotspots needed to blanket the bus transit routes.
- Permission to mount these hotspots in desired locations (light posts, utility poles, etc.) and potential rental of these locations would need to be negotiated.
- Running wired Internet connectivity to each hotspot would be an expensive major engineering and cost-heavy project.
- Although Wi-Fi mesh is cost-effective for small deployments (i.e., a park or shopping mall), blanketing major roadways for a mobile application would be too costly to be practical for providing the service only to bus passengers.

• *Cellular* – Using cellular technology to provide a backhaul for Internet data transport presented itself as a workable option. At the time of testing, 3G networks were rolling out and being improved. Different technology was being developed by different carriers; protocols such as Evolution-Data Optimized (EV-DO) and High-Speed Downlink Packet Access (HSDPA) surfaced and were able to move data across cellular channels at highly-acceptable levels. The relatively low monthly costs for these technologies, generous or non-existent data limits, and the ease of scaling made this option a clear winner for overall architecture.

As cellular technology provided promise to deliver Mobile Wi-Fi to the buses, research continued on the different carriers, their network solutions, and the equipment to bring the deployment to life. NKU evaluated wireless networks as candidates for the cellular backhaul. Cellular service providers considered were Sprint, Verizon, Cincinnati Bell, T-Mobile, and AT&T. The selection process was formulated in several phases, as follows:

1. Service provider policy review – Provider network usage policies were evaluated for policies that discouraged or prohibited sharing of one line of data service across multiple users (i.e., riders). The results are as follows:
   - Sprint – Allowed sharing
   - Verizon – Prohibited/discouraged sharing
   - Cincinnati Bell – Allowed sharing
   - AT&T – Allowed sharing
   - T-Mobile – Prohibited sharing

2. Service-provider-published service map analysis – Cellular providers publish regional coverage maps to their websites. These maps are typically kept up-to-date by their system engineers. This analysis could be considered a pre-road test as we mapped the selected bus routes against the published service coverage maps to get an overall expectation of coverage. We used Google Maps with route and service-provider overlays to accomplish this

testing. This created a comprehensive picture of the anticipated coverage levels along each selected route for each service provider. As a result of this testing, Sprint, AT&T, and Cincinnati Bell proved to have the best anticipated level of coverage for the selected pilot routes.

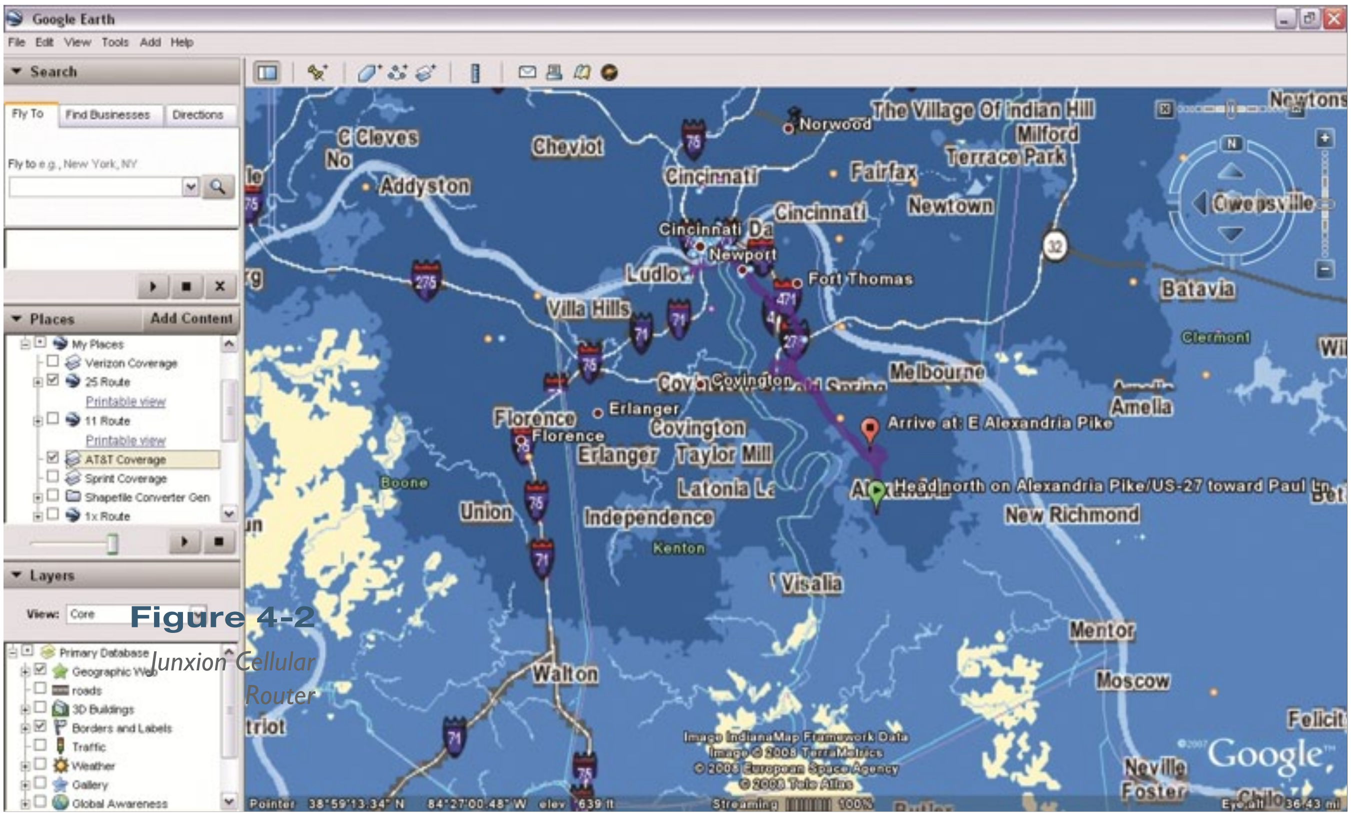


Figure 4-2

Junxion Cellular Router

Figure 4-1

Using Google Maps, cellular service maps, and fixed transit routes to evaluate estimated service coverage

3. Equipment evaluation – Cellular wireless routers provide a hardware solution to use a cellular backhaul but present an 802.11-based signal to the riders just as if they were connected to a traditional wireless network. At the time of evaluation, there were not many pieces of specialized equipment that performed this task. Hardware researched/tested included the following:
   - Junxion Box
     - *Pros*: Easy to set up and configure, works with most wireless carrier networks and cellular modems, upgradable firmware, road hardened (with mounting bracket), centralized management, low cost
     - *Cons*: Only supported 802.11b broadcast (later support for 802.11g was made available)

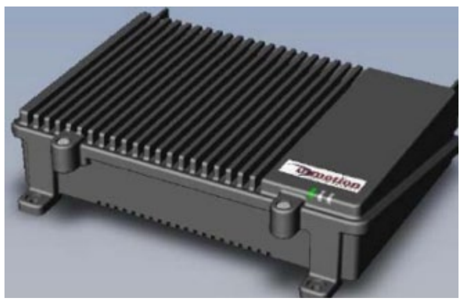
Figure 4-2

Junxion Cellular Router

- Onboard Mobile Gateway 1000 – In Motion Technology
  - *Pros*: Strong security, road-hardened
  - *Cons*: Cost, extraneous features that were not needed

Figure 4-3

Onboard Mobile Gateway 1000 Cellular Router



- Internet In Motion
  - *Pros*: Dual antennas, road-hardened
  - *Cons*: Cost, not upgradeable (built-in radio)
- Ridernet – Parvus
  - *Pros*: Road-hardened
  - *Cons*: Cost, not fully developed
- 3G Phoebus Portable
  - *Pros*: Low-cost, small form factor
  - *Cons*: Consumer-based, lacked central management, not road-hardened

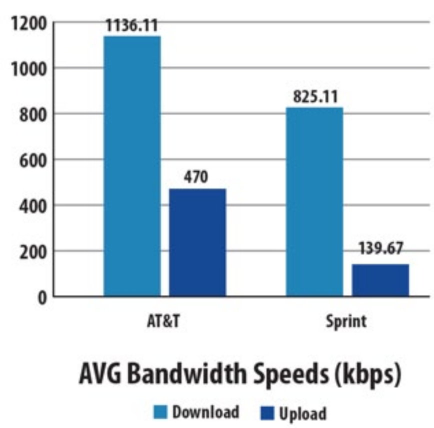
4. Cellular card evaluation – Mobile broadband network cards provide Internet access for mobile devices. The network card connects to the router to provide access to a specific mobile broadband network. CAI researched the following vendors:
   - Sprint
     - *Pros*: Supports EV-DO Rev A speeds just released, versatile, GPS capable, unlimited usage plan available
     - *Cons*: Network just rolled out

- AT&T
  - *Pros*: Fastest data speeds in certain areas
  - *Cons*: No GPS functionality, lacked vendor support, slow data speeds in non-3G areas, no unlimited plans available
- Cincinnati Bell
  - *Pros*: Strong customer support
  - *Cons*: Extremely slow data speeds, not compatible with lower cost hardware solutions
- T-Mobile/Verizon
  - *Pros*: N/A
  - *Cons*: No sharing of data traffic

5. Lab tests (speed and consistency) – CAI conducted a series of performance tests using cellular Wi-Fi routers and network cards from multiple vendors. The tests were conducted at CAI in a simulated environment. The goal of these tests was to determine overall signal strength and bandwidth speed for each network card and cellular router when used at varying distances and with varying numbers of users. The top two networks selected, based on coverage map testing and lab testing, proved to be AT&T and Sprint. These carriers run their 3G technologies on different platforms. AT&T uses the UMTS and Sprint uses EV-DO.

Figure 4-4

AVG bandwidth speeds of AT&T and Sprint



6. Road tests – CAI conducted a series of preliminary road tests using the pilot bus routes determined by TANK, along with the potential network cards and cellular router. Researchers used Google Maps and GPS to traverse the bus routes in cars and record and time-stamp signal strength reception using a laptop combined with the cellular router and each network card. The goal was to validate the solution set by determining signal strength at every point along the pilot bus routes and locating any potential "dead spots."

Figure 4-5

Sample schedule for 1x route used for road test

#1X Florence Express - Union & Turfway Outbound (From Cincinnati)

	7 BUS STARTS at Cinti Main at 4th Atrium	8 BUS LEAVES Biggs Park & Ride	9 BUS LEAVES Turfway at Dixie Hwy.	10 BUS LEAVES U.S. 42 at Dream St.	11 BUS LEAVES Old U.S. 42 at Farmview	12 BUS LEAVES Union Baptist Park & Ride
Weekday						
PM	3:20 PR	3:42	---	---	---	---
	3:45TU	4:07	4:18	4:24	4:30	4:33
	4:10 PR	4:32	---	---	---	---
	4:25T	4:47	4:58	5:04	---	---
	4:38TU	5:00	5:11	5:17	5:23	5:26
	5:08T	5:30	5:41	5:47	---	---
	5:19TU	5:41	5:52	5:58	6:04	6:07
	5:38T	6:00	6:11	6:17	---	---

PR: OPERATES TO BIGGS P&R,ONLY
TU: OPERATES TO BIGGS P&R, HEN VIA U.S. 42 TO UNION
T: OPERATES TO BIGGS P&R, THEN ENDS AT U.S. 42 & DREAM ST.

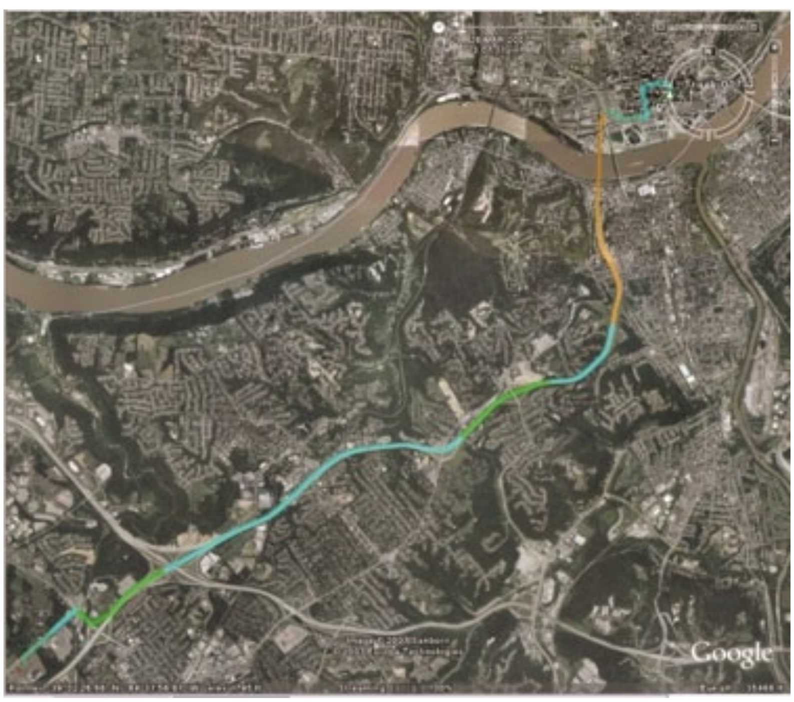
Figure 4-6

Road test signal evaluation key

Signal Strength	
Green	Signal High (< -54 dBm)
Teal	Signal Med High (< -59 dBm)
Blue	Signal Medium (< -64 dBm)
Orange	Signal Med Low (< -69 dBm)
Red	Signal Low

Figure 4-7

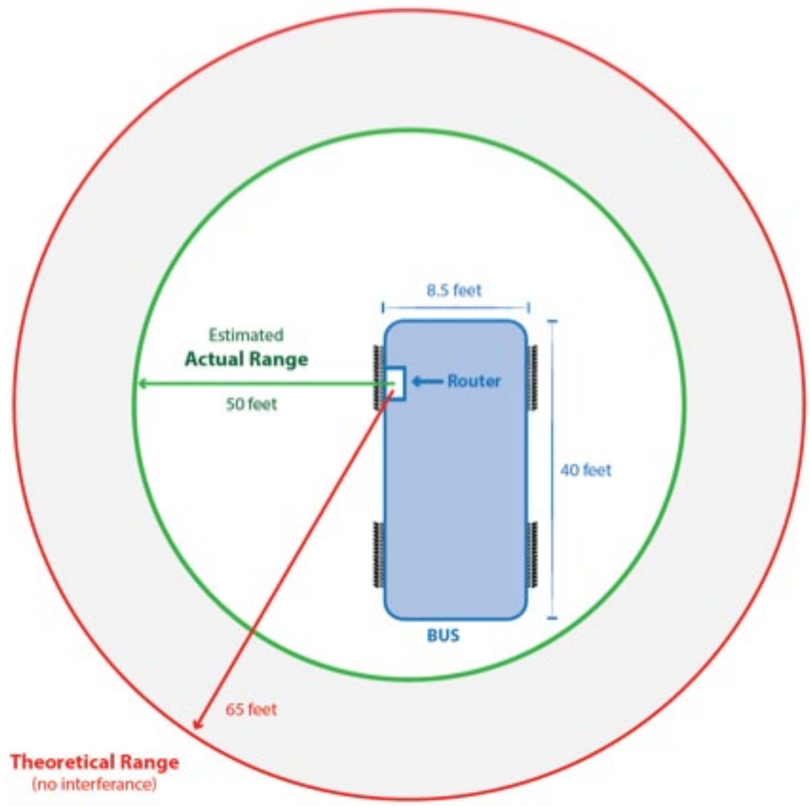
Sample signal collection from road test from 1x route



7. Signal tests on the bus – Positioning a test cellular router in the steel casing behind the driver's seat of a TANK bus, CAI conducted signal strength tests using laptops and PDAs. The goal was to determine whether every seat on the bus could receive adequate signal strength to identify and resolve any potential weak spots. In all cases, every seat on the bus received a full signal from the router, indicating that loss of signal strength due to on-bus position was not a concerning factor. Figure 4-8 depicts the estimated theoretical signal range and the estimated actual signal range.

Figure 4-8

Theoretical and estimated actual signal range for BAN



8. Security analysis – CAI performed security analysis using Nessus, a free comprehensive vulnerability scanning software, and Nmap, a free and open-source utility for network exploration and security auditing. The goal was to determine areas of potential vulnerability; ensure integrity, confidentiality, and availability of information resources; and prevent Denial of Service Attacks.

Optimal Solution Set

The optimal solution set consists of two components: hardware and software. The solution set was deployed on 20 buses for the pilot program in June 2007. The program was so successful that CAI and TANK expanded the solution set to 42 buses in March 2008.

Each Wi-Fi enabled bus contains a wireless router capable of connecting to cellular towers in the region. A cellular signal is sent from local cell phone towers and received by the router on the bus. The router turns the cellular signal into a Wi-Fi signal functionally identical to the Wi-Fi in homes and offices. The Wi-Fi signal is transmitted through the bus-area-network, or BAN, allowing riders to enjoy free Internet access.

Hardware

- Junxion Box Cellular Router – The Junxion Box uses a proprietary software platform to act as a connectivity bridge between cellular data service and client devices such as laptops, PDAs, BlackBerrys and Smartphones. End-users can connect their devices to wireless network card modems using common and easy-to-use interfaces like Ethernet and Wi-Fi. The Junxion Box includes remote monitoring and management software called Field Commander. This tool is used to monitor and make configuration changes to the deployed infrastructure. All Junxion boxes deployed on TANK buses report into Field Commander. Junxion Box determining factors include:
  - Remote management capability
  - Durability – compliant with U.S. military standards
  - Cost-effectiveness
  - Ability to be updated
- 3G network cards – Sprint Pantech PX-500 mobile broadband cards were used on the 20 buses involved in the pilot program. The expansion of the infrastructure included an additional 22 buses. Sprint Novatel Wireless Merlin S720 cards were used in 18 of the additional buses. AT&T Sierra Wireless Aircard 881 cards were used in the remaining four buses. Evolution Data Optimized (EVDO) is an evolving standard that was developed as a third-generation (3G) technology and currently offers data transfer rates up to 3.1 megabits per second.
- Antenna – An external antenna was attached to each bus and used to receive and amplify the cellular signal.
- Mounting brackets – Junxion's custom mounting brackets were used to attach the cellular router to each bus. The Junxion Box, when mounted with the Junxion brackets, meets U.S. Military Standards for durability, which includes exposure to extreme vibration, temperature, and humidity.

Figure 4-9

Mounted Junxion Box – shows mobile router, cellular card, antenna adapter cable, external bus antenna, and mounting bracket

Front End Software and Branding

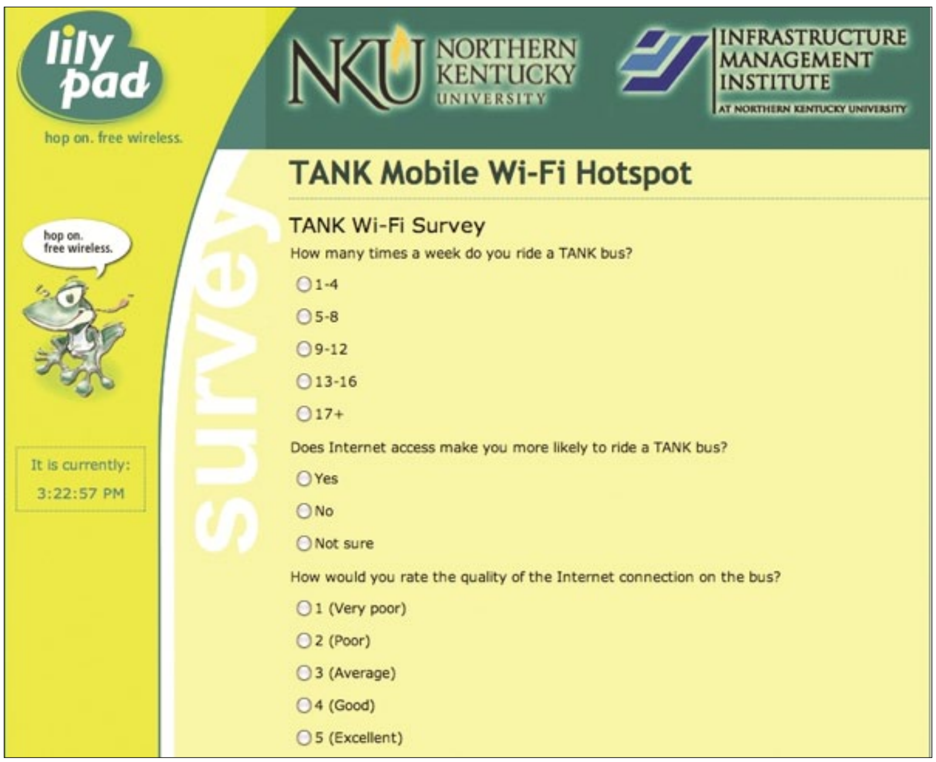
- LilyPad Branding – LilyPad was already a known brand in the region for free public Wi-Fi (fixed, not mobile). As it was not an objective to create a Wi-Fi brand, we partnered with LilyPad to attach a known brand to our solution and take advantage of the free promotion we would receive via this partnership. LilyPad was happy to partner, as it was looking to grow its coverage into Northern Kentucky. Decals were affixed to the exterior left side, right side, and rear of the bus to remind passengers that the buses were equipped with Wi-Fi. Simple connection instructions were provided on an overhead vinyl panel. Additionally, information cards were distributed to inform about Wi-Fi routes and to instruct them on how to connect.

Figure 4-10

LilyPad logo

- User interface – A splash page is the initial Web site page used to capture the user's attention for a short time as a lead-in to the main site home page. The TANK Wi-Fi splash page was created using XHTML and JavaScript scripting languages and featured Terms of Service information and an optional survey for users. The splash page was designed to remain aesthetically consistent with the Lily Pad theme, which has regional brand recognition.
- Landing page – A landing page is the first page users see after they agree to the Terms of Service and fill out the optional survey. The TANK Wi-Fi landing page was also created using XHTML and JavaScript scripting languages. The landing page was also designed to remain aesthetically consistent with the LilyPad theme.
- Online survey – An online survey was created to help evaluate the free wireless service. Passengers have the option to answer four simple questions when they log on to the network. The survey was created using XHTML and JavaScript scripting languages.

Figure 4-11
On-bus Wi-Fi survey



Applications

After the solution was deployed, the following applications were realized or built on this foundational technology.

- Public mobile Wi-Fi and promotion – As one of the initially scoped usages of this technology, TANK riders were able to experience free Wi-Fi while in transit to their destination. This innovation was a regional success story, and FTA, TANK, and NKU/CAI received significant press coverage and were contacted by several agencies for more information and advice on the developed solution.

- Print – News articles reporting the launch of TANK Wi-Fi appeared in the following notable print publications in traditional print form and online:
  - *Cincinnati Post* (newspaper)
  - *Cincinnati Enquirer* (newspaper)
  - *Business Courier* (Cincinnati's leading business publication)
  - *The Northerner* (independent student newspaper of NKU)
  - Redorbit.com (Web site devoted to space, science, health and technology)
  - *Kentucky Post* (newspaper; expansion article)
- Broadcast – News stories reporting the launch of TANK Wi-Fi appeared on the following TV and radio stations:
  - Hometown Business Weekly (Cincinnati TV program)
  - National Public Radio 91.7 WVXU Cincinnati
  - ABC WCPO Channel 9 News, Cincinnati
  - FOX WXIX Channel 19 News, Cincinnati
- Events
  - Florence Freedom minor league baseball
  - Local area Young Professional events
- Collateral materials
  - Data sheets
  - Brochures
  - Bus panels
  - TANK website

- Video – As the Wi-Fi solution was being developed, CAI researched ways to capitalize on the value of this network beyond use by riders with technology and EM personnel. As the Wi-Fi network presented an ideal way to bring in content from the outside world to bus riders, disseminating that information via video panels was a sound concept. The challenges to build a system like this were coordinating data providers, transporting data to the buses, and presenting this content, both video content and "info panel" content via an audio/video system, and ensuring that the system was secure.
  - Content collection – Providing information of regional interest was determined to be an essential.
    - Initial video content – This content was to be video-based and updated regularly to retain the interest of the riders. A partnership was forged with Broadcast television station WCPO (Channel 9) in Cincinnati. WCPO agreed to provide daily regional content clipped from its

broadcast news. This transitioned from manual delivery on the WCPO side to CAI building technology to pull the same segments from WCPO.com for a complete "lights-out" video acquisition. Video clips presented (each 3–5 minutes in length) to riders are:

    - News: Top headline stories of the day
    - Sports: Top sports headlines
    - Events: Scrolling local event listing
    - Feature: Local feature piece, which contains a unique public interest story like consumer tips or investigative reporting

  - Initial panel content – Folded between video clips are informational panels produced by TANK marketing, WCPO, and other providers to relay information to riders. Examples include:
    - Information on routes (i.e., take the bus to the Reds game)
    - Information on transit events (i.e., Dump the Pump)
    - System rules and info
    - Weather from WCPO (i.e., daily forecast, 7-day forecast, almanac)

- Content management and transport – Content from all sources is aggregated on a centralized server. This server supports both HTTP and FTP protocols, allowing files to be sent via automate scripts (FTP) or through a custom built, Web portal. Individual panels and videos can be manually replaced through this interface. Transport of the program pieces is performed via FTP. When a bus is started, the bus contacts the central server and requests the content by filename. When content is pulled, the video equipment presents the content in a looped playlist format for the riders. Updates to the content happen at both specified times and/or when the bus restarts.

Figure 4-12

Video Playlist manager

- Hardware evaluation – Two network media players were evaluated to play the on-bus content. A network media player is a media player that connects to the Bus Area Network (BAN) and retrieves digital media files (such as video) from a centralized location (TANK) and plays them on monitors installed on the buses. CAI researched the following media players:
  - TNET – Technovare Systems Inc.

    Pros: Cost, versatile, Web-based management, compatible with multiple video formats and non-video files, road-hardened
    Cons: No high-definition support

  - X3 Mobile DVR – Say Security

    Pros: External metric monitoring, four video inputs for camera
    Cons: Underdeveloped, lacked support

The TNET media player proved to be a reliable niche device for doing exactly what we were trying to accomplish with this application and was selected for the deployment.

Figure 4-13

TNET network video player

In regards to the video panel selection, we researched options that would ensure head room clearance as well as provide an option to retract the screen if the bus was being used for a non-fixed route and/or video capabilities were not desired. Through research and vendor recommendation, the Jensen model JE1569FDM 15.2" 16:9 Color Display monitor was determined to be the solution of choice given cost, reliability, and features. This monitor flips down while in use, but folds up (similar to a laptop) when not in use.

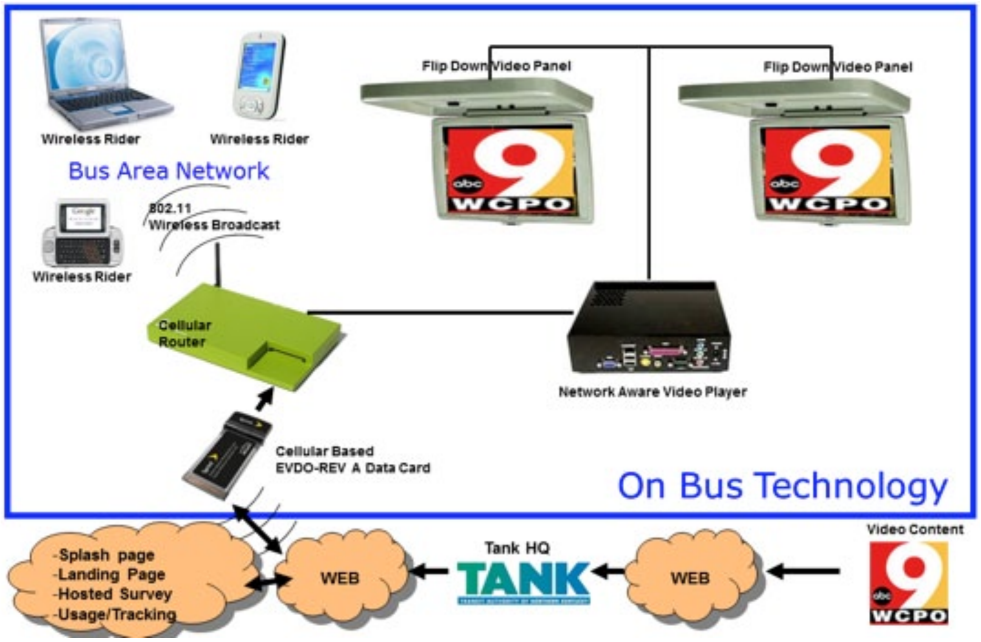
Figure 4-14

Jensen Model JE1569FDM 15.2" 16:9 Color Display Monitor

- Infrastructure design – The Wi-Fi/video system was designed to work together to extend the Wi-Fi system as a whole.

Figure 4-15

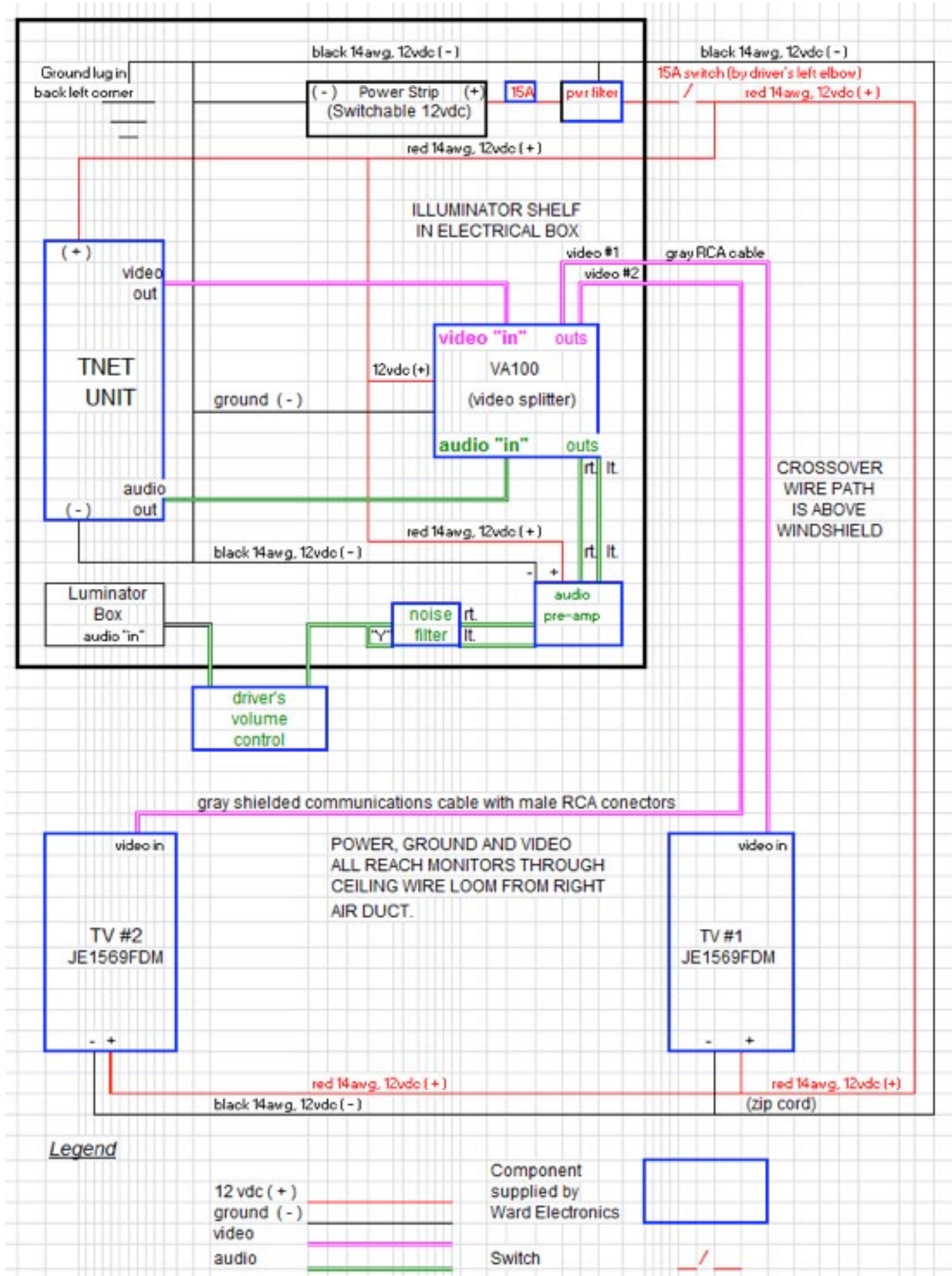
On-bus technology flowchart



- Integrating audio/video components into the bus would be a challenge, as the video application required retrofitting technology into current buses. We wanted to ensure seamless integration into current systems. The details of the integration are outlined in the wiring diagram in Figure 4-16. It is important to note the following decision points:
  - The application is wired into existing bus power and operational only when bus in running.
  - Two video panels were mounted in each bus ensuring every seat had an unobstructed view of the panel and security cameras were not obstructed by the installation
  - A kill switch to disable the entire audio/video system and a volume control switch to control the sound level output were installed for the driver.
  - The existing bus speaker system was used, but it was ensured that other systems (driver PA and Luminator auto stop announcements) would mute and restore video system sounds as they made their announcements (i.e., other systems always top priority).

Figure 4-16

Video wiring diagram showing integration with existing bus technology



- Details of information provided and extended outcomes:
    - *Weather Information*: The concept of weather information is defined as visuals displaying the current weather conditions and forecasts warning passengers when dangerous weather is geographically nearby or in the forecast. In everyday usage, weather information is important to keep riders aware of forecasted conditions at the bus stops to better prepare for their trip. This includes such visuals as the seven-day forecast, the daily forecast, and almanac comparisons from prior years. Moreover, the

Department of Homeland Security and Emergency Management strives to keep citizens informed of all dangerous weather situations, potentially saving lives. Work has been performed with a local weather provider to be the supplier of weather data for the buses. This information is shown on the video monitors to alert passengers of weather conditions and potential threats. School and business closings may also be displayed during inclement or unexpected regional conditions. This can provide riders with important decision-making data. During emergency weather situations, programming can be switched over to total weather programming, giving passengers full informational updates on the current situations.

- *Security alerts and PSAs*: The concept of Emergency Management Awareness and Preparedness is defined by regular videos or informational panels displayed on the video monitors giving passengers awareness information, including procedures to follow in the event of an emergency. These video feeds potentially save lives by making riders more aware, vigilant, and prepared for an emergency situation. Clips played in the buses contain what passengers should do in the event of an emergency such as a fire or dangerous flood. Some contain family preparedness, encouraging families to create a "Family Plan" in a disastrous event. Thirty-second PSA video clips were aired in between during regular programming to encourage thinking about emergency preparedness. Examples include:
    - "Cell Phones" – introduces a very real question into peoples' minds: "What if, during an emergency, both the cell and land line phones were down?"
    - "Laura Bush" – Laura Bush advises viewers on the necessary steps to prepare themselves for an emergency.[5]
    - "Meeting Place" – introduces the problem of families not making emergency plans, but thinking that they have one.
    - "Picking Up the Girls" – second take on introducing the problem of families not making plans, but thinking that they have one.[6]
    - "Tomato Paste" – third take on introducing the problem of families not making plans, but thinking they have one.

    Additional 3–5-minute instructional videos were aired at specific times of the day and on weekends. Some examples are:

    - "Older Americans" – steps for older Americans specifically to get ready for an emergency.[7]

[5] U.S. Department of Homeland Security, "Homeland Security Launches New Ads to Demonstrate Importance of Family Emergency Planning," 2006.

[6] "Picking Up the Girls," directed by BoyBlu.net, 2009.

[7] U.S. Department of Homeland Security, "Preparing Makes Sense for Older Americans. Get Ready Now," http://www.ready.gov/document/preparing-makes-sense-older-americans-0.

  - "Ready Instructional" – steps for Americans to get ready for an emergency.
  - "Ready Pets" – steps to get Americans' pets ready for an emergency.[8]
  - "Special Needs" – steps for Americans with disabilities or special needs to get ready for an emergency.[9]

  Many videos had already been created by Ready.gov. Others were available through local Emergency Management and Homeland Security Departments, including "Shelter in Place," "72-Hour Emergency Prep Kit," "Winter Storm Action," and "Flash Flood Watch," all enabling our citizens to stay prepared for an emergency situation.

- *"Lessons Learned"*: The video feature proved successful in delivering daily informational content to riders. Critical feedback received included that some riders could not hear the audio (driver-controlled) and some riders reported no video on routes; this is due to too many points of control that were given to the drivers. Program content may be unavailable if the driver did not lower the two overhead panels while prepping the bus, closed the two overhead panels while prepping the bus, turned the audio control knob to the off position, did not adjust the audio control that was previously turned all the way down, flipped the video switch to off, or did not flip the video switch to on. Drivers did receive sufficient communication regarding the initiative; it is their primary mission to drive and ensure passenger safety. Removing control variables from the driver would have delivered a more consistent video presentation experience to the riders. With the exception of these isolated cases, the pilot was well-publicized and generally well-received.
- *Wi-Fi Extended applications*: The research performed around mobile Wi-Fi technologies received significant attention, creativity, and collaboration across the region, as well as other applications of this technology. Technology collaboration occurred with the following organizations in their deployments of mobile Wi-Fi networks stemming from this sponsored research:
  - Saint Elizabeth CardioVascular Vehicle – a mobile diagnostic vehicle was Wi-Fi enabled to allow for on-site patient registration, immediate sharing of results with off-site doctors, and, potentially, discussion of results (via Skype) with patients and/or remote technicians.

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[8] Department of Homeland Security, "Caring for Animals," http://www.ready.gov/caring-animals.

[9] FEMA, "People with Disabilities and Other Access and Functional Needs," November 12, 2011, http://www.fema.gov/plan/prepare/specialplans.shtm, accessed June 6, 2012.

- Carroll County School Buses – Carroll County, a rural community, has many children with significant commutes to school. Two buses were enabled so that children could work online during their commute. Additionally, web connectivity was used for on-bus education during extended field trips.

  Pendleton County Bookmobile – The Pendleton County Library uses a bookmobile to provide access to books to a demographic that would otherwise have difficulty traveling to the library. The bookmobile used Wi-Fi to check out books in real-time, check availability of books, and provide a Wi-Fi hotspot as an extended service.

- Pendleton County Emergency Management – In alignment with our mission of working with Emergency Management to extend solutions, Pendleton County emerged as a platform for testing. Mobile Wi-Fi was installed in their Mobile Emergency Command Center which is brought onsite to major emergencies to ensure communication with their home office. Additionally, mobile Wi-Fi was installed in an emergency management vehicle. This Wi-Fi connection shares the connection with other public users in the area in need of connectivity. We additionally successfully tested streaming test emergency photographs and emergency video from the scene of the incident to EM's homebase.

The research performed with Pendleton County Emergency Management was based on scenarios and communication tools that were researched and scoped by CAI for TANK regarding using the bus as a command center. The concept of an emergency command center is defined as a vehicle that can be deployed in any capacity during an emergency situation by any authoritative agency of representatives, including first responders, to assist with a potential or existing situation. This is a place that is used to provide centralized control for the purpose of delegation during an emergency situation. It also enables the real-time visibility and management of an entire operation.[10]

During an emergency situation, these command centers could be used in many ways. They could house the people in charge of delegation during an emergency situation. They could also be used to shelter emergency personnel from the elements while they attempt to get an emergency situation under control. Since select TANK buses are equipped to broadcast Wi-Fi, the authoritative personnel can gain immediate access to:

[10] Center for Applied Informatics, "Design Concepts for EM/HS Usage of TANK Technology," 2008.

- Internet – During an emergency, such as a house or building fire, firefighters can have full access to building blueprints. This will create a more focused search plan to locate survivors, and give firefighters the security of knowing where the dangerous electrical and gaseous components of the building are located.
- Virtual Private Network (VPN) – Having a Wi-Fi internet connection can also allow emergency personnel to access a VPN network and locate files on their home base servers that may be useful. They could also gain access to a building's VPN and locate emergency/security system files to help the emergency personnel determine how and when the emergency started. This also allows the emergency personnel to gain access to Emergency Operation Plans.

Additional configurations can be done before deployment to the emergency situation, or remotely, to create a secured network on the bus if needed:

- Wi-Fi Protected Access (WPA Enterprise & WEP) – WPA provides authentication by distributing different keys to each user, and provides encryption using a RC4 stream cipher, with a 128-bit key and a 48-bit initialization vector, and provides better payload integrity by using a message authentication code.
- Password Protection – A password is a unique identifier that a user creates to log into a system. It verifies a user name with their password to ensure users are who they say they are.
- MAC address authentication – A MAC address is a quasi-unique identifier attached to most network cards and adapters. Wireless networks can be configured to only allow certain MAC addresses entrance into the network, allowing for additional security against potential hackers.
- Disable SSID Broadcast – Service Set Identifier (SSID) is the name of a wireless local area network (WLAN). Most Wireless Access Points automatically transmit their SSID into open air at regular intervals. This broadcasting feature makes it easier for hackers to break into a wireless network. Disabling SSID Broadcasting increases network security greatly.

To create an even more secure network, EM users could disable wireless access to the system and plug directly into the box for a wired network, free of potential wireless network offenders. A hub could be added to allow multiple users to have wired access.

To create this command center, some additional configuration and documentation will need to take place. This documentation will allow for easy transition into the command center, and give further instructions for the Emergency Management & Homeland Security personnel.

There are a few pieces of hardware that would need to be added to the bus to support this design. A hub would be added to allow a multiple-user wired network configuration to be created and allow multiple Ethernet cables.

The concept of an Emergency Broadcast Web Network was defined as a Web-based status portal displayed on the on-board bus video monitors, using the Wi-Fi infrastructure. System status can be updated from any remote computer with Internet access and log-in authority to keep emergency personnel informed about breaking news emergency updates.

This pilot extension was created to be used in the event that the TANK bus is being used for a Bus-Based Command Center. The practice of using public transit vehicles to assist during regional emergencies was an understood practice as this feature was developed.[11]

Common to every command center are three general aspects: inputs, processes, and outputs. The inputs, or inbound, aspect is communications (usually intelligence and other field reports) and this is exactly what this portal displays. Inbound elements include:

- SITREPS (Situation Reports of What is Happening) – Informs emergency personnel when a situation is under control in a certain part of the building or a new problem occurs in a section of the building. For example, a fire department is using a TANK bus as a command center during a fire; the SITREPS on the Emergency Broadcast Web Network may display if the fire spread to a new part of the building, or if the electricity is still up in a section of the building.
- PROGREPS (Progress Reports Relative to a Goal Which Has Been Set) – Informs emergency personnel of goals that have been set and need to be pursued. For example, the department could display the need to fight in a different part of the building where a fire has spread.

While the emergency personnel are taking a break, they can sit inside the bus, out of the elements, and stay up-to-date on the emergency. This allows for fast transitions between shifts and reduces error during

[11] Transportation Research Board of the National Academies,"Public Transportation Emergency Mobilization and Emergency Operations Guide," *Public Transportation Security.*

these emergency situations. It is very easy for an emergency employee to be misinformed about some task they need to carry out, to the point of making a drastic, or life threatening mistake. This system can avoid this misunderstanding all together because everyone will see the same information.

The personnel who enter the information will need only a computer or mobile device and access to the Internet, resulting in the ability to update the information from almost anywhere. Personnel can enter those updates, and the people in the Command Center will automatically be able to view them on the screens.

To build this system, we create a simple, secure portal. It has a window for message posting; log-in features, allowing for only authorized personnel to post to this site; and an automatic refresh code, forcing the page in the bus to refresh every minute, keeping the information on it as up-to-date as possible.

In addition to being piloted in a lab environment and displayed on a TANK bus, the system was reviewed and piloted by Pendleton County Kentucky Emergency Management team.

Case Study 2

Rider Communication and Alerting

Overview

Keeping riders abreast of logistical (and other) transit-related changes presents a challenge in a small to medium-size transit agency. In our analysis, TANK's pushed rider communications were in the form of periodic newsletters. The email distribution list also served as a method of push notification in the event of a major incident, but it was not a normal procedure. The system to store and send the newsletters was a single-purpose, standalone system with a subscription cost attached. If a system delay or other event happened, this was posted onto TANK's website; however, a user would have to proactively and continually check the website (a data pull) to get this info. Similarly, if there was transit news that needed to be shared with riders, these data would be placed on the website only. SMS (text message) alerting systems have a high cost of entry and require subscriptions and/or purchasing blocks of data.

From this research, we determined the following goals in building a system to alert riders:

- Maintain a single source for riders to subscribe and unsubscribe for:
  - Service alerts

  - Newsletters
- Create a single system (eliminating the current newsletter system) for the transit agency to communicate with their riders for:
  - Service alerts
  - Newsletters
  - News
- Propagate all communication (entered once) through several modes of communication:
  - Email
  - SMS (Text messaging)
  - Website
  - Mobile app
  - Desktop gadget
- Provide a targeted communication methodology for service alerts so riders are alerted only about routes that they ride.
- Use innovation to implement a low-cost, sustainable solution.

Research on SMS Solution Options

- Procure and setup an in-house SMS Server – If agencies implement an SMS system in an organizational IT environment, they need to calculate costs that occur during the setup. First, they need a server and a GSM modem to connect to the mobile network to be able to send SMS messages. If they connect directly to the SMS center of a mobile service provider over the Internet, then they need a subscription with their service provider. In this case, providers will sell them SMS credits and will provide a per SMS tariff. If they sign up with their local mobile network operator, they will probably be charged a monthly fee and a small rate per SMS. This will be the only regular fee. Finally, they need to purchase the license of the SMS gateway software. In this case, this cost is high. There would be more control of the system, but personnel would be needed to manage the solution. They would also have to build in the architecture of the system that stores and invokes messages to be sent over this gateway.
- Use a third-party SMS system – This is a cost-effective messaging methodology, and services such as Clickatell are leading providers for this. Unfortunately, a medium-size transit agency does not line up with their small business plan. Messages can be purchased in blocks at the cost of about 4 cents per message. Aside from the development cost to use this technology, if one assumed 5,000 subscribed riders, 3 service alerts per month, and 12 months per year, the system would have an annual cost of around $7,200. They would also have to build in the architecture of the system that stores and invokes messages to be sent over this gateway.[12]

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[12] Libertas Technologies, LLC, "SMS Report," Cincinnati.

- Support SMS via Email – As the transit agency already maintains an email gateway, SMS messages can be routed through the email gateway. This is a completely free solution and does not require additional personnel to manage new software or hardware. This also allows the system that will manage subscription requests to be co-located with the texting solution platform. Throttling traffic through the email gateway is a known concern that needs to be considered in the deployment. Additionally, riders must provide their cell phone carrier information and phone number. This allows an email to be formulated which will be received by the rider as an SMS text message.

Research on Customer Subscription System

At this point, the subscription management server would need to be procured or developed. Building a system that handles subscriptions from scratch would be a time-consuming and painstaking task.

Strategies

The CAI adapts open source software whenever possible. We researched multiple open source components and found "phplist," an open source free software, and users can view it, change it, and redistribute it.[13] The phplist package was downloaded, analyzed, and modified to work within the parameters to support the TANK implementation. This system was originally an engine for sending emails only. Notable changes to the code included the following:

- Branding of the solution set as myTANK alerts
- Ability to collect cell phone information to house for sending of SMS messages and/or email messages
- Sending of SMS messages
- Creation of RSS feeds (News and Alerts) for the tankbus.org website
- Integration of feeds and registration into TANK's website

Figure 4-17

myTANK alerts logo

Figure 4-18

myTANK alerts landing page

[13] *PHPLIST*, 2012, http://www.phplist.com/, accessed June 4, 2012.

Figure 4-19

TANK feeds and service alerts

- Addition of authorization email and/or SMS after subscription (limits spam registrations) as seen below:

You are almost subscribed to the TANK Alert System ...

Someone, hopefully you, has subscribed your email address to receive alerts for the following TANK routes:

- ☐ 11 - Ft. Thomas
- ☐ 25X & 26X - Alexandria Express & Southern Campbell County Express
- ☐ General Newsletter

If this is correct, please click the following link to confirm your alerts. Without this confirmation, you will not receive any alerts.

http://alerts.tankbus.org/?p=confirm&uid=a9b474ba3321ac507f2494532e17f17f

If this is not correct, you do not need to do anything, simply delete this message.

Congratulations, you are now signed up to receive TANK bus alerts for the routes you specified. Please keep this email for later reference. Your email address has been added to the following routes(s):

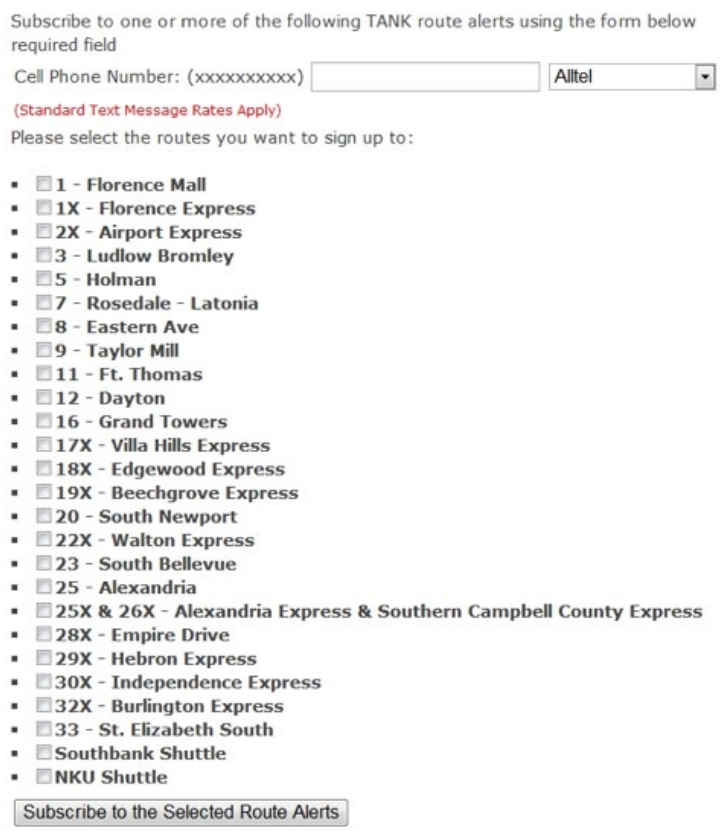
- ☐ 11 - Ft. Thomas
- ☐ 25X & 26X - Alexandria Express & Southern Campbell County Express
- ☐ General Newsletter

To add or remove routes you are signed up for, please go to http://alerts.tankbus.org/?p=preferences&uid=a9b474ba3321ac507f2494532e17f17f.

If you do not want to receive any more alerts and wish to be removed from out database, please go to http://alerts.tankbus.org/?p=unsubscribe&uid=a9b474ba3321ac507f2494532e17f17f.

Thank you.

- Customization of routes so riders can receive targeted communications



Subscribe to one or more of the following TANK route alerts using the form below
required field

Cell Phone Number: (xxxxxxxxxx) Alltel

(Standard Text Message Rates Apply)

Please select the routes you want to sign up to:

- 1 - Florence Mall
- 1X - Florence Express
- 2X - Airport Express
- 3 - Ludlow Bromley
- 5 - Holman
- 7 - Rosedale - Latonia
- 8 - Eastern Ave
- 9 - Taylor Mill
- 11 - Ft. Thomas
- 12 - Dayton
- 16 - Grand Towers
- 17X - Villa Hills Express
- 18X - Edgewood Express
- 19X - Beechgrove Express
- 20 - South Newport
- 22X - Walton Express
- 23 - South Bellevue
- 25 - Alexandria
- 25X & 26X - Alexandria Express & Southern Campbell County Express
- 28X - Empire Drive
- 29X - Hebron Express
- 30X - Independence Express
- 32X - Burlington Express
- 33 - St. Elizabeth South
- Southbank Shuttle
- NKU Shuttle

Subscribe to the Selected Route Alerts

Figure 4-20

myTANK alert SMS alert registration

- Addition of a facility to replace current newsletter system for email subscribers
  - Design/Development – myTANK alerts is a Web-based application that integrates with TANK's Web presence. At launch, it was hosted on a different webserver from www.tankbus.org. Migration to the hosting provider is a relatively simple task involving moving files, moving a database, and altering email and path parameters in the configuration file. We built and tested throttling rules to prevent overwhelming the email gateway. Minimum requirements to run myTANK alerts are:

Software	Minimum	Maximum
PHP	*4.3.x*	*5.2.x*
imap	Required for bounce handling	
iconv	Required for charset handling	
sessions	Required for session handling	
XML support	Required for session handling	
Pear http_request	Required for sending web pages	
MySQL	*4.0*	*5.x*
Charset utf8	UTF8 required for charset handling	
Apache	*1.3*	*2.x*

- Data Migration and deployment
  - Current data – Since we built this system to replace an existing system, we migrated existing email addresses from the now obsolete newsletter system and systematically created those users as validated subscribers to the newsletter system. Therefore, the transit authority retained their current mail list subscription base.
  - Where are myTANK alerts received?
    - Rider cell phone – SMS (Text messages)
    - Rider email
    - Rider smartphone via myTANK Mobile iPhone/Android app (discussed later)
    - Riders Windows computer via Desktop Gadget (Windows Vista, Windows 7)
    - TANK website

Case Study 3

Regional Trip Planning

Research

- State before research – One of the biggest logistical challenges for TANK riders was the ability to plan trips. There was no assisted trip planning functionality available via the transit authority's website. The only existing option for planning a trip was to call the transit authority's customer service phone number. This does provide a personal touch, but is labor intensive, potentially inconsistent, and only available during certain hours. Unassisted trip planning was available via hardcopy schedules available at certain locations and schedules for each possible route (paper-intensive) or viewing the online PDF equivalent of these documents in multiple browser windows/tabs. Trip planning tools were available for an annual licensing fee of around $300,000 per year. This was not a sustainable option for a small to medium transit agency.
- Google Transit platform – The Google Transit platform currently covers more than 485 cities.[14] When this research was started, Google Transit was only live in about a dozen cities and was considered "beta." We researched this new offering and discovered the potential. We applied to get the transit authority on the list of cities to be considered and we were ultimately accepted. Google did not yet offer rich toolsets for development or testing Google formatted (GTFS) data feeds.
- A more fundamental challenge existed. TANK's scheduling data was all kept in Microsoft Excel format, using codes and colors to denote route exceptions, weekday vs. weekend routes, and other special cases.

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[14] Google, "Google Transit—Plan a trip using public transportation," http://www.google.com/intl/en/landing/transit/, accessed June 20, 2012.

- Conversion tool – As the source data was in a non-standard format, a major undertaking was the conversion of that data to a GTFS standard for consumption by Google Transit. We wanted to make the conversion easy and repeatable so that when the transit agency modified their feed, they could easily create a new GTFS feed.
  - CAI created a Windows platform based tool that would accept TANK formatted (Excel) data and translate that into GTFS format that would pass validation by the validator that was provided by Google. The "Google Transit Feed Creator" (GTFC) is meant to take the spreadsheets and shape files that TANK currently uses to keep its data, combine them with some other necessary information and produce a complete Google Transit Feed.
  - There are three main sections to the GTFC user interface.
    - The feed data area provides a tab for each of the files in the transit feed that TANK needs, as well as a tab for reading in the files TANK provides. The tabs are divided into two types: editing tabs and viewing tabs. Editing tabs allows the user to enter new values for those files. These are used where information necessary for the feed cannot be read in from the files. Viewing tabs are used where the information could be read in from the files. These allow a user to check over the data and delete any unnecessary information that has been read in.
    - The program feedback section simply lets the user know whether or not an operation has succeeded. If an operation fails, it should display a descriptive error message to help solve the problem.
    - The feed write section lets the user choose a directory to write the feed in and then to write the feed out once all the data has been input.

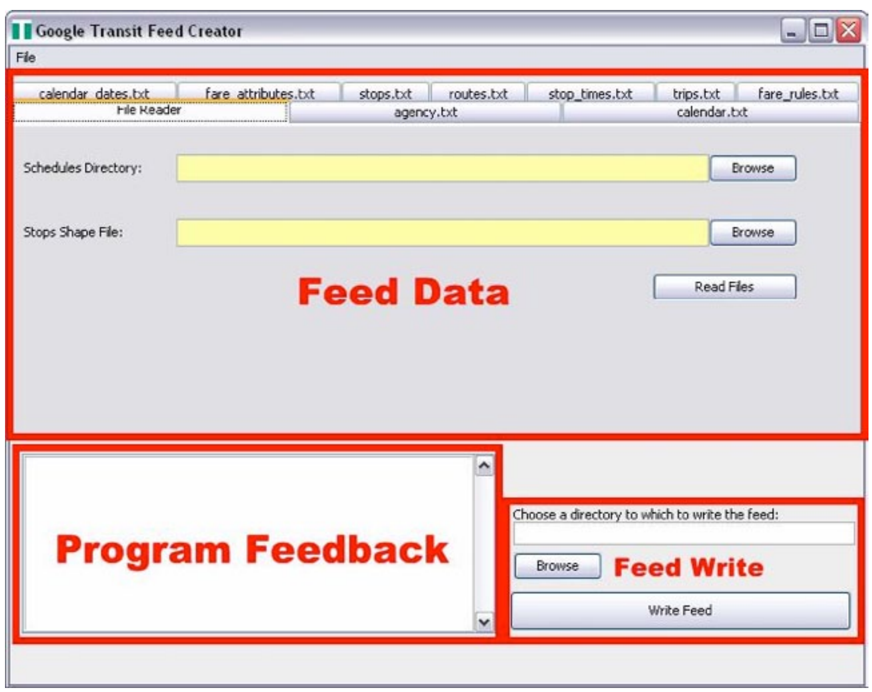


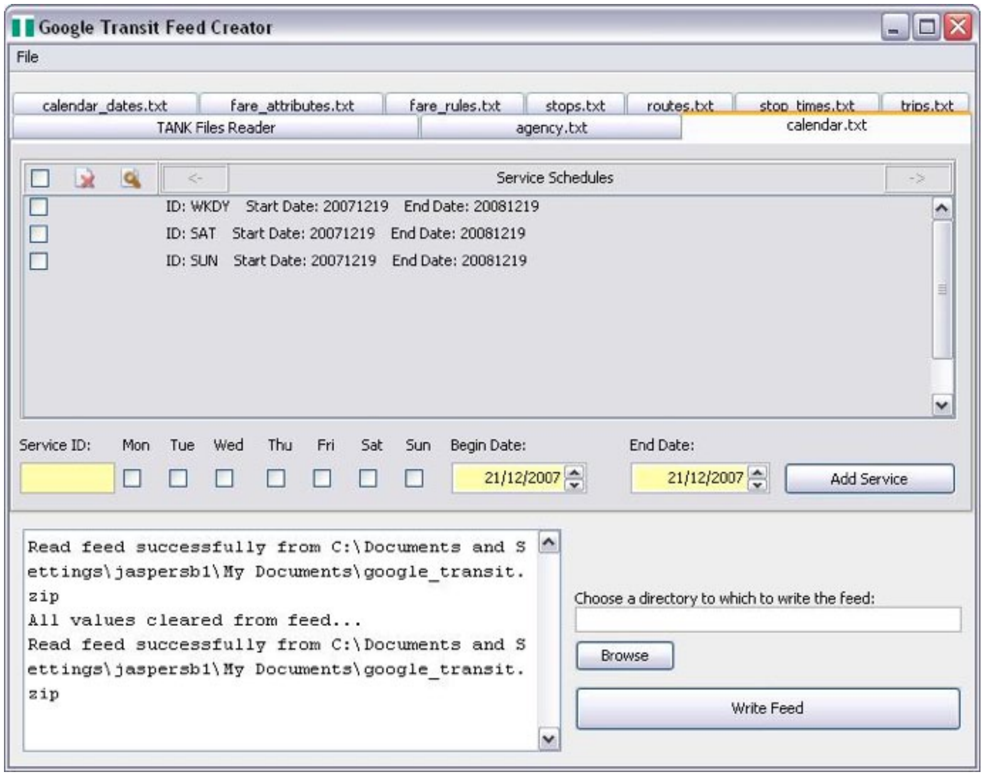
Figure 4-21

Google Transit Feed Creator – section breakdown

- As file data are read in, manual adjustments and/or additions for data that were not available in TANK's can be made via the GTFC interface.

Figure 4-22

GTFC interface



As research commenced, there were several iterations of feed adjustment working with the transit team at Google. Many testing tools later externalized by Google were only available to the Google team. A feed would be developed at CAI, locally tested, submitted to Google, published in two weeks, and then become available for testing by CAI. If CAI tests passed, a request was submitted to Google to make the feed live. Google would then evaluate the feed and return examples of how the feed was not working at 100% or Google would accept the feed. If the feed was not accepted, the two-week cycle would run again. Although this process was cumbersome, the process did help identify and correct some errors that we identified in the transit agencies source feed data that carried over into errors on the related paper schedules. Therefore, this process helps to assess, validate, and improve current transit data.

In January 2009, the TANK Google transit feed went live. There was significant press coverage, and this initiative was successfully deployed. More than 150,000 trips have been planned from TANK's website alone. Countless others have been planned directly from Google Transit and/or Google Maps interfaces.

The following excerpt from the press release from TANK captured the spirit of the engagement:

> "The new trip planner will allow TANK to be more accessible to more people and highlights the value of technology," commented Andrew Aiello, TANK Deputy General Manager. "Passengers are just a click away from planning a trip on TANK from start to finish." By partnering with NKU and Google, TANK was able to provide this hi-tech information option at no cost. The service itself is free to transit systems that provide Google with information in their requested format. NKU's College of Informatics provided technology students, through the Center for Applied Informatics, to transform all of the TANK schedule data into the Google format as well as to build customized interfaces to access the trip plans. "Our latest collaboration with TANK and Google to provide innovative tools to benefit public transit, both regionally and nationally, is another example of Informatics in action," commented Tim Ferguson, Executive Director of the Center for Applied Informatics at NKU. This project is the second phase of a four-year research initiative funded by FTA as a result of a Congressionally Directed Appropriation secured by U.S. Senator Jim Bunning for NKU's College of Informatics.

Regional Collaboration and Expansion

Since the initial development and release, major vendors have built in exports from planning tools so agencies can produce their own Google Transit feeds. Our research has shown that this export is not perfect, but gets the agency very close. We have worked with TANK to collaborate with its Manager of Planning to provide instruction on producing a valid feed and have extended tool-sets (i.e., a tool that takes an exported feed and separate blocking data to build blocked trips in the GTFS feed) to ensure the ongoing success and sustainment of this foundational tool.

Through the process, we have collaborated with Metro/SORTA in Cincinnati. They had been working with Google periodically for a couple of years, attempting to be included in Google Transit. In early 2011, we engaged Metro/SORTA to help them transform their exported Google Transit feed via a CAI developed extended web-based tool, which addressed the issues that Google had with their feed. In March 2011, Metro/SORTA went live on Google Transit. This was exceptionally good news for this project. Now that both agencies were on the Google Transit platform, true cross-agency regional trips could be planned by TANK and/or Metro/SORTA riders. As a result, both agencies have standardized their web-based trip planning solution on Google Transit.

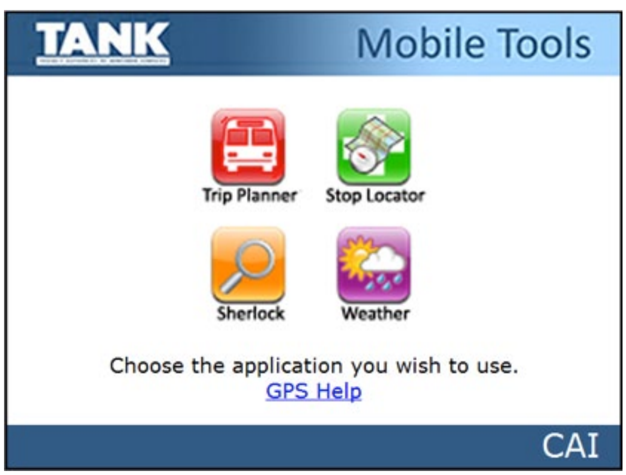
This foundational technology has set the stage for some of the most innovative applications to date with transportation technology. Extended applications that use the GTFS infrastructure are described below.

Trip Planning Applications

- Web Site based trip planning – As discussed above, CAI worked to put the Trip Planning box on TANK's website as a preferred option to plan trips. Additionally, data are being collected for each trip that is planned for the transit authority's later consumption. These data can be used to harvest the number of trips planned, the most popular origins and destinations, the information on whether users are planning trips for present or future travel, and a multitude of other valuable rider travel data. In addition to planning trips from a website, we extended planning capabilities to our first mobile platform—the Mobile Web.
- Mobile Web base trip planning – A mobile website allows ease of use through a smartphone without requiring the download of an application to the phone. This mobile browser based method of accessing the Web typically provides a user with critical tools they may want to access from a smartphone, while excluding much of the traditional Web information. Mobile websites are often feature-based. CAI extended the traditional trip planning tool on www.tankbus.org and presented TANK riders with useful features to enhance their transit experience. TANK's mobile website is located at m.tankbus.org.

  The developed mobile website provides three focused features, or four if the device has GPS (a selection of Blackberry devices were supported for the location features of the application). The application automatically determines if the device is supported for GPS and will load the proper interface.

Figure 4-23
myTANK mobile Web Tools



The four features are as follows:

1. Trip Planner – This feature provides trip-planning capabilities with the same functionality as the Web-based tool. The rider data are stored for

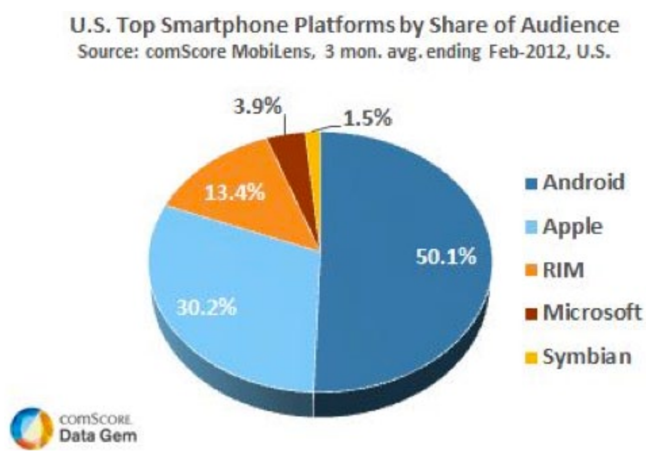
later analysis. In the GPS version, users can optionally allow their current location to be used as their starting location for planning purposes. The non-GPS version requires that users enter a start and end location.

2. Stop Locator (GPS version only) – This feature uses the GPS on the phone to return a list of stops, ordered by the closest stops to the user.
3. Sherlock – Sherlock supports rider during their trips by allowing them to locate businesses (by category) that are closest to them. This can be valuable if the users are unfamiliar with the area or have extra time between transfers. The GPS version uses the GPS location, whereas the non-GPS version requires that the user enter an address or ZIP code.
4. Weather – The weather feature supports riders by letting them know the forecast for the area they are in. This helps them plan their return trip appropriately.

- Mobile Apps (full spectrum transit tools) – A mobile application (or mobile app) is a software application designed to run on smartphones, tablet computers, and other mobile devices. They are available through application distribution platforms, which are typically operated by the owner of the mobile operating system, such as the Apple App Store, Google Play, Windows Phone Marketplace, and BlackBerry App World. The popularity of Apple and Android devices has exploded. Android is a strong player supported by several manufacturers making both smartphones and tablets.[15] The extended capabilities of these devices lend themselves to being the perfect tool for assistance while away from home. Our research shows this as a continuing trend, and we realized that this is another ideal platform to exploit and extend the already-powerful trip-planning capabilities.

Figure 4-24

U.S. top smartphone platforms by share of audience



[15] "Android Captures Majority Share of US Smartphone Market," April 3, 2012, http://www.comscoredatamine.com/2012/04/android-captures-majority-share-of-us-smartphone-market/, accessed June 6, 2012).

A sophisticated application was researched and designed to provide riders with personalized services and information for current and future trips. The myTANK mobile application provides on-demand, location-aware bus routes, times, and trip planning tools in the Northern Kentucky area and provides access to schedules for the TANK bus system. Riders can view targeted information for more than 2,600 trips across more than 1,500 bus stops for the TANK transit system, which carries nearly 4 million passengers per year.

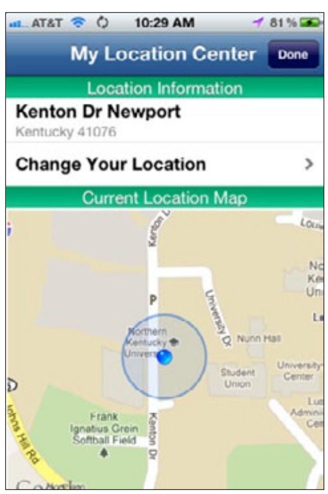
Figure 4-25

myTANK mobile Android app

- Major features include: My Location Center – This focuses on rider location and allows for automatic customization of the application for the rider. Upon startup, My Location Center suggests the current actual location of the rider. The rider can accept the suggested current location or manually enter a starting location.

Figure 4-26

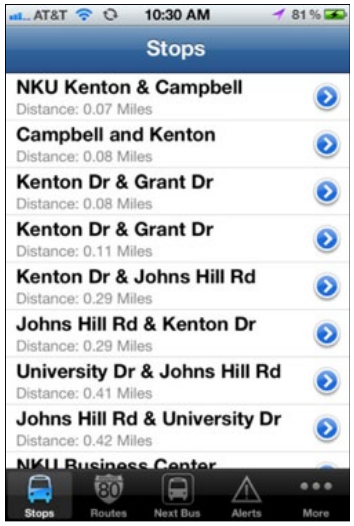
My Location Center (iPhone)



- Stops – Based on the rider's current location, Stops supplies nearby stops and times and guides the rider through planning his trip.

Figure 4-27

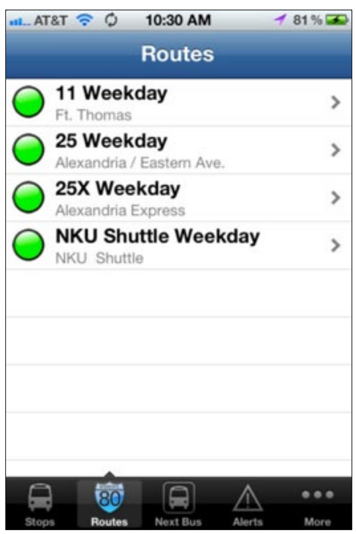
Closest bus stops (iPhone)



- Routes – for riders that know the route(s) they need, Routes shows routes that pass nearby their current location. From there, riders can view nearby stops for those routes and plan their trip.

Figure 4-28

Closest routes visiting nearby stops (iPhone)



- Next Time – this allows riders to know when buses will be at their stop or a nearby stop. This feature maps the closest stops and lets users know both the time and route of the next bus.

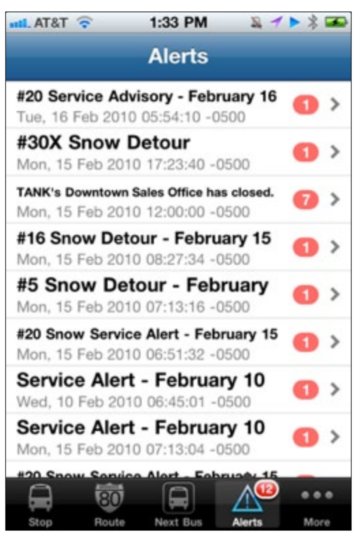
Figure 4-29

Next bus time for a chosen stop (iPhone)

- Alerts – helps riders stay informed of service alerts that could impact travel. This is the identical data that users receive via other modes of the service alerting system that was created as another facet of this research project. If alerts exist, the "Alerts" notifier is activated. Additionally, any routes impacted by that alert also indicate that alerts are in effect.

Figure 4-30

myTANK alerts (iPhone)



- News – This feature allows users to get the latest news and events at TANK. The news is available when the app starts as well as on demand through the app menu system.

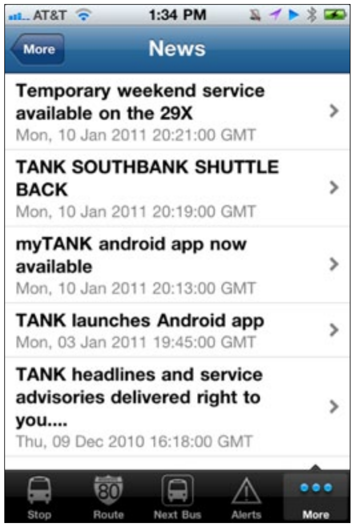


Figure 4-31

Transit agency news (iPhone)

- Map – this feature provides a searchable list of bus stops as well as an interactive map of all available bus stops, ordered by proximity to the user's current location. Additionally, visual reassurance can be gained that the rider is at the correct stop through integration with street views.

Figure 4-32

Bus stop map view in relation to current location (iPhone)

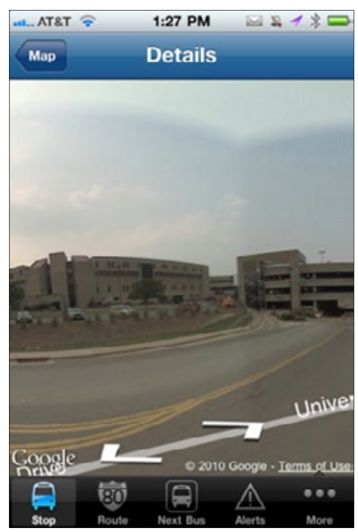


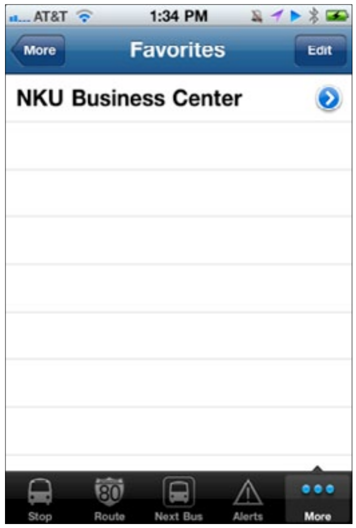
Figure 4-33

Street view selected bus stop (iPhone)

- Favorites – when users find stops that they typically use, this feature allows the rider to set specific stops as a favorite. Going forward, this provides quick access to view routes and next bus arrivals for a rider's favorite stops.

Figure 4-34

Favorite bus stops (iPhone)



- TANK Mobile Web – The Mobile Web feature, discussed earlier, is available as a classic tool for riders who are used to the Web-based tracking tools from http://m.tankbus.org.

Figure 4-35

TANK Mobile Web (iPhone)

- Schedules – PDF versions of TANK's printed route schedules are available through this feature. The data feed to the current schedule used the data stored in the Google Transit feed.

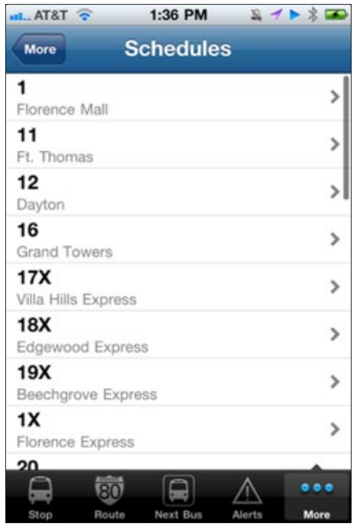


Figure 4-36

PDF schedule detail (iPhone)

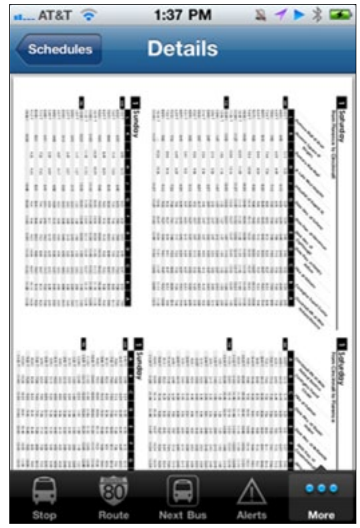


Figure 4-37

PDF version of schedule

- Details – This feature lets riders view full maps showing TANK's complete coverage area in one view.

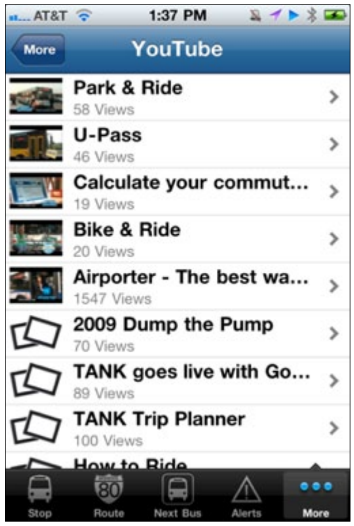
Figure 4-38

System map (iPhone)

- YouTube – The mobile app also integrates with YouTube to allow riders to view informational videos from TANK's YouTube channel. Videos range from "How to Ride" to extended information on programs and facilities.

Figure 4-39

TANK video feed from YouTube (iPhone)



Mobile Application Flow

Figure 4-40 indicates the application flow for the latest myTANK mobile app, showing the paths that users take to access the outlined features of the application. This flow assists not only in specification of the application, but also in quality testing to ensure all features are accessed and tested.

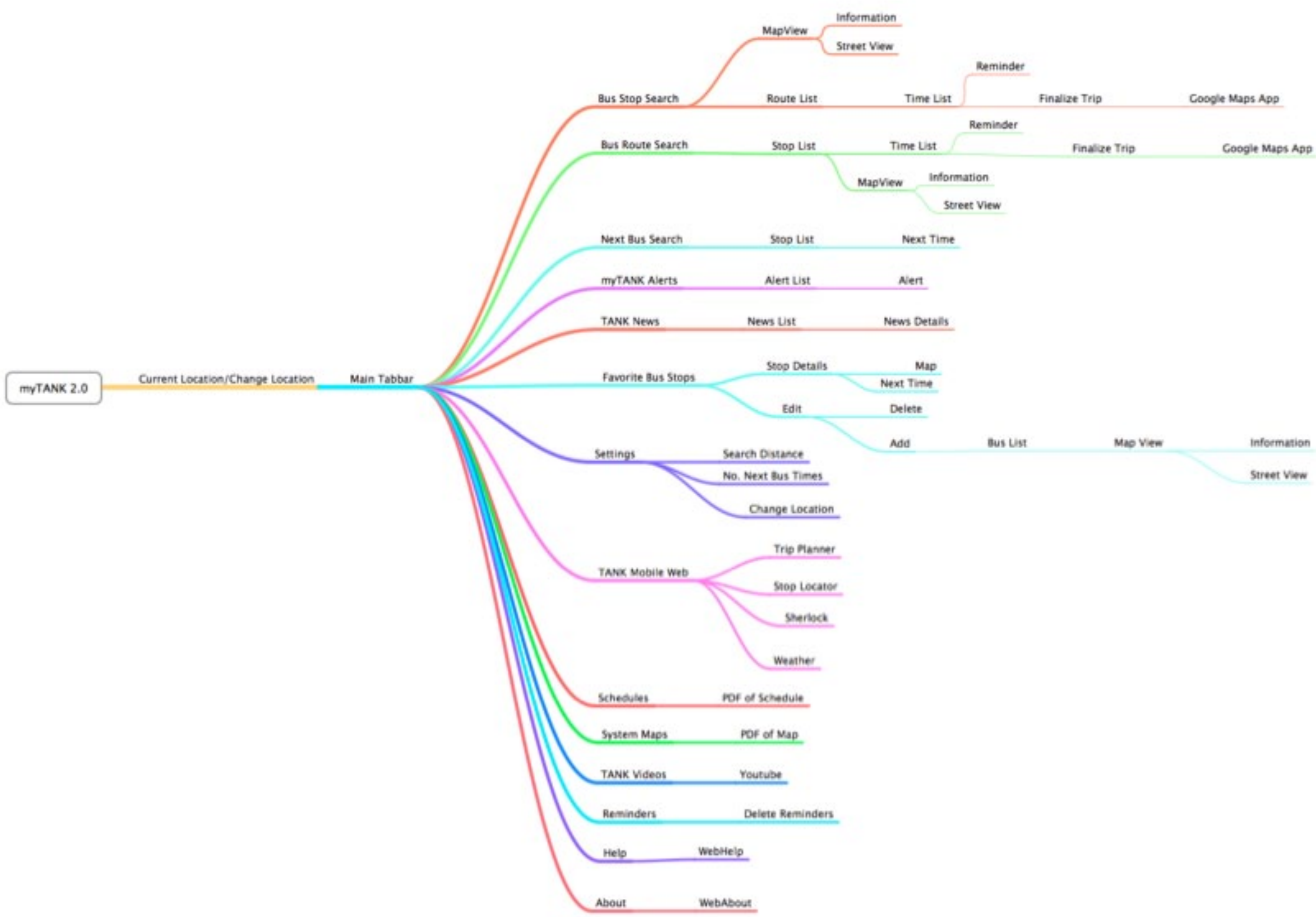


Figure 4-40

Mobile application flow for myTANK mobile app

Launch

The myTANK app was launched in early 2010, and the Android version was launched in early 2011. Several improvements have been made since the initial launch in features, performance, and supported OS versions and platforms (i.e., added the iPad). The following quotes from a TANK press release in January 2011 relays perspectives of TANK and NKU on the mobile application innovations created as a result of this research:

> “Social media and mobility have changed the way the world communicates, and at TANK we are no different. TANK is proud of all of our research work with NKU and pleased to be the first transit agency within our area to roll out both an iPhone app and an Android app to serve the growing needs of our tech-savvy passengers” – Gina Douthat, project manager for TANK

"It has been exciting to be a part of the development and growth of these transportation technologies. This project has really transformed how transportation information can be obtained and understood in Northern Kentucky. This project's effect on my professional development really underscores the importance of community partnerships with the NKU College of Informatics"– Eric Rolf, mobile applications coordinator at NKU, who began his work on the project as an NKU student and, following graduation, has had the opportunity to provide continued project support and oversight at NKU.

Windows Gadget

Windows Vista and Windows 7 contain mini-programs called gadgets, which offer information at a glance and provide easy access to frequently used tools. For example, one can use gadgets to display a picture slide show or view frequently updated headlines.

Why use gadgets? Desktop gadgets can keep information and tools readily available for use. For example, one can display news headlines right next to open programs. This way, if a user wants to keep track of what is happening in the news while he works, he does not have to stop what he is doing to switch to a news website. After installation, a gadget is launched with an icon from the gadget menu.

Figure 4-41

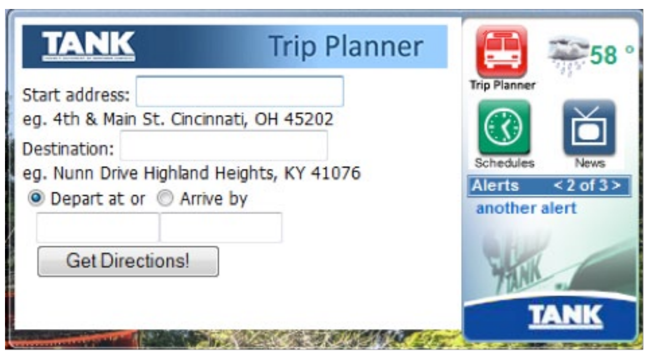
Gadget menu

When gadgets are run, they put information on a user's desktop. In Windows Vista, gadgets are corralled in the sidebar. In Windows 7, they are set free on the screen, where they can be moved and resized. Drag a gadget close to the edge of the desktop or another gadget and it snaps neatly into place for a streamlined look. The TANK gadget, upon startup, displays the current temperature, current alerts, and indicates if there is any new TANK news.

Figure 4-42
TANK gadget

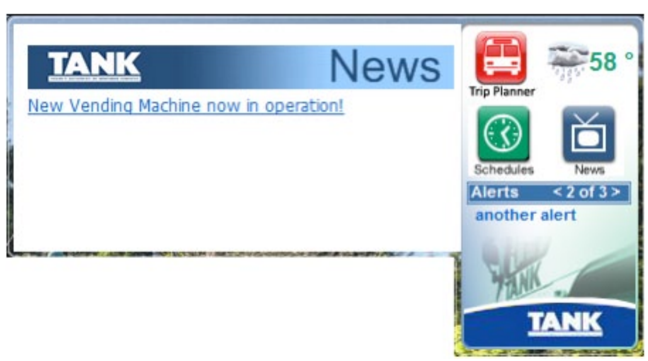
The TANK gadget has interactive features that make trip planning easy and convenient. For example, the Trip Planner button provides a "fly out" to allow for quick access to plan a trip, using Google Transit platform. Simply enter the requested information and a browser displaying full TANK trip plans in Google Maps is presented.

Figure 4-43
TANK gadget: Trip Planner



The News button provides quick access to TANK's latest news. When a fresh news story is published, the News button will pulse to let the user know. Simply click and a "fly out" will provide the latest TANK headlines. Users are just a click away from past TANK news topics.

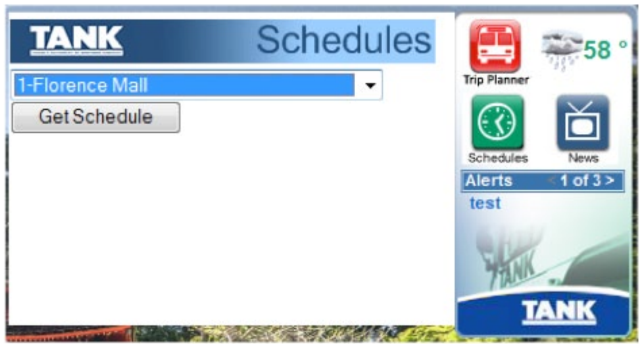
Figure 4-44
TANK gadget: News



One of the historically most popular buttons on TANK's website was the "one-click schedules." The schedule portion of the gadget provides that full functionality without requiring the user to bring up a Web browser and go to the transit authority website. This is also a handy logistical tool if riders are not sure if their paper schedule is outdated. Riders use the schedules button for quick access to electronic versions of the latest print schedules.

Figure 4-45

TANK gadget: Schedules



Transit Interactive Kiosks

Kiosks provide a cost-effective way of letting the public access information about services in high foot-traffic areas. Defining the services that the kiosk would offer was one area in which we gave considerable thought. Additionally, kiosk locations were specified as follows:

- CVG Airport – This strategic transit stop for the transit authority was traditionally under-advertised. When travelers deplane and head into baggage claim, options for rental cars and taxis were very visible and staffed. Public transit signage was minimal, and no information was available for someone considering taking the bus. The airport demographic heavily comprises business workers heading downtown (the main destination of the CVG route) and out-of-town visitors (potential new riders) to the Greater Cincinnati region who are highly unfamiliar with local transit options.
- Covington Transit Center – In August 1998, TANK opened its Covington Transit Center, housed within the Kenton County riverfront parking facility. The Covington Transit Center, often referred to with the acronym CTC, has improved TANK's transfer and hub operations in Covington, while also providing excellent fringe park and ride arrangements for Cincinnati workers. The CTC is an enclosed facility for those catching a bus or making a transfer. Nearly all TANK routes, with the exception of several express buses and the Southbank Shuttle, make a stop in the CTC during their trip. This facility is not staffed for travel assistance or customer service, and only paper-based schedules are available for trip planning.

Our project was to develop software for touch screen kiosks that would be deployed regionally. Through needs assessment conducted with the transit authority, we wanted the kiosk to:

- Be easy to navigate
- Provide time-sensitive information
- Provide traditional schedule information in a paperless form
- Take advantage of the trip planning infrastructure developed during this initiative
- Simplify planning by understanding the rider's current location
- Allow the rider to understand and choose trip options
- Provide the rider with visual and text representations of his trip
- Allow the rider to optionally take the trip with him (paperless)

Unique development challenges that were researched were:

- Displaying multiple page PDF schedules that are intended for folding and printing clearly on a kiosk
- Keeping the TANK data on the kiosk up to date
- Securing the kiosk programmatically
- Managing the kiosk remotely

CAI researched and developed a solution to allow users to gain valuable information about bus transit options through an easy-to-use kiosk-based interface. Special features were built in depending on location. For example, the airport kiosk highlights the 2X airport route and displays the time until the next bus to downtown. At all locations, the kiosks allow riders to see the current time, view schedules, use the trip planning feature (providing multiple options for each trip), view text and map views of planned trips, and take the trip with them on a smart phone via a QR code.

Initial challenges were resolved as follows:

- Displaying multiple-page PDF schedules that are intended for folding and printing clearly on a kiosk – PDF schedules typically change in content, not formatting. We analyzed current schedules and produced cleanup scripts that pull currently-published schedules from the location specified in the transit feed. The script then rotates and crops each schedule so that the end result is a weekday timetable, a weekend timetable, and a route map image that is rotated and cropped to fit the kiosk form factor. The rider can view each simply by toggling between options via buttons. This sanitation process is done once on a central server and each kiosk fetches this information daily.
- Keeping the TANK data on the kiosk up to date - As with the above, the central server produces the content for the kiosks to present an up-to-date schedule. Trip data are available daily.
- Securing the kiosk programmatically – The kiosk has been designed to be physically and programmatically secure. Programmatically, the interface is running in "kiosk" mode and will not allow exit of that state. The keyboard

is onscreen only and presented only via the created interface. If the interface were to stop, no controls to perform malicious acts exist. Additionally, the kiosk interface refreshes daily to ensure long-term stability. Kiosk Internet access is hardwired at both sites, further reducing security concerns.

- Ability to remotely manage the kiosk – To ensure sustainability, the remote control solution LogMeIn has been deployed on all kiosks. From anywhere with browser access, Internet connectivity, and the proper credentials, full monitoring and management can be performed.

Locations

Kiosks are deployed at the Cincinnati/Northern Kentucky International Airport (CVG) and at the Covington Transit Center.

The CVG kiosk launched in October 2011. The following excerpt from a TANK press release relayed the spirit of the airport kiosk:

> "The kiosk is in the perfect location to provide accurate information to potential users of the Airporter express route, which travels directly between CVG and downtown Cincinnati. The kiosk is located right at the spot when a passenger would be making their transportation decision…. TANK will now be known as a real option for people wanting to make that fast trip into downtown," said Gina Douthat, TANK spokesperson. "TANK receives hundreds of queries each month directly from the CVG website, so we know that there is a large group of travelers out there that want to be able to use public transportation to get to their destination after they arrive at CVG."

Located in Terminal 3 Baggage Claim, the kiosk is an interactive kiosk that allows passengers to learn when the next bus to downtown Cincinnati's business district leaves the CVG Airport. The kiosk allows users to search any transit trip via the Google Transit tool.

Figure 4-46

Deployed CVG Airport kiosk

Launched in March 2012, the Covington Transit Center kiosk provides another high-traffic venue for the valuable trip planning data. This kiosk, built for outdoors use, is sheltered under a breezeway in a very visible part of the transit center and sits next to a ticket sales kiosk.

Figure 4-47

Deployed Covington Transit Center kiosk

Kiosk Experience

As riders interact with the Airport kiosk, they are presented with clear information and options:

- Local time
- Next bus time
- Trip Pricing
- Transit agency branding
- Options to:
  - View the airport schedule timetables
  - Plan a trip
  - View all schedule timetables

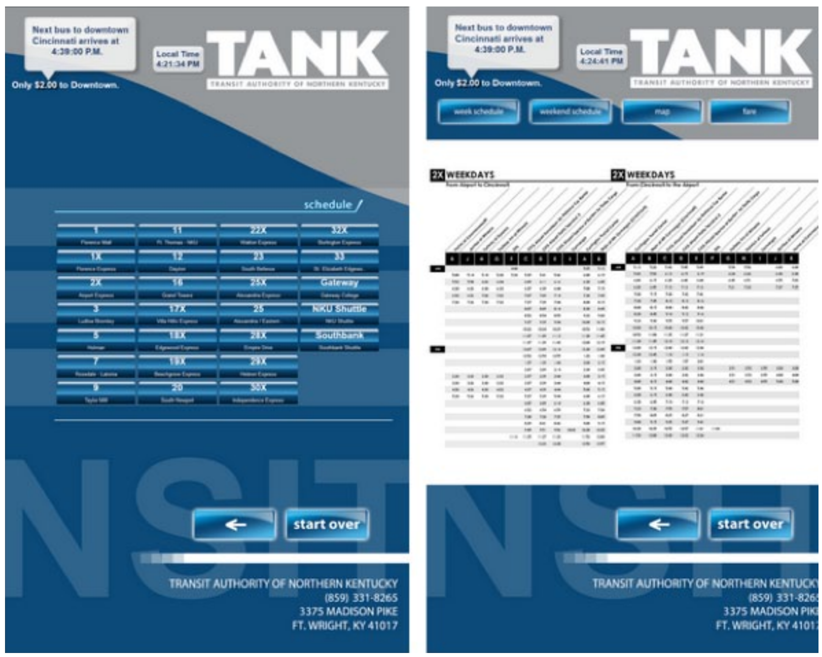
Figure 4-48

CVG Airport kiosk screen

If a user proceeds to view all schedules, a list of current, active TANK schedules is presented. When one is selected, the rider views an augmented version of the original PDF that has been cropped, rotated, and scaled to fit the screen. The user may toggle between weekday schedules, weekend schedules, a map of that route, and fare information. Navigation exists to go back and view another schedule or start over. (Note: If a rider abandons the system and the system becomes idle for more than 1 minute 30 seconds, the screen is slightly dimmed and a 30-second countdown starts telling the rider to touch to continue. If the rider touches the screen, he will be returned to the kiosk where he left off. If the screen is not touched, the kiosk will perform a “start over” automatically. This feature helps deliver a consistent experience as new riders approach the kiosk.

Figure 4-49

Kiosk schedule selector



If a rider wishes to plan a trip, he will see the dialogue shown in Figure 4-50. The formatting is very similar to other trip planning dialogues we have built on tankbus.org, iPhone app, Android app, and the desktop gadget. A virtual keyboard allows the user to enter their destination. The origin of all trips is the CVG Airport Terminal 3. As the rider finalizes his selection, he selects “Get Directions!” to initiate a trip search. If routes are found, typically three trip options are presented. At this point, the rider must choose a desired trip, choose to start over, or go back and re-enter his destination.

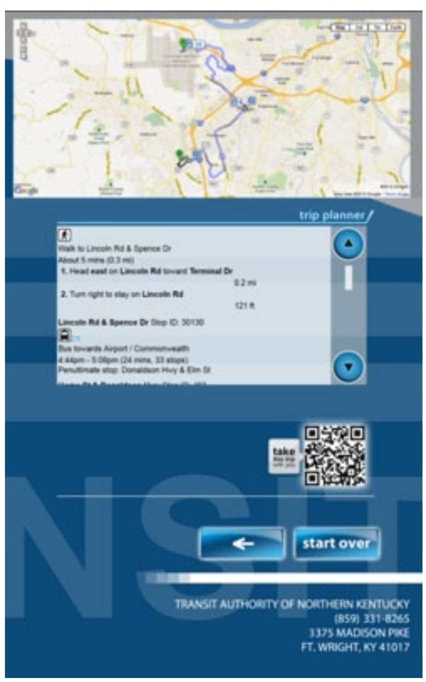
Figure 4-50

Kiosk trip planner

After a rider selects one of three suggested routes, a detailed dialogue is presented for the selected route. This screen presents a map that traces the route from start to destination. Below the map, a textual representation of the trip plan is provided. At this point, the rider may choose to go back and browse the details of the other two options, restart the kiosk experience completely, take the trip with them using QR code technology (discussed later), or simply leave the kiosk (which will reset itself for the next user).

Figure 4-51

Kiosk customized rider trip plan with map and text directions



QR Codes

QR codes are a logical extension of trip planning. They provide a paperless way for someone to scan in a trip plan. This allows him also to get “reverse directions” later via Google maps. QR codes have been used on the Airport Kiosk and CTC kiosks.

Additional collaboration and development has been conducted with TANK to use QR codes to allow riders to quickly pull up PDF schedules on their mobile devices. The schedules are kept current, as software we have developed via this initiative used static QR codes to allow them to dynamically redirect to always display schedules that match that of the Google GTFS feed.

Figure 4-52

Scanning a QR code for a planned trip

Figure 4-53

Custom trip loads on mobile device

Google Maps

All data designed are additionally available directly in Google Maps. As we were an early adopter of this technology, several changes in the GTFS data and presentation were realized during the research period. Advantages of having data in a public, open system not only allows for accessibility by out-of-town users who are not familiar with the specific transit options, and also integrates local results and provides public transit options when searching for businesses, etc. Google Transit has been fully integrated into Google Maps, and transit directions are completely integrated with driving, walking, and biking directions.

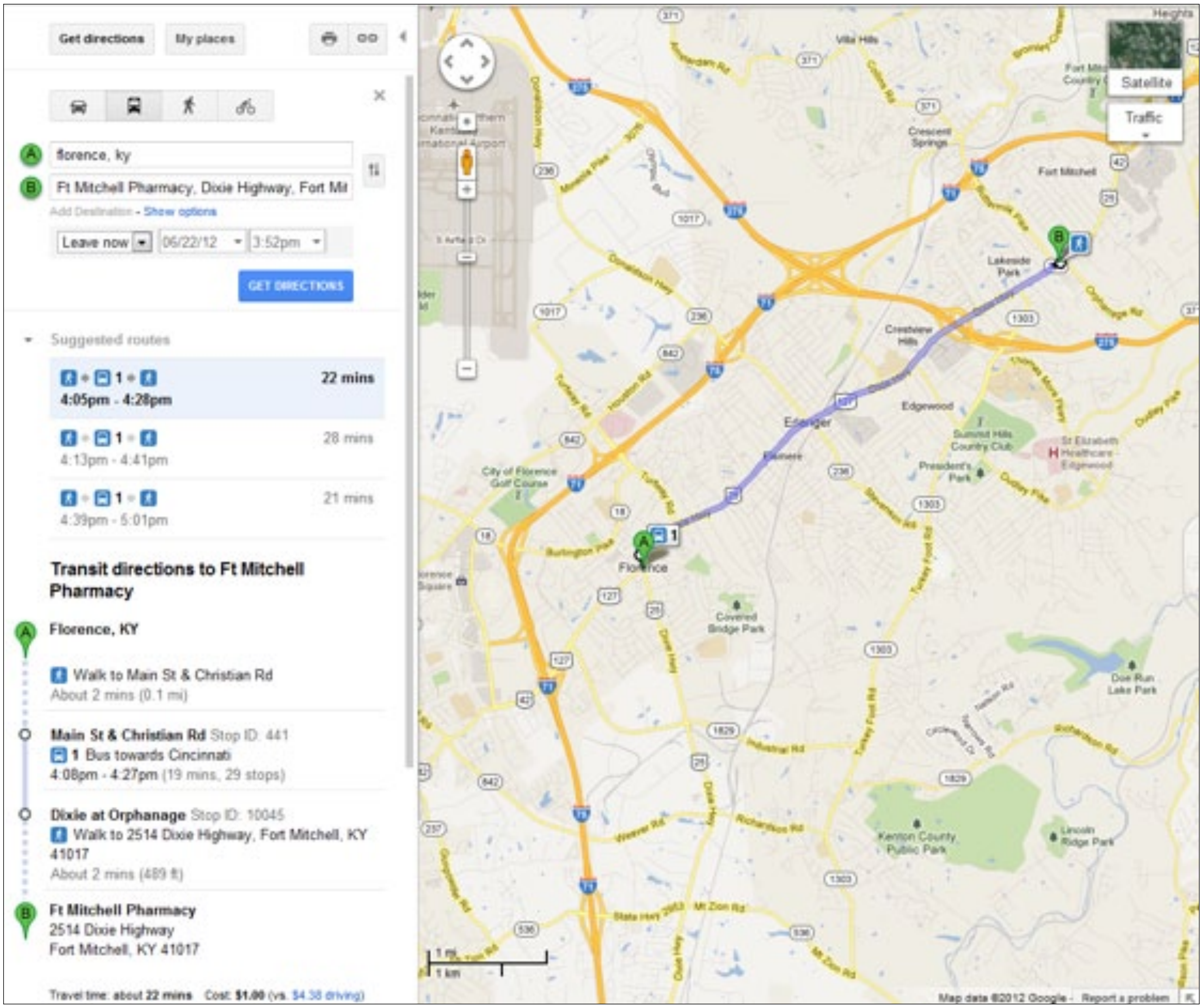


Figure 4-54

Planning a trip using Google Maps

Case Study 4

Green Portal

Overview

TANK Green Portal is an online dashboard that dynamically calculates and displays the benefits of using TANK Transit through an easy-to-use graphical interface. TANK Green Portal was developed using an SAP technology called XCelsius (now called SAP Crystal Solutions). XCelsius is used for the creation of dashboards that enable users to interact with data in meaningful ways that take into account various cost and environmental variables. The TANK Green Portal was developed by first creating an Excel spreadsheet with various calculations and data and then feeding the spreadsheet into a custom-created XCelsius dashboard.

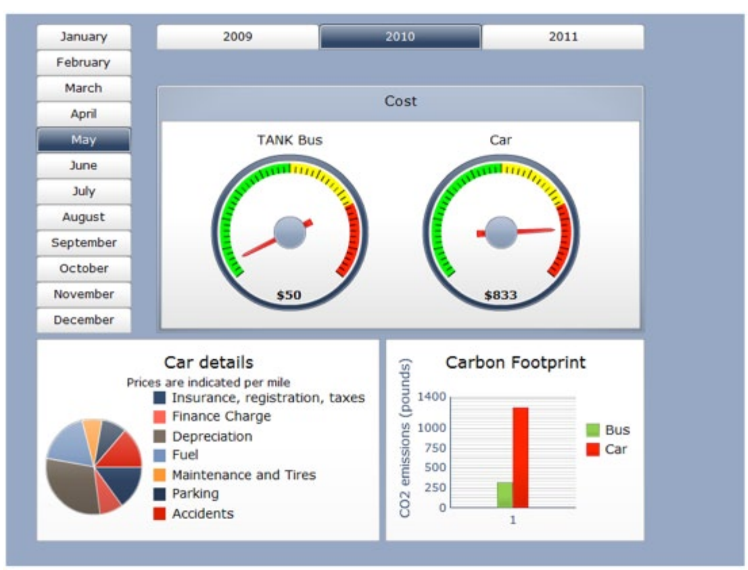
TANK Green Portal serves as an online dashboard to illustrate the financial and environmental benefits of using TANK buses for daily commutes. End-users not only get to see the breakdown and comparison of costs between the two methods of transportation, but they also get to witness the growth of car-related costs over time through dynamically-changing graphs and gauges.

TANK Green Portal provides users with two modes of display: an individual green-gauge view and a high-level dashboard. Each view calculates various aspects of car usage cost and carbon footprints compared to TANK transit financial and environmental costs. The individual green-gauge view calculates a cost comparison between TANK bus and car usage by month and year. It offers this comparison for every month from 2009 through 2011. In addition to the breakdown of costs, it calculates a carbon footprint for both car and bus usage.

Additionally, the dashboard displays a detailed breakdown of car usage costs. These cost breakdowns adjust themselves per month and year.

Figure 4-55

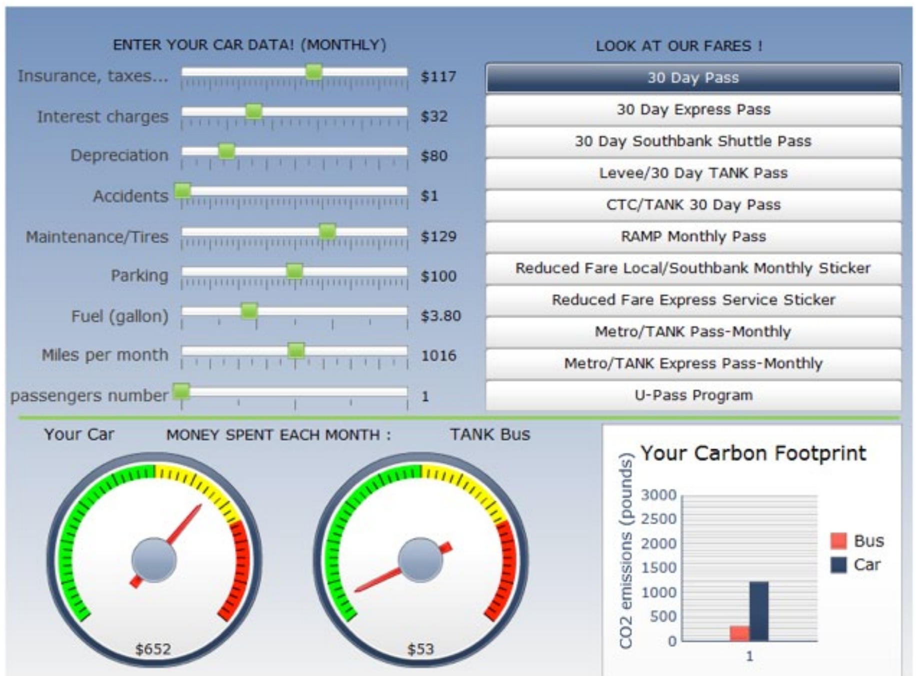
Green Portal individual green gauge



The specific view provides more in-depth customization of monthly costs accrued from driving a car. It allows users to personalize their own monthly costs spent on a car so they can easily see the accumulation of different costs invested over the span of just one month. This includes such factors as insurance, taxes, interest charges, depreciation, accidents, maintenance and tires, parking, fuel consumption, miles driven, and the number of passengers. Once personalized, users are able to select the different fare packages offered by TANK and can then compare that cost to their current costs spent on car usage. They are also provided with a graph that displays the carbon footprint difference between using a car and a bus for daily commutes.

Figure 4-56

Green Portal high-level dashboard



TANK Transit offers commuters both large financial and environmental costs over the course of even just one month. With significant funds being invested into cars every month, and with a lack of specific environmental information, this portal serves as a comprehensive resource to calculate and present these numbers to a commuter in a very meaningful way. This portal takes into account numerous variables that often go unaccounted for when calculating total costs so commuters can truly see the price and environmental disadvantages of solely relying on car transportation. Such information is important in current times when green initiatives are both more appealing and necessary.

When calculating these financial and environmental costs, numerous variables were used in the equations in order to derive sound results.

To calculate the costs incurred by using a car for transportation, the following factors were used to represent monthly cost[16]:

- Fixed cost (including insurance and registration)
- Finance charges
- Depreciation
- Fuel
- Maintenance costs
- Tire costs
- Residential parking
- Accidents

Depreciation and fuel costs were calculated based on national averages. For depreciation, the difference between what was paid for the vehicle and what it could be sold for today and was calculated using these averages derived at the time of this case study:

- Average price of a new car: $28,400[17]
- Average years of use: 10
- Average mile driven per year: 12,000

Depreciation can then be calculated at a rate of 23.7 cents per mile. Fuel consumption was calculated using an average of gas prices per month and an average of 20 miles per gallon. Calculating the carbon footprints for a car and bus required two different sets of factors. For a car, these factors were used in the calculation:

- 1 gallon of gas produces 20 pounds of CO_2
- Average miles driven per gallon of fuel: 20 miles

Based on this, it was concluded that roughly 1 pound of CO_2 are emitted per mile and that 2,000 pounds of CO_2 are released per year (based on the average of 12,000 miles per year).[18]

To calculate the carbon footprint for a bus, it is estimated that 0.301 pounds of CO_2 per mile is emitted. Based on this, 3,612 pounds of CO_2 is released per

[16] Calfo, Cathy. Guest Commentary, "Make It In America: Forward-Thinking Transportation Policy To Drive National Prosperity," 2011, http://www.surdna.org/component/content/article/249.html, aaccessed June 20, 2012.

[17] Cichetti, Joanne. "The Average Cost for a New Car," March 31, 2012, http://www.ehow.com/facts_5977729_average-cost-new-car.html.

[18] Solutions, "Commute, Calculate the Cost of Your Commute," n.d., http://commutesolutions.org/commute/cost-calculator/, accessed June 12, 2012.

year by a bus or 301 pounds per month. By using TANK transit, each individual person is reducing the amount of CO_2 released into the atmosphere by nearly 11,000 pounds per year. The TANK Green Portal shows current and potential riders the green benefits of using TANK in a manner that is very relatable to the person.

SECTION 5

Feedback and Outcomes

Feedback

Feedback was received from multiple sources. We consider rider feedback to be one of the most important sources. Following are two examples of communications (typically sent to the transit agency) that were forwarded to NKU to reinforce the work performed on the Wi-Fi deployment:

> The project to put Wi-Fi on the TANK bus routes is a fantastic application of this technology. I normally take a route that, unfortunately, is not yet equipped with Wi-Fi. This morning I had to change my route and was pleasantly surprised when I noticed the Lily Pad emblem on the bus. This saved about 20 minutes of time at work after I was able to update emails and perform other tasks. TANK should know that this project has made their product (public transportation) more valuable to their consumers. I would be willing to spend more money for the ride to/from work (which is already a bargain) for a bus equipped with Wi-Fi. This is an excellent way to make public transportation more attractive to Northern Kentucky commuters. You have provided an excellent product!

> Wi-Fi Internet access ROCKS!!! I get a jump start on my day by checking work emails. I can blog a little bit or IM with family out of state or pick something up on E-bay. If I'm not on my computer, I'm reading a book. TANK ROCKS!!!

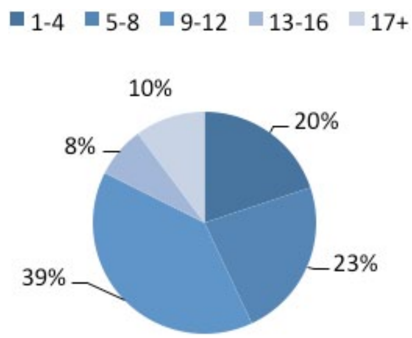
Wi-Fi – Online Survey

An online survey was created to gather high level feedback for this initiative from TANK riders/users. The survey assessed a range of how many times per week passengers rode a TANK bus, if having Internet access makes them more likely to ride a TANK bus, how they rated the quality of the Internet connection on the bus, and how easy it was to navigate the Wi-Fi system. Following are the results of the 2,065 surveys collected.

The question of how many times a week people ride the bus was intended to determine if the users were mostly "power" riders or if they were less frequent riders. Eighteen percent were power users (taking 13 or more rides per week). Another 39 percent of riders fell in the category of average but frequent bus riders, taking 9 to 12 trips a week. A total of 43 percent of riders were not frequent riders, taking 8 or fewer trips per week. This profile shows that we had a good diversity of user riding frequencies using the Wi-Fi service.

Figure 5-1

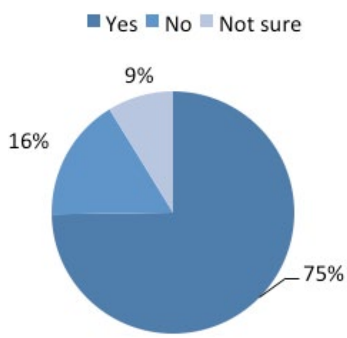
How many times a week do passengers ride a TANK bus?



The next question was posed to derive the value of the Wi-Fi service to the riders. Specifically, we asked if having Internet access available makes them more likely to ride the bus. A total of 75% of riders reported that this service makes public transit a more attractive option for them. Of the remaining respondents, 16% indicated that this service did not add to their decision to ride the bus. The remaining 9% were undecided about the impact of Wi-Fi in their decision making process.

Figure 5-2

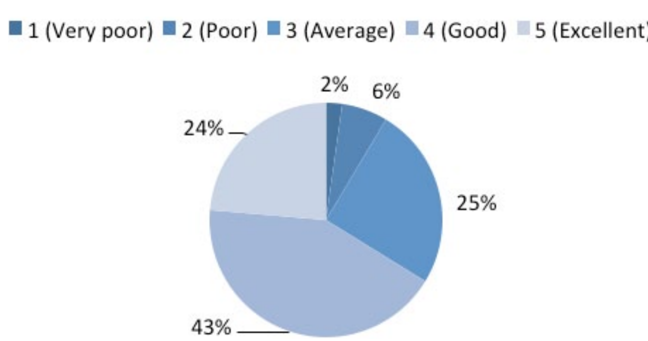
Does Internet access make you more likely to ride a TANK bus?



The third question posed of riders was in regard to the quality of the Wi-Fi service they had on the bus. This is a very valuable question as people are typically used to Internet response time in the home or office, typically wired, at very high speed levels. The fact that 92% of respondents reported average (25%), good (43%), or excellent (24%) quality of connection was a key success metric.

Figure 5-3

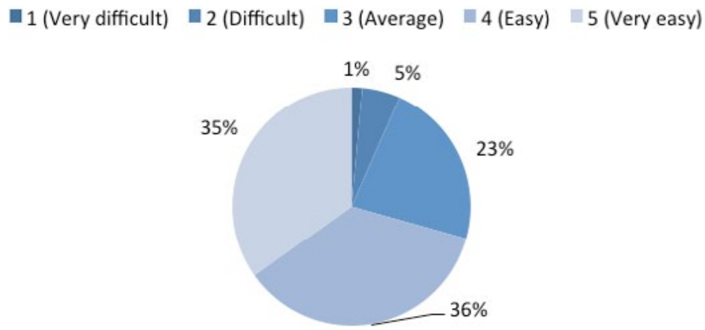
How would you rate the quality of the Internet connection on the bus?



The final question posed of riders was in regard to the ease of use. As we realized that the ease of use is critical to rider adoption, we strove to ensure that the process was simple and well- documented on the bus and on-screen upon connection. The fact that 94% of respondents reported very easy (35%), easy (36%), or average (23%) ease of use was a key success metric.

Figure 5-4

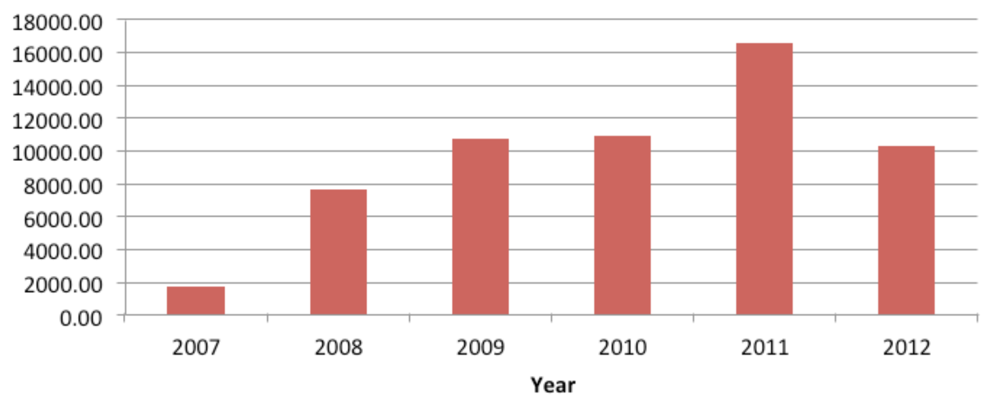
How easy was it to navigate the homepage?



In addition to collecting surveys, we collected anonymous information on the number of connections over time. Each year, riders using the service increased. The results shown for 2012 are incomplete, but it is projected that usage for 2012 will bypass 2011 usage numbers.

Figure 5-5

Number of TANK bus Wi-Fi connections by year



Note: 2012 data are incomplete; represents data through 6/22/2012.

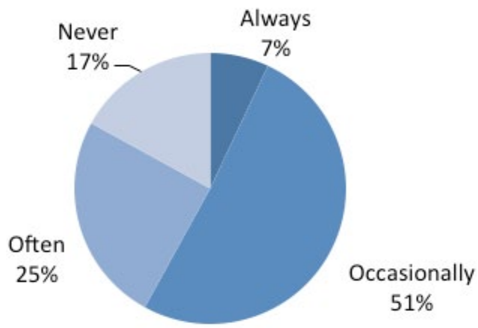
Onboard Passenger Survey

The survey was administered to 358 people commuting on TANK buses to assess the functionality and passenger satisfaction of the above features. This survey was administered in person over the course of two days by a team of four student workers. The students rode the routes and collected surveys from riders who were willing to contribute. Surveys were collected immediately.

The survey results showed that 83% of the time passengers ride a bus that is equipped with video capabilities. Video capabilities refer to the on-board monitors that deliver current news headlines to passengers. NKU partnered with WCPO to deliver these headlines to passengers and to also ensure that breaking headlines and alerts are aired as they happen. This is yet another way that important information is delivered to passengers.

Figure 5-6

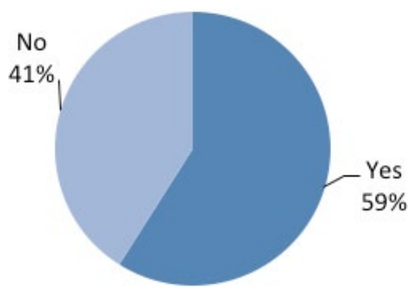
How often are you on a bus equipped with video capabilities?



At the time of the survey, 59% of passengers were already aware of TANK's online trip planning tools (released just a few months prior to the survey). These tools include a trip planner that calculates different bus routes based on a start and end address and an arrival time. It informs passengers of the average route time and what routes they will need to take to arrive at their destination. The online trip planning tool helps to reduce dependence upon paper schedules, phone calls, and manual navigation of TANK's website and instead allows Web and mobile access with trip customization.

Figure 5-7

Are you aware of TANK's online trip planning tools?



Of those interviewed, when planning trips, 54 passengers reported that they used their mobile device to plan their bus routes, and 99 passengers reported using Google Transit and Google Maps to plan their routes. As previously mentioned, our goal is decreasing dependence upon paper schedules and manual methods of searching for information. Instead, users can enter a minimal amount of route preferences and the planning tool performs the rest of the work.

Passengers can also sign up for myTANK alerts. myTANK alerts keep passengers informed of service alerts that could impact their travel and notify users of any schedule-impacting events such as severe weather, delays, route changes, etc. This method also consolidates signup of the traditional newsletter enrollment. Of the interviewed passengers,123 were signed up for the alerts and 108 of them had already received alerts. Passengers preferred receiving the alerts via text message or e-mail; 116 passengers preferred text messages and 162 passengers preferred e-mail alerts.

Figure 5-8
myTANK alerts

Riders who took this survey also had the opportunity to answer open-ended questions regarding their personal opinion of the onboard Wi-Fi. The following are a few of the comments left by riders:

- "This is a wonderful service. I'm not just a college student, where Wi-Fi helps me with my homework, but I'm also a businessman. The on-bus Wi-Fi allows me to have a mobile office for my online business. This gives me an ever-changing view and enough variety to make my day fun and productive at the same time."
- "I am a faithful TANK rider and I use the WI-Fi on the bus whenever I am able to get service! What a wonderful service and I have been riding the TANK bus for 19 years! I enjoy the ride and so enjoy this new service available to us!"
- "For me, I am happy to be able to access my iPod touch to send an email to my family who are all over the United States! I appreciate this service and am happy to use it when available!"
- "Great bus service. I use it every day. Please keep up the good work."

Outcome: Regional Trip Planning

As a result of this research, a valuable logistical rider tool was built and extended to provide TANK with capabilities that it was evaluating for purchase at a cost of more than $300,000 per year. We integrated this tool into their website, built a mobile website, built mobile apps for Android (Google) and iOS (Apple) that take advantage of a rider's location and extended features, built a Windows (Microsoft) Gadget for instant desktop planning, and developed touch screen kiosk technologies that are deployed at the CVG airport and the Covington Transit Center, two major transit hubs for TANK. In addition, we worked with regional partner Metro/SORTA to assist it in getting onto the Google Transit platform. By doing this, the value of the entire researched trip planning tools increased by being able to plan regional trips that transcended agency lines. This means a rider using a kiosk or any other medium of trip planning can seamlessly plan a cross-agency trip.

Outcome: Rider Communication and Alerting

Keeping riders informed of both logistical and security issues was an important focal point for this research. Previously, alerts could be communicated only via the transit agency's website. Riders would have to check the website often (a "pull" model) to ensure they did not miss information that may impact their trip. Additionally, normal communication from the transit agency was a separate email system that did not have alerting functionality. We wanted to ensure that riders received "pushed" information related to them in a timely manner and in a mode that was easily available to them, regardless of their location.

To address this issue, we developed an alert system called myTANK Alerts. myTANK Alerts delivers customized route alerts to riders' mobile device or email inbox. Riders are able to select only the route(s) pertinent to them. In the event of a service interruption, such as bus delays, detours, etc., the rider will receive either an email or text alerting them of the situation. This type of alerting system revolutionizes the way that riders receive such alerts. In the past, riders had to actively visit TANK's website to check for the existence of alerts and see if those alerts pertained to their route(s). myTANK Alerts automatically does this for the rider and also makes this information accessible to a rider without smart phone capabilities.

This has resulted in cost savings for the agency in the procurement of an alerting system. The system is built on an open source platform and uses email technology to send both emails and text. Therefore, we have created a zero-cost platform for keeping riders abreast of issues. This ability has inspired inquiries from other small to medium-size transit agencies in Kentucky as they look for low-cost solutions to provide rider alerts. In addition, we created a single entry point for alerts that can be propagated not only to email and text, but also to the website, Windows gadget, mobile app, etc. This eliminated an operational step of updating the website with alert data. Finally, this application replaced an existing piece of software used for newsletters. This saves TANK a monthly usage fee and reduces another system that requires maintenance.

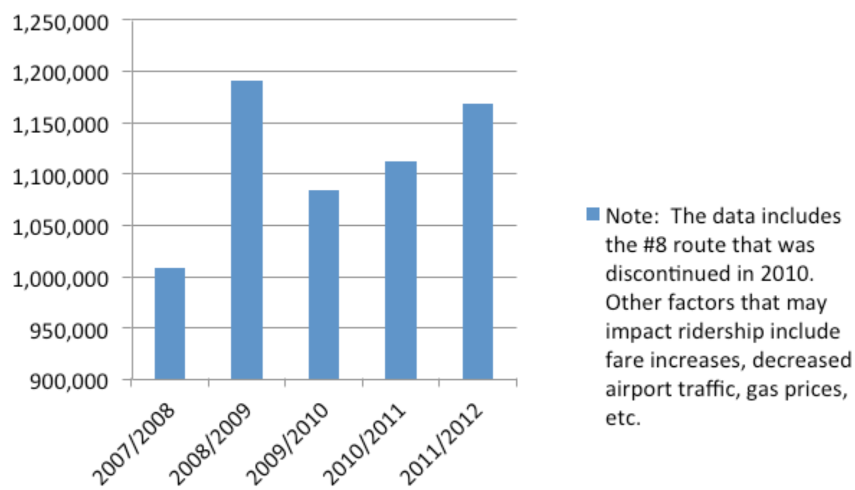
Outcome: A Connected Bus – Mobile Wi-Fi Connectivity

Putting Wi-Fi technologies on buses to create a rolling hotspot was pioneering when this research started and is now a technology that continues to provide benefits to public transit and emergency management using public buses as emergency command centers. It is a technology that is continually improved. On buses, riders without technology can learn about transit services and keep up to date on local news, weather, and alerts.

Ridership on Wi-Fi-enabled routes has increased since the initial pilot (note: these are raw ridership numbers). External factors that have occurred through the timeframe may positively or negatively impact ridership numbers. Such factors are route elimination, service reductions, fare increases, decreased airport traffic, changing gas prices, and other technology developed as a result of this research. That said, the average ridership increased from the baseline on all Wi-Fi routes over the course of the research.

Figure 5-9

Ridership for Wi-Fi routes



We created this to be a lights-out operation; content is generated (or uploaded, if desired) and buses broadcast Wi-Fi to riders and pull content automatically. This technology has been tested and subsequently deployed in dedicated emergency management vehicles and command centers, setting up an infrastructure for communication, especially in rural areas where Internet infrastructure is sparse. We have proposed and piloted applications and procedures with regional emergency management to promote video-based event broadcast, on-vehicle streaming cameras, and automatic sending of emergency pictures to headquarters wirelessly via the Wi-Fi network.

SECTION
6

Conclusion

We have been privileged to be able to conduct technology research and deployment to better public transit. We have enjoyed local and national collaboration regarding the exciting transit technologies with which we have worked. The research FTA has sponsored can be applied to transit agencies across the country. It is rewarding to see this technology being adopted not only by other agencies, but also by schools, libraries, and healthcare assessment vehicles that have taken note of the advancements realized via this research.

GLOSSARY

3G – Third-generation mobile cellular technologies.

802.11b/g – Wireless standards developed by Institute of Electrical and Electronics Engineers (IEEE). These standards help to define how users can connect to a network or each other wirelessly. 802.11g is faster than 802.11b.

Backhaul – The portion of the network that comprises the intermediate links between the core network or backbone network and the small sub networks at the “edge” of the entire hierarchical network .

Bandwidth – The transmission capacity of a computer network or other telecommunication system.

Bus Area Network (BAN) – The wireless area surrounding each bus in the TANK system as it travels its route.

EVDO (Evolution-Data-Optimized, Rev A) – The cellular telecommunications standard used in this project.

GMS modem – Specialized type of modem that accepts a SIM card and operates over a subscription to a mobile operator, just like a mobile phone.

GPS (Global Positioning System) – A global system of U.S navigational satellites developed to provide precise positional and velocity data and global time synchronization for air, sea, and land travel.

GTFS (General Transit Feed Specification) – Defines a common format for public transportation schedules and associated geographic information. GTFS “feeds” allow public transit agencies to publish their transit data and developers to write applications that consume that data in an interoperable way.

Interactive kiosk – A computer terminal featuring specialized hardware and software designed within a public exhibit that provides access to information and applications for communication, commerce, entertainment, and education.

Media network player – A media player that connects to BAN and retrieves digital media files (such as video) from a centralized location and plays them on monitors installed on buses.

Mobile Web – Refers to access to the World Wide Web, i.e., the use of browser-based Internet services, from a handheld mobile device, such as a smartphone, a feature phone, or a tablet computer, connected to a mobile network or other wireless network.

Network Access Point (NAP) – One of several major Internet interconnection points that serve to tie all the Internet access providers together.

Pull technology – Style of network communication in which the initial request for data originates from the client and then is responded to by the server.

Push technology – Style of Internet-based communication in which the request for a given transaction is initiated by the publisher or central server.

QR (Quick Response) code – A two-dimensional matrix bar code that is used to identify products.

Router – A network device that forwards data packets to parts of a computer network.

SMS (Short Message Service) – A system that enables cellular phone users to send and receive text messages.

UMTS (Universal Mobile Telecommunications System) – One of the third-generation (3G) mobile telecommunications technologies.

Virtual Private Network (VPN) – A private network that interconnects remote (and often geographically-separate) networks through primarily public communication infrastructures such as the Internet.

Web service – A method of communication between two electronic devices over the Web.

Wi-Fi (Wireless fidelity) – Network standard of mobile computing devices and regulated by the Wi-Fi alliance.

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