Final Report

Development of a Continuing Process for Monitoring Performance Data on Transit-Related ITS Investments

Northern Virginia Transportation Commission

TranSystems Corporation

formerly

MultiSystems

December 2003

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ACKNOWLEDGMENTS

The consultant team wishes to thank Richard Taube, Executive Director, and Alfred Titus-Glover and Adam McGavock, Project Managers, of Northern Virginia Transportation Commission. We would also like to thank the representatives of Northern Virginia transportation agencies who served on the Project Steering Committee:

Lora Byala, Washington Metropolitan Area Transit Authority (METRO)

James Carrell, Fairfax County Department of Transportation.

Sharmila Samarasinghe, Virginia Department of Rail and Public Transportation

Alexis Versoza, City of Fairfax (and CUE)

We also wish to thank the staff of WMATA and Virginia Railway Express for their cooperation with the survey effort and all the agency staff that participated in interviews.

1. INTRODUCTION

This report describes the performance of transit–related intelligent transportation systems (ITS) deployments in the Northern Virginia region and documents ways for NVTC to continue gathering this information and monitoring performance. It is the culmination of a study for Northern Virginia Transportation Commission (NVTC) conducted by Multisystems (now TranSystems), entitled *Development of a Continuing Process for Monitoring Performance Data on Transit-Related ITS Investments in Northern Virginia*. The purpose of this study has been to document transit-related ITS systems that have been deployed in the Northern Virginia area, and identify measures of performance and the benefits that have been realized from these investments. This information will be indispensable in NVTC's efforts to publicize the benefits of transit ITS and encourage decision makers to support further transit ITS infrastructure investments in the future.

The study consisted of three tasks. Task 1 involved preparing an inventory of transit-related ITS projects in Northern Virginia, including those investments in nearby jurisdictions that may affect the entire metropolitan area or that represent a pioneering effort. The information and data gathered was then used to determine which ITS projects would be included in the Task 2 analysis.

Task 2 of the study addressed the performance and benefits of these deployments and how they have been measured. It included two subtasks: interviewing transit managers and industry representatives involved in specific applications in the region; and conducting a survey of the region's transit customers about their experiences with transit ITS.

Over 14,000 surveys were distributed to transit riders at Metrorail and VRE stations over the course of several weekdays in April 2003. Approximately 16% (2,292) of the transit riders who received the questionnaire responded. The survey asked the consumers to express their opinion about the use of new technologies by Northern Virginia transit systems, select the three most important uses of new technologies in transit to them, describe how new transit technologies changed their use of transit, indicate their familiarity with the various ITS services deployed in the region and how often they use the services, state how useful the ITS services have been, and report how easy it is to use the ITS services.

Task 3 of the study involved the preparation of this report documenting the study results including the extent of deployment in the region, the project objectives and the measures being used to evaluate performance, the documented benefits, consumer response and other impacts of the deployments as well as recommendations for ongoing performance monitoring.

This report is divided into three sections: Introduction, Summary of Research Tasks, and Approach to Continuous Performance Monitoring. Section 2, Summary of Research Tasks, provides a concise summary of the study research findings as well as describing the methodologies that were employed. The section includes descriptions of projects selected for interviews while the Appendix provides descriptions of a number of other projects in the region.

Section 3 describes the recommended steps to be taken for a successful continuing process for monitoring performance data, and is made up of the following three subsections:

- *Policies for the Monitoring Process* -This subsection describes what needs to be done before actual data collection begins. It recommends a number of policies to be set and to which all stakeholder agencies should adhere.
- *Developing and Applying Specific Performance Measures* - This subsection describes which measures should be developed for each type of technology. Two tables are included in this subsection that provide specific characteristics of each performance measure (grouped by ITS system).
- *System for Storage and Dissemination of Information* -This subsection describes the best and most efficient way to maintain and disseminate the gathered data. It illustrates how a website could be organized to facilitate public access to the information.

2. SUMMARY OF RESEARCH TASKS

2.1 Inventory of Transit-Related ITS Investments in Northern Virginia

The first task of the study was to research and document all transit-related ITS projects currently planned, operational or completed, in Northern Virginia. The information reviewed included existing documents and reports, information available on websites of various agencies and information gathered via telephone conversations and in-person interviews.

While the primary emphasis of the inventory effort was to document existing services, ongoing implementations and planned projects in Northern Virginia, projects in adjacent areas such as Prince William County (VA), Montgomery and Prince George's County (MD) and the District of Columbia were included in the inventory phase of the study. In addition, as part of the inventory work, a generic overview of the different ITS applications for transit was prepared, identifying example implementations both inside and outside the region to provide a foundation for understanding the status of efforts within the region to deploy ITS for transit. These are summarized in Section 2.1.1.

Transit-related ITS projects in the region were categorized according to Federal Transit Administration (FTA) classification, as follows:

- Fleet Management Systems
  - Advanced communications
  - Automatic vehicle location (AVL)
  - Automatic passenger counters (APC)
  - Maintenance information systems
  - Operations software
  - Transit signal priority (TSP)
- Electronic Fare Payment (EFP)
- Transit Traveler Information Systems
  - Pre-trip information
  - In-terminal/wayside information
  - In-vehicle information
- Transit Safety
  - On-vehicle surveillance
  - Station/facility surveillance
- Intelligent Vehicle Initiative
  - Collision avoidance

Based on the inventory, it was clear that the Northern Virginia area and surrounding counties and cities have been actively involved in the deployment of transit-related ITS systems. Some 80 projects, either already implemented, currently being implemented, or still in the planning stage, were identified and described in the Task 1 report. Table 1 provides a summary of the type of transit-related ITS projects that were identified and the agencies that are engaged in these deployments. A more detailed inventory is contained in Section 2.1.2.

Table 1: Transit-Related ITS Projects Identified

Type of ITS	*Agency*
Data Sharing	Metropolitan Washington Council of Governments (MWCOG) Montgomery County
Electronic Fare Payment	WMATA, Regional Stakeholders
Fleet Management	City of Falls Church WMATA (MetroAccess, MetroBus) Arlington County Fairfax County District of Columbia (DCDOT) Montgomery County Virginia Tech/George Mason University (GMU) City of Alexandria City of Fairfax Virginia Railway Express (VRE) Virginia DOT (VDOT) DCDOT Montgomery County Prince Georges County/Maryland State Highway Administration (Md SHA)
Intelligent Vehicle Initiative	WMATA
Planning	MWCOG, Md SHA, VDOT, DCDOT WMATA, NVTC, Volpe Center, George Mason University DCDOT Md SHA Dulles Corridor Task Force Montgomery County
Transit Safety/Security	MWCOG WMATA, VDOT Regional Stakeholders
Transportation Demand Management	Potomac Rappahannock Transportation Commission (PRTC) DCDOT Montgomery County
Traveler Information	PRTC Arlington County Fairfax County VDOT, Md SHA, DCDOT, MWCOG, WMATA VRE City of Alexandria City of Falls Church Loudoun County City of Fairfax Montgomery County MWCOG, and the state DOTs

2.1.1 Generic Applications of ITS Technologies for Transit

Table 2 provides an overview of the universe of transit ITS projects identified by the Joint Program Office of FTA and FHWA, identifying the following for each:

- Description
- Delivery mechanism
- Modalities
- Examples of existing or current deployments
- Potential benefits and impacts
- Performance measures

It is noteworthy that there are examples within the region of many of these applications.

Table 2: Generic Transit-Related ITS Applications

2a. COMMUNICATIONS SYSTEMS		
Description	**Delivery Mechanism**	**Examples of Existing/Current Deployments**

Media/equipment used for voice communications and/or data transfer for transit operations. The most critical link is between the transit vehicle and management center, where a digital and/or analog radio system is typically employed. Could also include mobile data terminals (MDTs).	• RF
	• Fiber Optics
	• CDPD
	• WAN and LAN
	• DSRC(Dedicated Short Range Communications)
	• DSL
	• T1
	• Radio
	• Cell phones
	• MDT
		• Ann Arbor, MI - Text messages via MDTs reduced congested voice radio traffic, up to 70% in some cases.
		• Denver, CO - The mean number of calls per weekday to the Denver RTD Dispatch Center has increased 34% since the implementation of the CAD/AVL system, from 224 in 1992 to 300 in 1996. However, the number of vehicle hours increased 14% from 1992 to 1996, and dispatchers may be attending to less critical calls than they did with the previous communications system.
		• Milwaukee, WI - Under Milwaukee County Transit System's old voice-only radio system, dispatchers received about 1,500 calls per week. If the number of calls exceeded the communication system's call holding capacity, some calls would be lost. After the installation of a CAD/AVL system, which utilizes voice and data communications, calls to dispatchers were able to handle 4,500 per week.
		• Regional Deployment (see Section 2.1.2 for detailed information)
		  ○ WMATA MetroBus
		  ○ WMATA MetroAccess
		  ○ PRTC

	Modalities	
	• Real Time	

Potential Benefits and Impacts	
Capital Cost Savings	**O&M Cost Savings**
• No cost savings as communication systems are a requirement for most agencies	• O&M costs may be shared among agencies using the same communications infrastructure
Safety & Security	**Energy & Environment**
• Improved because you have communication with all operators and extends to passengers • Allows for silent alarm capability	N/A
Service Quality	**Ridership/Market Share**
• Enables transfer coordination	• Improved communications leads to improved reliability of service—a key issue for riders
Efficiency	**Productivity**
• Data transmission is much more efficient than voice • Less voice radio communications needed • Improved drivers efficiency	• Data transmission increases throughput (number of messages) greatly over voice transmission.

Performance Measures
• Coverage of service area • Downtime • Percentage blocked calls • Access delay time • Reduced voice communications • Increased total number of communications

Table 2: Generic Transit-Related ITS Applications (continued)

2b. AUTOMATIC VEHICLE LOCATION (AVL) SYSTEMS

Description	Delivery Mechanism		Examples of Existing/Current Deployments

Automatically determines/tracks the real-time geospatial location of a vehicle. Several different technologies may be used to perform AVL, such as global positioning system (GPS), ground-based radio, signpost and odometer, dead-reckoning, and combinations of these	• Cellular digital packet data (CDPD)
	• Radio frequency
	• DSRC (Dedicated Short Range Communications)
		• GPS/Differential GPS (DGPS)
		• Sign Posts
		• Loop detectors
		• Dead Reckoning
			• London, Ontario – London Transit's AVL system saves the agency from spending $40,000 to $50,000 on a schedule adherence survey.
			• Atlanta, GA – MARTA saved $1.5 million through schedule adjustments using APC and AVL data .
			• Prince William County, VA – PRTC estimated an annual savings of $869,148 because of its AVL system.
			• Portland, OR – Tri-Met's AVL/CAD system produced an estimated annual operating cost savings of $1.9 million based on an analysis of 8 routes that are representative of Tri-Met's service typology.
			• Portland, OR – From Fall 1999 to Fall 2000, weekday ridership increased by 450 for one route after Tri-Met used AVL data to adjust the route's headways and run times.
			• Baltimore, MD – A test conducted by the MTA on 2 routes demonstrated a 23% increase in on-time performance of AVL-equipped buses.
			• Hamilton, Ontario – Hamilton Street Railway Company increased schedule adherence from 82% to 89% after implementing AVL.
			
			• Regional Deployment (see Section 2.1.2 for detailed information)
			  ○ WMATA MetroBus,
			  ○ WMATA MetroAccess
			  ○ PRTC
			  ○ Montgomery County
			  ○ GEORGE

	Modalities		
	• Real-time		

Potential Benefits and Impacts

Capital Cost Savings	O&M Cost Savings
• Lower fleet requirement • Reduced service vehicles and equipment	• Reduced data collection costs • Additional location information allows better fleet utilization
Safety & Security	**Energy & Environment**
• Reduced incident response time • Crime deterrence • Situational awareness	• Reduced vehicle requirements • Reduced fuel requirement • Reduced dwell times • Reduced SOVs • Reduced highway capacity needs
Service Quality	**Ridership/Market Share**
• Schedule adherence • Reliability • Service control • Operator monitoring • Management and maintenance • Improved transfers	• Some increase can be anticipated due to increased sense of improved reliability of service.
Efficiency	**Productivity**
• Dynamic dispatching & road control • Allows for flexible routing and better incident detouring • More efficient / representative schedules • Fleet deployment improvement	• Reduced extra board • Reduced supervisors and peak pullouts • Dispatcher efficiency and effectiveness • Improved system oversight • Improved road call response

Performance Measures
• Improved incident response time • Improved route & schedule adherence • Improved dispatcher efficiency • Reduction in fleet requirements • Increased transfers through connection protection • Reduced emissions • Reduced non-revenue vehicle miles/hours

Table 2: Generic Transit-Related ITS Applications (continued)

<table>
<tr><th colspan="3">2c. AUTOMATIC PASSENGER COUNTERS (APCs)</th></tr>
<tr><th>Description</th><th>Delivery Mechanism</th><th>Examples of Existing/Current Deployments</th></tr>
<tr><td rowspan="3">Device that counts passengers automatically as they board and alight transit vehicles, typically buses. Most common technologies include treadle mats and infrared beams.</td><td>• PCMCIA Card
• Infrared garage connection
• RF (in real-time mode)
• Hard wire connection
• Step Treadle
• Infrared beams</td><td rowspan="10">• London, Ontario - London Transit saves $50,000 over manual methods per system-wide count.
• Atlanta, GA - MARTA reduced the number of traffic checker positions from 19 to 9.
• Columbus, OH - Data collected by Central Ohio Transit Authority's APCs are 95% accurate.
• Portland, OR - Data collected by Tri-Met's APCs are 98% - 99% accurate.
• Fairfax County Connector- Two units are installed on the fleet as pilot project.

• Regional Deployment (see Section 2.1.2 for detailed information)
o WMATA MetroBus
o GEORGE</td></tr>
<tr><th>Modalities</th></tr>
<tr><td>• Real-time data
• Could also be downloaded at end of day when vehicles pull into garage</td></tr>
<tr><th colspan="2">Potential Benefits and Impacts</th></tr>
<tr><th>Capital Cost Savings</th><th>O&M Cost Savings</th></tr>
<tr><td>• Realize payback in short time</td><td>• Reduced data collection costs</td></tr>
<tr><th>Safety & Security</th><th>Energy & Environment</th></tr>
<tr><td>• Know how many people on board during accident</td><td>• Justifies service by documenting ridership
• Enables more efficient allocation of vehicles to respond to ridership</td></tr>
<tr><th>Service Quality</th><th>Ridership/Market Share</th></tr>
<tr><td>• Provide service where it is needed most
• Reduced crowding as additional vehicles are added where demand is high</td><td>• Increase ridership by adapting routes to demand</td></tr>
<tr><th>Efficiency</th><th>Productivity</th><th>Performance Measures</th></tr>
<tr><td>• Increase throughput by optimizing routes/stops based on need</td><td>• Optimize routes and schedules to ridership needs
• Reduce time to collect data
• Reassign passenger checkers to other duties</td><td>• Reduced manual data collection costs
• Improved accuracy of ridership data</td></tr>
</table>

Table 2: Generic Transit-Related ITS Applications (continued)

<table>
<tr><td colspan="3">2d. VEHICLE COMPONENT MONITORING SYSTEM</td></tr>
<tr><th>Description</th><th>Delivery Mechanism</th><th>Examples of Existing/Current Deployments</th></tr>
<tr><td rowspan="3">Automatically monitors the condition of transit vehicle engine/transmission components, via engine sensors, and provides warnings if failures occur. The system transmits real-time data to the transit management center or depot, and may be linked to the AVL system.</td><td>• Wireless LAN
• RF (in real-time mode)
• Hard wire connection</td><td rowspan="11">• Regional Deployment (see Section 2.1.2 for detailed information)
o WMATA MetroBus
o GEORGE</td></tr>
<tr><td>Modalities</td></tr>
<tr><td>• Real-time data
• Could also be downloaded at end of day at garage</td></tr>
<tr><td colspan="2">Potential Benefits and Impacts</td></tr>
<tr><td>Capital Cost Savings</td><td>O&M Cost Savings</td></tr>
<tr><td>• Could be substantial</td><td>• Could be substantial
• Material (parts, fuel, oil, etc) savings</td></tr>
<tr><td>Safety & Security</td><td>Energy & Environment</td></tr>
<tr><td>• Reduce breakdowns</td><td>• Monitor emissions, fuel use and efficiency</td></tr>
<tr><td>Service Quality</td><td>Ridership/Market Share</td></tr>
<tr><td>• Reduce service delays</td><td>• Enhances reliability for customers and for public image</td></tr>
<tr><td>Efficiency</td><td>Productivity</td></tr>
<tr><td>• Maintain service so riders reach their destinations</td><td>• More efficient to prevent breakdowns than respond to them after the fact
• Improved tracking of history of vehicle maintenance</td><td>Performance Measures
• Reduced vehicle out-of-service time
• Reduced maintenance costs
• Reduced service disruptions (when a vehicle breaks down and riders have to be transferred to another)
• Reduced parts inventory</td></tr>
</table>

Table 2: Generic Transit-Related ITS Applications (continued)

2e. TRANSIT OPERATIONS SOFTWARE (FIXED ROUTE)

Description	Delivery Mechanism	Examples of Existing/Current Deployments

Computer software that assists transit properties in planning and operating fixed-route bus service. Includes run-cutting, scheduling, and dispatching software.	• LAN
	Modalities
	• Static
	• Real-time (transfer connection protection)
		• Ann Arbor, MI – AATA estimates that its computer-assisted transfer management (CATM) software (also known as transfer connection protection) accounts for the majority of the estimated 70% reduction in voice traffic on its radio system.
		• Chicago, Illinois' transfer connection protection system.
		• Santee Wateree, South Carolina's "Service on Demand" rural transit system.
		• New York City's decision support system.
		• **Regional Deployment** (see Section 2.1.2 for detailed information)
		  o WMATA MetroBus
		  o Fairfax County Connector

Potential Benefits and Impacts

Capital Cost Savings	O&M Cost Savings
• Reduced vehicle requirements	• May reduce drivers' hours as drivers are scheduled more efficiently
Safety & Security	**Energy & Environment**
• None	• Reduced fuel needs • Minimize dead-head miles
Service Quality	**Ridership/Market Share**
• Greatly improves service planning	• Improves due to better scheduling
Efficiency	**Productivity**
• Better utilization of routes and scheduling	• Balance labor requirements with schedules and labor rules

Performance Measures

- Improved dispatcher efficiency
- Reduction in fleet requirements
- Reduced operating costs (reduced non-revenue time)
- Reduced operators over-time (better run-cutting)

Table 2: Generic Transit-Related ITS Applications (continued)

<table>
<tr><td colspan="3">2f. TRANSIT OPERATIONS SOFTWARE (PARATRANSIT)</td></tr>
<tr><th>Description</th><th>Delivery Mechanism</th><th>Examples of Existing/Current Deployments</th></tr>
<tr><td rowspan="3">Scheduling and dispatching software for paratransit operations that accommodates advanced trip reservations, standing orders, and immediate requests. The software also supports route deviation service and intermodal/interagency connections. Information from scheduling and dispatching can be integrated into management information, billing, and accounting functions of the paratransit service provider.</td><td>• LAN</td><td rowspan="10">• Winston-Salem, NC - After WSTA implemented a CAD and scheduling system for its paratransit service, the operating cost per vehicle-mile decreased by 8.5% to $1.93/vehicle-mile, the operating cost per passenger trip decreased by 2.4% to $5.64/passenger trip, and the operating cost per vehicle-hour decreased by 8.6% to $24.70/vehicle-hour.
• Santa Clara, CA - Santa Clara Outreach realized an annual savings of $488,000 from the installation of AVL and paratransit scheduling and dispatching software.
• Florida - A dispatch system with AVL, which can coordinate trips among several agencies, has the potential to reduce fraud in Medicaid transportation by $11 million annually in Florida.
• Sweetwater County, Wyoming - Sweetwater County's computer-assisted dispatching system has contributed to a ridership increase from 5,000 to 9,000 passengers per month without increasing the dispatch staff. Five years after the system was installed, ridership increased 5 folds.
• Blacksburg, VA - Blacksburg Transit increased productivity from 0.8 passengers to 2 passengers per hour (50% efficiency improvement).
• St. Johns County, Florida - Routing and scheduling software contributed to a reduction from 8 to 4.5 administrative staff positions associated with coordination, oversight, scheduling, billing, and reservations.
• Regional Deployment (see Section 2.1.2 for detailed information)
o WMATA MetroAccess
o Fairfax County FASTRAN
o Arlington County STAR</td></tr>
<tr><th>Modalities</th></tr>
<tr><td>• Interactive</td></tr>
<tr><th colspan="2">Potential Benefits and Impacts</th></tr>
<tr><th>Capital Cost Savings</th><th>O&M Cost Savings</th></tr>
<tr><td>• Reduced vehicle requirements</td><td>• Larger systems may benefit more
• Reduced vehicle maintenance
• Improved efficiencies result in reduced driver staffing needs</td></tr>
<tr><th>Safety & Security</th><th>Energy & Environment</th></tr>
<tr><td>• Reduced lost trip/missed pickup to most vulnerable riders
• Allows scheduling customers more safely taking into account their special medical needs</td><td>• Reduced vehicle miles travel, therefore, reduced emissions, pollutions
• Reduced energy consumption</td></tr>
<tr><th>Service Quality</th><th>Ridership/Market Share</th></tr>
<tr><td>• Trade-off with efficiency concerning exclusive ride versus shared ride</td><td>• Increased productivity allowing for increased ridership</td></tr>
<tr><th>Efficiency</th><th>Productivity</th><th>Performance Measures</th></tr>
<tr><td>• Better use of vehicles
• Trade-off with service quality</td><td>• Increased vehicle productivity
• Lower administrative costs
• Better data tracking and reporting
• Reduced dispatcher and call taker time</td><td>• Reduced reservation time
• Reduced vehicle requirements
• Reduced operations costs
• Increased ridership
• Reduced emissions
• Reduced dispatcher time</td></tr>
</table>

Table 2: Generic Transit-Related ITS Applications (continued)

2g. TRANSIT SIGNAL PRIORITY (TSP) SYSTEMS

Description	Delivery Mechanism	
Giving transit vehicles priority over other vehicles at signalized intersections. Holds traffic signal green, or turns it green earlier than scheduled, to provide right-of-way to transit vehicle. Can be implemented conditionally for vehicles behind schedule.	• RF (in real-time mode) • DSRC • Light/Infrared • Sound (siren)	• Emitters/receivers • Centralized (AVL to signal system)
	Modalities	
	• Real-time	

Potential Benefits and Impacts

Capital Cost Savings	O&M Cost Savings
• Lower fleet requirement	• Reduced vehicle running time • Reduced layover time • Reduced fuel usage, and brake wear
Safety & Security	**Energy & Environment**
• Staying on schedule provides schedule adherence "security" for passengers - knowing they will get to destination on time • Can also be used for emergency vehicles signal pre-emption	• Reduced fuel usage and emissions (less idling at stops)
Service Quality	**Ridership/Market Share**
Reduced delay at signals Reduced running/travel time Improved travel time reliability Perceived service improvement	• Increased ridership due to expanded service, and faster, more reliable service
Efficiency	**Productivity**
• Increased person throughput • Reduced fuel usage • Reduced brake wear	• Average 10% productivity improvement, validated by several studies

Examples of Existing/Current Deployments

• Los Angeles, CA – The LADOT and LACMTA estimate a savings in operating costs of $6.67 per bus hour due to the LADOT/LACMTA transit priority system.
• Helsinki, Finland – Fuel consumption decreased by 3.6% after a pilot TSP system was implemented on one bus route.
• Gothenburg, Sweden – Simulations show that TSP produces a 4% to 6% reduction in fuel consumption and emissions.
• Aalborg, Denmark – The consumption of diesel fuel has been reduced by 4,683 liters per year due to a TSP system implemented at 15 intersections along two bus routes.
• Seattle, WA – Average signal delay for King County Metro buses was reduced from 7.7 seconds to 3.3 seconds (57% reduction). Effects on side street and overall intersection delay were insignificant.
• Phoenix, AZ – Signal priority reduced signal delay for buses by 16%. Impact on cross traffic was minimal.
• Minneapolis, MN – Metro Transit buses experienced an average reduction of 9 seconds waiting at red signals.
• Oakland – Berkeley, CA – Signal priority (on a major arterial with 21 signalized intersections) reduced signal delays for buses by 14%.
• Charlotte, NC – Transit signal priority reduced average travel time for buses by 4 minutes.
 	
• **Regional Deployment** (see Section 2.1.2 for detailed information)
  o Columbia Pike, US 1
  o Georgia Ave
  o Montgomery County

Performance Measures
• Reduced dwell time at signals • Reduced travel time • Reduced fleet requirements • Improved on-time performance (reduced bunching) • Reduced fuel usage/emissions • Increased ridership

Table 2: Generic Transit-Related ITS Applications (continued)

<table>
<tr><th colspan="4">2h. ELECTRONIC FARE PAYMENT SYSTEMS</th></tr>
<tr><th>Description</th><th colspan="2">Delivery Mechanism</th><th>Examples of Existing/Current Deployments</th></tr>
<tr><td rowspan="3">Provides an electronic means of collecting and processing fares. Customers use a magnetic stripe card, smart card, or credit card instead of tokens or cash to pay for transit trips.</td><td>• Wireless LAN
• RF (in real-time mode)
• Hard wire connection</td><td>• Magnetic Strip
• Contact Smart Card
• Contactless Smart Card</td><td rowspan="9">• New York, NY - Fare evasion decreased from 4% to 2% (50% reduction) with implementation of NYCT's Metro Card system, new turnstile design, and increased police presence. As a result, the agency realized an additional $43 million in 1993 and $54 million in 1994.
• Cleveland, Ohio-- Greater Cleveland Regional Transit Authority's Smart Card Demonstration Project involved 30,000 payment cards accepted on approximately 100 buses.
• San Francisco, California-- In February 2002, the MTC launched the first phase (the pilot project) of the TransLink® regional smart card program. The project is being implemented and managed through a design-build-operate-maintain arrangement with the system integrator, ERG. The six-month pilot involves six of the region's operators: AC Transit, BART, Caltrain, Golden Gate Transit, San Francisco Muni and Santa Clara Valley Transportation Authority. The ultimate plan for full rollout is to serve approximately 26 of the region's transit providers with a single farecard.
• Ventura County, CA-- RFP for a new regional payment system was issued in February 2000. Installation of equipment began in July 2001and the system went live in January 2002. The new system includes contactless smart card readers. However, the cards are "dual interface," operating in both a contactless and contact mode.
• Regional Deployment (see Section 2.1.2 for detailed information)
  ○ SmarTrip
  ○ VRE Automatic ticket vending</td></tr>
<tr><th colspan="2">Modalities</th></tr>
<tr><td colspan="2">• Transactions could be in real-time with financial institutions, or
• Data could be stored onboard to be downloaded at end of day</td></tr>
<tr><th colspan="3">Potential Benefits and Impacts</th></tr>
<tr><th>Capital Cost Savings</th><th colspan="2">O&M Cost Savings</th></tr>
<tr><td>• Could be shared with private sector (e.g., banks)</td><td colspan="2">• Savings by automating labor-intensive processes
• Floating revenue benefits the agency</td></tr>
<tr><th>Safety & Security</th><th colspan="2">Energy & Environment</th></tr>
<tr><td>• Increased security for people carrying automated fare media rather than cash.
• Restore value for lost cards</td><td colspan="2">• Reduces dwell times compared with cash fareboxes (for buses)</td></tr>
<tr><th>Service Quality</th><th colspan="2">Ridership/Market Share</th></tr>
<tr><td>• Improve customer convenience though use of easier-to-use media
• Lost smartcards can be replaced
• Expedited passenger boarding
• Improved transfers
• More flexible fare structure</td><td colspan="2">• Improved data enables system enhancements to increase ridership
Increased customer convenience due to easier, cashless transaction encourages ridership</td><th>Performance Measures</th></tr>
<tr><th>Efficiency</th><th colspan="2">Productivity</th><td rowspan="2">• Increased revenue (floating revenue, merchant fees)
• Reduced fare handling costs
• Reduced fare evasion
• Increased ridership
• Expedited passengers boarding
• Customer convenience</td></tr>
<tr><td>• Increase throughput due to common format, easy-to-use media (reduce delays fumbling for exact change)</td><td colspan="2">• Improved productivity by automating labor-intensive processes, such as issuing transfers and counting cash
• Improved productivity due to reduced dwell time</td></tr>
</table>

Table 2: Generic Transit-Related ITS Applications (continued)

2i. PRE-TRIP TRANSIT INFORMATION SYSTEMS

Description

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

Delivery Mechanism

- Internet
- E-mails
- Phone
- Cell phones
- PDA
- Pagers

Modalities

- Static
- Real-time
- Interactive

Potential Benefits and Impacts

Capital Cost Savings	O&M Cost Savings
• Reduces customer service representative labor	• May reduce customer service staff requirements

Safety & Security	Energy & Environment
• Personal security (e.g., can lessen exposure to weather and crime)	• The availability and accessibility of information makes transit easier and more attractive thus more people may take transit instead of automobile

Service Quality	Ridership/Market Share
• Allows passengers better and faster access to information • May improve the patron's trip time by finding the most optimal OD path • Redistributes passengers during periods of interrupted service • Reduces wait time for transit vehicles • Increases perception of transit reliability	• Ridership should increase because transit system is easier to use and more attractive

Efficiency	Productivity
• Automation increases efficiency of customer service agents	• Increases productivity of the transit system as well as the customer service department

Examples of Existing/Current Deployments

- Ventura County, CA - 56% of survey respondents said they would not have made a transit trip without pre-trip information.
- London, England - A survey of users of London Transport's ROUTES computerized route planning system revealed that 80% of callers made the trip about which they inquired, 30% changed their route based on info received, and 10% made a trip they would not otherwise have made via transit.
- Newark, NJ - New Jersey Transit's telephone automated transit info system reduced caller wait time from an average of 85 seconds to 27 seconds.
- Minneapolis, MN –After implementing an automated transit trip itinerary planning system, 19% of customers felt the service was "much improved" while 18% perceived that the service was "somewhat improved.
- Rochester, NY - Rochester-Genesee Regional Transportation Authority's automated transit information system resulted in an increase in calling volume of 80%. The system handles 70% of calls and allowed 4 part-time customer information agent positions to be eliminated.
- Portland, OR-- Tri-Met Transit Tracker
- King County Metro--MyBus Information
- Washington State – Vessel Watch
- Tri-County Rail, FL
- **Regional Deployment** (see Section 2.1.2 for detailed information)
  - Fairfax CUE – NextBus
  - Arlington County
  - WMATA Metro
  - VRE
  - Loudon County
  - PRTC

Performance Measures

- Improved customer service
- Improved customer convenience
- Improved perception of service reliability
- Increased ridership

Table 2: Generic Transit-Related ITS Applications (continued)

<table>
<tr><th colspan="4">2j. IN-TERMINAL/WAYSIDE TRANSIT INFORMATION SYSTEMS</th></tr>
<tr><th>Description</th><th colspan="2">Delivery Mechanism</th><th>Examples of Existing/Current Deployments</th></tr>
<tr><td rowspan="3">Provides arrival/departure information of transit vehicles at stops and stations. Information is displayed on dynamic message signs and/or electronic kiosks. May provide static (scheduled) or real-time information.</td><td>• CDPD
• Land-line phone</td><td>• DMS
• Monitors
• Kiosks</td><td rowspan="10">• Helsinki, Finland - In a customer survey regarding a real-time transit vehicle arrival display system implemented on one tram line and one bus route, 16% of tram passengers and 25% of bus passengers reported that they increased their use of the line/route because of the displays. Also, 95% of respondents found the system useful, and 68% felt that the system increased their level of comfort. The most frequently reported benefits were being informed of the remaining waiting time and knowing whether the vehicle expected had already arrived.
• London, England - In a survey of the London Transport Countdown System (real-time bus arrival information), 82% said information displayed was acceptably accurate, 64% believed service reliability improved, 83% said time passed more quickly knowing that the bus was coming, and 68% said their general attitude toward bus travel improved.
• Turin, Italy - An opinion survey regarding the provision of forecasted arrival time of vehicles at bus/tram stops revealed that 75% of customers found the system useful.
• Tri-County Rail, Florida
• San Luis Obispo, CA
• Los Angeles Metro Rapid
• River Valley Transit, PA

• Regional Deployment (see Section 2.1.2 for detailed information)
o WMATA Metro
o City of Fairfax CUE
o Arlington County STAR
o Montgomery County
o VRE</td></tr>
<tr><th colspan="2">Modalities</th></tr>
<tr><td colspan="2">• Static
• Real-Time
• Interactive (kiosks only)</td></tr>
<tr><th colspan="3">Potential Benefits and Impacts</th></tr>
<tr><th>Capital Cost Savings</th><th colspan="2">O&M Cost Savings</th></tr>
<tr><td>• None</td><td colspan="2">• None</td></tr>
<tr><th>Safety & Security</th><th colspan="2">Energy & Environment</th></tr>
<tr><td>• Personal security (e.g., lessens exposure to weather and crime)
• Alerts customers of incidents and emergencies and instructs them on what to do</td><td colspan="2">• Negligible effect</td></tr>
<tr><th>Service Quality</th><th colspan="2">Ridership/Market Share</th></tr>
<tr><td>• Making info available enables users to choose the correct route and to be in the right place at the right time
• Reduces wait time for transit vehicles
• Increases perception of transit reliability</td><td colspan="2">• Ridership should increase because transit system is more attractive and easier to use</td></tr>
<tr><th>Efficiency</th><th colspan="2">Productivity</th><th>Performance Measures</th></tr>
<tr><td>• Allows users to use system efficiently to get where they need to be</td><td colspan="2">• Increases productivity of the transit system as well as the customer service department</td><td>• Improved customer convenience
• Improved perception of service reliability
• Increased ridership</td></tr>
</table>

Table 2: Generic Transit-Related ITS Applications (continued)

<table>
<tr><td colspan="4">2k. IN-VEHICLE TRANSIT INFORMATION SYSTEMS</td></tr>
<tr><th>Description</th><th colspan="2">Delivery Mechanism</th><th>Examples of Existing/Current Deployments</th></tr>
<tr><td rowspan="3">Automatically provides visual and/or audio announcements on transit vehicles. Typically, announcements made to identify next stop, major cross road, transfer point, landmark, and destination information. Additional information, such as public service announcements and advertisements, may be provided at other times.</td><td>• Wireless LAN
• PCMCIA Card
• Hard wire connection</td><td>• DMS
• Audio/speakers</td><td rowspan="9">• Turin, Italy - An opinion survey regarding the provision of next-stop information on board transit vehicles revealed that 75% of customers found the system useful.
• San Antonio, Texas--VIA Metropolitan Transit equipped their entire fleet, including paratransit vans and supervisory service and police vehicles, with an integrated in-vehicle information system by Siemens. Each vehicle is equipped with audio/visual units to announce the next stop.

• Regional Deployment (see Section 2.1.2 for detailed information)
o City of Alexandria
o Falls Church GEORGE
o WMATA Metro, MetroBus
o City of Fairfax CUE</td></tr>
<tr><th colspan="2">Modalities</th></tr>
<tr><td colspan="2">• Static
• Real-time</td></tr>
<tr><th colspan="3">Potential Benefits and Impacts</th></tr>
<tr><th>Capital Cost Savings</th><th colspan="2">O&M Cost Savings</th></tr>
<tr><td>• None</td><td colspan="2">• None</td></tr>
<tr><th>Safety & Security</th><th colspan="2">Energy & Environment</th></tr>
<tr><td>• Reduce driver distractions
• Users feel safer knowing they will get off at their right stop</td><td colspan="2">• Reduce dwell time at stops (as riders know exactly when to get off)</td></tr>
<tr><th>Service Quality</th><th colspan="2">Ridership/Market Share</th></tr>
<tr><td>• Consistent and clear announcements
• Making info available enables users to be in the right place at the right time, and it facilitates transfers
• Meets ADA requirements by offering both audio and visual information</td><td colspan="2">• May increase ridership because of increased comfort level</td><th>Performance Measures</th></tr>
<tr><th>Efficiency</th><th colspan="2">Productivity</th><td rowspan="2">• Improved customer convenience
• Improved perception of service reliability
• Reduce dwell time at stops (as riders know exactly when to get off)</td></tr>
<tr><td>• Allows users to use system efficiently to get where they need to be</td><td colspan="2">• Increases productivity of the transit system as dwell time at stops is reduced</td></tr>
</table>

Table 2: Generic Transit-Related ITS Applications (continued)

<table>
<tr><td colspan="3">2l. ON-VEHICLE SURVEILLANCE</td></tr>
<tr><th>Description</th><th>Delivery Mechanism</th><th>Examples of Existing/Current Deployments</th></tr>
<tr><td rowspan="3">Provides remote monitoring / recording of the passenger safety environment on board transit vehicles. Includes cameras, silent alarms, covert microphones, and/or intercoms.</td><td>• VHS
• Digital recording
• Digital channel (for live monitoring)</td><td rowspan="10">• Denver, CO - Assaults on bus operators and passengers dropped by 20% after the Denver RTD implemented its AVL/CAD system, which contained a silent alarm and covert microphone feature.
• Philadelphia, PA - Anecdotal information from SEPTA and other transit systems indicate that the total dollar amount of claims can be reduced by 10% - 20% by having video cameras and recorders on-board transit vehicles.
• Columbus, Ohio--Central Ohio Transit Authority started equipping its fleet with video cameras in 1995.

• Regional Deployment (see Section 2.1.2 for detailed information)
o WMATA MetroBus</td></tr>
<tr><th>Modalities</th></tr>
<tr><td>• Recorded but could also be monitored in real-time</td></tr>
<tr><th colspan="2">Potential Benefits and Impacts</th></tr>
<tr><th>Capital Cost Savings</th><th>O&M Cost Savings</th></tr>
<tr><td>• None</td><td>• Reduction in vandalism costs
• Reduction in legal costs
• Lower insurance costs
• May have the potential to reduce security staff requirements</td></tr>
<tr><th>Safety & Security</th><th>Energy & Environment</th></tr>
<tr><td>• Reduction in crime onboard buses and trains
• Reduction in vandalism</td><td>• No impact</td></tr>
<tr><th>Service Quality</th><th>Ridership/Market Share</th></tr>
<tr><td>• Provides staff and passengers with increased feeling of security and comfort</td><td>• If riders feel safer, this could contribute to increased ridership
• Removes a real or perceived barrier about public transportation</td></tr>
<tr><th>Efficiency</th><th>Productivity</th><th>Performance Measures</th></tr>
<tr><td>• More efficient use of security/surveillance staff</td><td>• Systems may reduce incidents and avoid operational disruptions
• Possible ridership increase would improve productivity</td><td>• Reduced crimes
• Reduced vandalism costs
• Reduced legal costs
• Improved sense of safety for riders and operators
• Potential reduction in security staff</td></tr>
</table>

Table 2: Generic Transit-Related ITS Applications (continued)

2m. STATION/FACILITY SURVEILLANCE

Description	Delivery Mechanism	Examples of Existing/Current Deployments
Provides remote monitoring / recording of the passenger safety environment in stations, parking lots, and at transit stops. Allows customers to request assistance in case of an emergency. Includes cameras and passenger activated emergency systems.	• VHS • Digital recording • Live monitoring **Modalities** • Recorded but could also be monitored in real-time	• **Regional Deployment** (see Section 2.1.2 for detailed information) o WMATA Metro stations

Potential Benefits and Impacts

Capital Cost Savings	O&M Cost Savings
• None	• Reduction in vandalism costs • Reduction in legal costs • Reduced station personnel
Safety & Security	**Energy & Environment**
• Improves customers' and staff safety • Reduction in vandalism • Reduction in crime	• N/A
Service Quality	**Ridership/Market Share**
• Provides staff and passengers with increased feeling of security and comfort	• If riders feel safer, this could contribute to increased ridership • Removes a real or perceived barrier about public transportation
Efficiency	**Productivity**
• N/A	• Systems may reduce incidents and avoid operational disruptions • Possible ridership increase may improve productivity

Performance Measures

- Reduced crimes
- Reduced vandalism costs
- Reduced legal costs
- Improved sense of safety for riders

Table 2: Generic Transit-Related ITS Applications (continued)

2n. COLLISION AVOIDANCE SYSTEMS		
Description	**Delivery Mechanism**	**Examples of Existing/Current Deployments**
Provides a warning to the driver and/or controls the longitudinal and/or lateral movement of a vehicle in order to avoid a potential collision. May employ an impending collision detection means such as radar, a mitigation deployment means like air bags, and an automatic brake application.	• Audio • Visual • Mechanical **Modalities** • Real-time	• St. Nicholas, Quebec – Transport Besner Trucking Company was able to reduce at-fault accidents by 33.8% in the first year after the Eaton VORAD EVT-200 forward and side collision warning system was installed on its truck. • Pennsylvania--The Port Authority of Allegheny County installed a side object detection system from Collision Warning Systems on 100 vehicles operating out of their East Liberty garage. The system includes six sensors on each side of the bus and a sensor on the back corners. The system detects objects and provides both an audible and visual warning to the driver. • Houston, Texas--The Metropolitan Transit Authority of Harris County (Metro) has taken the lead in the testing and demonstration of automated highway systems in transit applications. In 1997, these applications were demonstrated by the transit industry in the National Automated Highway System (AHS) Demonstration '97 in San Diego, California.
Potential Benefits and Impacts		
Capital Cost Savings	**O&M Cost Savings**	
• Possible savings in rolling stock • Mitigation equipment lower cost than heavy structure in vehicles and guideway	• Reduces collision costs and insurance, liability	
Safety & Security	**Energy & Environment**	
• Improves perception of safety • Less stressful employment environment	• None	
Service Quality	**Ridership/Market Share**	
• Reduced disruption to service • More frequent service potential if significant O&M cost savings	• Ridership may increase due to safety perception and more frequent service at same O&M cost levels	**Performance Measures**
Efficiency	**Productivity**	• Reduced collision costs and insurance • Improved safety of riders and operators • Reduced operating and maintenance costs • Reduced number of out-of-service vehicles
• Reduced disruption to service	• Opportunity for claims litigation reduction • Lower operating and maintenance costs	

2.1.2 Detailed Inventory of Projects

This section summarizes the status of applications in the region in a convenient matrix table. For each project, the following information was sought:

- Type of application
- Technologies employed
- Lead and participating organizations
- Contact person
- Implementation status or timing
- Project objectives
- Evaluation activities and measures of performance

Particularly valuable resources for the inventory were the MWCOG draft inventory of projects prepared in 2000 and the Multisystems report for the WMATA Regional Bus Study, as well as the suggestions from the Project Steering Committee supplied during the kick-off meeting.

A large number of area agencies are involved in leading the implementation of ITS projects for transit. Within Northern Virginia, these include:

- Washington Metropolitan Area Transit Authority (WMATA or Metro)
- Virginia Department of Transportation (VDOT)
- Virginia Railway Express (VRE)
- Metropolitan Washington Council of Governments (MWCOG_
- CUE (City of Fairfax)
- City of Alexandria
- Fairfax Connector (Fairfax County)
- Loudoun County Transit (Commuter Bus)
- Arlington County/ART
- Virginia Department of Rail and Public Transportation (VDRPT)
- Potomac Rappahannock Transportation Commission (PRTC)
- George Mason University (GMU) and Virginia Polytechnic Institute (VA Tech)

In adjacent jurisdictions, these include:

- District of Columbia DPW and DOT
- Montgomery County
- Prince George's County
- Maryland State Highway Administration

Table 3 provides a summary of the projects in the region identifying the project name type of application, lead or sponsor agency(ies) and the modality. Section 2.3 provides detailed descriptions of projects selected for detailed interviews, while Appendix contains descriptions of other projects listed in the table.

Table 3: Regional Projects Sorted by Type of ITS Application

Type of ITS	*Agency*	*Description*	*Modalities*	*Status*
Data Sharing	MWCOG	RITIS (Regional Integrated Transportation Information System)	Dynamic	Scheduled to begin in 2003 and end in 2006; will involve design and development of data fusion for real-time use and archives (will not deliver to public)
Data Sharing	MWCOG	ITS as a Data Resource Study	N/A	Completed in 2001; recommended RITIS (see above)
Data Sharing	Montgomery County	Integration of Advanced Transportation Management System (ATMS) Database with Partners in Motion	Real-Time	The County is cooperating with other agencies on regional projects.
Electronic Fare Payment	WMATA	Electronic Fareboxes for SmarTrip (Cubic/GFI)	Interactive	Started in –service test on 70 buses in November 2002, with 60-customer test group and drivers. Will probe them and conduct a survey. Will take 10 weeks to install on all buses (note that contract doesn't provide for reporting of data but WMATA's IT department (ITSV) will be addressing data reports)
Electronic Fare Payment	WMATA, Regional Stakeholders	SmarTrip Regional Customer Service Center/Clearing house/Point of Sale network	Interactive	Contractor (ERG) to conduct all customer service functions for SmarTrip as it rolls out to Metrobus, MTA and local bus operators
Electronic Fare Payment	WMATA, Regional Stakeholders	SmarTrip Electronic Fare Payment	Interactive	On Metrorail and parking facilities since May 1999 (not currently set up for permit parking); 300,000 in circulation; operating now intra-agency; have consortium of Metro, MTA and 15 other operators for expansion by early 2004
Electronic Fare Payment	WMATA, Regional Stakeholders	Multi-use SmarTrip card	Interactive	Working on pilot with First Union Bank, GSA, DC employee ID card
Electronic Fare Payment	City of Alexandria	SmarTrip Fareboxes for DASH buses	Interactive	Planned; installation after Metrobus.
Electronic Fare Payment	City of Fairfax	SmarTrip Farebox	Interactive	Planned
Electronic Fare Payment	WMATA, Regional Stakeholders	SmartBenefits (distribution of employer commuter benefits on SmarTrip purse)	Interactive	In place

Table 3 (continued)

Type of ITS	Agency	Description	Modalities	Status
Electronic Fare Payment	VRE	Automated Ticket Vending	Interactive	VRE conducted a procurement for fare collection system enhancements in 2000. VRE may choose to equip their ticket vending machines (TVMs) to read WMATA SmarTrip cards since VRE is expected to be a participant in SmarTrip in the future. It is our understanding that interoperability is an issue since VRE selected a vendor other than Cubic.
Electronic Fare Payment	DCDPW	TransPass Public Parking Smart card	Interactive	On-street smart card parking program in DC, involving about 2,000 parking meters and 10,000 cardholders. The demonstration was to last 6-9 months. This type of integration is a longer range goal for SmarTrip.
Fleet Management	Falls Church and WMATA	In-vehicle diagnostics system	Dynamic	Four George buses were equipped with Clever Device IVN2 in-vehicle diagnostics monitoring system. Installed in Dec. 2002. They are now installing wayside equipment for wireless download of data.
Fleet Management	WMATA	Automatic Vehicle Monitoring (AVM)	Static	100 buses are equipped with Clever Devices IVN II for in-vehicle diagnostics. New buses will also have Clever Devices IVN II. This is not a real-tine system as data is downloaded at the end of the day as buses return to their garages.
Fleet Management	WMATA	New scheduling system	Interactive	Funded; in place by 2004; will have all bus stops geo-coded not just time-points
Fleet Management	WMATA (MetroAccess)	MetroAccess Reservation System	Interactive	LogistiCare (paratransit management contractor) uses Emtrack's reservation and scheduling system. System was introduced in 2000.
Fleet Management	Arlington County	STAR Paratransit Scheduling System	Interactive	Contract operator, Dyntech, has acquired the latest Trapeze paratransit software and they will transition to that. Arlington County hopes to introduce flexible service on ART using the same call center and transition clients off STAR and onto ART.
Fleet Management	Fairfax County	Scheduling Software	Interactive	Acquired Trapeze fixed route and paratransit software; now operational.

Table 3 (continued)

Type of ITS	Agency	Description	Modalities	Status
Fleet Management	Montgomery County	Transit signal priority (TSP)	Interactive	Implemented in 2001 on Bus Rt 55 along MD RT 355.
Fleet Management	MWCOG, VA Tech	Signal Priority Study	N/A	Stakeholder Needs done Columbia Pike and US 1 Simulation done. Emergency Vehicle Pre-emption done. TSP tested on a small segment of US 1 and ongoing on a small segment of Columbia Pike Expansion of US 1 test getting underway. Evaluation work underway
Fleet Management	WMATA	TSP Demonstration: *see Arlington County*	Real-Time	Program in progess (design phase is ongoing)
Fleet Management	Arlington County, WMATA	TSP Demonstration on Columbia Pike	Real-Time	Several intersections along Columbia Pike are equipped with TSP.
Fleet Management	City of Alexandria	Signal System Project	Real-Time	Upgrade completed including fiber optics; will facilitate future TSP but currently no specific plan
Fleet Management	City of Fairfax	TSP	Real-Time	Planned but not funded
Fleet Management	VDOT	Smart Traffic Signals and Signal Optimization	Real-Time	(not TSP or transit ITS)
Fleet Management	DCDOT	Georgia Ave Transit Signal Priority (TSP)	Real-Time	Installation was expected to begin in May 2003 followed by a 90-day acceptance testing period.
Fleet Management	Prince Georges County/Md SHA	TSP on MD Route 5 (as well as MD Route 2 in the Annapolis area)	Real-Time	For express buses (not conditional); since turned off
Fleet Management	VDOT	Tysons Area ITS Support	Real-Time	Beginning in 1994, Fairfax, Prince William, and Loudoun Counties, Virginia, deployed a system to connect approximately 700 signalized intersections with central control. During the month of May 1999, optimization of the system in the Tysons Corner area of Virginia was completed.
Fleet Management	WMATA	Automated Train Control System (ATC)	Real-Time	The project includes design, procurement and installation of various ATC-related components

Table 3 (continued)

Type of ITS	Agency	Description	Modalities	Status
Fleet Management	WMATA (MetroAccess)	MetroAccess AVL system	Real-Time	84 vehicles are equipped with AVL and MDT units. All new/replacement vehicles will be equipped
Fleet Management	City of Fairfax	GPS and AVL on all buses for NextBus	Real-Time	12 buses (all); August 2001 (as part of NextBus)
Fleet Management	VRE	AVL (Orbital GPS)	Real-Time	Since 1997
Fleet Management Transit Safety/Security	WMATA	Orbital AVL & Motorola Radio Communications System (including silent alarm)	Real-Time	As of August 2003, 500 vehicles have been equipped with AVL and MDT units. It is anticipated that the entire fleet will be retrofitted with the new AVL/MDT system by the end of 2003.
Fleet Management	Montgomery County	ATMS (Advanced Transportation Management System)	Real-Time	In operation. ATMS combines traffic and transit systems and includes an array of systems: Signal Priority, AVL, surveillance, signal timing, and data collection from CAD to enhance traffic (including transit) flow.
Fleet Management	Montgomery County	AVL for Ride On (provides schedule adherence alert to dispatchers)	Real-Time	In place on all directly operated buses since 1998. The system also includes silent alarm feature and route/schedule adherence application
Fleet Management: Travel Information	City of Fairfax	GPS on Buses for Automated Stop Announcements (Luminator)	Real-Time	6 buses in 1998; on 6 more buses when replaced in August 2003
Fleet Management	WMATA	Automated Passenger Count (APC) system	Static	185 buses plus all new buses; not yet in use
Fleet Management	City of Fairfax	APC	Static	Planned but not funded
Fleet Management	Fairfax County	APC	Static	2 buses run by Yellow Transportation (contractor) are equipped with APC (from UTA). This is just a test.
Fleet Management Traveler Information	WMATA	SAP- ITS	Real-Time	Communications between Central Control and Supervisors, Station Agents
Intelligent Vehicle Initiative	WMATA	Collision avoidance systems on buses	Real-Time	No progress; lower priority in ITS plan
Planning	MWCOG	MW Region ITS Strategic Plan	N/A	Done

Table 3 (continued)

Type of ITS	Agency	Description	Modalities	Status
Planning	WMATA	ITS Strategic Plan – Phase 2	N/A	In development for 3 years by TSDV (Transit Systems Development Office); Follow on to ITS Strategic Plan Phase 1 (1999); CTC ITS Plan (2000); Transit Customer Information Systems Plan (2001); AVL Plan.
Planning	WMATA	ITS Strategic Plan – Phase 1	N/A	Developed in October 1999 augmented by ITS Plan Phase 2 documents.
Planning	MWCOG, MDSHA, VDOT, DCDOT	Metro Region ITS Architecture	N/A	Done
Planning	WMATA	AVL Feasibility Study Plan	N/A	
Planning	WMATA	SmarTrip Five Year Strategic Plan	N/A	Being developed
Planning	WMATA, VDOT, NVTC, MWCOG, Volpe	Regional Payment System Partnership Action Plan	N/A	In September 2000, a Regional Payment Systems Partnership Action Plan was prepared for VDOT by Volpe National Transportation Systems Center and Multisystems. In addition to regional smart card acceptance for transit, the report also considered the integration of other types of transportation and non-transportation payment applications.
Planning	VDOT	No VA. Smart Travel ITS Architecture	N/A	Done (2002)
Planning	VDOT	VA. Smart Travel Strategic Plan	N/A	Done (2001)
Planning	VDOT	No VA. Smart Travel Program Plan	N/A	Done (1999)
Planning	DCDOT	511 Study	N/A	Obtained federal grant to plan a 511 system for the region; hiring consultant to do a 6 month study during 2003.
Planning	Dulles Corridor Task Force	Dulles Corridor Rapid Transit Project Technology Plan	N/A	The Task Force developed a five-phase implementation plan for new services. Phase 1 (1999-2000) was to involve express bus service and new routes.
Planning	Montgomery County	Using ATMS Data for Planning	Static	ATMS data is being used for planning but only when investigating a particular corridor or conducting a study.

Table 3 (continued)

Type of ITS	Agency	Description	Modalities	Status
Planning	GMU/ VDOT	Public Perception and Elected Officials Reaction to ITS; Customer Reaction to VMS Messages	N/A	Study grant from VDOT. Scope of work was under development in late 2002.
Transit Safety/Security	WMATA	Video Cameras on Buses for Security	Dynamic	Installed on 100 buses delivered in early 2003; 5 on each bus
Transit Safety/Security	WMATA	Camera Surveillance at Metrorail stations and parking, bus terminals	Real-Time	In place at Metrorail stations; have at Addison Road, Franconia-Springfield, Glenmont and possibly Wheaton garages; none yet at bus terminals.
Transit Safety/Security	WMATA, VDOT	Sharing CCTV information from VDOT	Real-Time	A video camera over internet provider solution is in the scope and budgetary estimate process.
Transit Safety/Security	Regional Stake-holders	CapWIN In-Vehicle Emergency System (LAN for police agencies to communicate)		Not really transit ITS
Transit Safety/Security	MWCOG	RICCS Regional Incident Communications and Coordination System (uses Nextel CDPD technology)	Interactive Dynamic	Homeland security project developed by MOITS
Transportation Demand Management	Montgomery County	County Unified Automated Transportation Management Center and Transit Control Center	Real-Time	Been in place since 1997. It houses both traffic technicians and transit dispatchers.
Transportation Demand Management	PRTC	SaFIRES	Real-Time	SaFIRES is a system used in conjunction with OmniLink to enhance flexible-route service provided by the The Potomac and Rappahannock Transportation Commission (PRTC)
Transportation Demand Management	DCDOT	Integrated Transportation Management Center	Real-Time	New traffic management center to oversee the management and operations of roadways and traffic signals. System completion expected in 2004

Table 3 (continued)

Type of ITS	Agency	Description	Modalities	Status
Traveler Information	WMATA	Ride Guide Itinerary Planning System on the web (covers all regional operators)	Interactive Static	In place since September 1999 including web, email and fax itineraries; will expand to Loudoun Commuter Bus, VRE and MARC in 2003; Metro Information is automatically updated; other systems done manually; created working group to address information flow
Traveler Information	WMATA	Service Status Info on website	Real-Time	Report as alert any delay of 10 minutes or more on rail, bus or elevators
Traveler Information	VRE	Train Brain website	Real-Time	Implemented about 1 ½ years ago; uses information from AVL system described above in Fleet Management
Traveler Information	WMATA	Email alerts	Real-Time	Pilot to ADA clients regarding elevator service in 2002. In early 2003, implemented full Metrorail email alert project. Employs a private contractor to host email announcements, selected by competitive bid. Plan to do email survey of users.
Traveler Information	Loudoun County	Bus Biz email alert for Loudoun Commuter Bus riders	Real-Time	In operation.
Traveler Information	VRE	Train Talk email alert	Real-Time	Implemented about 4 years ago; 6500 passengers on email list; not route or station specific; sent to any email address; experimenting with PDAs
Traveler Information	PRTC	E-mail alert system	Dynamic	This service started in Dec. 1999. The system provides information on any incident that may affect the transit service. The e-mail messages are sent to all subscribers. Messages can be received via PC, cell phones, or PDAs. There are 3,700 subscribers.
Traveler Information	Arlington County	Mobile Commuter Buses	Interactive	This program consists of 4 buses that have been converted into mobile "kiosks". Each bus is outfitted with roof-mounted satellites, point-of-sale systems to process credit card transactions, flat screen monitors and laser printers, ride-matching (car/vanpool) information and signup, and other transit related information. Progam started in May 2002.

Table 3 (continued)

Type of ITS	Agency	Description	Modalities	Status
Traveler Information	Fairfax County	CRiS information kiosks	Interactive	CRiS kiosks are located at 25 different locations providing users with a wealth of information. The kiosks are interactive and allow the users to get information on various transportation modes, renew vehicle registration, pay taxes, and many other options. It started in 1998/1999.
Traveler Information	Arlington County	Information Kiosks	Static	As part of a Partners-in-Motion project, 4 information kiosks were installed at 4 bus stops on Moore Street. The system is not interactive and is not real-time. It tells you the scheduled arrival of the next two buses for the appropriate direction. This was done in mid 2000.
Traveler Information	VDOT, Md SHA, DCDOT, MWCOG, WMATA	Partners in Motion	Interactive Real-Time	SmarTraveler ended December 19, 2002; decided that it can never be self-sufficient and that RITIS is deemed to be better use of public funds
Traveler Information	Arlington County	CommuterPage.com® Mobile Services	Interactive	In fall 2002, Arlington County launched its CommuterPage.com® Mobile Services. This new service allows passengers to read the latest commuter news on their Palm Pilot or Pocket PC during their commute, or check bus schedules on their web-enabled cell phone while they're out on the town
Traveler Information	WMATA	IVR Phone system for customer service (ARTS upgrade)	Interactive Static	Started November 18, 2002 with static information; 60 days of initial testing; will refine system over next 2 years.
Traveler Information	VRE	IVR Phone System (1-800-RIDE-VRE)	Interactive Static Real-Time	VRE offers delay information via its 1-800 IVR phone system where more detailed announcements are voice recorded and disseminated.
Traveler Information	MWCOG, VDOT and other State DOTs	511 Travel Information	Real-time Interactive	Virginia has statewide 511 with only canned information (not interactive); Operational 511 system in Shenandoah Valley; decided to implement Washington region last
Traveler Information	City of Alexandria	Traveler Information and 511	Interactive/ Real time	By 2005, the City is planning on having an automated telephone information system, 511 telephone system, real-time information system (via pagers, PDAs, and Internet).
Traveler Information	City of Alexandria	Annunciators for DASH buses (Digital Recorders)	Real-Time	Have installed on 4 buses; discontinued use due to malfunction.

Table 3 (continued)

Type of ITS	Agency	Description	Modalities	Status
Traveler Information	City of Falls Church and WMATA	In-vehicle annunciator system	Real Time	Four George buses are equipped with Clever Devices in-vehicle annunciators. Operational since Dec. 2002
Traveler Information	WMATA	In vehicle signage for information	Real-Time	On new rail cars
Traveler Information	WMATA	In-vehicle annunciator/signage for information	Real-Time	On 721 buses; will be on half of fleet by end of 2002; cheaper to have separate system from AVL
Traveler Information	WMATA	Passenger Information Display Signs (PIDS) provided by INOVA	Real-Time	In place for Metrorail at all stations since early 2001 (started installing in 1999); 430 LED signs indoor and outdoor
Traveler Information	WMATA	Wayside and in-terminal dynamic message signs	Real-Time	Have NextBus on 8 buses on MB38 in Arlington as a pilot; by 2004 will have capability for this type of information system-wide; will be meeting with NextBus to integrate with AVL; planning to have at 30 bus bays at Pentagon using VDOT FTA grant funds
Traveler Information	Arlington County	Bus Information Technology	Real-Time	NextBus pilot project began operating in Fall 2001 on Route 38b. There are 9 signs in place, two of which are in DC. Besides the wayside signs, information is available on the NextBus website.
Traveler Information	City of Fairfax	NextBus Information for DMS, web, WAP enabled phones, web--enabled PDAs	Real-Time	At 6 stops; August 2001; plan to have DMSs at more stops in future
Traveler Information	Montgomery County	Real-time bus arrival information system	Real-Time	This system was developed in house and provides real time arrival times of buses at 5 locations. Delays less than 5 minutes are not reflected in the predicted arrival time. The County is planning on equipping Bethesda stop with DMSs to provide real time arrival information.
Traveler Information	WMATA	Parking Lot Space Availability Information	Real-Time	Not operating; began working 2 years ago on website info about parking availability; in process of upgrading garage systems; new garages first;
Traveler Information	MWCOG	Commuter Connection Program Information (including transit and CP/VP matching)	Static	Exists in parallel to Ride Guide

2.1.3 Conclusion and Selection of Projects for In-depth Interviews

The inventory conducted under Task 1 revealed that there were a number of projects that were still in the planning or implementation stages, hence, providing little or no actual data describing system performance. Furthermore, quite a few of the projects that are currently operational lacked any set of defined performance measures and/or explicit objectives making it difficult to assess project performance relative to objectives.

In order to select candidate projects for Task 2 interviews in a methodical way, the team established the following criteria to use in the selection process:

- Projects that have been implemented
- Potential large investment in the future
- Systems with tangible/measurable benefits
- High-profile systems
- Lack of adequate information on a system

Based on the approach described above, the ITS projects (from Task 1) were labeled as high, moderate, or lower priority (high priority ranking projects were included in Task 2 effort). Twenty (20) of the projects were assigned high priority, four were assigned moderate priority, and the rest were assigned lower priority. In a few cases, further information was gathered before a final determination was made. In all, 22 ITS projects were included in the Task 2 analysis and report covering the entire spectrum of transit-related ITS technologies. Table 4 summarizes the projects included in Task 2.

2.2 Key Findings from the Manager Interviews

Interviews with transit managers and others involved in the 22 projects selected for further research in Task 2 provided several interesting observations, as follows.

- The region, as a whole, is very aware of ITS technologies and understands the benefits of these technologies. Also, the development of the regional ITS Architecture shows that the region is cognizant of and striving to meet federal requirements regarding implementation of ITS.
- The region is actively pursuing the deployment of ITS systems for transit as well as non-transit use. This was apparent from the sheer number of projects that have been or are being implemented as well as projects that are in the planning stage. It is also important to mention that although most projects are agency-specific, there is quite a bit of regional coordination and integration among the agencies in the region. Projects such as RICCS, SmarTrip, signal priority studies and RideGuide are all examples of successful regional deployments.

Table 4: ITS Projects Included in Task 2

Type of ITS	Project	Agency
Electronic Fare Payment System	SmarTrip	WMATA—and regional stakeholders
Safety and Security	Metrobus On-Board Video Cameras	WMATA
Safety and Security	RICCS	MWCOG
Fleet Management	Automatic Vehicle Location System	Montgomery County
Fleet Management	Paratransit Computer Aided Scheduling and Dispatching System	Arlington County STAR
Fleet Management	Vehicle Component Monitoring System	WMATA Metrobus
Fleet Management	Automatic Passenger Counting System	WMATA Metrobus
Fleet Management	Transit Signal Priority	Regional efforts
Passenger Information	Automated Annunciator System	WMATA Metrobus
Passenger Information	Passenger Information Display System (PIDS)	WMATA
Passenger Information	NextBus Arrival Information System	Arlington County and City of Fairfax
Passenger Information	Bus Arrival Information System	Montgomery County
Passenger Information	Train Brain	VRE
Passenger Information	E-mail Alert System	WMATA Metrorail
Passenger Information	Train Talk E-mail Alert System	VRE
Passenger Information	E-mail Alert Service	PRTC
Passenger Information	Interactive Voice Response Trip Itinerary Planning System	WMATA
Passenger Information	Commuter Page Mobile Services	Arlington County
Passenger Information	Mobile Commuter Store	Arlington County
Travel Demand Management	Transportation Management Center	Montgomery County
Travel Demand Management	SaFIRES	PRTC

- There has not been a structured approach to monitoring the performance of transit ITS systems. A large number of projects investigated appeared to lack formal objectives or performance measures. Although not critical in terms of getting a system deployed, they are critical in ensuring that the system is delivering the expected results (which may include savings in time or costs, or improved service, convenience, revenue, or customer perception). Recognizing the gap, NVTC has taken the initiative to develop a continuing process for monitoring performance data on various transit-related ITS deployments in the Northern Virginia region through this study.
- The region has implemented a few unique ITS technologies. For example, RideGuide's interactive voice response (IVR) system is the first of its kind in the nation. Another unique system deployed in the region is Arlington County's Mobile Commuter Store.
- There have been some tangible benefits from several transit ITS systems that have been deployed, including those described below.
  - Surveillance cameras deployed onboard Metrobuses proved effective in three incidents. In one of these incidents, a camera on board one of the buses managed to capture the image of a suspected murderer allowing Metro police to produce a print out of the suspect's face. In another instance, it helped WMATA prevail in a legal case.
  - WMATA staff indicated that the deployment of MetroAccess paratransit scheduling and dispatching and AVL systems has had a positive impact on the customers. MetroAccess claims that the share of pre-scheduled trips has been declining, an indication that customers are becoming more comfortable with same-day reservations. Further, MetroAccess anticipates potential savings of between $500,000 and $700,000 annually in the future by implementing a suspension policy for repeated no-shows (the AVL system will be used to verify if a no-show was the result of vehicle delay or was the customer's fault).
  - WMATA has stated that the vehicle component monitoring (VCM) system it acquired for Metrobus in 1999 has been of benefit in reducing road calls. Also, Metrobus is planning on reducing its B-level maintenance staff in half (down to three staff) as a direct result of the VCM system. Metrobus also realized an unexpected benefit when the VCM system helped point out that the new CNG buses had faulty oxygen sensors, which the bus manufacturer then agreed to replace.
  - Although transit signal priority (TSP) was not in place during the Task 2 investigation, simulation analysis using INTEGRATION software of TSP in the 16-signal Columbia Pike corridor showed benefits for transit vehicles and some negative impacts for the overall traffic flow. Statistically significant improvements in bus service reliability (standard deviation of arrival time deviation) of 3.2% and in bus efficiency (running time) of 0.9% resulted when conditional priority was tested, and this was achieved without significant negative impacts on general traffic. TSP has now been implemented in the U.S. 1 (Richmond Highway) Corridor but performance measures have not yet been made available. Rigorous performance measurement is, however, being conducted employing specific pre-defined measures in a test-control comparison. In this respect, the TSP deployment is somewhat unique (among the projects described in this report), most likely due to the fact that the transit agencies

need to convince the traffic agencies that TSP provides significant benefits to transit without detrimental impacts to traffic.

- RideGuide has also provided tangible benefits to both transit customers and WMATA. Both the RideGuide website and the IVR system provide customers with seamless regional trip itinerary planning service. This has allowed customers to complete their itineraries in one inquiry instead of having to call up to 3 or 4 different agencies to plan their multi-operator/multi-mode itinerary. Also, the new system will eliminate the need for Metro to hire 5-10 new staff every year to keep up with increased calls. Furthermore, the new system improved the call service rate of the Metro call center. The Metro call center used to get 3.2 million calls a year, of which 15% did not get served (not even including the calls that used to get a busy signal). After RideGuide was launched, the service rate improved to about 95% and the number of calls has grown dramatically. Furthermore, busy/no answer complaints have dropped from a high of 40 complaints per month in 2002, to no complaints in early 2003. Metro has continuously monitored calls, service rates and complaints.
- Finally, the provision of traveler information (by a number of transit agencies in the region) has had a positive effect on users as is evident from the increased number of individuals who are using these services. Although the benefits of traveler information systems are difficult to measure in terms of monetary value, they do, however, help improve image of the transit service, as well as keep the customers better informed about their trips.

While transit operating agencies may have rigorously been monitoring service performance (Metro, for example, reports quarterly measures of performance to its Board including a wide range of service measures for bus, rail, paratransit and the customer service center), measures of the performance of ITS deployments and how they have met their objectives have been less rigorous. For those deployments that have customer information components, where customer perception is a key measure, there is more performance information. Both Metro and VRE have ongoing market research efforts that address customer reaction to various customer services and initiatives. In some cases, these are routine tracking surveys; in other cases, they are more targeted research efforts. Metro used more targeted research efforts to help identify the customer needs it should address both in the customer information area and the fare payment area.

Detailed descriptions of each of the selected projects are provided in Section 2.3 below. Section 2.4 then describes the results of consumer surveys.

2.3 Detailed Discussion of Selected Projects

2.3.1 Electronic Fare Payment System: SmarTrip

Background and Rationale

WMATA's SmarTrip system was designed by *Cubic Transportation Systems, Inc.* (CTS) and is considered the nation's first mass transit smart card fare collection program. SmarTrip was first deployed by WMATA in May 1999 for Metrorail and Metro parking facilities[1]. It has also served as the Metro employee ID used for building access. Since the system's inauguration, WMATA has issued more than 325,000 smart cards to its commuters and is currently issuing some 8,000 cards per month. The system is currently operating alongside the magnetic strip paper Metrocard used only on Metrorail. The implementation on Metrobus, still in progress, has included in service qualification testing and monitoring activities. An interdepartmental group, representing all departments with involvement in the fare collection system and the information it generates, meets weekly to review progress and address issues.

The primary benefit and objective of SmarTrip is improved customer convenience. The contactless card does not need to be inserted in fareboxes or faregates, as it communicates via radio frequency with card readers; in fact, one need not remove the card from a wallet or purse. This offers greater convenience to all users and makes fare payment easier for disabled customers. Users may load up to $200 value on a single card, so frequent reloading of value is unnecessary. An "auto-load" feature – preauthorized automatic replenishment (by credit card or checking account) – makes recharging the card easy and reduces reliance on sales outlets. It may also be possible to have social agencies replenish them for low-income clients. Customers are also able to have their employer-paid commuter benefits distributed as a SmarTrip purse. In this program, known as *SmartBenefits,* the customer simply taps the card at a smart card vending machine to obtain his/her commuter benefits. Finally, as the SmarTrip card becomes operational across the region—which includes a half-billion transit rides annually -- customers will benefit from seamless fare payment as they transfer between systems in the multi-operator region.

Besides convenience benefits, the enhanced SmarTrip card system will allow greater flexibility in the fare structure, with the capability of offering up to 64 fare categories compared to 13 for the current Metrocard system. Another important benefit is that the value on lost or stolen SmarTrip cards that customers have registered is salvageable, unlike Metrocards. Of course, there is an added cost to the customer associated with SmarTrip; a rider pays $5 for the card itself.

SmarTrip also offers the potential for savings to the operator, although this is not the primary objective of the program. The largest potential for savings would occur only if the existing Metrocard ticket vending machines and gates were completely replaced by SmarTrip; however, this could occur only if a less expensive, disposable version of the SmarTrip card

[1] Between February 1995 and 1996, WMATA had conducted a demonstration of the contactless smart card system. The successful test of the card's feasibility on Metrorail, Metrobus and Metro parking facilities set the stage for SmarTrip.

were available as a single ride ticket for tourists and occasional users. The *CTS* system does not currently have such a card, although other vendors have lower priced paper versions of smart cards, though not nearly as low cost as the current Metrocard.

In addition to the potential savings associated with the fare collection system, it is expected that the transit agency will benefit from the "float" (cash balance on hand) since customers are willing to load more value on SmarTrip cards than on paper Metrocards (particularly since the value on lost or stolen SmarTrip cards is salvageable). A counterbalancing factor, however, would be any loss in the revenue the agency currently receives when the stored value on paper Metrocards expires before being used by passengers.

While SmarTrip is currently operating only on Metrorail and parking kiosks, it is the subject of a regional cooperative effort. A consortium has been developed consisting of WMATA (Metro), Maryland MTA and 15 other operators in Maryland and Virginia to institute a cooperative Regional SmarTrip System. Members of the consortium meet regularly to coordinate efforts. The goal is to have 17 transit systems using SmarTrip in 2004. SmarTrip expansion to the Maryland MTA (a state agency) will extend almost statewide, including the light and heavy rail rapid transit, bus and commuter rail modes. Like WMATA, MTA will be conducting an in-service qualification test (ISQT) of SmarTrip.

The implementation on Metrobus will also be followed by SmarTrip implementation by all Northern Virginia local bus operators, which have allocated funds to purchase and install SmarTrip compatible fareboxes. The local operators have been waiting for Metrobus to conclude its implementation of SmarTrip before proceeding, although they have contracts in place to obtain the fareboxes.

A key component of the Metrobus roll out is the installation of new fareboxes, a project that WMATA is spending over $20 million to accomplish. The new fareboxes, the Odyssey model manufactured by *GFI*, will be electronic (the current fareboxes have more mechanical components and require considerable maintenance). The addition of the *Cubic* smart card reader to the farebox adds only a small increment to the farebox cost. Other differences between these fareboxes and the current ones are that they will validate coins and bills as they are deposited; paper currency will need to be fed in for validation and coins deposited one at a time. Furthermore, pennies were not accepted during the Metrobus ISQT. The new fareboxes are highly configurable and can update their configuration automatically at the garage as they are probed. They record detailed information on each transaction and upload this information to the garage computer through wireless communication. They reflect a major advance in technology for the transit agency, whose older version of the GFI farebox is now outdated. The new fareboxes will have the capability for integration with other on-board bus systems and with the fare collection equipment used on Metrorail and at Metro parking lots. Although the current contract does not call for reports of data from the fareboxes, WMATA's information technology group (ITSV) is addressing data reporting. Although the fareboxes will not be integrated with the radio/AVL system, WMATA is considering such integration in the future. The driver log-in will be integrated via the new fareboxes. As a result of the differences between the new fareboxes and the current fareboxes, testing the operation of the new fareboxes in service is an important step in the implementation process, as described below.

The "first article testing" or acceptance testing took place at the factory. It addressed how the farebox met the design specifications, which included minimum rates for processing coins and bills, for example. The specific acceptance testing procedures were proposed by the vendor, in response to the RFP. The acceptance testing took longer than expected as various problems were detected and had to be addressed; however, all problems were resolved. Once this laboratory testing was completed, WMATA operations engineers conducted ad hoc, in-house testing for a couple of months. Only then did WMATA deem the farebox ready for customer acceptance testing. Early promotional activities related to the Metrobus implementation included demonstrating the SmarTrip compatible bus farebox to customers at major boarding and transfer locations in the test area. In November 2002, Metrobus began an in-service qualification test (ISQT) of the new high-tech fareboxes that accept SmarTrip cards, marking the first step toward extending the use of smart card technology on transit services throughout the region. The test, which lasted for 90 days, was conducted on all 83 Metrobuses that operate from the Arlington garage (serving approximately 18,000 customers daily). Approximately 7% of the riders on these buses (nearly 100,000) used SmarTrips cards although almost none used the add value feature on the bus. During this time, in addition to monitoring driver experiences, a 60-customer test group used the SmarTrip card and was probed on their experiences. The Customer Services department produced daily reports based on customer and employee feedback. The ISQT, as of February 2003, found that the hardware performed well but that the software needed some modifications; these are now underway. Although the ISQT did not include measurement of boarding times, WMATA has baseline data on boarding times from the current fareboxes and intends to measure boarding times with the new fareboxes after customers have gained more experience with the system. No formal evaluation is planned however. Lessons learned to date include how important it is to have easy to understand information on how to use the new fareboxes, particularly for those who do not read English well, and to have lots of hands-on experience before putting the fareboxes in revenue service.

The full roll-out of SmarTrip on the 1,600-bus Metrobus system was expected to take about 3 months once the fareboxes are delivered; although originally expected to be completed by Spring 2003, farebox installation has not started since Metrobus is awaiting resolution of software issues.

SmarTrip transactions on buses are not "real-time." Data gets downloaded at the end of the day after a bus returns to the garage rather than being transmitted during the day. Each day the hot list (of bad cards) will get downloaded to all 17 participating systems.

The proposed point of sale network (which may include government buildings, retail stores, etc.) will expand the current distribution system which includes sales at stations, special Metro ticket outlets and on-line. (Unlike regular Metrocards, which are sold in grocery stores, SmarTrip cards are not currently sold outside transit agency outlets.) Equipment for these sales outlets will be provided by *Cubic*, the SmarTrip equipment vendor.

The development of an independent regional clearinghouse (Regional Customer Service Center or RCSC) to enable SmarTrip to expand is a very important part of the overall plan. WMATA and its regional partners have led this effort to procure a regional clearinghouse contractor, *ERG,* to handle all customer services, card management and sales, and the vital revenue clearinghouse function.

The procurement for the RCSC was an RFP, not just bids; each proposer developed a unique approach. The WMATA Board has approved contracts with *ERG* (the customer service vendor) and with *CTS* (to provide the necessary software to link with other agencies), as well as contracts with a hardware vendor. Transit operators will share fixed operating costs as well as pay a fee for each SmarTrip transaction on their systems.

The 5-year strategic plan for the SmarTrip program is considering the full potential for a shift from paper-based magnetic media to plastic-based contactless cards. Although only transportation uses are being addressed currently, it is envisioned that the card will eventually have multiple uses and the card does have multiple purse capability. WMATA has been involved in a pilot since April 2000 of multi-uses with First Union Bank (ATM/Credit Card) in which 1,000 users can shift value from the bank account using the magnetic strip ATM card to the SmarTrip account on the same card for use on Metro. Other pilot projects involve the federal General Services Administration (GSA) and District of Columbia for employee ID cards. The Metropolitan Washington Airports Authority and the District of Columbia are also considering other uses for the card. One potential use is for parking; new meters in the District have slots for a smart card but do not have a smart card reader. Discussions have taken place with FlexCar, a carsharing operator in the region. WMATA has a large investment in the existing SmarTrip technology and the SmarTrip office indicated it is open to working with any agency or private organization interested in making use of this technology.

Costs

There are a variety of costs associated with the SmarTrip program for the various modes. The Metrobus fareboxes cost about $20 million for 1,600 buses but only an estimated 5-15% of this cost can be attributed to SmarTrip. The Northern Virginia operators will spend another $5 million for fareboxes. The Customer Service Clearinghouse contract is nearly $20 million for both capital and operating for a five year operating period plus one year start-up period. About $7.8 million of this is attributable to capital costs. Combining the total cost of fareboxes and the capital costs associated with the clearinghouse results in a total capital cost of about $30 million.

It is difficult to separate the cost of the SmarTrip implementation on Metrorail and at Metro parking facilities from the other elements of a large project to upgrade the rail fare collection system (an $80 million contract). WMATA believes it was able to negotiate a very competitive cost for the project since the vendor (Cubic) was interested in demonstrating the technology in a large U.S. transit system. On an ongoing basis, WMATA pays its customer service contractor $1 million per year for serving its rail and parking SmarTrip customers. The costs of SmarTrip cards ($5 each) are passed along to the customers. Passing along this cost also encourages customers to reuse the cards unlike the disposable magnetic fare media.

Performance/Results

WMATA has been monitoring customer reaction to SmarTrip through its market research activities. These included Fare Initiatives Research in 2000 and routine (biennial) tracking survey of adults in the service area conducted by telephone. The 2000 research indicated that 35% of respondents were aware of SmarTrip and 4% has used it. In the 2001 tracking survey, 48% were aware and 12% had used it. During both of these surveys, SmarTrip was offered on Metrorail but not on Metrobus. The survey allows for a comparison of awareness and use among frequent, infrequent and non-riders of Metrorail. Among frequent riders, awareness and use were considerably higher.

Table 5: Awareness and Use of SmarTrip by Metrorail Use (October 2001)

Category	Frequent	Occasional	Non-rider
Used SmarTrip	44%	14%	5%
Aware, not used	41%	50%	33%
Not aware	15%	36%	62%

The lower expected maintenance cost associated with the SmarTrip fare collection system should yield long run savings; however, it is difficult to measure the cost savings now. WMATA is quantifying all costs associated with existing fare collection so that a comparison can be made. These would include current costs associated with the production, packaging, delivery and accounting for paper fare products and cash handling. WMATA's SmarTrip office suggests that a five-year window may be needed to conduct such an evaluation, since there are substantial start-up costs even though operating costs for the system may eventually be less costly. The five-year plan it is developing for SmarTrip includes projections of the expected operating and capital savings.

While the Regional SmarTrip System is still in implementation stages, the project has already demonstrated its appeal to riders, the feasibility of multimode operation and multi-applications. Much is yet to be learned about the economics and benefits of the regional, multimodal system that is being implemented.

2.3.2 Safety and Security: WMATA – Metrobus On-Board Video Cameras

Background and Rationale

As of January 2003, Metro has 100 buses equipped with on-board video cameras for transit safety/security purposes and as a security measure at the regional level. Each bus is equipped with five cameras to provide coverage of the entire bus interior. One camera monitors the road through the windshield while the other four monitor the inside of the bus.

Metro is using cameras from two different vendors: Safety Vision, and Kalatel. The technology employed by these cameras is digital recording. Data is stored on magnetic tapes. The system has the capability to record voice. However, this function is currently disabled as there was a concern that audio recording was illegal in the state of Maryland.

The system is linked to an emergency button. When a driver presses the emergency button, the video monitoring system saves the previous several minutes of data and protects it from being written over. Viewing of tape can be accomplished in two ways: on a laptop connected directly to the system on-board the bus; images can also be viewed on a monitor by pulling out the video monitoring box and placing it in a docking station. Hard copies of selected images can also be printed.

Costs

The average cost per vehicle for the 5 cameras is $8,000.

Performance/Results

Metro feels that the on-board video monitoring system has been beneficial. Feedback from drivers has been very positive and many have expressed that they feel safer with the cameras on-board of buses. A few drivers, and one passenger, have had concerns about the system and felt that "big-brother" is watching.

Since January 2003, there have been three incidents when the on-board cameras proved particularly effective. In one of these incidents, a camera on board one of the buses managed to capture the image of a suspected murderer. Metro police was able to produce a print out of the suspect's face. In another instance, a passenger on board one of the camera-equipped buses hit his head against the seat in front of him. The passenger claimed that the driver's reckless driving was at fault. When the video data was reviewed, it clearly showed that the passenger was drunk and was not able to sit up straight, and that this was the cause of the accident.

As has been demonstrated above, an on-board surveillance system has numerous benefits to the transit agency and the public at-large. Also, given the heightened security measures being taken across the nation and in the Washington metropolitan area in particular, it is anticipated that more transit agencies will be installing cameras on-board their vehicles. With one hundred vehicles equipped with cameras, Metro is in a good position to provide useful implementation and operation data for other agencies in the region. To this date, Metro's system has shown tangible benefits and good return on investment by reducing fraudulent insurance claims as well as in identifying wanted persons. Providing useful data on installing surveillance cameras on-board vehicles will help other agencies in their efforts to improve the Washington metropolitan area's levels of safety and security.

2.3.3 Safety and Security: MWCOG - Regional Incident Communication and Coordination System (RICCS)

Background and Rationale

The Regional Incident Communication and Coordination System, or RICCS, is a 24-hour, seven-day a week communications capability in use since Spring 2002. The system is hosted on an interim basis by the D.C. Emergency Management Agency's Emergency Communications Center, at least for notification and conferencing calls. Two more RICCS sites are planned to be established, one each in Maryland and Virginia. The impetus for the system was boosted immediately after the 9/11 terrorist attacks, when arranging a teleconference among regional leaders took 10 hours; the goal for the system now is 30 minutes.

Participating organizations will use multiple means of communication, including conference calling, secure websites, and wireless communications systems. When an incident takes place in a member jurisdiction, the local Emergency Communication Center (ECC) will assess the event to decide whether to request regional notification through the RICCS. The RICCS will reach key decision makers and representatives of the corresponding emergency support functions via telephone, cell phone, two-way radios, pagers, e-mail, or other means as necessary. Nextel CDPD technology is used since it is more efficient in emergencies as it records and sends packets of data.

Costs

Cost information was not available for this project.

Performance/Results

The system has been used several times since Spring 2002. Incidents have to have a regional impact to be handled through RICCS. Hazmat incidents are communicated through RICCS as they impact the region as a whole. Snow emergencies, bomb threats, and most major traffic incidents are not reported or handled through RICCS.

In addition to speeding up communications with critical agencies, the system provides benefits by identifying whom to contact and how. Through the RICCS Website, an authorized user can select, from a drop down menu, contact information for any of the agencies participating in RICCS. This certainly speeds up the dissemination of the information as well as reduces the chance of not sending the information to the right individuals. Another benefit of the system is that it forces the agencies to think at the regional level.

Given the significance of this system to the security of the region and to Homeland Security, its success may convince other regions to establish a similar service. It is thus important to establish if MWCOG's system is meeting its objectives. Monitoring should help MWCOG improve on the current system while helping to guide Virginia and Maryland in deploying their sites.

2.3.4 Fleet Management: - Montgomery County Ride On Automatic Vehicle Location System

Background and Rationale

The Montgomery County local bus system, Ride On, started acquiring an AVL/CAD system in 1998. The system allows for the exchange of text messages between dispatchers and bus drivers via a mobile data terminal (MDT) unit and includes a silent alarm feature. By 2001, the entire fleet of fixed route buses was equipped with a Unix-based Orbital CAD/AVL system, which replaced the former radio system. The system includes route schedule adherence (RSA) software. Route and schedule data are stored on PCMCIA cards and are updated every four months.

Costs

The cost for the AVL system was $4 million for 236 buses. In addition, the County spent $1 million to upgrade fixed end communications infrastructure.

Performance/Results

According to Montgomery County staff, drivers and dispatchers have been very satisfied with the AVL system. Drivers like the schedule adherence feature as it helps them stay on time. During layover, the system provides a countdown to departure time, a feature drivers especially like.

Dispatchers, on the other hand, like the fact that the new AVL system displays the location of the buses on a map. Dispatchers have found this feature very handy, especially during incident or snow emergency, as it allows them to see exactly where the buses are and how to re-route them in the most effective way. Having the ability to send text messages has also been valued by dispatchers, who feel that it helps them work more efficiently.

Furthermore, the AVL system relieved on-street supervisors from conducting on-time checks, a task that used to consume 25% of their time. As a result, on-street supervisors have been re-assigned to other tasks.

Finally, the AVL has come in handy during incidents on board buses. In those cases, drivers hit the silent alarm button alerting dispatchers to dispatch help immediately. This has resulted in improved safety onboard the vehicles.

Montgomery County has already experienced numerous benefits from its AVL system. Documenting these benefits and the return on investment in a more formal manner would enable other agencies in the region to have a better grasp on the benefits of these systems as well as help the County identify areas for further improvement.

2.3.5 Fleet Management: - MetroAccess Paratransit Computer-Aided Scheduling and Dispatching System and AVL Systems

WMATA provides paratransit service through its MetroAccess program, managed since January 2000 by LogistiCare Inc. MetroAccess currently has 12,600 registered customers who have been certified as being ADA eligible for paratransit service. The program provides 3,000 trips per weekday, of which 40%-45% are pre-scheduled trips. New ITS technologies have been employed to improve system operations and service and were included in Logisticare's proposal to manage MetroAccess. These include a computer-aided scheduling and dispatching system and automatic vehicle location system employing mobile data terminals.

Computer-Aided Scheduling and Dispatching System:

Background and Rationale

Logisticare uses Emtrack, its proprietary reservation and scheduling system, which it has been using for years and was modified for use at MetroAccess. Emtrack was introduced at the outset of the Logisticare contract in January 2000.

When MetroAccess customers call the reservations center, reservationists enter the customers' origin/destination (O/D) information and the customers are informed instantly about their pick up time. The system calculates the duration of the trip and that information is also passed on to the customer. Origin/destination information can be entered in a couple of ways. Reservationists can start typing the intended address, at which point the system will jump to that address if it is already available in the customer's database. Also, by entering the customer's ID number, the system provides a drop down list of all the O/D addresses related to that customer. Reservationists can then simply click on the desired address.

Manifests are created manually and then distributed to the MetroAccess service providers. MetroAccess uses 10 dedicated providers and four taxi companies. All service providers have network connections to MetroAccess and are able to download their manifests via the network. In addition, all providers have Emtrack at their sites, which allows them to automatically receive cancellation information. Providers also use the system to enter any feedback and/or comments (e.g. no shows) from their drivers.

Costs

Cost information was not available for this project.

Performance/Results

No information was available to compare the performance of the reservations/scheduling systems with more manual methods.

AVL/MDT System:

Background and Rationale

In an effort to improve its service, MetroAccess is deploying an automatic vehicle location (AVL) system and is equipping its vehicles with mobile data terminals (MDT). AVL implementation began in Spring 2001 but ran into some hardware-related problems six months into implementation. This has slowed down implementation. As of March 2003, 131 vehicles were equipped with AVL and MDT units.

In addition to providing real-time location of vehicles, a major benefit of the new system is that it allows text messages to be exchanged between dispatchers and vehicles. Once a driver logs in on the MDT, the manifest is automatically downloaded to that MDT. Also, any cancellation is sent automatically to the MDT. Through the MDT, drivers are able to acknowledge receiving messages.

Costs

The cost was $3,000 per vehicle for the GPS-based AVL and MDT system. In addition, there was a $20,000 licensing fee for the entire system.

Performance/Results

MetroAccess feels the information provided by the AVL and MDT system is 100% reliable, although not 100% complete because the entire fleet is not equipped. Although dispatchers were not very happy about the new system, initially, as they felt uncomfortable dealing with technology, they have come to appreciate the system with time. According to MetroAccess, dispatchers like the fact that they can send a cancellation to the driver via MDT rather than having to read it over the two-way radio, usually repeating it several times. Furthermore, dispatchers have come to appreciate the value of knowing exactly where the vehicles are—via the AVL system. This has allowed dispatchers to reschedule certain trips in a much more efficient way. A customer who is delayed at a location, e.g. dialysis center, is easily rescheduled on the next vehicle near that location.

Generally, drivers have expressed concern about the new AVL system, feeling as if “big-brother” is watching them. However, they seem to appreciate the benefits they obtain. Drivers who have used the MDT units to receive text messages found them to be very helpful. They feel that they are getting clearer information and do not have to repeat the information over the radio.

Finally, MetroAccess believes that the new AVL system will help in greatly reducing its operating cost. It is a common practice for paratransit service providers to suspend subscribers for a period of time, after accumulating a certain number of no-shows, MetroAccess is implementing such a policy and will use the AVL system to verify if a no-show was the result of vehicle delay or was the customer’s fault. With about 180,000 no-shows a year, MetroAccess anticipates saving between $500,000 and $700,000 a year by implementing a suspension policy.

Since paratransit service, mandated by the ADA, is very costly to the transit agency, improving the service in any way should have a high return on the investment. Furthermore, since the disabled customers are often highly dependent on the system for basic mobility, improvements in the quality and quantity of service offered are very desirable. MetroAccess, like many other agencies across the country, has employed ITS (e.g. AVL/MDT) to improve efficiency and accommodate more riders without adding vehicles and drivers. While MetroAccess understands the potential benefits these ITS systems offer, monitoring the impacts will help MetroAccess to document these benefits.

2.3.6 Fleet Management: Arlington County STAR - Paratransit Computer- Assisted Scheduling and Dispatching System

Background and Rationale

For its STAR paratransit service Arlington County has recently purchased new scheduling and dispatch software (Trapeze PASS); the software was to be operational in late spring. One of the County's objectives is to increase number of shared rides and hence, reduce the average cost per trip, currently about $24. The County also expects to increase productivity and efficiency of reservationists since the software automatically pulls up all relevant information about a customer. As the reservationist starts typing a pick up/drop off location, all matching addresses for that customer also pop up. The system also allows reservationists to e-mail manifests to carriers instead of faxing them.

The STAR ADA paratransit service is provided through three carriers all managed by a single broker, DynTek. One carrier, a taxi operator, provides sixty percent of the service. The remainder of the service is provided by the other two carriers, using a total of six vans and two sedans. The total ridership is 450 trips a weekday. Currently, DynTek employs 2 full-time and 2 part-time reservationists and a transportation coordinator. The reservationists handle a total of 400 calls a day. DynTek currently uses Intellitran Mobility Master dispatch software acquired in 1997. When customers call to make a reservation, they do not know immediately which service provider will pick them up. The customer is contacted only when the provider is other than the taxi operator. Manifests are not generated automatically by the scheduling software. Instead, at the end of the day, DynTek manually produces manifests of trips for the next day's trips.

Reservationists have complained that the current scheduling software does not display travel locations of a particular customer in any specific order. Reservationists quite often will have to scroll through dozens of locations before arriving at the intended location. Another issue with the current scheduling system is its inability to perform taxi reconciliation (because taxi vehicles are not dedicated solely to STAR's service, odometer readings cause an error with Mobility Master software). Because taxi records are not included in the database, certain reports such as the client history report are incomplete.

Costs

The cost of the system was $200,000.

Performance/Results

Arlington County's recent acquisition of a paratransit scheduling system should provide useful experience for others. Since the system was not yet operational at the time of the interview, the performance and results could not be determined. The operation of the new system should be monitored to see if it addresses the various issues Arlington County has already identified as problems with the earlier system. Given the high cost of each paratransit trip, performance data on any impacts on productivity would be particularly valuable.

2.3.7 Fleet Management: WMATA Metrobus Automatic Vehicle Monitoring (AVM) System

Background and Rationale

In 1999, Clever Devices—the vendor—approached Metro (WMATA) to test its AVM system. Metro had been interested in taking more preventive action (rather than simply performing repairs) as well as containing maintenance and maintenance staff costs. As a result, Metro installed and tested Clever Devices AVM system on 8 of its buses for a period of one year. No specific objectives had been established for the test—beyond the general motivations described above. As of early 2003, 164 Metro buses (about 10% of the fleet) and four GEORGE[2] buses are equipped with Clever Devices IVN II system. All new Metro buses are also scheduled to be equipped with a AVM system.

The system provides a host of reports that help maintenance staff to detect potential problems. Reports can be generated for a specific date or any range of dates. Reports can also be generated for a particular bus, or a type of buses (e.g., manufacturer). Information included in the reports includes bus ID, date, time, and fault code. Components monitored and reported are: transmission control, air conditioning systems, engine coolant temperature, fuel delivery pressure, oil pressure, and transmission oil temperature.

The current AVM system does not operate in real-time. Instead, data are downloaded at the end of each day as buses pull into the garage. Clever Devices maintains a "trailer" set at one of Metro's garages that houses the system's server and communications. Clever Devices performs all required data processing and report generation for Metro. Metro is planning to take over system management in July 2003.

Costs

Average cost of the AVM system per vehicle is $4,500.

Performance/Results

Since testing the system in 1999, Metro has been satisfied with the results. According to Metro, staff regularly checks the IVN II reports to identify potential problems. Once a bus is suspected of having a problem, it is pulled out of service, checked, and repaired if necessary. Metro claims that this has been of benefit in reducing road calls.

The AVM is also having an impact on Metro's B-level maintenance staff; B-level inspection—which requires two to three hours—is the 14-day routine inspection of vehicle

[2] GEORGE is the new local bus service provided by Metrobus under contract to the City of Falls Church.

fluids, lights, brakes, and safety components. Metro is planning on reducing its B-level maintenance staff in half (down to three staff) as a direct result of the VCM system.

Metro also realized an unexpected benefit from the IVN II system. In 2002, Metro received delivery of new CNG buses that were also equipped with a AVM system. The AVM system constantly reported a problem with the oxygen sensors. After careful examination of the CNG buses, it was found that they had faulty oxygen sensors. The manufacturer agreed to replace all oxygen sensors on those vehicles.

Although an AVM system is a relatively new technology with few existing installations, the system potentially offers significant benefits for transit agencies. WMATA's AVM has already displayed some benefits for the agency that can be duplicated by other agencies in the region. Unlike most other transit ITS technologies, AVM systems do not differ a lot from one agency to another. Hence, results from studying WMATA's AVM system should be applicable to other agencies in the Washington, D.C. metropolitan area.

2.3.8 Fleet Management: WMATA Metrobus Automatic Passenger Counters (APC)

Background and Rationale

Metro became interested in acquiring an APC system after acquiring the automatic annunciator system. As part of the annunciator system contract, the vendor, Clever Devices, had to geo-code Metro stops. This paved the way for Metro to seriously think about acquiring an APC system. Metro's aim was to improve the reliability and efficiency of its ridership data collection. The APC system should also help Metro to maintain its ride checking program with a reduced checker staff, as a result of a budget and staff reduction.

Metro started equipping its new buses with APC systems in 2002 and currently has 185 buses equipped. However, the APC data is not yet being utilized due to some discrepancies with the resulting load counts (for example, negative load counts at some locations). One of the factors causing this problem is the fact that the APC system is linked to the destination sign—which provides the APC system with the route number and destination. If a driver does not change his/her destination signs at the end of a route until after passengers have boarded the bus, the APC will reset the counter to zero. Metro staff expressed some concern that the accuracy of APC data will always be subject to some uncertainty due to the need for driver involvement in the process.

Costs

No cost information was available for this project.

Performance/Results

While it is too early to evaluate potential cost savings due to APC, the potential is great since manual ridership counts are costly. Metro's ridership counts are currently conducted by twenty-five full-time traffic checkers. With 17,000 daily trips and 25 checkers, even scheduling the checkers is very time consuming; two staff members are dedicated to this task. After collecting ridership counts, the data are manually entered and reports are generated using spreadsheet software. The Data Analysis Section, consisting of eight staff members and a manager, conducts these tasks among others. It should be noted that the traffic clerks conduct stationary checks at maximum load checkpoints throughout the bus and rail system, in addition to ridechecks, and they also monitor paratransit services. Furthermore, traffic clerks perform verification checks on the APCs.

Due to budget constraints, WMATA will be reducing the number of traffic clerks from 25 to 21 in the next fiscal year. Although staff reduction was not the objective of APC deployment, a fully operational APC system could enable counts to be conducted in spite of staff reductions.

According to Metro, there are a number of stumbling blocks that need to be overcome before a fully operational APC system can be achieved. These include:

- Updating the Clever Devices database and keeping it up to date
- Achieving integration between the Clever Devices database and the Trapeze scheduling system database, as well as with CUBIC fare databases and Orbital/Motorola AVL databases
- Rigorously testing and calibrating the APC system
- Developing more useful reports

It is anticipated that the new APC system will ultimately help Metro improve reliability and accuracy of ridership data, as well as efficiency of ridership data processing and reporting. Reports should be available within hours of data downloads from vehicles. It currently takes about 4 weeks from the time a special request for ridership data is received until the data is delivered. This is mainly due to the complexity of scheduling checkers while not disrupting Section 15 data collection. This will no longer be an issue with the APC system. It is anticipated that the APC system should be able to sample every trip at least once every about 4 months, compared to 12-18 months currently.

The full implementation should be closely monitored to confirm the benefits actually realized.

2.3.9 Fleet Management: Transit Signal Priority

Background and Rationale

Transit Signal Priority (TSP) technology enables specially equipped buses to obtain priority over other traffic in order to avoid delay at specially equipped signals so as to improve schedule adherence and/or running time. By reducing travel times and/or recovery times, TSP also has potential to improve operational efficiency, particularly for limited stop routes.

Priority differs from pre-emption (although they are related technologies). Preemption technologies, which have been implemented using hard-wired or wireless systems in various communities in the Washington region, preempt the normal traffic signal cycles to facilitate the safe passage of fire and emergency vehicles. Priority, on the other hand, is only granted to specific vehicles and only under certain conditions; typically, in the US, TSP is provided only for buses that are running behind schedule or that operate on express routes. Priority is generally granted either by extending the green phase or advancing the beginning of a green phase.

The TSP technology detects an approaching bus, determines if priority is desirable, and potentially requests and enacts an extension of the green phase, through communications with the signal control system. Since conditional priority requires information about whether a bus is behind schedule, the deployment of TSP requires the prior deployment of an AVL system with schedule adherence capability, besides an adaptive traffic control system (ATCS) and a communications infrastructure. Communications may be directly between the bus and signal, using either infrared emitters and detectors (with an interface to the signal controller) or alternatively, between the bus and the traffic signal control center, using loop detectors in the roadway and transponders on the vehicles, with subsequent communication to the appropriate signal if a request is granted.

The region as a whole has been quite interested in providing priority treatment for transit buses. Currently, signal priority equipment is in place at intersections along Columbia Pike in Arlington County and Fairfax County and on U.S. 1 in Fairfax County as well as in the District of Columbia (Georgia Avenue), and in suburban Maryland (Prince George's County and Montgomery County). The U.S. 1 corridor in Fairfax County is the first operational system in Northern Virginia. Conditional priority for transit vehicles began operation in the spring of 2003.

The Metropolitan Washington Council of Governments commissioned a project with Virginia Polytechnic Institute (Virginia Tech) to address preferential treatment including signal priority for transit and signal pre-emption for emergency vehicles. The goal of the project is to assist the ITS Technical Task Force in understanding the merits and limitations of traffic signal priority strategies. The key stakeholders are: Maryland DOT, Virginia DOT, DC Department of Public Works, WMATA, the fire rescue community, and others. The study includes "before & after" and/or "test & control" evaluation studies on TSP demonstration corridors in northern Virginia. The study has examined both actual and simulated runs for both safety and transit vehicles. The study has five tasks, the first three of which have now been completed.

Task 1 involved surveying stakeholders and determining needs and requirements. Stakeholders identified the following objectives for signal priority:

- Improve schedule adherence
- Improve efficiency of bus operation, reducing operating costs and increasing schedule flexibility
- Be part of a larger ITS system offering other benefits
- Increase ridership and therefore overall efficiency of the use of the roadway network.

Key system requirements were identified:

- Accountability – Recordkeeping and data extraction to identify how preemption is used and avert unwarranted use.
- Interoperability - While relatively few bus routes travel across state lines, the regional bus operator (WMATA) does shift buses between jurisdictions and states.
- Flexibility and Adjustability – in terms of being able to adjust vendors and match to local and real-time conditions
- Ease of Maintenance
- Clear Control of Operations and Maintenance – avoiding lengthy coordination for routine maintenance or interference with traffic control functions
- Minimal Operator/Equipment Interaction

Task 2 involved mapping specific technologies against these requirements. Technologies included sound (siren), radio and strobe light. Although emergency agencies typically prefer sound-based technologies, they are not appropriate for transit use. Transit requires a technology that also can distinguish between high and low priority requests; in the case of the northern Virginia applications, this has required changes to the existing version of the Bitrans signal software, which has in turn delayed implementation.

Task 3 of the study involved simulation analysis using INTEGRATION software of TSP on a small segment of the 16-signal Columbia Pike corridor (already controlled by SCOOT Adaptive Signal Control software). The Columbia Pike simulation examined a variety of priority scenarios involving express and local buses and measured performance in terms of vehicle and person travel time and delay, vehicle stops, fuel consumption and emissions of various pollutants. This analysis tested conditional priority to eastbound buses in the AM period (buses that were behind schedule at a certain checkpoint were given priority at all remaining signals for that trip) and assessed the resulting impacts on transit and traffic. Conditional priority included both advance green and extended green phases. The simulation showed benefits for transit vehicles and negative impacts for the overall traffic flow. Statistically significant improvements in bus service reliability (standard deviation of arrival time deviation from scheduled time) of 3.2% and in bus efficiency (running time) of 0.9% resulted when conditional priority was tested, but other results included overall increases in vehicular traffic delay (1.0%) and person delay (0.6%)3. It was found that overall benefits would occur when the number of transit vehicles requesting priority is not high and the traffic demand is low or moderate. The simulation analysis also suggested that attention should be paid to benefits that may be obtained indirectly as a result of the fact that the initial signal timings are not yet optimized. The conclusion was that an optimized signal plan is needed as the foundation for TSP, reflecting the overall goal to minimize delay for all vehicles before investigating priority. VDOT's Northern Virginia region has been developing optimal signal timing plans using SYNCHRO. The signal priority study staff has been working with VDOT to ensure that any TSP strategy does not negatively impact the optimization of signals; this is a key concern of VDOT, particularly since most corridor travelers use automobiles.

Task 4 involves a field test on Richmond Highway (U.S. Route 1). Pre-emption for emergency vehicles has already been deployed and a before-after study completed. To enable both high (emergency vehicle) and low (transit) priority, the VDOT Bitrans signal system on U.S.1 required additional hardware and software, which resulted in a delayed implementation.

Besides the specific corridor tests of TSP, it is noteworthy that the VDOT-NOVA region has been spending a great deal of resources on signal optimization. While signal optimization does not include signal priority for transit, recent simulation studies by Virginia Tech suggest that some of the objectives of TSP can be achieved through signal optimization to benefit all traffic, and furthermore, that it is sub-optimal to proceed with TSP without first completing signal optimization. VDOT-NOVA is using SYNCHRO to develop signal timing plans and

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[3] James Chang, John Collura, Francois Dion and Hesham Rakha, *Evaluation of Service Reliability Impacts of Traffic Signal Priority Strategies for Bus Transit*, Paper accepted for Publication in the 2003 Transportation Research Record, March 31, 2003 (in press).

acquired the MIST® application (Management Information System for Transportation®) to improve management of its signal system. [4]

Costs

The costs of detectors/readers on the main corridor are approximately $5,200 per intersection. The costs of emitters are approximately $1,100 each excluding installation costs. The installation was an in kind service provided by the transit operator and the fire and rescue agencies. For the entire U.S. 1 project, including 25 intersections equipped for mainline flow only and for 25 vehicles, the total cost of detectors/readers and emitters is approximately $200,000. The Virginia Tech contract includes approximately $100,000 for this project.

Performance/Results

While the hardware and software modifications for the U.S. 1 corridor were underway, the project staff simulated signal priority strategies under varying traffic conditions on a 1.5 mile segment of the corridor(containing six traffic signals) using VISSIM simulation software. The simulation concluded that, if properly integrated into signal control system, TSP (extended green phases only) can be implemented without disrupting the traffic flow (signal optimization, signal progression or cross-street traffic). Specifically, the results indicate a 3.6% improvement in bus reliability (measured as the standard deviation of travel time) and a 2.6% improvement in bus efficiency (measured as the mean travel time). These results, now being documented in a report, are also summarized in a paper submitted to the Transportation Research Board for presentation at the January 2004 annual meeting.

VDOT installed the required equipment in the fall of 2002 and the software modifications (to allow the signal controller software to distinguish between requests for priority from buses and emergency vehicles) were completed in the winter of 2003. Emitters on buses are now operational and a field test of the system was conducted (from March to August 2003). The test involved evaluating whether transit service was improved as well as whether the software was working correctly. VDOT downloaded a data log from the signal controller containing all requests by transit and emergency vehicle by time of day and the system's response. Since only a subset of buses has emitters, the test group of buses was able to be compared with a control group of buses that did not benefit from signal priority. An evaluation framework had been prepared and identified objectives based on stakeholder input and intended measures of effectiveness or performance (see the following table). This evaluation approach was also used in the simulation studies described above to the extent possible. Although the table shows intent to conduct user surveys, none have been conducted to date. The preliminary results from the field test are reported to show improvements in bus efficiency comparable to those produced in the simulation.

Work on signal priority is continuing with an expansion of the U.S. 1 field test; the larger test will include a segment of over eight miles and almost three times the number of signalized intersections. In the Columbia Pike corridor, there is a field test of a segment with two or three signalized intersections that has recently gotten underway.

[4] MIST (developed by PB Farradyne) is a traffic responsive system that changes cycles based on actual demand through the use of loop detectors. Despite MIST being a traffic responsive system, it is currently being run as a time-of-day system

Table 6: Objectives and Measures for the Evaluation[5]

Objective	Measure	Measurement
1.0 Bus Service Reliability (transit schedule adherence)	1.1 On Time Performance (OTP)	% of arrivals in on-time window at timepoint(s)
	1.2 Time Reliability	Standard deviation of elapsed time between timepoints or endpoints
	1.3 Perceived OTP	Survey measure of rider opinion
	1.4 Spacing	Maximum headway measured at timepoint (s)
	1.5 Arrival Reliability	Standard deviation of delta (actual time vs. scheduled) at timepoint(s)
2.0 Bus Efficiency (transit travel time savings)	2.1 Running Time (RT)	Elapsed time (mean) between start and end points
	2.2 95th-percentile RT	95th-percentile elapsed time between start and end points
	2.3 Trip Time	Weighted passenger time on board (in-vehicle)
	2.4 Perceived Travel Time	Survey of change in riders' opinions before & after
3.0 Other Traffic-Related Impacts	3.1 Overall Delay	Delay by [corridor or intersection], [person or vehicle]
	3.2 # of stops	Stops by [corridor or intersection], [person or vehicle]
	3.3 Mainline Travel Time	percentile or average operating speed
	3.4 Cross Street Delay	Maximum, 95th-percentile, or average delay
	3.5 Fuel Consumption and Emissions	Model output for corridor, average per vehicle
	3.6 Overall System Efficiency	Throughput achieved vehicles per hour, persons per hour
	3.7 Intersection Safety	Red light running, accident frequency

Besides the above signal priority projects in Northern Virginia, the City of Fairfax indicated that it is also planning to conduct a TSP project but it had not yet funded a project.

There are also signal priority projects in place, being implemented or planned in other parts of the region.

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[5] Ibid.

District of Columbia:

Georgia Avenue (and Florida Avenue) in the District of Columbia is the site of a separate TSP demonstration project (operational test) that is ongoing under the auspices of the District. A different version of Bitrans is used in the District that does not require any new software to implement conditional transit signal priority. Installation of the equipment at 32 intersections was expected to start at the end of May 2003 and a 90-day installation period was expected to be followed by acceptance testing. A formal evaluation is expected to take place once the project is operational. The primary objective of the project is to reduce travel time on the bus route rather than to maintain schedule adherence. Data collection will focus on measuring the resulting travel time improvements. The project RFP identifies other objectives and measures in general terms but detailed performance measures were still to be determined. The signal system will be able to handle conditional priority and conditions other than whether the vehicle is on schedule are envisioned, e.g., not giving priority to two consecutive buses. Interoperability is an issue that is being kept in mind as this is one of several projects MWCOG has been involved with in the region. Ultimately, the regional agencies would hope to select a single system for use throughout the region. The Georgia Avenue project is using Opticom equipment, which is line-of-sight rather than GPS-based. This system was already being used for emergency vehicle pre-emption in this corridor. WMATA agreed to the use of this system for the test but ultimately could choose another system for regional application.

Maryland:

TSP was implemented in 2001 in Montgomery County. It is currently operational on one route only (Ride On bus route 55 which operates along Maryland Route 355 to the Rockville Metrorail station). Although traffic engineers have been cooperative, they had some reservations on implementing TSP at major intersections. The system works as follows: when a bus reaches a pre-determined trigger-point, the bus sends a message to the Transportation Management Center about its location and schedule adherence. The centralized system then determines if priority should be granted; if so, it passes the request on to the traffic signal system, which directs the appropriate signal to extend the green phase. An independent consultant evaluation of the system was performed a year ago. Future implementation of TSP is planned as part of a transitway project for Veirs Mill Road, in Montgomery County, and MTA is currently conducting a study of bus rapid transit along East-West Highway.

A simplified form of signal priority has also been implemented in Maryland for MTA express buses that operate infrequently and non-stop. For this service, minimizing travel time is the goal rather than maintaining adherence to schedule. As a result, signal priority for this route does not need to be conditional.

WMATA Regional Bus Study:

The Regional Bus Study identified priority corridors for a variety of future running way improvements and for bus rapid transit services; TSP is one of the strategies considered in these corridors. The Regional Bus Study is continuing with implementation activities to examine a few selected corridors for bus rapid transit and other priority treatments.

2.3.10 Passenger Information: WMATA Metrobus - Automated Annunciator System

Background and Rationale

One reason for Metro's interest in automated annunciator systems was Metro's need to comply with the requirements of the ADA . Another reason was to relieve drivers of the task of making the announcements as a "fair number" of drivers were not complying.

In 1995, Metro conducted an annunciator system test evaluation. Metro asked three vendors, Luminator, Clever Devices, and Digital, to each equip one Metro bus with an annunciator system. All three buses were then assigned to run the same route for several weeks. At the end of the test period, Metro evaluated each system. Evaluation was based on the following criteria:

- Driver feedback
- Rider feedback
- Maintenance needs
- Accuracy of system
- Performance of system

Based on the evaluation, Metro selected Clever Devices to install its annunciator system on its vehicles and installation began in 1997. The Clever Devices system had an open architecture providing the possibility for subsequent expansion. The annunciator system is a stand-alone system that has its own GPS receiver. Currently, 721 Metro buses (about half the fleet) and four GEORGE[6] buses are equipped with the system. The system provides internal messages, in both audio and text formats, of the next stop as well as other Metro messages (e.g., greetings and system information). The system also provides external audio route number/name and destination announcements to passengers at bus –stops to supplement existing route and destination signage. There is no further formal performance monitoring or evaluation currently being conducted of this system.

Costs

The average cost per vehicle is $12,000.

Performance/Results

One issue, encountered during implementation of the system, was discrepancies between the text and audio messages at a handful of locations. Once these discrepancies were identified, they were easily corrected.

Initially, the system was set up to greet passengers whenever the doors open by saying "Hello, welcome to Metro". It soon became evident to Metro, mainly through drivers' complaints, that this was annoying. Metro modified the system to delete the greeting announcement.

Another issue with the system had to do with the external announcements. Metro received several complaints from residents along two community-based routes regarding the external announcements. Residents claimed that ambient noise was too loud during the evening

[6] GEORGE is the new local bus service provided by Metrobus under contract to the City of Falls Church.

hours. Metro modified the system to not make any external announcements between 8 PM and 6 AM on those two community-based routes.

Providing reliable, timely, and accurate information to passengers onboard is important and in some cases critical. Given the widespread interest in implementing annunciator systems in the Washington metropolitan area and elsewhere, monitoring the performance of these systems is critical. (Note that DASH had an annunciator system but stopped using it due to reliability issues.) Metro's annunciator system has already provided some valuable information on the implementation and operation of this system. With continued monitoring, more valuable data (e.g., correct messages are announced at the correct location, maintenance costs) can be obtained for the benefit of other agencies in the region.

2.3.11 Passenger Information: Real Time Arrival Time Information WMATA - Passenger Information Display System (PIDS)

Background and Rationale

In an effort to provide better service to its customers, Washington Metropolitan Area Transit Authority (WMATA) developed plans in the early 1990s for a real-time arrival time information system that would provide elevator/escalator outages, incident information and actual arrival times of trains. A request for proposals (RFP) was put out in 1995 for the Passenger Information Display System (PIDS) and INOVA was the selected vendor. In April 1999, installation of the system began; by 2001, the system was operational at all stations with over 400 signs.

DMSs at Metrorail stations display arrival times of the Metro trains in a countdown fashion, "Red Line/6 Cars/4 Minutes". The DMSs are also used to display time and to provide information during an emergency or terrorist situation. The agency uses the DMSs to disseminate events messages especially on weekends when there is more time between trains and therefore greater opportunity for other messages to be displayed.

The current system does not provide announcements in audio format although they are possible. The signs have speakers but they are not used for audio communication of PIDS information. These speakers are currently tied into the existing Public Announcement (PA) system although the system specifications did not address any such integration or coordination.

There are two inputs to the LightLink server that manages the sign displays –ROCS and Other Clients. ROCS is the real-time arrival component. The Other Clients provide messages from Passenger Operations and Marketing that could be about an emergency, an incident, an event, or just background information. Elevator/escalator availability information is still done manually although Metro hopes to automate this function in the future.

Using a fixed-block system, the Rail Operations Computer System (ROCS), which is not a part of the PIDS system determines the location of the train and computes its projected arrival time. Each block has a fixed running time. When a train passes by a certain block, the train information and block code are sent to the ROCS central computer. Using this information, the system calculates estimated arrival time. The estimated arrival time along with Line (color)/ destination and number of cars are sent to a group of signs at a particular station. A multiplexer then directs the message to the right sign. The arrival time is displayed on the signs for a specific time.

To remove the message from the DMS, the computer has to communicate with that particular sign and directs it to remove the message. Not only does this delay the system and affect its efficiency, but it could also be an expensive alternative, as it doubles the communications usage...WMATA is looking into improving on this by embedding the "removal" time in the message itself. The sign would then remove the message once the preset time expires. This ought to reduce communications traffic considerably.

WMATA has a separate program that a staff member from the Information Technology department designed in June 2002 to allow WMATA to check the status of the system (not of the trains); it tells which signs are down, disconnected, or reconnected; this is used for monitoring purposes and for failure analysis and is available on the agency intranet. It shows a 30-day bar chart of incidence of down signs by sign. The status information is archived in an Oracle database.

The software had to be modified to eliminate passengers' confusion when a train is at the station. At first, signs at stations used to show next train arrival information even when another train is waiting at the station. This used to confuse riders as they thought that the train waiting at the station is indeed the same as the train displayed on the DMSs. As a result, many riders ended up getting on the wrong train. The software was modified to resolve this problem. Now, when a train is waiting at the station, no information on future trains is displayed.

Costs

The system, which consists of 430 Dynamic Message Signs (DMSs)—both indoor and outdoor, cost almost $12 million.

Performance/Results

Market research has provided useful information to monitor customer acceptance. WMATA conducted market research in the spring of 2001 to obtain a baseline evaluation of all information systems provided to customers. This included focus groups in May 2001 and telephone survey research in June 2001 soon after PIDS was implemented.

The focus groups of website users and non-users included discussion of the PIDS. The discussions revealed that the PIDS were useful but were not yet providing maximum value in delivering information. Some participants commented that the PIDS display some incorrect information. Focus group members made several suggestions. Among the suggestions were listing the arrival times of several trains instead of only the next train, on platforms serving multiple (color) lines. This has been implemented as of this writing.

The survey revealed that 93% of survey respondents (screened to exclude those who do not ride either Metrobus or Metrorail) are aware of the PIDS and 88% identified the "length of time to the next train" as information the PIDS provide. There were lower levels of awareness of other information -- 41% for line color of the next train, 38% for current time and 25% for elevator/escalator status. The most common idea for providing more information via PIDS was more information about train delays (22%). Survey respondents were fairly satisfied with PIDS, and very few expressed dissatisfaction, as shown below:

Table 7: Satisfaction with Metrorail's New PIDS (2001)

Very satisfied	30%
Somewhat satisfied	36%
Neutral	22%
Somewhat unsatisfied	9%
Very unsatisfied	2%

The primary reason for dissatisfaction with the PIDS among the few dissatisfied respondents was that they "don't display the information desired," "they don't display accurate information" and "they were a poor use of funds." Respondents, when asked to make suggestions about using technology to provide passengers with information, frequently suggested improving accuracy of information and improving display of the information including placement and clarity of PIDS. Since the research, improvements to the system have been made to enhance accuracy and improve information.

WMATA continued to monitor consumer response in bi-annual tracking studies. The tracking studies involve about 1,200 telephone surveys of adults residing in the WMATA service area. The tracking study in October 2001 identified that 71% of service area adults had heard or read about PIDS and 59% said they had used PIDS. Among frequent Metrorail riders, 99% were aware of and 98% had used PIDS; occasional riders also had very high usage and awareness rates, as shown below:

Table 8: Awareness and Use of PIDS by Frequency of Use of Metrorail (Oct. 2001)

Category	Frequent	Occasional	Non-rider
Used PIDS	98%	96%	45%
Aware, not used	1%	2%	16%
Not Aware	1%	3%	39%

PIDS was reflected in WMATA's ITS plan which was in development in 2001. The Transit Customer Information System Plan dated August 2001 noted that the system had overcome initial reliability problems and that reliability was still increasing. It also noted that it was still being examined for expansion of its capabilities (potentially to include bus transfer information once AVL was available on the bus system). The PIDS were considered to be a "young" application based on relatively mature system components.

Overall, the PIDS system has proven successful in terms of informing their passengers on train arrival times. Although other agencies in the region have implemented other real-time bus arrival information systems, these have been pilot projects. The PIDS system, on the other hand, was implemented on a grand scale covering almost the entire Metrorail network. Continued monitoring of the PIDS systems should provide valuable data on system-wide deployment of ITS systems. The positive response to PIDS has been cited as one factor supporting expansion of real-time arrival time information systems to the bus system.

2.3.12 Passenger Information: NextBus Real-Time Bus Arrival Information Technology at Metrobus in Arlington County and at CUE in the City of Fairfax

NextBus is a proprietary real-time arrival system that provides predicted arrival times of buses. Arrival information is provided to users via two outlets: dynamic message signs (DMSs) at bus stops and on the Internet. DMSs and the website display arrival times of the next 2 or 3 buses in a "countdown" fashion (e.g. "The Bus Will Arrive in X Minutes"). Vehicle locations, however, are available only on the website as the DMSs do not have the capability of displaying graphics. By moving the cursor over a particular bus on the map, a small box opens up indicating the name of the next stop and the expected arrival time of that bus. Moving the cursor over a bus stop on the map will cause a small box to open showing the arrival times of the next three buses. Furthermore, *My Nextbus* allows the user to set alerts so that he/she will automatically be notified by the web browser when his/her vehicle is about to arrive. NextBus has been implemented in both Arlington County on a Metrobus route and in the City of Fairfax on the CUE local bus system.

Arlington County/Metrobus:

Background and Rationale

In 2000, Arlington County negotiated with NextBus to provide real-time bus arrival information at eight bus stops along MetroBus Route 38B. By September 2001, the system was operational, consisting of nine buses equipped with the NextBus AVL system, and nine signs installed at the eight bus stops (Ballston stop has a double-sided sign).

In Winter 2003, Arlington County considered shifting the NextBus system from Route 38B to other routes. However, the cost to do so was estimated to be $40,000; hence, Arlington County is maintaining the status quo for at least one more year until it can expand this service to all ART routes. A systemwide technology may be supplied by a different vendor since an RFP procurement process will be employed. WMATA is also exploring ways to obtain capability to provide real time arrival time information systemwide including ways to integrate NextBus with the WMATA AVL system, which will become operational in 2004. WMATA has been particularly interested in extending the provision of real-time bus arrival information to the 30 bus bays in the Pentagon area.

Costs

The NextBus system cost $100,000 including nine dynamic message signs and MDTs for nine buses. Additionally, it costs $2,000 per month in operating costs.

Performance/Results

No formal evaluation of the system has been conducted although the County indicated that it intends to conduct one. The County has received some complaints from users regarding the accuracy of the predicted time. Some passengers have complained that a sign will sometimes display a longer than actual time to the next bus. The cause of this discrepancy is from the fact that the system does not take into account a bus that is in the garage and is turned off even though this bus will be starting its trip in few minutes.

City of Fairfax CUE:

Background and Rationale

In February 2001, NextBus approached CUE to provide real-time arrival information at selected bus stops. The system was launched in early July and was fully operational by August 2001 (just prior to the above application on Metrobus in Arlington County).

Twelve buses running on two routes (Green Line and Gold Line) are equipped with AVL and MDTs, and 6 dynamic message signs (DMS) are installed at 5 bus stops and at one Metrorail station (Vienna Station). All signs run on AC power except for one shelter sign that utilizes a solar cell.

NextBus location data is received by NextBus in California and all data manipulation is performed there. Projected arrival times are then sent to DMSs at stops and are posted on the website. In addition to providing arrival times on the DMSs and the Internet, to be compliant with the ADA, CUE also provides visually impaired riders with a device (which they carry with them) that offers them audio versions of the messages on a sign where they happen to be waiting.

Costs

The NextBus contract cost (for the entire system of AVL, signs, software, communications and installation) was $151,000. There was an additional expenditure of $9,000 for power connection related construction. Five-years of communications and maintenance costs are built in to the contract as well as initial training of supervisors.

Performance/Results

Some of the operational/maintenance issues that CUE had faced included more frequent breakdowns than originally anticipated (about one component every two months); and because NextBus is in California, it takes longer to respond to maintenance issues. No formal evaluation of the system is being undertaken.

The provision of actual vehicle arrival times for passengers waiting at the stops/stations, as well as on the Internet, has been gaining momentum in the Washington metropolitan area as demonstrated by the numerous applications that currently exist in the region. Providing a continuous monitoring process for such real-time arrival time information systems will not only be critical in helping other agencies in implementing similar systems, but will also ensure that existing systems continue to provide reliable information. Accuracy and reliability of information to customers is essential. Therefore, data precision should be monitored on an ongoing basis. Particular attention should be paid to how interlining and leap-frogging buses are accounted for.

2.3.13 Passenger Information: Montgomery County - Real-Time Bus Arrival Time Information System

Background and Rationale

In 1998, Montgomery County developed an application to provide real time arrival information at certain bus stop locations. The system was developed in house and takes advantage of the existing Orbital AVL system installed on the vehicles. Five locations are equipped with dynamic message signs (DMSs): two main transit centers (Lake Forest Mall and Montgomery Mall transit centers) as well as three other locations. The County is also planning on equipping its Bethesda intermodal station with DMSs to provide real time arrival information.

Actual arrival times of buses are derived from the AVL schedule adherence system. Information about vehicles that are not running on schedule (running early or late by a certain threshold) is stored in an Exception Report—the off-schedule time is also recorded. The bus arrival system uses the information from the exception report to display actual arrival times of buses on DMSs.

Costs

The cost for equipment was $58,000 in total. This includes $20,000 at each transit center and $8,000-$9,000 per bus stop location. The system was developed in house and staff hours for programming and integration are not included in this estimate.

Performance/Results

Although the method of arrival time prediction used simplifies the implementation of such a system, it had caused some problems. For example, when a bus is in service with the AVL system turned off, the schedule adherence component assumes that bus is not in service and hence excludes it from the exception report. In turn, the real-time bus arrival system reports that the bus is on time when the bus may actually be running early or late. In addition, the system only reports delays that are over 5 minutes. This has been of concern to some users as the system reports a bus to be on time even if it is 4 minutes and 59 seconds late. Montgomery County, however, is planning on upgrading the software and they anticipate it will be accurate to one minute.

Montgomery County has not conducted any formal evaluation of the system.

Although Arlington County's NextBus system in Northern Virginia has also been included in this review, Montgomery County's system has been included as well since it provides a different perspective on real-time arrival systems. Arlington County's system was developed and installed by a vendor that specializes in such technology. Montgomery County's system, on the other hand, was developed in house with vehicle location data furnished by Orbital's AVL system. Monitoring both Arlington and Montgomery's systems should provide valuable data for other agencies interested in acquiring similar technologies, particularly by comparing a system developed in-house based on existing AVL capability with an "off-the-shelf" one containing its own GPS devices. Key indicators for such a comparison would include: accuracy of prediction time, handling of interlining, how often the system is down and of course the cost of acquiring or developing, maintaining and operating the system.

2.3.14 Passenger Information: VRE Train Brain Website and AVL

Background and Rationale

Virginia Railway Express operates commuter rail service on two lines serving 18 stations. Customers can view the location of trains on VRE's Train Brain webpage to determine if a train is delayed. Train Brain is a schedule-based java applet program that displays the location of VRE trains on a map on the VRE website (www.vre.org/trainbrain/disrupt.shtml). Initial planning began in late 1999 when VRE became interested in acquiring this system from Reynolds Transit Software, which was hoping to deploy it in a demonstration site.

Train Brain integrates the pre-existing GPS-based AVL system (acquired in 1997 from Orbital Science) and Train Information Provider (TRIP) systems so it can update the location of trains as shown on the website. The Train Brain webpage on the VRE website is setup to display the trains operating according to schedule. The display is periodically updated with information about major problems and delays from the Communications Center; this information derives from the GPS system or from the train conductor. The system is not fully automated as Train Brain only shows delays that Customer Service decides to show. The customer service agent must verify the delay before a delay message is prepared. The customer service agent then clicks an *ok* box and the e-mail is generated that creates the Train Brain applet. Location of the train on the map is updated accordingly.

Although Train Brain was not developed in response to an overall ITS plan, there were specific requirements developed for the VRE application. Thus, considerable customizing was required to present Train Brain in a format that conveys it as a VRE service integrated with its other website information.

Costs

VRE obtained this system at a very low initial cost ($5,000) since the vendor was interested in demonstrating the program. VRE purchased the system with a sole source purchase order and continues to pay an annual license fee of a few thousand dollars besides occasional maintenance costs on an hourly basis as needed. The Train Brain system is dependent on the AVL system that was already in place; the AVL system cost $1.2 million (this included the IVR telephone information system).

Performance/Results

VRE monitors customer opinions regarding service through an annual onboard survey. The survey includes questions about use of the VRE website, although not specifically about Train Brain. In the 2002 survey, customers reported that 89% had ever visited the VRE website and 86% indicated that they use the website when they need more detailed information. When asked to rate the timeliness and quality of the website information, the results were as follows:

Table 9: Customer Ratings of the VRE Website

Rating	Timeliness	Quality
Excellent	33%	33%
Very Good	47%	50%
Average	17%	15%
Needs Improvement	2%	1%
Poor	0%	0%

Clearly, the customers are quite happy with the website.

2.3.15 Passenger Information: WMATA - Metrorail E-mail Alert System

Background and Rationale

WMATA's Metrorail e-mail alert project has its origin in a series of incidents in 1998 when a number of system fires occurred and information provided to customers was inadequate. Since then, WMATA has adopted a "we stop, we tell" policy of providing more accurate information to customers during any incident.

WMATA's initial e-mail alert effort was a pilot limited to alerts on elevator outages made available to ADA clients only.

In January 2003, Metro launched a new more comprehensive Metrorail e-Mail alert service for all customers providing information on Metrorail delays. Subscribers have 25 options from which to choose, including subscribing to alerts by line, time, or mode. To subscribe to this service, a customer simply selects Service Status from the menu on Metro's website, enters his/her e-mail address and selects the category of information he/she is interested in receiving. Users also select any Metrorail line of interest for any of the five time frames (morning peak, midday, evening peak, night, and weekend).

The e-mail alert delivers specific information. Messages state the nature of the delay, length of delay, and direction of delay. Messages are sent in pairs to help users know when the delay is over. The first message provides information on the delay while the second message informs the user that the previous message has been canceled. The following is a sample e-mail message:

> *"A 10 minute Orange Line delay is in effect at East Falls Church station in the direction of New Carrolton. Cause: Malfunctions: Door."*

Prior to its introduction, WMATA had obtained an expression of interest in e-mail alerts from a 2001 baseline survey on information systems. In that telephone survey of Metrorail and Metrobus users, 37% of respondents indicated that they would be very interested in e-mail alerts in Metrorail delays, particularly among frequent Metrorail users. Another 15% were somewhat interested. There were also 17% very disinterested and 9% somewhat disinterested, for various reasons.

Costs

The cost of the system development was between $50,000 and $60,000. The development involved creating input screens, setting up fields to capture required data, and designing and setting up data list in a way to allow for easy management. A private vendor provides Mail List service at an annual cost of $35,000. The vendor is responsible for "posting" the alert messages to the subscribers.

Performance/Results

The service is becoming very popular among the Metrorail riders as evident in the surge of subscribers. Between January 22^{nd}, 2003 and March 3^{rd}, 2003, 6,300 new subscriptions were logged. Because each subscriber can have more than one subscription (for different lines and/or time period), this translates to 16,000 individual alert requests.

Metro feels that it has met its main objective -- to provide the same information being provided on the web site.

Focus groups conducted as part of this baseline market research effort in Spring 2001 suggested that user and non-users of the WMATA website were favorably disposed to e-mail alerts for major delays.

Although some complaints were received during a major snowstorm about inconsistency of information between e-mail alerts and other Metro sources (i.e., press releases, media, web site, etc.), no statistics are available to document customer feedback since implementation. However, Metro claims that feedback from customers has been positive overall.

The Metrorail e-Alerts system is a rather unique system in the region with the promise of expanding to other agencies and modes. Making riders continuously aware of any delays and/or incidents on any of their routes of travel, Metro should be better positioned to retain its riders and perhaps increase ridership. Any increase in ridership should have a positive impact on congestion. A continuous monitoring of the program's performance may encourage other agencies to follow in Metro's footsteps.

2.3.16 Passenger Information: VRE Train Talk E-mail Alerts

Background and Rationale

Virginia Railway Express (VRE), which operates commuter rail service on two lines serving 18 stations, implemented an e-mail alert service in the spring of 2001, about two and half years after the Train Brain website became operational. This service, know as Train Talk, provides e-mails about VRE train status to those riders that sign up for this service.

Train Talk messages are neither route- nor station-specific, that is, the same e-mails are sent to all Train Talk customers. Train Talk is primarily for conveying information about large service disruptions, potential disruptions and potential equipment changes – anything that would affect riders. Train Talk has also been used to convey information about speed restrictions that are in effect from time to time and to inform customers about the new fare collection system. Customer service agents use their judgment to determine whether certain information is better disseminated via station platform announcements rather than Train Talk. Train Talk is not used for minor delays unless they will impact subsequent trains.

Although Train Talk e-mails can be received by cell phone, the system was not set up for small devices and doesn't work well with personal digital assistants (PDA's). VRE is currently experimenting with sending train-specific information to cell phones and PDAs; About 300 riders are currently testing this service and have been doing so for some time. The test has involved sending short messages such as "train 531 – 10 min late." The test participants email comments. Since riders seem to want more explanation in the message, VRE is hoping to utilize codes to provide more descriptive information in a short message.

Costs

There was minimal cost as the functionality was already available.

Performance/Results

There are 6,500 passengers on the Train Talk e-mail list, a relatively high number given that the daily ridership is 12,000-14,000 one-way. VRE has been monitoring consumer opinion in annual on-board surveys. This survey covers many topics, including Train Talk. Respondents are asked to rate the timeliness and quality of Train Talk. In the 2002 surveys, the response was as follows:

Table 10: Consumer Ratings of Train Talk

Rating	Timeliness	Quality
Excellent	38%	33%
Very Good	40%	42%
Average	17%	21%
Needs Improvement	3%	3%
Poor	1%	1%

Clearly, the vast majority of users rate the service quite highly.

2.3.17 Passenger Information: PRTC - E-mail Alert Service

Background and Rationale

PRTC OmniRide's Rider Express e-mail alert service started in December 1999. The system provides information on significant service changes and major service disruptions. Customers subscribe to the service by submitting their e-mail address via the OmniRide Website. Messages can be received via PC, cell phones, or PDAs. Unlike Metro's e-mail alert service, Rider Express does not allow the users to select routes or times of interest. Instead, the same general e-mail messages are sent to all subscribers.

Costs

The cost to establish the system and integrate it with the PRTC website was $5,000.

Performance/Results

Currently, there are 4,600 subscribers. No specific project objectives were set and no evaluation has been conducted so far. However, e-mail messages from users indicate widespread satisfaction with the service.

2.3.18 Passenger Information: WMATA – RideGuide and Interactive Voice Response (IVR) Trip Itinerary Planning System

Background and Rationale

WMATA provides a regional itinerary planning and customer information service known as RideGuide. The RideGuide automated trip planner has been available on the web since September 1999. However, users can also utilize RideGuide through the automated interactive voice response (IVR) phone system and have their trip itineraries announced to them over the phone or faxed. The IVR phone system was introduced in November 2002, making it the first transit agency in the country to offer fully automated voice-enabled trip planning. Even though the IVR phone system is now in place, telephone customer service by live agent continues to be available as is the traditional push button telephone menu system.

The RideGuide application informs riders on how to travel to their destinations in the Washington metropolitan region by bus or rail. It provides several alternatives for each trip request including walking directions and fare information. The current application covers all bus and rail operators in the region except Loudoun County Transit Commuter Bus and Washington Flyer bus service to the airports. Upgrades to RideGuide have been taking place this year to include the Loudoun Commuter Bus as well as commuter rail service operated by VRE and MARC. The service allows travelers to obtain immediate or advance pre-trip static information. The majority of the itineraries requested through Ride Guide are for trips to be made within the next 4 hours.

The system utilizes a customer information database known as ARTS (which has been in existence since 1979. Prior to 1999, customer service agents used the ARTS system to respond to customer questions. Initially a UNIX system was used, then a closed-loop LINUX system. In 1999, the system was converted to Windows so it could interface with the web. Then, WMATA was able to offer on the website the same information that is and has been available to the customer service agents.

Although Metro route and schedule information is automatically updated, that is not the case with the other systems. Information about the other regional systems is updated manually. This has created some problems with reliability of accurate and up-to-date information. A working group has been created to address information flow. One idea being entertained is to enable the other systems to place their service information on their own websites instead of just on WMATA's Ride Guide website. This will allow the different systems to present the information in their own style and colors rather than just linking to Metro website.

The main goals of RideGuide, including the new IVR system, are:

- Move from fragmented information services to seamless, regional trip planning with integration of modes/services
- Move from telephones to telephony (integrated telephone/computer systems) with expanded capabilities
- Provide greater customer satisfaction by offering new technological alternatives with 24/7 service
- Contain the cost of staffing the customer call center

Metro faced an increasing number of calls to the customer call center requiring constant staff augmentation. Metro estimated the need to hire 5-10 new staff every year simply to keep up with increased calls (on average, each customer representative can handle 50,000 calls/year, and calls were increasing by about 400,000-500,000 a year).

Both the RideGuide website and the IVR system provide seamless regional trip planning service to the customers. Previously, users had to call up to 3 or 4 different agencies to plan their multi-operator/multi-mode itinerary. With RideGuide and/or the IVR phone system, it only takes one inquiry and a few minutes to get a complete itinerary.

Costs

The original web version of RideGuide required 3 person-months of effort to develop. The cost of the IVR phone system was $680,000 for hardware, software, programming and integration. An additional cost was $200,000 for the Trapeze scheduling software.

Performance/Results

Before the introduction of the RideGuide website, the Metro call center used to get 3.2 million calls a year, of which 15% did not get served (that does not include the calls that used to get busy signal). After RideGuide was launched, the service rate has improved to about 95%. Furthermore, busy/no answer complaints have dropped from a high of 40 complaints per month in 2002, to no complaints in early 2003.

The elimination of long waiting times for calls to be answered reduced customers' anxiety and frustration. In turn, Metro indicated that the call center representatives were much happier and their morale increased once they did not have to deal with callers who were frustrated and angry about long waiting times.

It is also estimated that about 5% of callers to customer service elect the IVR system now that they have the choice. It is likely that this percentage will increase once Metro starts marketing the new enhancements. Between November 2002 and February 2003, even though the new IVR system was still undergoing acceptance testing, more than 35,000 itineraries were produced by the new application. Another benefit of the new IVR system is that it allows callers to get the information they need even when the call center is closed. It is estimated that an average of 500 itineraries are requested daily between 10:30 PM and 6:00 AM.

The IVR may also be beneficial to certain segments of the population such as elderly users and individuals with sight impairment who have difficulty using a push button menu.

Finally, with the introduction of RideGuide website, Metro was able to double its call handling without adding personnel. In the first year of its operation, RideGuide provided over one million itineraries. Currently, RideGuide website provides an average of 3 million itineraries annually.

WMATA has been evaluating consumer response to Ride Guide and other information services through market research activities. A baseline telephone survey of Metrorail and Metrobus users in 2001 was conducted specifically focusing on customer information. Ongoing biennial tracking surveys of service area adults also conducted by telephone have addressed these topics among other issues.

The baseline survey found that among those with regular access to the Internet, 43% were aware of Metro's on-line service providing door-to-door directions (i.e., Ride Guide). Few of these (6%) could name the service unaided although more (19%) recalled hearing of it when the name Ride Guide was mentioned. Just over half of those who were aware of Ride Guide reported they had used it. User satisfaction was relatively high – 24% were very satisfied and 48% somewhat satisfied; 17% were neutral and only 7% dissatisfied.

The baseline survey was conducted prior to the introduction of the new computerized IVR phone service. When asked how likely they were to use the service, the respondents gave a mixed reaction – about 20% answered in each of five categories, with the response slightly more negative than positive. The reasons for being unlikely to use the service included preferring a live operator, too impersonal and preferring to use the on-line Ride Guide.

Focus groups were conducted as part of the baseline market research effort with users and non-users of the WMATA website. Among website users, although there was some confusion, the response to Ride Guide seemed positive. Suggestions included providing a simplified way to input origin and destination and providing a graphic map besides text directions. As might be expected, the non-users of the website, were somewhat less receptive. The response to a potential IVR phone service was neutral. Participants offered the suggestion that the option to speak with a live operator be offered to users after receiving automated directions for clarification or more information. The participants stressed that both the on-line and IVR system be kept simple and easy to use.

A subsequent (October 2001) telephone tracking survey of service area adults (conducted biennially) provides an opportunity to evaluate awareness, use and reaction to Ride Guide later in 2001 (and on an ongoing basis). The results were similar -- awareness at 46% overall, with 22% indicating they had used it. This survey enabled comparisons between frequent and infrequent riders and between Metrobus and Metrorail users. Users of Metrobus only exhibited lower awareness (41%) and use (16%) of Ride Guide and were more similar to non-users than to Metrorail users in this respect. The highest use of Ride Guide was among frequent Metrorail riders (48%), who were also most aware of Ride Guide (73%).

WMATA indicated that it was planning to survey customers who use the IVR system. WMATA will also be examining the effectiveness of the system in terms of number of completed itineraries, capture rate, and queue time.

RideGuide and the IVR phone system are two of the most important transit ITS projects in the region as they reach out to potential transit users and they cover transit services throughout the region. Providing accurate, and fast, customized itineraries is critical in encouraging riders to use transit more often, especially new or infrequent riders who may not be very familiar with routes and schedules. WMATA has already identified numerous benefits from these two systems and has indicated its willingness to add more transit agencies to its database. Continuous monitoring would provide data on performance and benefits for the entire region.

2.3.19 Passenger Information: Arlington County - CommuterPage Mobile Services

Background and Rationale

Arlington County's CommuterPage Mobile Services launched in Fall 2002 allows passengers to read the latest commuter news on their Palm Pilot or Pocket PC during their commute, or check bus schedules on their web-enabled cell phone while they're out on the town. Users subscribe to the service through the Commuter Page Website. In addition to receiving messages about delays and incidents and other information, customers can download schedule information. Web-enabled PDAs and/or cell phones can download the data directly from CommuterPage Mobile Services system. Otherwise, data may be downloaded to PDAs from a PC. While downloading via the PC allows the customer to download entire schedules, direct wireless communication provides only the next four scheduled arrivals.

Currently, customers do not have the option to sign up to receive information for a particular route. Instead, all users receive all messages broadcasted by the service. The County is planning, however, on making the service route-specific. The service is now being expanded by NVTC to include all Northern Virginia bus routes and Virginia Railway Express service. Transit providers in Maryland and WMATA have shown some interest in possible expansion of this service regionally but at this time there are no specific plans to do so.

Costs

The cost of the system was $30,000.

Performance/Results

CommuterPage Mobile Services currently has about 3,000 users who download information on a weekly basis. The system has great potential for growth in both variety of information provided and the number of subscribers. CommuterPage Mobile Services differs from WMATA's E-mail Alert system in that it provides schedule information. Another and perhaps more important difference is that the CommuterPage information is accessed on demand (i.e., interactively) whereas WMATA's system simply disseminates information in a one-way fashion (from agency to subscribers). Monitoring the performance of this system should help the region in its efforts to expand of the scope and variety information provided to customers.

2.3.20 Passenger Information: Arlington County Mobile Commuter Store

Background and Rationale

Arlington County started its rather unique mobile commuter store program in Spring 2002. This program consists of 2 buses that have been converted by The Redmon Group into mobile "kiosks".

Each bus is outfitted with roof-mounted satellites, point-of-sale (POS) systems to process credit card transactions, flat screen monitors and laser printers, ridematching (car/vanpool) information and signup, and other transit related information. Focus groups showed a need for commuter information and customer service in areas not currently served by the fixed location transit stores. The Mobile Commuter Store program is intended to extend the reach of these services to thousands of new customers.

The MotoSat satellite provides digital quality sound and video to the 42-inch Fujitsu plasma monitor located in the rear of the bus. Each bus is also equipped with several user stations (customer internet stations) that consist of a monitor, keyboard, and mouse. These units provide the users with a wide array of transit information.

The POS stations for purchasing fare media are located on the right side of the bus and consist of a monitor, keyboard, mouse, cash drawer, receipt printer, and a credit card swipe.

The mobile commuter units provide the following services:

Tickets, Tokens and Passes: Metrorail Passes and Farecards; SmarTrip Card; Metrobus Tokens and Passes; DASH Passes ; Ride On Tickets; OmniRide Tokens; ART-Arlington Transit Tokens for Route 90; VRE & MARC Tickets; Loudoun County Commuter Bus Tickets; Metrocheks Accepted and Exchanged; Senior/Disabled REduced Fares Available; Visa, Mastercard, AmEx and Discover Accepted

Commuter Connections: Ridematching (Car/Vanpool) Information and Signup (via a link to MWCOG's ridesharing service); Guaranteed Ride Home Program Information and Signup; Telework Information

Local and Regional Services: Commuter Bus and Train Schedules; Metro & Local Bus Schedules and Route Maps; Bike Trails Information; HOV, Slug & SmarTag Information; Ozone Action Day Programs

The mobile commuter stores rolled out in May 2002, making stops at various companies as well as at Reston Town Center and Pentagon City. The mobile stores have fixed schedules so that particular locations are visited by the mobile store the same day each week.

Costs

The cost per vehicle was about $240,000--$50,000 for each used chassis; $60,000 for equipment installed in each vehicle; and $130,000 for building the vehicle.

Performance/Results

Although no official evaluation or surveys have been conducted to measure the effectiveness of the program, the general feedback received from the users has been overwhelmingly positive, according to the County.

One of the main objectives of the program was to help reduce congestion in Northern Virginia by getting more people ride public transportation. Even though the County thinks that the cost of the vehicle may not be cheaper than renting an office space, its mobility offers convenience to customers and flexibility to the County. Furthermore, the two mobile stores sell more fares than Arlington County's smallest rented store. Monthly sales for the two mobile stores total about $3,500.

One issue that reportedly arose during implementation was the perception on the part of fixed location transit stores that the mobile stores might encroach on their "turf."

This service is certainly a unique one in the region and despite the fact that it is relatively new, it has shown a great potential in terms of acceptance by the users as well as in the amount of sales. Although the initial cost may be high, the service seems to make purchasing fare media as well as getting transit information more readily available and convenient to current as well as potential new riders. Developing a monitoring process for this system will help in examining its effect on ridership, and its potential impact on congestion, as that is one of the project's objectives.

2.3.21 Travel Demand Management: Montgomery County - Transportation Management Center

Background and Rationale

The Montgomery County Transportation Management Center (TMC) was established in 1997. Traffic technicians and transit dispatchers are co-located in one facility sharing equipment and information. They can view bus flow and speed on monitors; buses are also used as probes to report on road conditions or other incidents. Both traffic technicians and transit dispatchers have full access to cameras mounted on highways and major roadways. When an incident is reported, TMC staff immediately checks the views from the cameras at that location. If a Montgomery County Ride On bus is spotted in the vicinity of the incident, TMC staff contacts the driver by radio and asks him/her to provide information on the situation.

In August 2003, the TMC was integrated into a new Public Safety Communications Center that also includes police, 911, fire and the emergency operations center. This new center was constructed at an existing leased building.

Costs

The recent integrated Public Safety Communications Center involved an expenditure of $30 million for technology and equipment as well as remodeling at the leased building which houses the Center.

Performance/Results

The TMC allows traffic technicians to make appropriate traffic decisions to minimize congestion/traffic disruptions. The TMC also allows the staff to pull up traffic signal information and to grant more green time for buses to go through the intersection. This is mainly done when re-routing buses during incidents.

Another benefit of the TMC to Ride On is it allows transit dispatchers to see exactly where the bus is and what the situation is around it (i.e. traffic congestion). This allows the dispatchers to get the bus out of the area by giving the driver specific turn-by-turn directions.

TMC is a concept that is gaining momentum in many parts of the country. The TMC benefits all parties involved in the system—whether it is transit, traffic, or emergency services. Benefits to the transit system, for example, could include improved travel times and a decrease in accidents and response time to incidents. Monitoring and documenting benefits to all participating Montgomery County agencies should not only help the County decide on whether to maintain the TMC but also provide lessons for other jurisdictions in the area considering or developing a TMC.

2.3.22 Travel Demand Management: PRTC OmniLink - SaFIRES

Background and Rationale

The Potomac and Rappahannock Transportation Commission (PRTC) operates two transit services within Prince William County, Virginia: OmniRide and OmniLink. OmniRide is a commuter bus service that runs between various park-and-ride lots in Prince William County and Washington, D.C. OmniLink, which started in 1995, is a flexible-route (route deviation) transit service that operates along five corridors using 13 peak vehicles. Upon receiving a trip request for a location not near an existing bus stop, customer service agents determine off-route pickup/drop off locations that are within certain parameters. After off-route service is completed, buses do not have to return to the route at their point of departure as long as they serve all fixed stops. As of February 2003, 12% of OmniLink trips entailed a deviation.

For the Advanced Public Transportation Systems (APTS) operational test sponsored by the Federal Transit Administration, known as the Smart Flex-Route Integrated Real-time Enhancement System (SaFIRES), PRTC added and is adding components to OmniLink to demonstrate how intelligent transportation systems (ITS) can be a cost-effective approach to reducing automobile use (per capita vehicle trips and vehicle miles) and improving the efficiency of transit service in suburban sprawl areas, like Prince William County. The SaFIRES operational test started in Fall 1997 and officially concluded in the middle of 2002.

OmniLink, in conjunction with the SaFIRES ITS enhancements, was designed to:

- Test and implement a flexible-route bus system that would provide Prince William County's population with an attractive, convenient transportation alternative and user-friendly link to an integrated, multi-modal network.

- Provide mobility for the transit-dependent population of the Prince William County area through a single transit service rather than separate fixed-route and demand responsive services.
- Provide an attractive alternative to the single occupant vehicle, thereby reducing vehicle trips, miles traveled, and traffic congestion (and contributing toward air quality goals).
- Demonstrate through innovative technology that route deviation service can provide a cost-effective and efficient service in a low population density environment.
- Improve operational control in the day-to-day running of the system.
- Decrease the required time between requesting and providing pick-ups and drop-offs.
- Integrate new and innovative services into an existing transit mode.

PRTC has been planning on upgrading SaFIRES by adding state-of-the-art automatic vehicle location (AVL) and mobile data terminal (MDT) technologies in order to make the service more efficient and productive. "In January 2002 PRTC awarded the successor MDT/GPS contract to ARINC, Inc., and its subcontractors—Trapeze, GreyHawk Technologies, and Dynamic Concepts, Inc. The new system, which was expected to be fully operational within a month of the interview, will work as follows:

- A driver's logon triggers the downloading of the route to the GreyHawk MDTs onboard the buses. The GreyHawk MDT is a ruggedized Windows CE computer system with a 10.4-inch color touch screen used to display the combination of fixed-route stops and flex-route deviations in chronological order.
- When the deviation stop is at the top of the list, the driver leaves his or her route and drives to the deviation stop. Drivers can press a button to show a color map on the MDT screen with the destination plotted in the center. By pressing another button on the map screen, the MDT will calculate a "suggested route" and highlight the streets from where the bus is located (its GPS location shown on the display) to the destination. After completing the pickup or drop-off, the driver can have the MDT determine and display the best path to return to the fixed-route.
- For fixed-route stops and time points, the GreyHawk MDTs use the built-in GPS to detect that the bus has arrived. The screen then displays a simple method for the driver to enter the number of passengers boarding or alighting. This ridership data is stored and later transmitted for stop analysis. As each fixed-route stop or deviation stop at the top of the list is completed, it is removed from the list, and the remaining stops scroll up to the top.

The MDTs also allow the drivers to send messages to dispatch. These can be "canned" messages that are used over and over, or custom messages typed using the keyboard provided on the touch screen. Dispatch can send messages to the drivers that will "pop up" on the driver's display, as well as trip cancellations and insertions (add-ons) to modify the driver's route in real time.

The MDT also transmits automatic vehicle location (AVL) and schedule adherence data back to dispatch every two minutes (this parameter is changeable). The vehicle location and on-time status are displayed on maps at dispatch workstation monitors. Vehicle icons show the location, direction, and color-coded on-time status at a glance. Filtering is used to show, for example, “only the vehicles running late.” The system is fully integrated with the Trapeze Flex routing and scheduling software.”[7]

Costs

The total project budget was $5.0 million. The federal government funded approximately $1.2 million; PRTC provided about $3.4 million in matching funds.

Performance/Results

The following are among the benefits PRTC has (or expects to be) realized from ITS.

“Same day reservations for flex-route service –Using the central computer system that tracks reservations and on-street activity (such as vehicle location, on-time performance, passenger boardings and alightings, etc.), customer service agents (CSAs) can quickly determine the best times and vehicles to handle requested pick-ups and drop-offs. Same day reservations (two hours advance notice) make OmniLink flex-route service more convenient and attractive to all riders, including “choice” riders (those who have an automobile alternative). It permits riders to be more spontaneous in requesting service (formerly, trips had to be reserved one to two days in advance). This service has been operational since Spring 1997.

Improved customer communication - With the ITS enhancements customers can make reservations and receive trip details in one phone call for both advanced and same day service. Previously, reservations were taken in one phone call, all the trips were then scheduled, and customers were then called back with detailed information on their reserved trip. Once the AVL/MDT system is operational, “real-time” reservation capability will also allow CSAs to offer multiple options (trip time, pick-up and drop-off location, etc.) that are efficient for PRTC to serve with the customer determining the itinerary that best meets his/her needs. Response to inquiries regarding on-time performance will be improved as each vehicle can be “polled” electronically to determine exact location (via GPS) without driver involvement. This will make it easier for customers to find out whether their vehicle is operating on schedule.

Improved fleet tracking - Using GPS, the system will compare actual time with scheduled time and automatically notify the dispatcher when vehicles are running late. With this information, the dispatcher can take corrective action to get the vehicle back on schedule either by modifying the itinerary, having another vehicle assist or introducing another vehicle, if available. This enhancement will be particularly important because the dispatcher will always know where vehicles are located and when they are running late, without any verbal communication between the driver and dispatcher. Emergency response will also improve since the GPS signal will provide the vehicle’s exact location.

Increased efficiency and ridership - ITS technologies are expected to increase system ridership. Being able to accept same day reservations will allow PRTC to schedule trips when vehicles have excess time in the schedule. This will provide a “win-win” situation both for PRTC and riders with flexible schedules desiring same-day deviation service. The new system will also allow PRTC to fill holes created by same day trip cancellations.

Enhanced operating data and automated collection - With all travel information to be captured in the system database, a wealth of historical data will be available. PRTC will be able

[7] Ibid

to quickly and easily track such information as route and bus stop on-time performance and ridership to aid in improving service and making needed route and timing modifications. The database will also simplify National Transit Database (NTD) reporting.

Improved working environment – Automation has made CSAs' jobs easier and less stressful than the cumbersome, time-consuming "paper" process. Since agents can "negotiate" with customers at the time they make a reservation, they no longer have to deal with customers who are subsequently disappointed because pick-up is not available at the exact time they requested. Drivers will be relieved of the requirement of accurately completing paper manifests, since the MDTs will automatically transmit time and location data whenever a message is sent. In-vehicle map, navigation, and routing instructions will reduce the stress associated with locating a new off-route point and improve on-time performance by cutting down on time spent looking for unfamiliar locations."[8]

OmniLink service, in conjunction with the flexible-routing software application, has had positive impact. From a recent survey, PRTC concluded the following:

- 12% of the riders formerly drove alone to shop
- 34% of riders own a car
- 74% like the flexible aspect although 76% don't use the deviation feature
- 89% of riders rated the service as either "excellent," "good" or "average"
- Estimated annual savings versus providing both fixed route and paratransit - eight vehicles, 62 daily service hours (additional 50% expenditure to operate both systems)

The accomplishments of SaFIRES so far indicate a very promising solution to accommodating current riders' needs as well as to attracting new riders. Even before the ITS features were implemented, OmniLink flexible routes had an approval rate of 89% and were effective in attracting new riders to transit. With the current installation of the ITS features, it is anticipated that OmniLink will achieve higher efficiency and productivity. To evaluate these potential achievements, it is important that ridership, trip length, passengers per vehicle and on-time performance be monitored. The monitoring process should also provide an excellent opportunity to examine how the systems provided by these vendors perform. Other agencies in the region, whether or not they are implementing flexible routing , should benefit from this information.

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[8] Eric Marx, " PRTC's Innovative Local Transit Services and ITS Project", February 2002, PRTC

2.4 Consumer Response to Transit ITS in Northern Virginia

While market research has been a part of the ongoing monitoring of service to customers in the region, and has been particularly extensive at Metro and VRE, this study incorporated a specific survey effort to gauge customer response to all the transit ITS deployments in Northern Virginia that customers could be aware of. Specifically, the survey instrument addressed the following:

- Demographic and socioeconomic characteristics;
- Use of computers and the Internet;
- Attitudes towards the current use of technology on transit;
- Importance of various uses of technology;
- Behavior changes as a result of transit ITS;
- Familiarity with and frequency of use of various ITS applications in Northern Virginia; and
- Usefulness and ease of use of ITS applications.

Overall, the survey respondents were widely supportive of the current use of technology on transit services in the region and to a large extent of expanded use of technology. The currently offered transit ITS applications have generally been viewed as useful and there is widespread feeling that they are easy to use. This represents an important accomplishment for the region.

The following describes the survey methodology and findings.

2.4.1 Survey Sample

Surveys were distributed to Northern Virginia transit riders at a number of large transit stations, including Metrorail and Virginia Railway Express stations where passengers also transfer to and from Metrobus and local bus routes. Over 14,000 surveys were distributed over the course of several weekdays. Approximately 16% of the transit riders who received the questionnaire responded, resulting in a total sample size of 2,292. Characteristics of the respondents, including demographics and computer/internet usage, are described later in this paper.

The survey sample had two potential sources of bias: frequency bias and the non-random nature of the sampling methodology. Frequency bias may have occurred because the survey was distributed on a single day at each specific location. Thus, the survey may be skewed towards frequent riders. To correct for the bias, information obtained from the respondents on their frequency of use was used to weight the data. The result of the weighting was to boost the effect of less frequent riders and decrease the effect of the frequent riders.

Another potential source of bias was in the non-random nature of the survey sampling methodology, which involved surveying transit riders at certain rail stations. The survey sample may thus have been biased toward riders on some services and against others. For example, by surveying riders at rail stations, the survey was biased against bus riders who do not use rail. However, since so many bus riders use buses to access the rail system, it was decided that the survey captured a sufficient sample of bus riders to provide useful feedback on the consumer reactions to transit ITS services offered on the region's bus systems. Table

11 shows the number of individuals in the sample that reported that they use the various transit services available in Northern Virginia.

Table 11: Use of Northern Virginia Transit Services

	Frequency	Percent
Metrorail	2190	96.39%
Metrobus	701	30.85%
Fairfax Connector	350	15.40%
DASH	290	12.76%
VRE	160	7.04%
CUE	82	3.61%
ART	54	2.38%
Falls Church GEORGE	24	1.06%
MetroAccess	23	1.01%
PRTC/OmniRide/OmniLink	22	0.97%
None of the Above	7	0.31%
Loudoun County Transit	6	0.26%
FASTRAN	5	0.22%
STAR	4	0.18%
Loudoun Transit (VRTA)	1	0.04%

While the overall sample may not have reflected the distribution of riders among the various transit services in Northern Virginia, the sample could still be used to obtain meaningful information about the wide variety of ITS services offered on transit in Northern Virginia; this was done by excluding riders who do not use a particular transit service from tabulations of questions relating to ITS services on that transit service.

Residents of the major jurisdictions of Fairfax County, Arlington County, and the City of Alexandria were well represented in the sample. Loudoun County was not well represented, nor were the City of Fairfax and the City of Falls Church. Figure 1 contrasts the residential distribution of the sample, for the major jurisdictions, with the population distribution. Since the use of transit varies by jurisdiction, this comparison is not a perfect assessment of the sample's representativeness. While our sample would seem to under-represent Loudoun and Fairfax Counties in favor of the Cities of Alexandria and Fairfax and Arlington County, our sample most likely reflects the lower use of transit in the former and the higher use of transit in the latter.

2.4.2 Attitudes Toward Transit ITS Technology in Northern Virginia

Respondents were asked a general opinion question about transit agency use of new technologies for information and fare payment in Northern Virginia. As can be seen in Figure 2, the overall response was supportive of the use of technology, with almost 80% responding that either the current use of technology was sufficient or greater emphasis on technology was needed. Only 4% of respondents felt that there was too much emphasis on technologies.

To evaluate some of the differences in opinions among subgroups of the sample, the response to this question was also tabulated with regard to residential jurisdiction, age, household income and computer access. In general, there was not a great deal of difference evident among the subgroups. The exception was with regard to respondent age and computer use. Older (60 and over) respondents seemed somewhat less interested in greater use of new technology than younger respondents. In fact, whereas only 2-4% of respondents under age 60 thought there was too much emphasis on technology, close to 10% of respondents over the age of 60 held this opinion. Likewise, respondents without access to a computer were somewhat more likely to think there was too much emphasis on technologies (12% without access vs. 4% with access), or to not have enough information to respond to this question. However, the vast majority of these respondents were still supportive of the use of technology on transit.

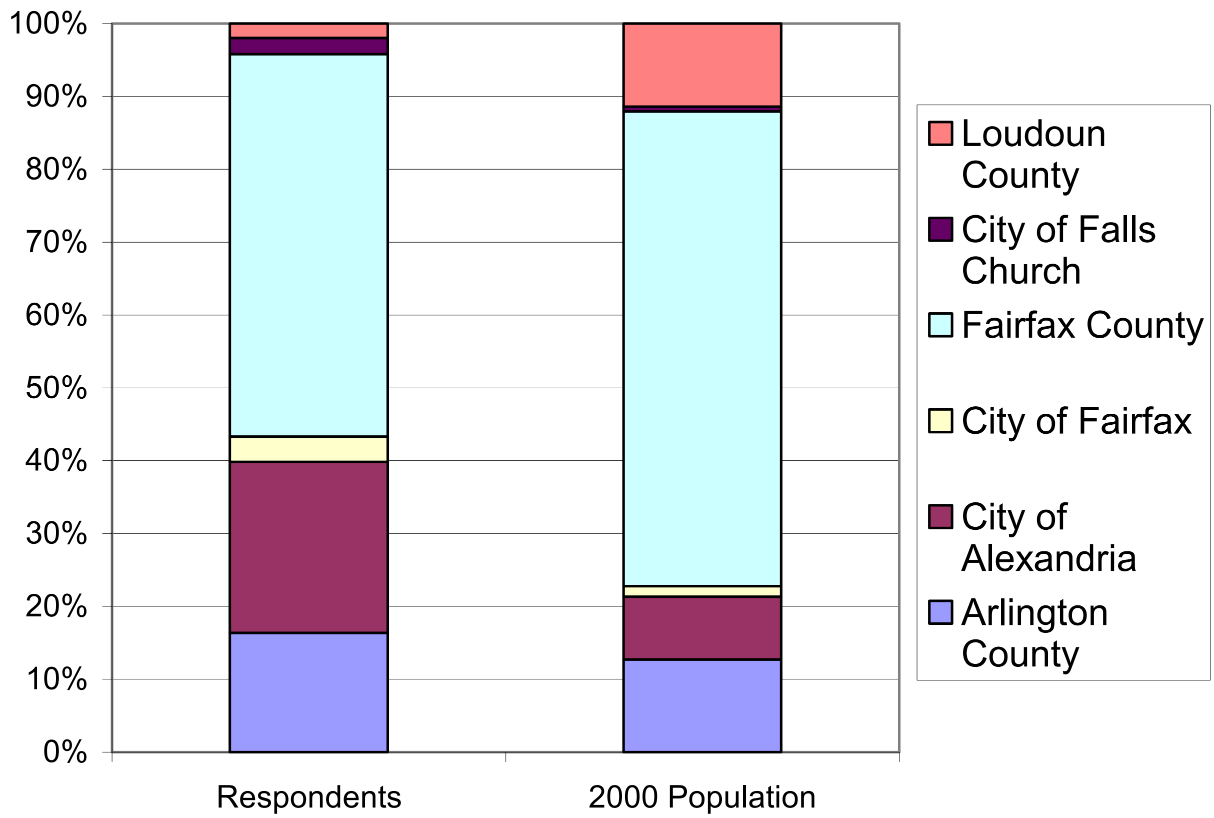


Figure 1: Residential Distribution of Major Jurisdictions vs. Population

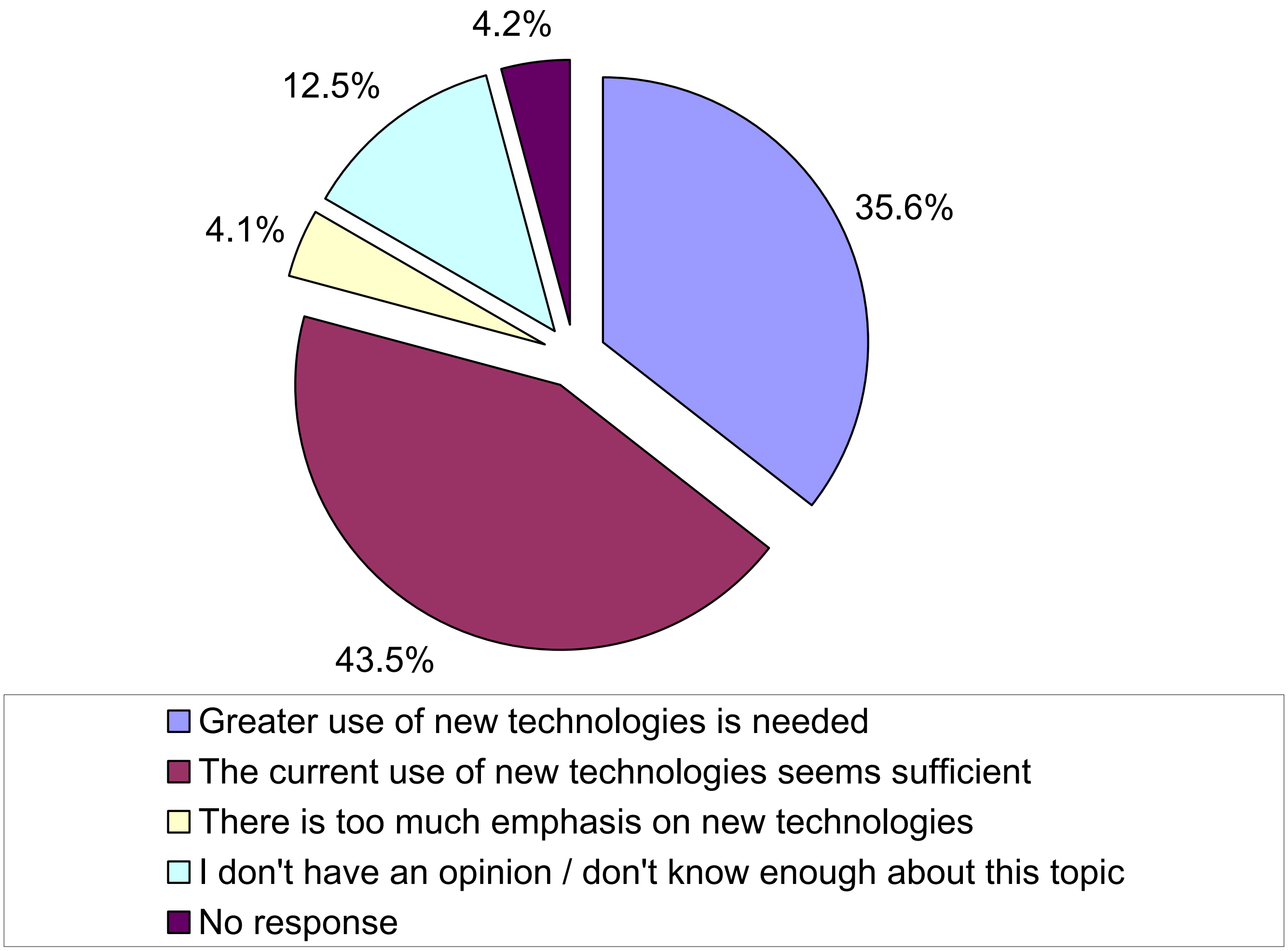


Figure 2: Opinions on Use of New Transit ITS Technologies

2.4.3 Importance of Various Uses of Technology

Respondents were asked to select the three most important uses of new technology from a list of choices. As shown in Figure 3, the most important by far (71.5%) was to "ensure service reliability (on-time arrival)". This was followed by another time-related measure – "reduce overall travel time" (45.5%). Following these two categories were issues related to safety and security, namely "ensure safe movement of trains and buses" and "ensure everyday personal security". Another safety issue ("handle emergency situations") was ranked sixth, after "provide more accurate and convenient information." If all the safety and security goals were pooled, the combined category would be second in importance (69.3%).

Cross-tabulations for this question were done to identify the differences in opinion among subgroups of the population distinguished by age, income, frequency of riding transit, and access to computers and the Internet. The most noticeable difference was by age group, in which the younger respondents (age 35 and under) seemed more concerned about travel time and reliability and less concerned about safety and security. Some difference was also observed between frequent and infrequent transit riders (frequent rider was defined as one who rides three or more days per week). Infrequent riders were more likely than frequent riders to see as important the use of technology to address everyday personal security. Frequent riders focused a bit more on handling emergency situations, providing accurate and convenient information, and ensuring reliability (on-time performance).

Additionally, opinions on a couple of the uses of technology exhibited significant differences with regard to respondents' computer access. Because of the relatively small sample of persons without computer access, we performed a chi-square test of statistical significance on cross-tabulations conducted with respect to this subgroup. This test showed (to a level of statistical significance) that respondents without computer access were more concerned about everyday personal security, better customer service, and anxiety about traveling on transit than those with access to a computer.

2.4.4 Behavior Changes As a Result of Transit ITS Technology

Respondents were asked how their use of transit ITS technology had changed their behavior. As shown in Figure 4, nearly half reported no change in behavior. Nevertheless, considerable shares of respondents reported some changes. The next largest share (29%) reported sometimes making adjustments to their route, time of departure, or means of travel. Another 14% said they traveled on transit more frequently as a result of new technologies. Only 4% reported a permanent change to their usual route or means of travel.

There were some differences in the response to this question by age group. Younger riders were more likely to say that they "sometimes adjust their route, time of departure or means of travel" (40.6%) while they were less likely to say there was no change in their travel behavior (44.0%). In contrast, the oldest group (aged 60 and over) was less

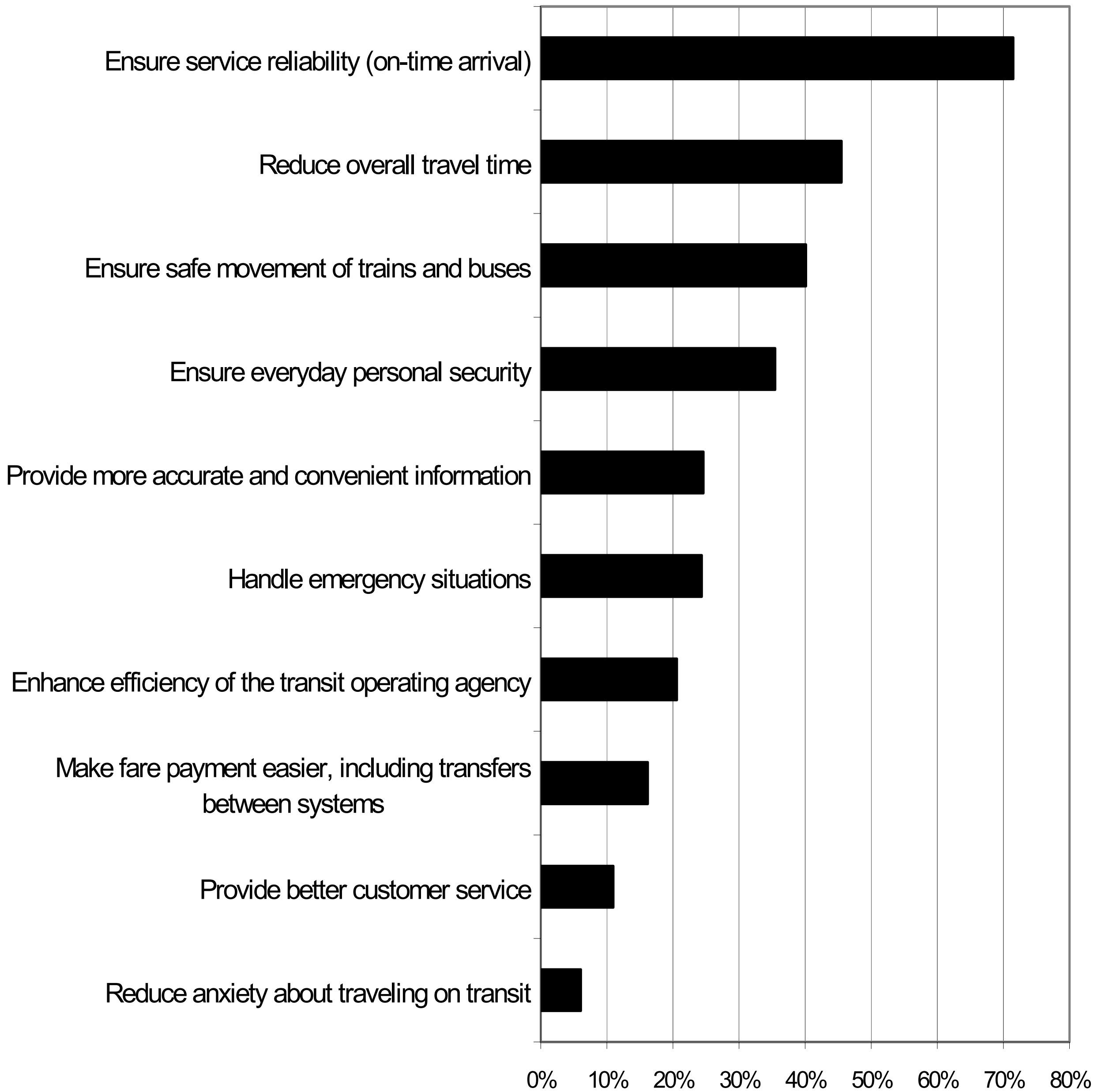


Figure 3: Importance of Uses for New Transit Technologies

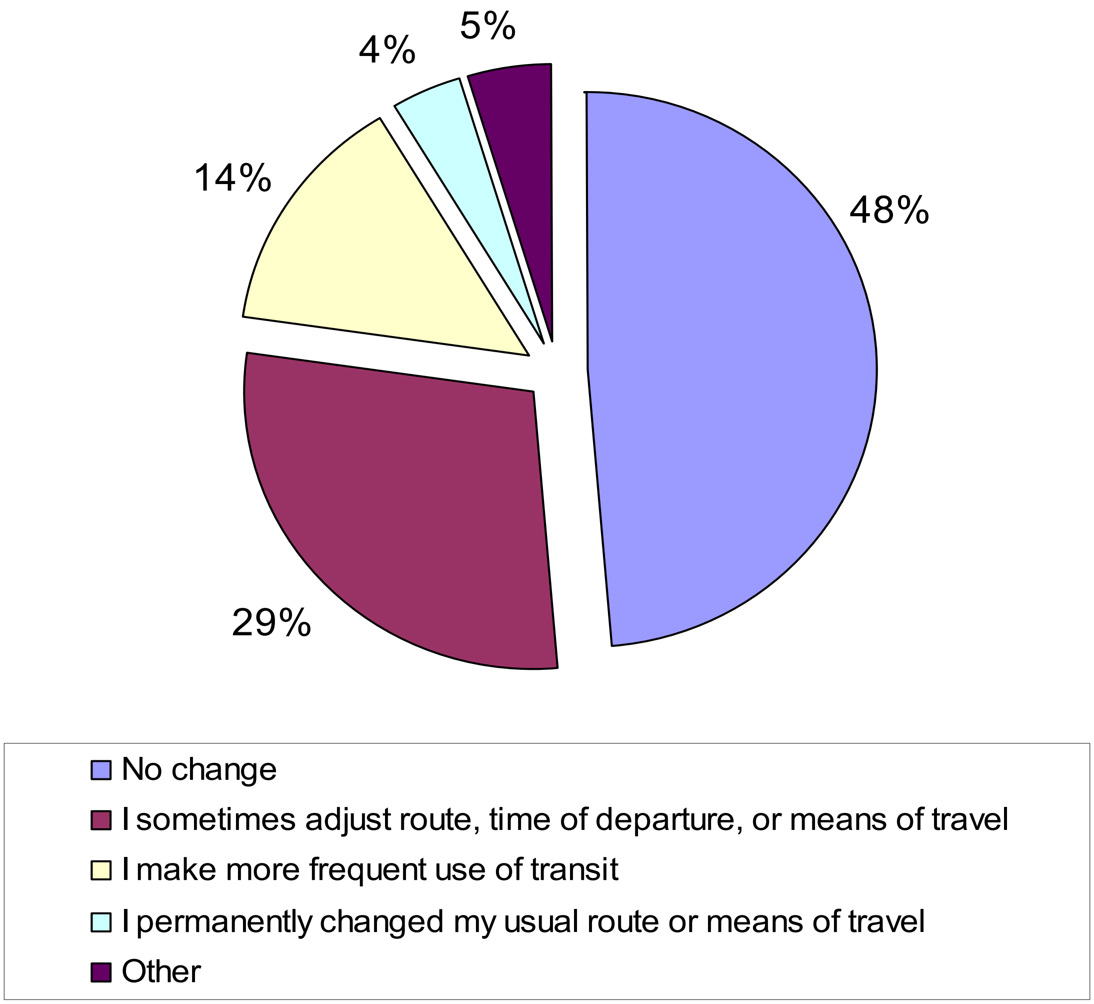


Figure 4: Behavior Changes Due to Use of New Technology

likely to report occasional changes (22.3%) and most likely to report no change (62.2%) in their travel behavior.

Additionally, there were some statistically significant differences between respondents with and without access to a computer. Respondents without access to a computer were less likely to say that they "sometimes adjust their route, time of departure, or means of travel" (14.1%), but more likely to report using transit more frequently as a result of technology (23.1%).

2.4.5 Familiarity with Specific Transit ITS Applications

Respondents were asked if they were familiar with each of the transit ITS applications in Northern Virginia. Some of these applications, such as the Ride Guide Itinerary Planner, serve all transit riders, while others are only of use to those who ride a particular transit system, like CUE's NextBus Dynamic Message Signs showing Real-Time Bus Arrival Information. Those applications that are specific to riders of a specific system were analyzed using responses only from those who indicated that they ride that system. Those that were available to all were analyzed for all riders. Some services provided by Metro were also analyzed using responses from Metrobus, Metrorail and MetroAccess riders only. The responses (for weighted data) are shown in Figure 5.

Many applications had relatively high awareness levels, such as Metrorail Passenger Information Display Signage (97%) and Metrorail on-board audio and visual announcements (93%). Of course, these services require no special action on the part of the user since all riders are automatically exposed to them. Similarly, CUE on-board audio and visual announcement had high awareness among CUE riders (86%).

Other features with high awareness levels included:

- VRE automatic ticket vending machines (78%);
- SmarTrip fare payment on Metrorail (76%);
- VRE Train Brain website (69%);
- Metro Ride Guide (64%); and
- Metrobus/GEORGE bus on-board audio and visual announcements (58%).

Several ITS applications had relatively low awareness levels, including:

- Metro Automated Interactive Voice Response (IVR) Telephone Information (23%);
- Metrorail e-mail alerts;
- Arlington CommuterPage.com;
- Commuter Connection website; and
- CUE NextBus information via cell phone or PDA.

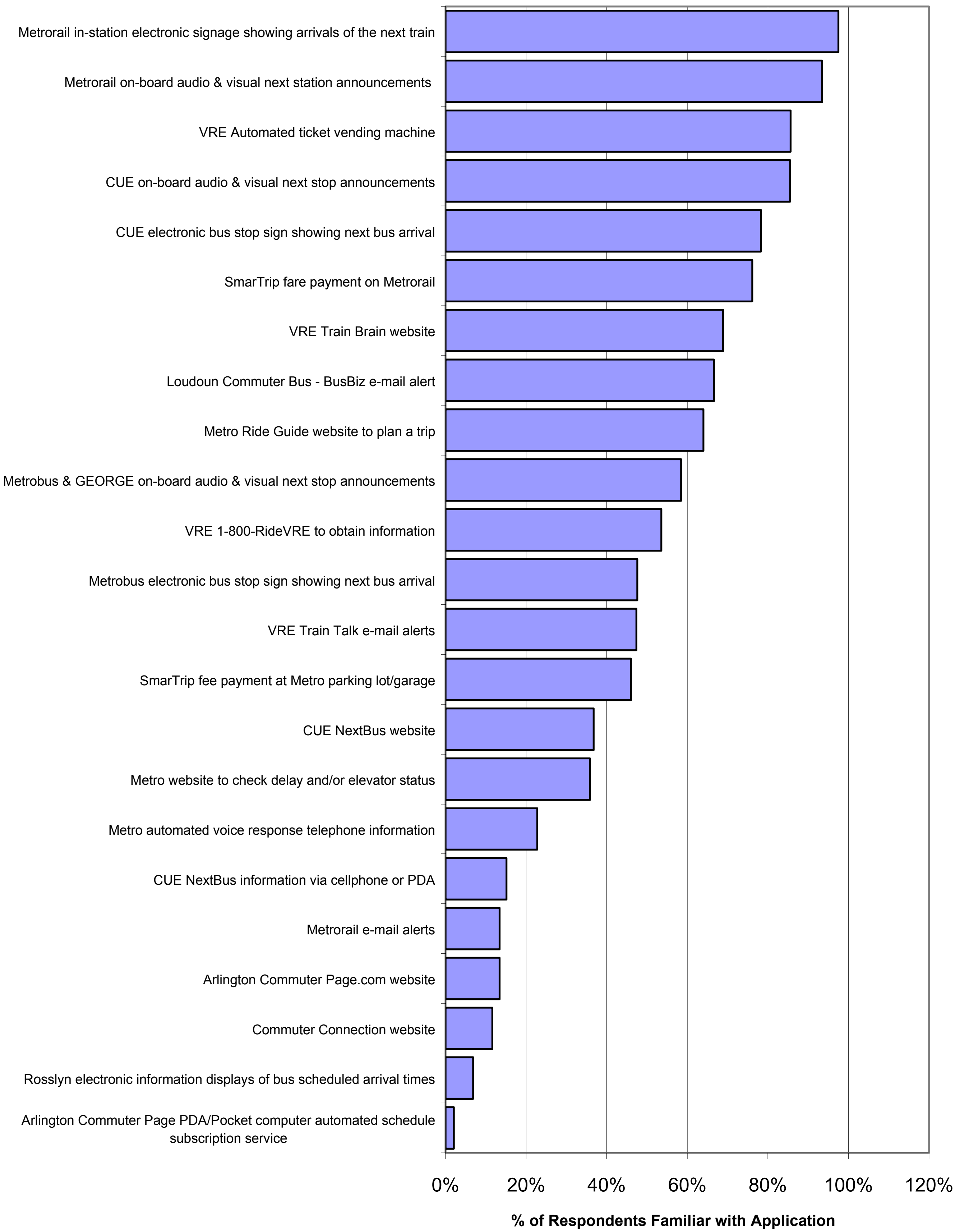


Figure 5: Familiarity with Transit ITS Applications in Northern Virginia

However, Metro's IVR system and the e-mail alerts are relatively new services, which may partially account for their low awareness levels. Similarly, low awareness levels of CUE's NextBus information via cell phone or PDA may be due to the fact that this service is likely not be of interest to those without Internet service on their cell phones or PDAs. Additionally, while the overall awareness of the arrival time information signs in Rosslyn was low, there was somewhat higher awareness among Arlington residents (15%).

While it was interesting to note the overall awareness of ITS applications that require the use of a wireless device such as a cell phone or PDA, we thought it would be of particular interest to isolate the responses of those individuals who own one of these devices. We found that of the 43 CUE riders who own a cell phone or PDA, only 14% were aware of the CUE NextBus information available via these devices. The Arlington Commuter Page PDA/Pocket computer automated schedule subscription service had even lower awareness among Arlington residents who own a PDA (3%).

It is also interesting to compare the awareness levels of the Ride Guide website and the Interactive Voice Response (IVR) Phone Service since these are alternative means of accessing the same information. Ride Guide has been in service longer than the IVR phone service, although the phone service had been operated with a push button menu for some time before the IVR was introduced during Fall 2002. The survey showed that more respondents were familiar with the Ride Guide website than with the IVR. The vast majority of those familiar with only one of the two services was familiar with the website only (46% familiar with website only vs. 5% familiar with IVR only).

2.4.6 Frequency of Use of Specific Transit ITS Applications

Those who were familiar with the services listed were then asked how often they used the ITS applications. Table 12 shows the weighted results of this question (only for respondents who claimed familiarity with the application). The reader should note that the applications with a sample size smaller than 10 for this question have been eliminated from the table.

Among the applications with higher response levels, the highest frequency of use was found to be for Metrorail in-station electronic signage, Metrorail on-board audio & visual next station announcements, and Metrorail SmarTrip fare payment. The former two require no action on the part of the rider, so most Metrorail commuters naturally reported very frequent use. For SmarTrip, the results show that the application has been accepted well by commuters. Naturally, those who have SmarTrip would use it whenever they ride.

Table 12: Frequency of Use of Transit ITS Applications

	Sample Size	Total Never	4 or fewer days/month	1-4 days/week	5+ days/week
Metro Ride Guide website to plan a trip	1,353	24.69%	69.62%	4.88%	0.81%
Metro website to check delay and/or elevator status	724	55.94%	37.02%	4.83%	2.21%
Metro automated voice response telephone information	454	49.12%	44.71%	3.96%	2.20%
Metrorail in-station electronic signage showing arrivals of the next train	1,886	0.95%	21.21%	18.61%	59.23%
Metrorail on-board audio & visual next station announcements	1,784	2.30%	24.05%	19.90%	53.76%
Metrobus electronic bus stop sign showing next bus arrival	233	21.46%	31.76%	16.74%	30.04%
Metrobus & GEORGE on-board audio & visual next stop announcements	309	8.41%	37.86%	25.57%	28.16%
Metrorail e-mail alerts	231	58.44%	14.29%	10.39%	16.88%
SmarTrip fare payment on Metrorail	1,477	24.71%	13.61%	10.09%	51.59%
SmarTrip fee payment at Metro parking lot/garage	869	37.40%	24.28%	9.32%	29.00%
VRE Train Brain website	98	7.14%	64.29%	19.39%	9.18%
VRE Train Talk e-mail alerts	85	36.47%	12.94%	24.71%	25.88%
VRE 1-800-RideVRE to obtain information	76	27.63%	65.79%	6.58%	0.00%
VRE Automated ticket vending machine	124	8.06%	58.06%	16.13%	17.74%
CUE electronic bus stop sign showing next bus arrival	47	4.26%	55.32%	19.15%	21.28%
CUE NextBus website	24	37.50%	41.67%	8.33%	12.50%
CUE on-board audio & visual next stop announcements	52	1.92%	55.77%	19.23%	23.08%
Arlington Commuter Page.com website	32	43.75%	46.88%	6.25%	3.13%
Rosslyn electronic information displays of bus scheduled arrival times	93	54.84%	31.18%	9.68%	4.30%
Commuter Connection website	173	40.46%	53.18%	4.05%	2.31%

Perhaps more surprising is the fact that several other applications have achieved significant use, including Metrobus electronic bus stop signs (surprising since they have only been implemented on Columbia Pike), Metrobus (& GEORGE) onboard automated announcements, SmarTrip parking fee payment, VRE Train Talk e-mail alerts, CUE onboard automated announcements, and CUE NextBus signs. Of course SmarTrip parking fee payment is only relevant to those who drive to Metrorail, so the actual use of SmarTrip for parking fee payment may be higher as a percentage of such riders. Much lower usage rates were found for websites such as Ride Guide, Train Brain, the Metro website, and Commuter Connection, as well as the Metro automated IVR phone system and the 1-800-RIDE VRE phone system. However, given the nature of the Ride Guide, the IVR phone system, and Commuter Connection, one would expect that they would be used on a more occasional basis.

Metrorail e-mail alerts are relatively new and there appeared to be a high percentage of non-users (58%) and relatively few frequent users (17%). VRE Train Talk e-mail alerts, which have been around for a couple of years, showed only 36% non-users and higher shares of frequent users (26%). It is surprising that the percentage of non-users is so high, since the number of subscribers is reportedly quite high relative to the daily ridership. The Train Talk experience may represent an upper bound for use of e-mail alerts since it is a more mature application and the ridership is made up of regular commuters, while Metrorail has a more diverse ridership profile.

2.4.7 Usefulness of Specific Transit ITS Applications

Those who had used each application were asked how useful they thought it was. One way to look at this data is to compare the average or mean rating based on the semantic scale used (where 1 is not useful and 5 is very useful). The results are shown in Figure 6 (sorted in order of usefulness). By and large, the respondents rated all of the applications quite useful. Most applications received an average rating of 4.0 or more, indicating they were somewhat or very useful.

2.4.8 Ease of Use of Specific Transit ITS Applications

Those who had used each application were also asked how easy it was to use. The results are shown in Figure 7 (in order of ease of use). As can be seen in the figure, the respondents overwhelming rated ease of use high and the range was rather narrow (84-100%). The 100% ratings were typically in situations with very small samples. Even some applications with more reliable, large samples had very high ratings, such as SmarTrip payment of Metrorail fares and parking fees, Metrorail electronic signs (PIDS), and Metrobus/GEORGE annunciation systems. Systems that require more user actions such as Ride Guide and other websites received somewhat lower but still very high ratings.

It is interesting to compare the ease of use attributed to the Ride Guide website and the IVR phone system. Those who were familiar with both systems and used them were candidates for this comparison: a total of 123 individuals. Most (78%) rated both as easy to use, while only 3% rated both as not easy to use. Among those 23 individuals that

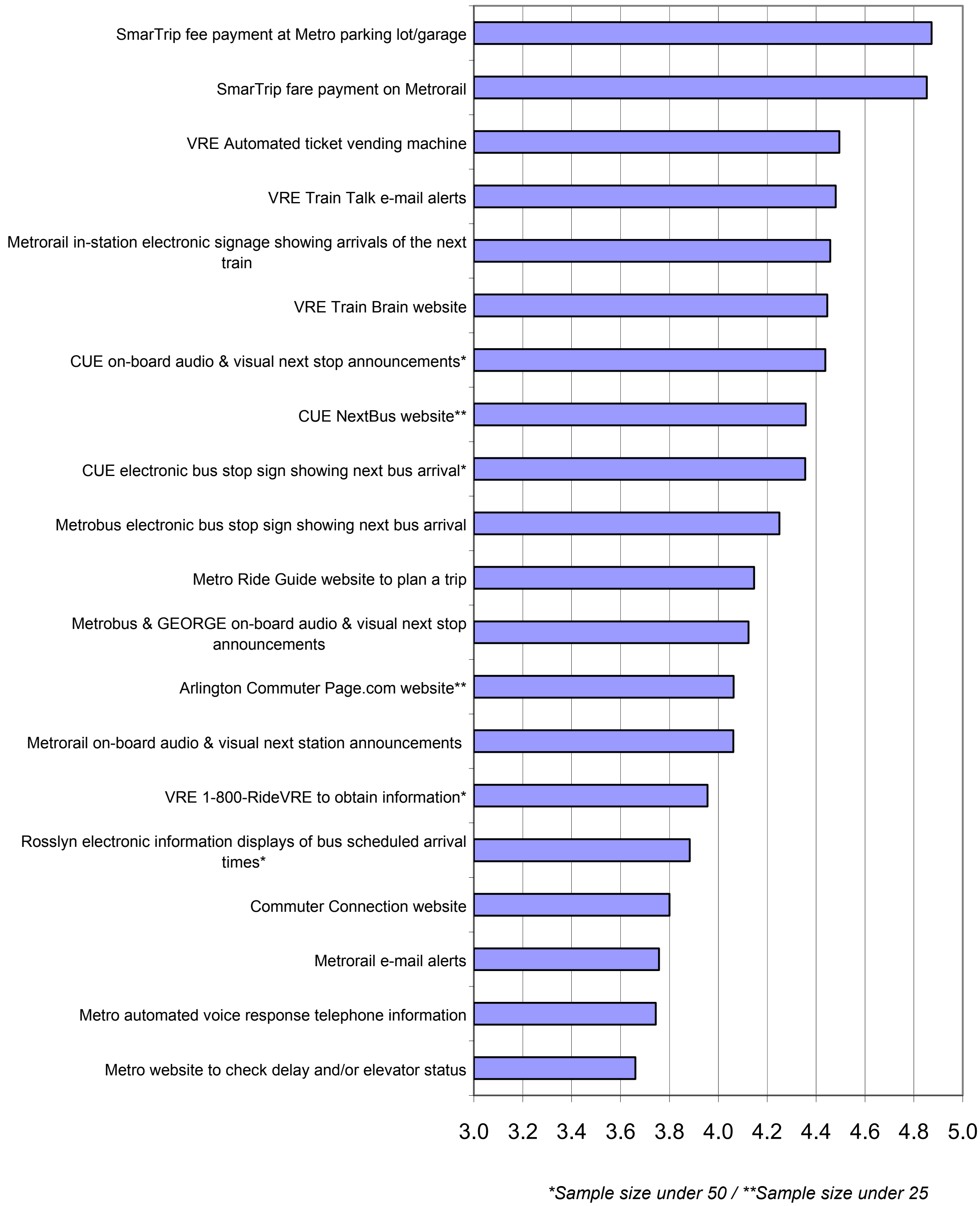


Figure 6: Mean Ratings of Transit ITS Application Usefulness

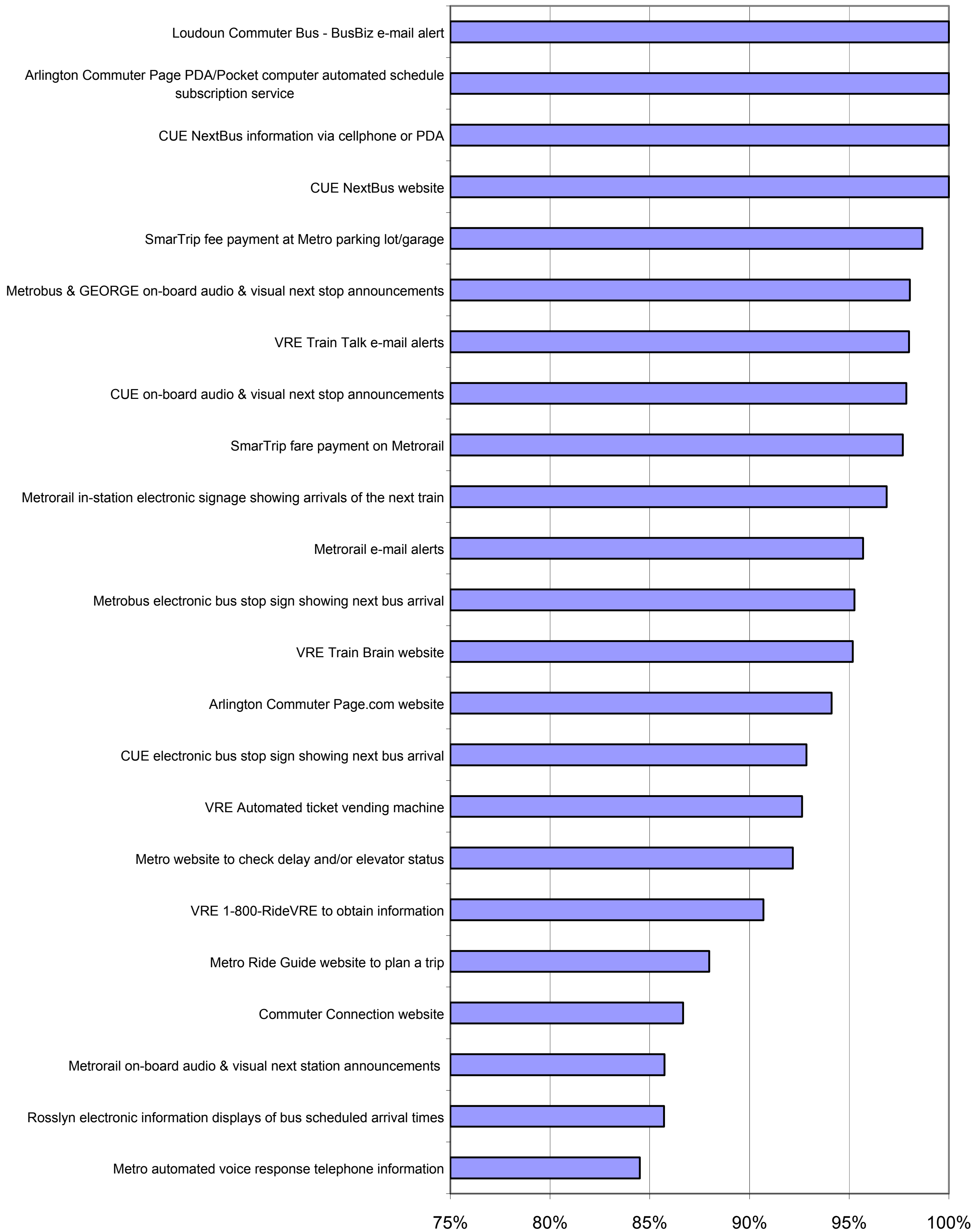


Figure 7: Ease of Use of ITS Services by Users of Specific Transit Services

rated only one system easy to use, the majority (19) rated the Ride Guide website as easy to use. While this is too small a sample to draw a conclusion, it is still interesting to note that the website was rated easy to use by more individuals than the voice response phone system.

2.4.9 Characteristics of the Sample

Demographic characteristics provide a profile of the respondents that is useful for two purposes: 1) to assess the representativeness of the sample when compared with other available data on transit riders, and 2) once representativeness is established, to investigate the influence of the demographic characteristics on the attitudes that are the subject of this survey. Figure 8 shows the age distribution of the survey sample. The sample, not surprisingly, was largely comprised of individuals who are of typical working age. Only a tiny share were 18 or under and only 5.4% were under the age of 25. The share of persons aged 65 and over was about 9%, while the share between 25 and 64 was 85.6%. About 1/3 each were in the age groups of 35-49 and 50-64.

In order to evaluate the representativeness of the sample with regard to age, it is interesting to compare it to both Census information and data collected in other survey efforts. According to the 2000 Census, the age distribution in the Northern Virginia region (the Virginia portion of the Washington PMSA) exhibits greater shares than the sample of youth and elderly. Similarly, when compared with a 2000 survey of Virginia bus riders conducted by NVTC and WMATA, the ITS survey sample seems to be older than the Virginia bus riders, with fewer in the under 35 group (26% vs. 44%) and more in the over 50 age group (41% vs. 22%).

The income levels of respondents to the ITS survey were quite high – 40% reported household incomes of $100,000 or more and a total of 63% reported incomes of $70,000 or over. Very few were in the lower income category – only 3% reported incomes under $20,000, as shown in Figure 9. Of course, household incomes are quite high in the Northern Virginia region. Data from the 2000 Census indicates that nearly 21% of Fairfax County households have incomes of $100,000 or more, as do 14% in Arlington County and 12% in both Loudoun County and the City of Alexandria. The fact that such a high percentage of respondents are in the highest income group may be due to the high incomes of those who commute to the region's core and ride the Metrorail and VRE services. As another means of comparison, data on Metrorail rider income was available from a Customer Satisfaction Telephone Survey conducted in the third quarter of FY2003. The distribution of income in that study was nearly identical to that shown for the current survey effort.

The survey included questions on the use of computers and the Internet, factors that might make some respondents more disposed to the use of transit ITS applications. As can be seen in Figure 10, the vast majority of respondents made use of computers at work and/or at home – over 97% used a computer at one or the other and the vast majority used computers at both locations. Cell phones were also widely used (76%). Use of pocket computers was much less used at only 25%. Virtually none (less than 2%) of the respondents reported that they used <u>none</u> of these devices.

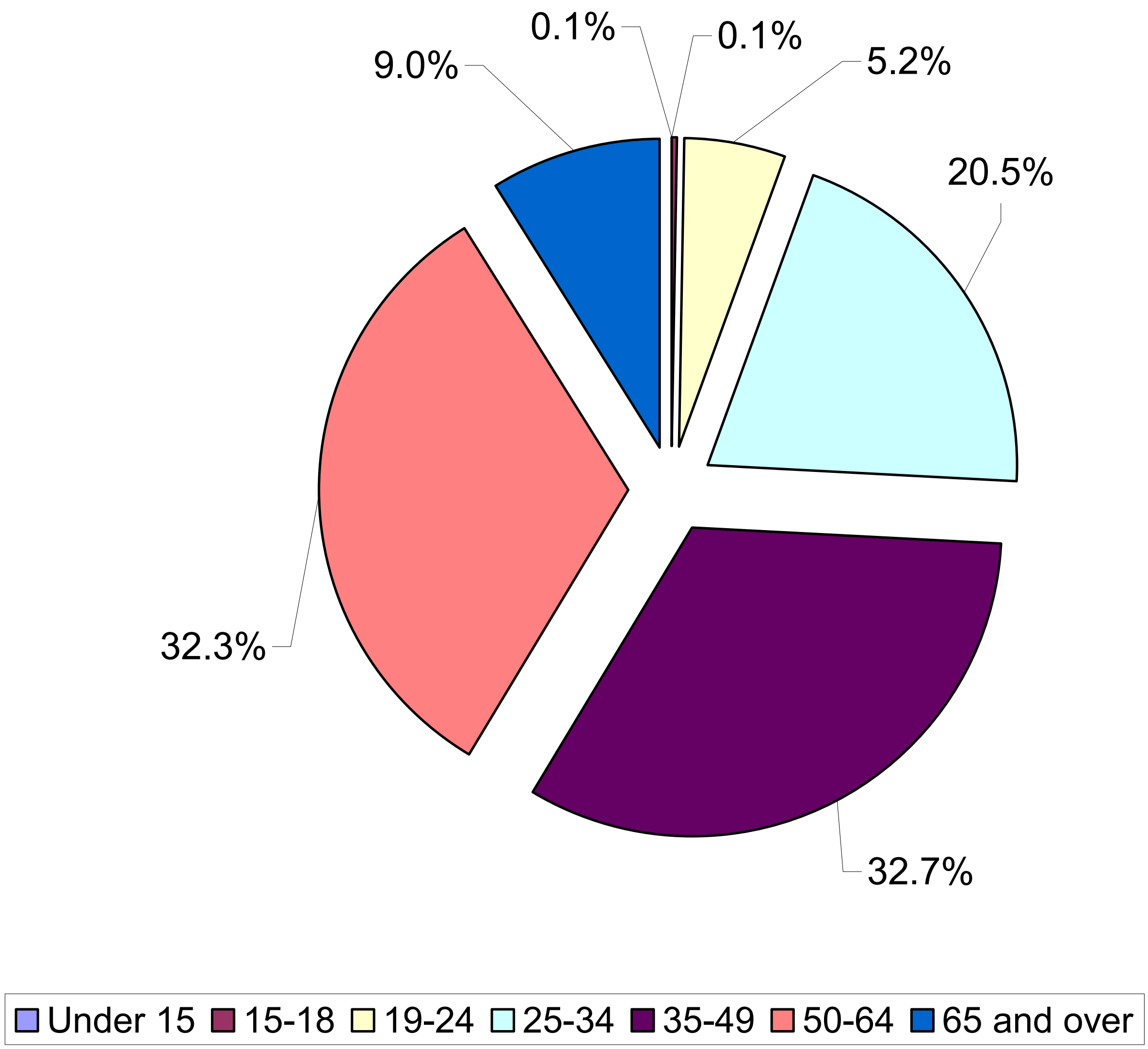


Figure 8: Age Distribution of Survey Respondents

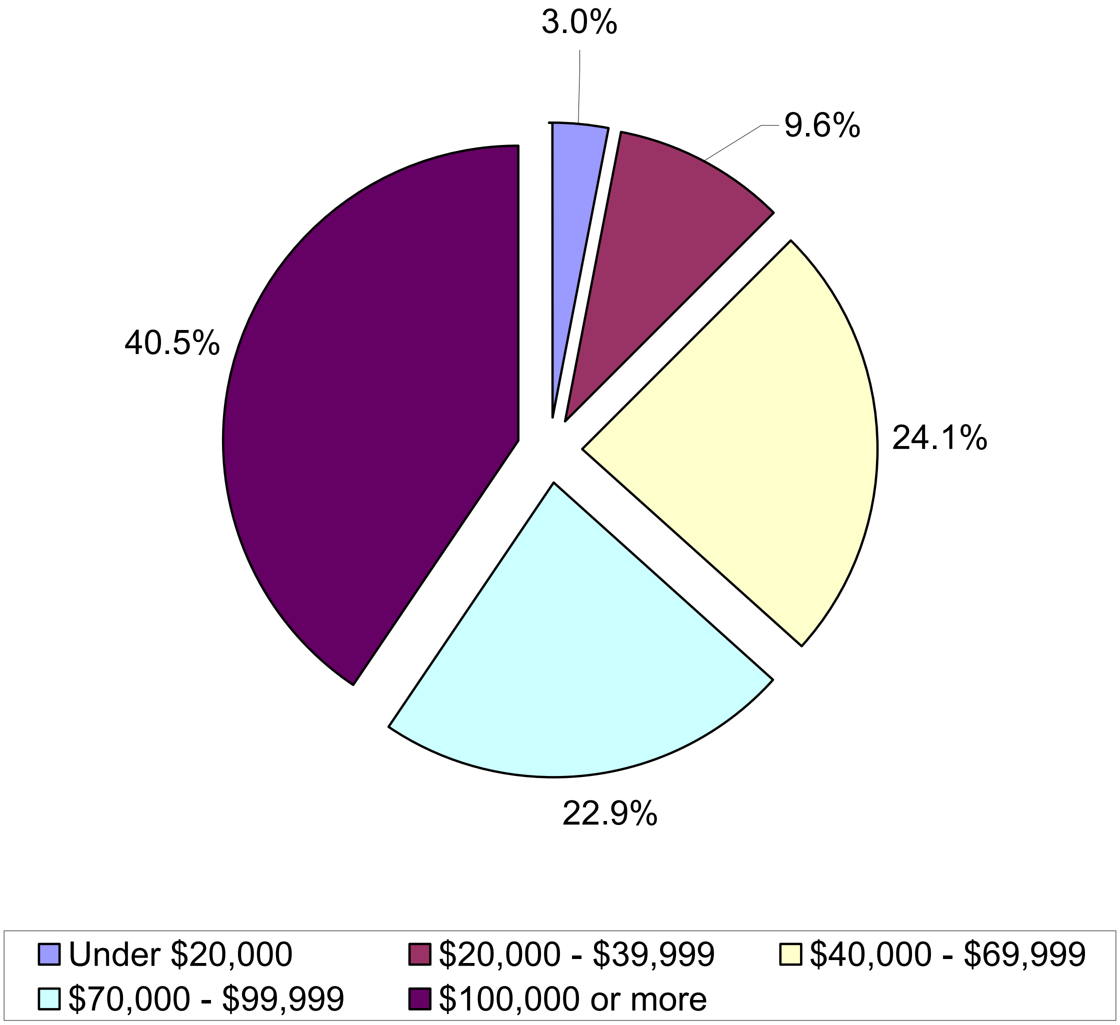


Figure 9: Income Distribution of Survey Respondents

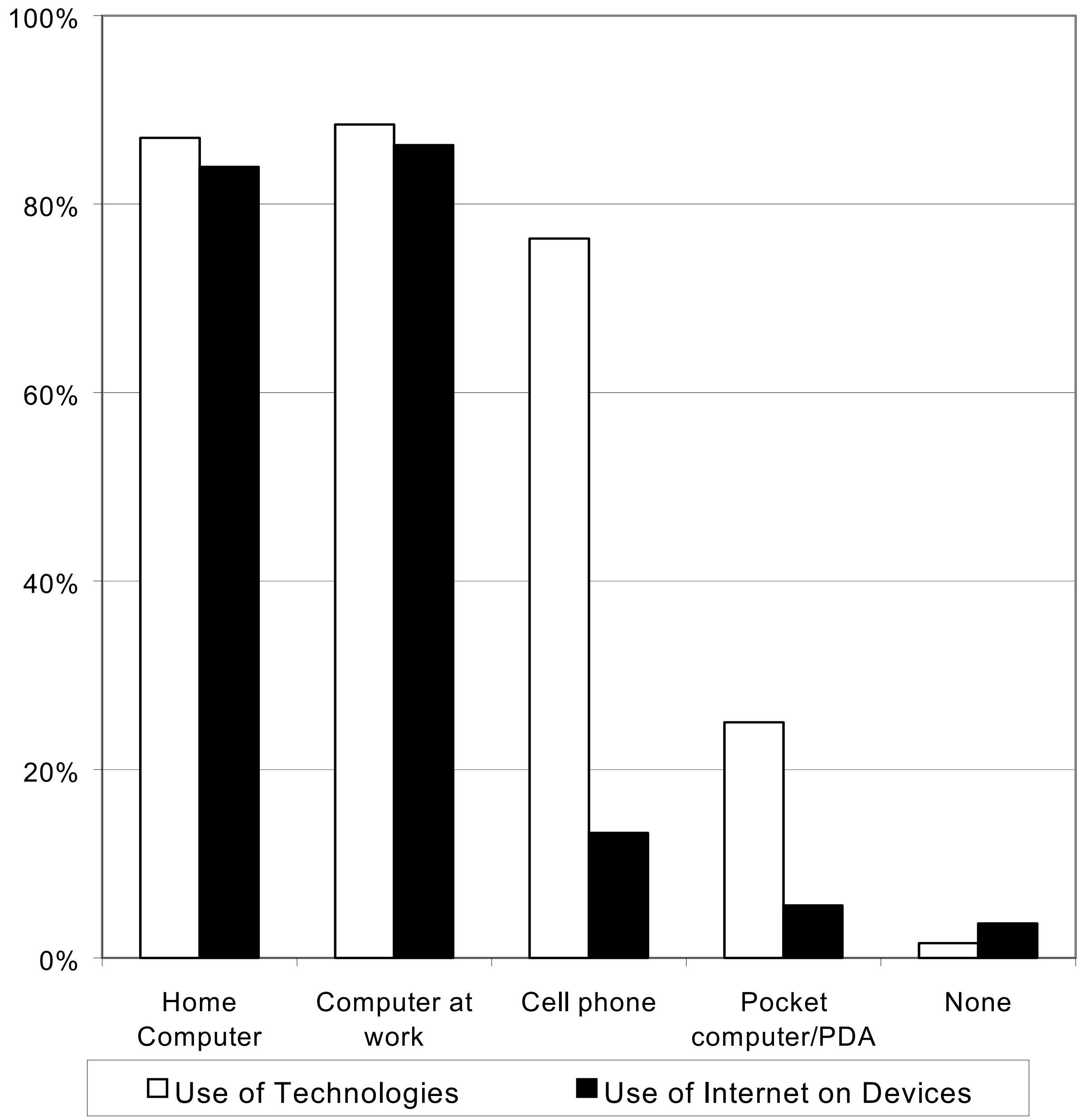


Figure 10: Respondent Use of Devices and the Internet

Since the Internet is an important medium for conveying information to and from the above devices, the survey also included a question on the availability of the Internet on the devices. As shown in Figure 10, the vast majority of respondents had Internet access on either or both home or work computers. Fewer had access to the Internet on portable devices such as cell phones (13%) or pocket computers (5.6%). Only a tiny fraction of respondents had no Internet access at all.

2.4.10 Survey Summary and Conclusions

The survey of Northern Virginia transit riders highlighted a number of interesting points regarding the use of ITS applications on transit, including the following:

- The survey respondent group was quite affluent and had high computer availability. These characteristics may reflect the affluent demographics of Northern Virginia transit riders as a whole.
- While there is almost universal access to computers at home and/or at work that enables area transit riders to access services offered on the Internet, and while most have cell phones, at the current time only a small percentage have Internet services on cell phones and/or pocket computers/personal digital assistants (PDAs).
- The survey respondents were widely supportive of the current use of technology on transit services in the region and to a large extent of expanded use of technology.
- Most respondents felt that the most important focus of technology should be on offering time savings to riders (through improved on-time performance and reduced travel times) and ensuring overall safety and security. Information services were also rated as important.
- Based on their current use of the transit ITS applications, respondents reported some effects on travel behavior although half reported no impact.
- There is a wide range of familiarity with, and use of, current ITS services. Some services have reached just about everyone (like Metrorail PIDS) and are used virtually all the time, while others have achieved less awareness.
- In some cases, awareness is lower because a service is new or would appeal only to a subset of travelers (such as those with PDAs).
- Some services are designed to be used only occasionally, such as trip itinerary planners - most commuters travel the same routes every day and would not find it necessary to use the service unless they were planning an unusual trip.
- Based on the previous point, it is clear that one cannot measure success on the same scale for all applications; each needs to be measured against the expectations and objectives set for that application.
- The currently offered transit ITS applications have generally been viewed as useful and there is widespread feeling that they are easy to use. This is an important accomplishment for the region.

3. APPROACH TO CONTINUOUS PERFORMANCE MONITORING

One of the main objectives of this study was to develop a continuing process for monitoring performance data on transit-related ITS investments in Northern Virginia. Despite the fact that many transit related ITS deployments have been taking place in the region, few of these projects have any formally established objectives or performance measures to document benefits from these systems.

Development of performance measures is a task that should be part of the planning phase of any ITS project. Establishing, and signing off on, a set of performance measures will help the implementing agency to determine whether the expected benefits are worth the investment in that system and to continue monitoring the performance of the system to make sure that it is making the most of its investment. From a regional perspective, performance measurement and ongoing monitoring will help other operating agencies and state and regional funding agencies determine whether to continue funding similar investments in the future.

In order for NVTC to successfully continue monitoring performance data, two things must take place. First, a set of policies, dealing with the monitoring process, need to be established and agreed upon by various stakeholders in Northern Virginia. Second, performance measures for each transit-related ITS technology need to be identified.

3.1 Policies for the Monitoring Process

While specific performance measures will quantify the benefits of ITS technologies, monitoring policies will help ensure the continuous gathering of the required performance data. Without such policies, it will be difficult to enforce the gathering of the data as well as collecting the data in a standard format. The consultant team recommends that the following policies be adopted by the regional stakeholders:

1. Grantee agencies should be required to identify the need or problem being addressed, the project objectives and an approach to evaluation. Agencies seeking funding for transit ITS projects should identify in their grant application what the need or problem is that is being addressed, what the specific objectives of the project are and how the agency will evaluate performance relative to these objectives. In addition, in accordance with the FTA National ITS Architecture Policy on Transit Projects and the FHWA Rule on ITS Architecture and Standards, the agencies must identify how and where the project fits into the regional ITS architecture and how the architecture will need to be updated to accommodate the project. It is worth noting that the updating of the regional architecture must also be monitored by the appropriate regional agency(ies).)

2. Agencies to perform Before/After studies or Test/Control investigations for each system to be implemented. It is recommended that either a Before/After study or Test/Control analysis be performed for each deployment where feasible and appropriate.

   A Before/After study involves gathering performance data for the old system to be replaced or upgraded as well as for the new system once it is deployed so that the old and new systems can be compared to measure realized benefits of the new deployed technology as well as cost impacts. Of course, to do so requires some advanced planning, since before data must be collected before the new system is deployed and the before and after measurements must be done in a consistent way. Many times, agencies fail to collect before data and begin to think about evaluation once the new system is in place, making most before/after comparisons infeasible. This is another reason why it is important to have a policy that makes evaluation planning a requirement for obtaining project funding. Before/after analysis may not always be feasible due to the influence of exogenous factors that may make it hard to attribute changes to the project being deployed. An example of a system where before and after data are being collected is the SmarTrip fareboxes on Metrobus; measurements of boardings times were made prior to installation of new fareboxes to allow subsequent comparison. The same project may serve as an example of where a before/after comparison may be confounded by exogenous factors – ridership on Metrobus would be influenced by many factors and it would not be reasonable to attribute ridership changes to the SmarTrip implementation alone.

A Test/Control analysis may be better in such cases provided that it is feasible. A Test/Control analysis is used when the deployed system can be applied to part of the transit system or some of the users while others continue to use the old system (as a control). Then the test and control groups are compared, in the same manner as the testing of a new pharmaceutical. While this type of test is not subject to the influence of exogenous changes that do affect before/after tests, it is subject to other confounding influences. If the test and control groups are not identical, such as two different bus or rail lines, there may be other differences that affect the comparison. For the U.S.1 Transit Signal Priority (TSP) project, the evaluation is utilizing a test/control comparison to evaluate the impact on bus travel time, delay and reliability. This is being done by equipping only some buses with the equipment to initiate priority.

3. One agency should coordinate evaluations in the region. Grant-making agencies should agree on one agency to coordinate evaluations of transit-related ITS investments in Northern Virginia**.** While NVTC is typically not a grant-making agency, by agreement with other agencies (DRPT, VDOT, MWCOG, NVTA) NVTC could be assigned the role of working with grantee agencies to coordinate, process, analyze and report performance results for the transit grants and investments made by these other agencies in Northern Virginia. MWCOG should perform a similar role of bringing together this information for Maryland and the District of Columbia for transit and highways.

4. Periodic submission of performance reports. It is recommended that grantee agencies be required by grantors to submit, to NVTC or other regional agencies, periodic reports on performance of implemented systems. This will encourage operating agencies to ensure that data is being collected regularly and the ITS systems are being monitored. It is advisable that specific deadlines for submitting reports be established to ensure that all agencies are submitting their data at the same time.

5. Standardize reporting for each technology. To ensure consistency of data being collected from one period to another, as well as among agencies, standardization of data reports is critical. Using standardized reports will make it easier for agencies to

collect and enter required data. At the same time, a standardized report will enable agencies to compare apples to apples, as all agencies implementing a similar technology will be gathering exactly the same data. This should also lessen the burden on NVTC when performing data analysis (if NVTC is selected to perform such analyses). Finally, there will be standardized federal reporting requirements associated with the regional architecture in effect by April 2005; implementing a conforming standardized performance reporting system by 2005 will enable the region to meet these requirements.

6. NVTC develops standardized reports and consolidates the data. To lessen the burden on the agencies and ensure their compliance, it is recommended that--if NVTC is selected--NVTC take the lead in standardizing the report formats and consolidating the data. This task should be conducted based on the guidance provided in this document. While NVTC's role should be to coordinate this effort for all transit ITS projects in the Northern Virginia region, it should encourage similar efforts to be undertaken by others for the entire metropolitan region (for transit and highways) in cooperation with the MOITS Task Force at MWCOG.

7. Publish results. It is important to publish and disseminate the measures and results to all the agencies in the region to help them track performance of their own as well as other ITS systems in the region. Publishing the performance results will also encourage agencies to maintain a closer control on the deployed ITS technologies in terms of operations and maintenance, to ensure a continuous high level of performance. In turn, this helps the region to protect its investment in ITS technologies.

   In addition to disseminating performance results to agencies in the region, these results should also be made available to the public. One of the primary objectives of this study was to assist in encouraging decision makers to support future investments in ITS infrastructure whose benefits have been demonstrated to provide a good return on investment. Publishing the results of the performance reviews will help the public to better understand why ITS investments are needed. Dissemination of the results to the public can be accomplished either through printed media or the Internet.

8. RFPs to require submittal of performance examples/data. One of the difficulties the consultant team faced in completing Task 2 of this project was getting vendors to provide examples of the performance of their products. Although a couple of vendors did furnish the requested information, most did not have any data or did not have it readily available. It is recommended that RFPs for transit ITS systems include a clause requiring vendors to submit evidence of the performance of their own products in operation to enable local agencies to have realistic expectations that can be used as a benchmark for subsequent post-deployment evaluation.

3.2 Developing and Applying Specific Performance Measures

Once the policies described above have been established and adopted by the stakeholders, specific measures and formats can be developed and actual collection and processing of performance data can take place. Data collected about performance should be consistent among all agencies and systems. Obviously, not all ITS technologies would be evaluated using the same set of measures. The benefits or impacts of an automatic vehicle location (AVL) system, for example, are completely different from those of a pre-trip traveler information system. Table 13 and Table 14 provide a list of specific performance measures for each of the transit-related ITS technologies. These measures were developed based upon a review of benefit literature including ITS Benefits and Unit Costs Database (at http://www.benefitcost.its.dot.gov/), and Transit ITS Impacts Matrix (at http://web.mitretek.org/its/aptsmatrix.nsf/frameaccess?OpenFrameSet).

Table 13 identifies each measure in terms of type of benefit, addresses the type of evaluation test required and indicates whether it is a primary or secondary measure. Table 14 indicates which groups are impacted by the particular ITS technologies. Beside the measures of impact shown in the tables, performance measurement should include the cost of each system (purchase and operating/maintenance cost). The tables can offer some guidance to both NVTC and operating agencies as they address the issue of monitoring performance. They are not meant to be completely comprehensive in representing all possible measures, however. Nor are they expected to be rigidly adhered to, since the specific circumstances and objectives of each project will dictate the most appropriate measures to be used. The level of performance measurement may also vary with the degree of prior experience with the technology; newer, more experimental technologies would likely be subjected to more comprehensive evaluation while performance monitoring for more mature technologies might be streamlined.

Type of impact (and measurement): Not all ITS technologies have benefits or other impacts that can be quantified in monetary terms. While some technologies such as automatic passenger counting (APC) systems may offer direct cost savings, other technologies such as communications systems and traveler information systems are implemented to improve staff efficiency and effectiveness and customers' convenience, respectively. While these impacts may be difficult to monetize, some direct impacts may be quantifiable or perceptual impacts may also be measurable. The table shows measures of impacts that fall into all of these categories. In some cases, more than one category is indicated since measurement can include both perceptions and actual impacts, or both non-monetary and monetary measures.

Type of evaluation test: Three types of evaluation may be conducted to monitor the performance of implemented ITS systems. A Before/After evaluation method is most suitable when trying to measure benefits of a new system relative to the old system and when exogenous factors are likely to be limited. Replacement of or upgrading a communications system would benefit from a Before/After evaluation. Even in cases where no older system exists, such as introducing an Automated Passenger Counter (APC) system for the first time, Before/After evaluation would still be suitable since performance of the APC system can be compared to manual count procedures.

The second type of evaluation test is Test/Control. Test/Control testing is useful when the system can be applied to a subset of users (the test group) while another subset does not use the new system (serving as the control group). This type of evaluation is best used when Before/After comparisons are infeasible or confounded by exogenous factors.

The third and final evaluation suitable for some performance measures is a descriptive one. This is a useful technique when benefits cannot be quantified directly and evaluation will rely on perceptions of the new system, such as customer opinions regarding the usefulness and ease of use of a new traveler information system.

Level of impact: Table 13 identifies whether each measure relates to a direct benefit or primary impact or an indirect benefit or secondary impact. For example, reduced crimes, vandalism costs and legal costs, and improved sense of safety for riders and operators are all primary measures of the impact of on-vehicle surveillance systems, while the potential for reduction in security staff is a secondary one as it is not the main objective of deploying surveillance cameras.

Who is impacted: Table 14 identifies which group is impacted in the case of each measure -- the general public, customers, drivers, dispatchers, supervisors, schedulers and other operations staff, maintenance staff, or other transit departments (which includes the planning, marketing, customer service and administrative functions).

Information provided in Tables 13 and 14 should help NVTC and regional stakeholders reach consensus on which of the performance measures listed in the two tables are of greatest concern/interest to them and develop the standardized reports. Then NVTC, along with the other stakeholders, would proceed to implement the recommended policies and procedures for ongoing monitoring.

Table 13: Performance Evaluation Measures by Technology

Technology	Measure	Type of Impact			Type of Comparison			Level of Impact	
		Measurable Dollar Impact (Cost/ Revenue)	Measurable Non-monetary Impact	Perception	Before/After	Test/ Control	Descriptive	Primary	Secondary
Advanced communications	Coverage		✔		✔	✔		✔	
	System downtime		✔		✔	✔		✔	
	Frequency of blocked calls		✔		✔	✔		✔	
	Access delay time		✔		✔	✔		✔	
	Quantity of voice communications between drivers and dispatchers		✔		✔	✔		✔	
	Ease of use/usefulness (driver/dispatcher)			✔			✔	✔	
Automatic vehicle location	Incident response time		✔		✔	✔			✔
	Schedule adherence and travel time		✔	✔	✔	✔		✔	
	Quality of incident report information		✔		✔	✔			✔
	Fleet requirements and revenue hours	✔	✔		✔	✔			✔
	Convenience and use of (Connection Protection) transfers		✔	✔	✔	✔			✔
	Emissions (based on fleet requirements and travel time)		✔		✔	✔			✔
	Non-revenue miles/hours	✔	✔		✔	✔			✔
	Dispatcher efficiency	✔	✔		✔	✔		✔	
	On-street supervisor hours	✔	✔		✔	✔			✔
	Driver and dispatcher reaction			✔	✔	✔			✔

Table 13: Performance Evaluation Measures by Technology (continued)

Technology	Measure	Type of Impact			Type of Comparison			Level of Impact	
		Measurable Dollar Impact (Cost/ Revenue)	Measurable Non-monetary Impact	Perception	Before/After	Test/ Control	Descriptive	Primary	Secondary
Automated passenger counters	Efficiency of data collection and processing staff	✔	✔	✔	✔	✔		✔	
	Quality of service and route planning		✔	✔		✔	✔	✔	
	Turn around time for special ridership count requests (Timeliness data and availability of information)		✔		✔	✔		✔	
	Accuracy of ridership data		✔		✔	✔	✔	✔	
Maintenance information systems	Vehicle out-of-service time	✔	✔		✔			✔	
	Maintenance costs	✔			✔			✔	
	Maintenance staff requirements	✔	✔		✔				✔
	Service disruptions (when a vehicle breaks down and riders have to be transferred to another)	✔	✔	✔	✔		✔	✔	
	New vehicle warranty costs	✔			✔				✔
	Parts inventory required	✔	✔		✔			✔	
	Ease of use			✔			✔	✔	
	Fuel efficiency	✔	✔		✔				✔

Table 13: Performance Evaluation Measures by Technology (continued)

Technology	Measure	Type of Impact			Type of Comparison			Level of Impact	
		Measurable Dollar Impact (Cost/ Revenue)	Measurable Non-monetary Impact	Perception	Before/After	Test/ Control	Descriptive	Primary	Secondary
Transit operations software	Dispatcher efficiency - Length of call - Speed of providing info. - # of calls	✔	✔	✔	✔		✔	✔	
	Fleet requirements	✔	✔		✔				✔
	Operating costs (non-revenue hours)	✔	✔		✔			✔	
	Operator overtime hours	✔	✔		✔				✔
Paratransit operations software	Time to complete reservations	✔	✔		✔			✔	
	Queue time and percent of calls served		✔		✔			✔	
	Fleet requirements	✔	✔		✔			✔	
	Operating costs	✔			✔				✔
	Number of passenger trips and passengers/vehicle		✔		✔			✔	
	Number of reservations/call taker and call taker requirements	✔			✔				✔
	Customer satisfaction			✔	✔		✔	✔	
	Revenue due to increased ridership	✔			✔				✔
	Emissions (derived from fleet requirements)		✔		✔				✔
	Dispatcher requirements	✔	✔	✔	✔		✔		✔

Table 13: Performance Evaluation Measures by Technology (continued)

Technology	Measure	Type of Impact			Type of Comparison			Level of Impact	
		Measurable Dollar Impact (Cost/ Revenue)	Measurable Non-monetary Impact	Perception	Before/After	Test/ Control	Descriptive	Primary	Secondary
Transit signal priority	Travel time for buses and general traffic	✔		✔	✔	✔		✔	
	Fleet requirements	✔			✔	✔		✔	
	On-time performance /Incidence of bunching		✔	✔	✔	✔		✔	
	Fuel usage/emissions	✔	✔		✔	✔			✔
	Driver hours and associated labor cost	✔	✔		✔	✔			
	Ridership		✔		✔	✔			✔
	Customer perception of service			✔	✔	✔	✔		✔
	Dwell time at signals for buses and general traffic		✔		✔	✔		✔	
Electronic fare payment	Revenue (floating revenue, merchant fees)	✔			✔	✔			✔
	Fare collection costs	✔			✔	✔		✔	
	Incidence of fare evasion and mishandling	✔	✔		✔	✔			✔
	Ridership		✔		✔	✔			✔
	Passenger boarding time		✔	✔	✔	✔		✔	
	Customer convenience			✔	✔	✔	✔	✔	

Table 13: Performance Evaluation Measures by Technology (continued)

Technology	Measure	Type of Impact			Type of Comparison			Level of Impact	
		Measurable Dollar Impact (Cost/ Revenue)	Measurable Non-monetary Impact	Perception	Before/After	Test/ Control	Descriptive	Primary	Secondary
Pre-trip traveler information system	Ridership		✔		✔	✔			✔
	Customer convenience and quality of information			✔	✔	✔	✔	✔	
	Perception of service reliability			✔	✔	✔	✔		✔
In-terminal/ Wayside Traveler information system	Ridership		✔		✔	✔			✔
	Customer convenience and quality of information			✔	✔	✔	✔	✔	
	Perception of service reliability			✔	✔	✔	✔		✔
In-vehicle traveler information system	Driver effort			✔	✔	✔	✔	✔	
	Customer convenience and quality of information			✔	✔	✔	✔	✔	
	Perception of service reliability			✔	✔	✔	✔		✔
	Dwell time at stops		✔		✔	✔			✔
On-vehicle surveillance	Incidence of on-board crimes		✔		✔	✔		✔	
	Vandalism repair costs	✔			✔	✔			✔
	Legal costs for passenger/employee claims	✔			✔	✔			✔
	Sense of safety for riders/operators			✔	✔	✔	✔	✔	
	Security staff requirements	✔	✔		✔	✔			✔

Table 13: Performance Evaluation Measures by Technology (continued)

Technology	Measure	Type of Impact			Type of Comparison			Level of Impact	
		Measurable Dollar Impact (Cost/ Revenue)	Measurable Non-monetary Impact	Perception	Before/After	Test/ Control	Descriptive	Primary	Secondary
Station/facility surveillance	Incidence of in-station crimes		✔		✔	✔		✔	
	Vandalism repair costs	✔			✔	✔			✔
	Legal costs for passenger/employee claims	✔			✔	✔			✔
	Sense of safety for riders			✔	✔	✔	✔	✔	
Collision avoidance	Collision costs and associated insurance costs	✔			✔	✔		✔	
	Safety of riders/operators			✔	✔	✔	✔	✔	
	Number of out-of-service vehicles		✔		✔	✔		✔	

Table 14: Incidence of Impact by Measure

Technology	Measure	Incidence of Impact					
		General Public	Customers	Drivers	Dispatchers, Supervisors and Operations	Maintenance Department	Other Departments[9]
Advanced communications	Coverage			✔	✔		
	System downtime			✔	✔		
	Frequency of blocked calls			✔	✔		
	Access delay time			✔	✔		
	Quantity of voice communications between drivers and dispatchers			✔	✔		
	Ease of use/Usefulness			✔	✔		
Automatic vehicle location	Incident response time		✔	✔		✔	
	Schedule adherence and travel time			✔	✔		✔
	Quality of incident report information				✔		✔
	Fleet requirements			✔	✔	✔	✔
	Convenience and use of (Connection Protection) transfers		✔	✔	✔		
	Emissions	✔					
	Non-revenue miles/hours			✔	✔		✔
	Dispatcher efficiency				✔		✔
	On-street supervisor hours				✔		✔
	Driver and dispatcher reaction			✔	✔		

[9] Other departments include impacts on customer service, planning, marketing and management.

Table 14: Incidence of Impact by Measure (continued)

Technology	Measure	Incidence of Impact					
		General Public	**Customers**	**Drivers**	**Dispatchers, Supervisors and Operations**	**Maintenance Department**	**Other Departments** [10]
Automatic passenger counters	Data collection costs						✔
	Efficiency of data collection and processing staff						✔
	Quality of service and route planning						✔
	Turn around time for special ridership count requests (Timeliness of data and availability of information)						✔
	Accuracy of ridership data						✔
Maintenance information systems	Vehicle out-of-service time			✔	✔	✔	
	Maintenance costs					✔	
	Maintenance staff requirements					✔	
	Service disruptions (when a vehicle breaks down and riders have to be transferred to another)		✔	✔	✔	✔	
	New vehicle warranty costs						✔
	Parts inventory required					✔	
	Ease of use					✔	

[10] Other departments include impacts on customer service, planning, marketing and management.

Table 14: Incidence of Impact by Measure (continued)

Technology	Measure	Incidence of Impact					
		General Public	Customers	Drivers	Dispatchers, Supervisors and Operations	Maintenance Department	Other Departments[11]
Transit operations software	Dispatcher efficiency - Length of call - Speed of providing info. - # of calls				✔		
	Fleet requirements			✔	✔	✔	✔
	Operating costs (reduced non-revenue time)				✔		✔
	Operator overtime hours			✔	✔		✔
Paratransit operations software	Time to complete reservations		✔		✔		
	Queue time and percent of calls served		✔		✔		
	Fleet requirements			✔	✔	✔	
	Operating costs				✔		✔
	Number of passengers and passengers/vehicle		✔	✔	✔		✔
	Number of reservations/call taker and call taker requirements				✔		✔
	Customer satisfaction		✔				✔
	Ridership						✔
	Emissions (derived from fleet requirements)	✔					
	Dispatcher requirements				✔		

[11] Other departments include impacts on customer service, planning, marketing and management.

Table 14: Incidence of Impact by Measure (continued)

Technology	Measure	Incidence of Impact					
		General Public	Customers	Drivers	Dispatchers, Supervisors and Operations	Maintenance Department	Other Departments[12]
Transit signal priority	Travel time for buses and general traffic	✔	✔	✔			✔
	Fleet requirements			✔	✔	✔	✔
	On-time performance/Incidence of bunching		✔	✔	✔		✔
	Fuel usage/emissions	✔					✔
	Ridership						✔
	Customer perception of service		✔				✔
	Dwell time at signals for buses and general traffic	✔	✔	✔	✔		✔

[12] Other departments include impacts on customer service, planning, marketing and management.

Table 14: Incidence of Impact by Measure (continued)

Technology	Measure	Incidence of Impact					
		General Public	Customers	Drivers	Dispatchers, Supervisors and Operations	Maintenance Department	Other Departments [13]
Electronic fare payment	Revenue (floating revenue, merchant fees)						✔
	Fare collection costs including maintenance of fare equipment		✔	✔		✔	✔
	Incidence of fare evasion and mishandling						✔
	Ridership						✔
	Passenger boarding time		✔				✔
	Customer convenience		✔				
Pre-trip traveler information system	Ridership						✔
	Customer convenience and quality of information		✔				✔
	Perception of service reliability		✔				✔
In-terminal/wayside traveler information system	Ridership						✔
	Customer convenience and quality of information		✔				✔
	Perception of service reliability		✔				✔
In-vehicle traveler information system	Driver effort			✔			
	Customer convenience and quality of information		✔				✔
	Perception of service reliability		✔				✔
	Dwell time at stops			✔	✔		

[13] Other departments include impacts on customer service, planning, marketing and management.

Table 14: Incidence of Impact by Measure (continued)

Technology	Measure	Incidence of Impact					
		General Public	Customers	Drivers	Dispatchers, Supervisors and Operations	Maintenance Department	Other Departments[14]
On-vehicle surveillance	Incidence of on-board crimes		✔	✔			✔
	Vandalism repair costs					✔	✔
	Legal costs for passenger/employee claims						✔
	Sense of safety for riders/operators		✔	✔			
	Security staff requirements				✔		
Station/facility surveillance	Incidence of in-station crimes		✔	✔			✔
	Vandalism repair costs					✔	✔
	Legal costs for passenger/employee claims						✔
	Sense of safety for riders		✔				
Collision avoidance	Collision costs and associated insurance costs					✔	✔
	Safety of riders/operators		✔	✔			
	Operating costs				✔		✔
	Number of out-of-service vehicles		✔		✔	✔	✔

[14] Other departments include impacts on customer service, planning, marketing and management.

Table 15, below, shows an example of the measures of performance for the RideGuide/IVR project based on the available information from the interviews conducted as part of this project. Ideally this project would be evaluated by phase since the RideGuide website was introduced prior to the IVR phone system. We have not entered the number of calls handled prior to the Ride Guide website or the IVR system since a more detailed evaluation would be required. User surveys had not yet documented perceptions of the IVR phone system (as of this research), however, a 2001 survey of showed user satisfaction with RideGuide was relatively high – 24% were very satisfied and 48% somewhat satisfied.

Table 15: Performance Measures for WMATA's IVR/RideGuide System

Measures	Perception		Measurable Non-Monetary		Measurable Dollar Impact
	Improved	Not Improved	Before	After	
Volume of RideGuide Internet Itineraries (annual)			0	3 million	Equivalent to time of 50 staff
Volume of IVR Calls Handled (annual)			0	0.5 million	Equivalent to time of 8 staff
Volume of Calls Handled by Live Operators (annual)			Not Available	2.8 million	
Total Volume of Calls Handled (annual)			Not Available	3.3 million	
Total Itineraries (annual)			Not Available	6.3 million	
Call Capture Rate			80%	90%-95%	
Busy/No Answer Complaints (monthly)			40	0	
Staff Cost Savings (due to reduction)					$ **
Average Call Length			Not Available	1min, 7sec	
Improved Customer Service*	✔				
Improved Customer Convenience (24/7 service)*	✔				
Improved Perception of Service Reliability*	✔				

* Ideally, this measure should be presented as the measured perceptions based on survey data. In this particular example, WMATA indicated that feedback from users was positive but did not yet have specific data on perceptions associated with the IVR.

** Cost savings associated with IVR equals the salaries plus benefits of 8 operators that would otherwise be needed to accommodate growth in call volume.

3.3 System for Storage and Dissemination of Information

Data gathered from the ITS systems and analyzed must be made accessible to staff of these agencies and other agencies in order to learn more about the other ITS systems deployed in the region. This will foster coordination and cooperation among the regional stakeholders and allow the agencies to learn from each other's experiences.

Sharing the results of the collected data with elected officials and funding decision makers is also critical. Benefits and impacts of ITS on the region as a whole should be highlighted to these individuals to ensure that they understand why ITS investments are needed in Northern Virginia. It is recommended that printed media be used to deliver the message to the elected officials and decision makers.

The third group of individuals, who also should have access to the data, is the public. Increasing the public's understanding of ITS technologies and the benefits they offer is crucial in getting public support for future deployments. It also serves to increase public awareness of ITS technologies available for their use. Among the most efficient and cost-effective ways to disseminate the results of performance measures to the public is through the Internet.

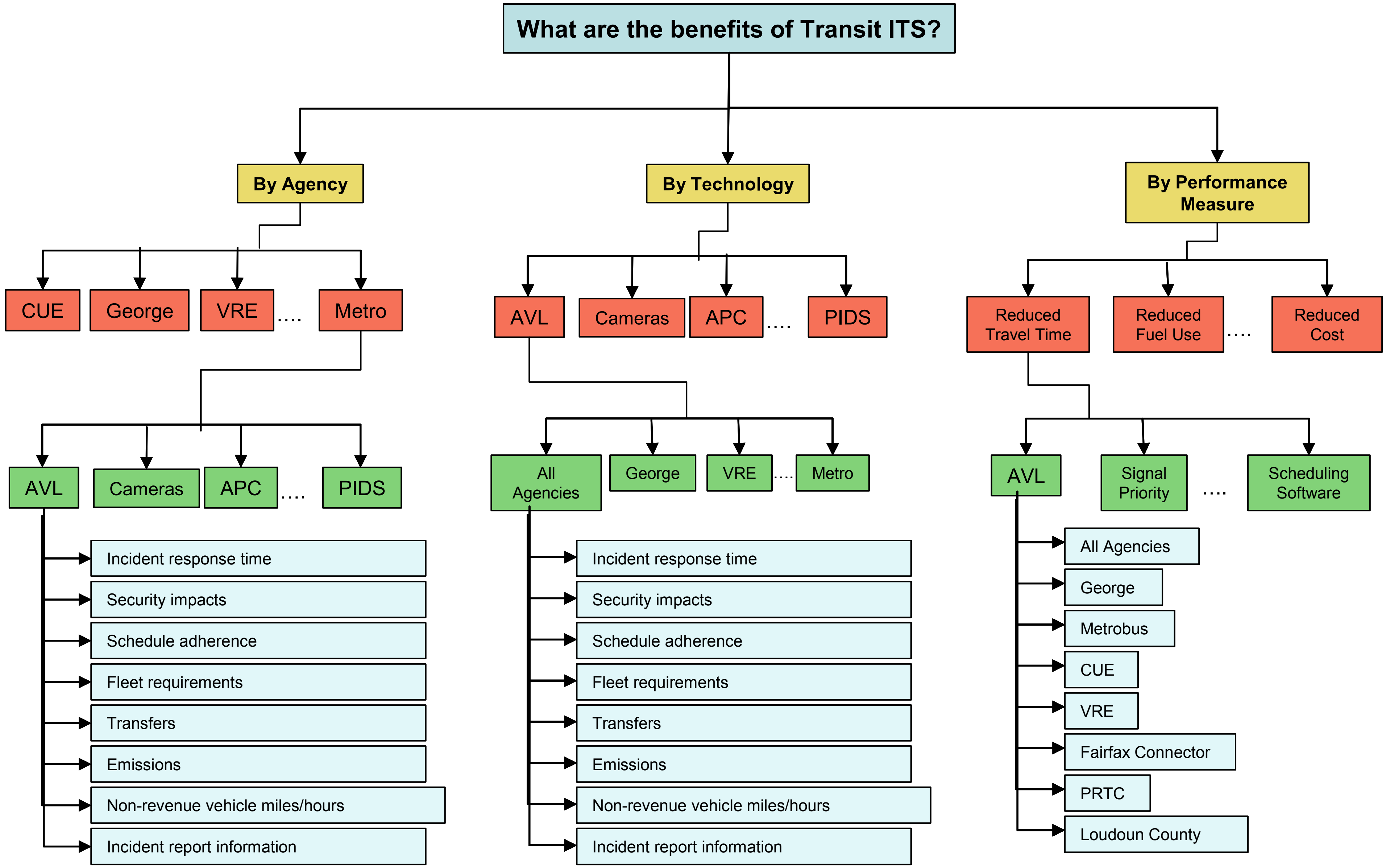
Using standardized reports to collect data on various ITS systems in the region will facilitate the storage of this data and the development of comparative analyses in a straightforward format. A database should be designed to mirror the standardized reports to simplify and speed up the data entry process. Agencies should be able to enter data directly into the database, via on-line forms.

Performing queries and basic statistical analysis on any of the data categories in the database should be made possible via the website. A user should be able to request, for example, average transit maintenance cost reduction due to implementation of a particular type of maintenance software for a particular agency, or a group of agencies. The user should also have the option to define the period of time, such as for a particular period or a group of periods.

Figure 11 illustrates the hierarchical organization of an interactive web site for accessing desired information on the performance measure. The top blue box symbolizes the *Home* page of the web site containing the link: *"What are the impacts (or benefits) of transit ITS"*. If a user clicks on that link, he or she will be directed to that page containing the options described in the second row of boxes (yellow boxes). At this point, the user has the option to access the information he/she wants by agency, technology, or performance measure. For example, the user may be interested in investigating all technologies deployed by a certain agency, or simply interested in looking at measures of a single ITS system deployed at numerous agencies in the region. The third option will allow the user to request information on a specific measure that may be common to a number of technologies (e.g., reduced emissions).

The user will proceed until he/she reaches the final web page containing the last set of links. At that point, requested data should appear in tabular format allowing the user to scroll through the results. Figure 11 provides an overview of the recommended web site structure.

Figure 11: Overview of Web Site Structure



Appendix: Additional Project Information

Costs Associated with Transit ITS Projects

The following table provides a summary of cost information primarily on projects described in Section 2.3. This information was obtained in the course of interviews conducted to determine the objectives and performance results of these projects,, rather than to fully document the costs. The reader is cautioned that the information may not include all the costs associated with each project, nor is every project included in the table since information was not as readily available for some projects.

Agency	System	Cost	Comments
WMATA Metrorail	Passenger Information Display Signs (PIDS)	$12 million	430 signs, both indoor and outdoor
WMATA Metrorail	Metrorail E-mail Alert System	$50,000 - $60,000	Mail List service at an annual cost of $35,000
WMATA Metrorail	SmarTrip	Part of an $80 million contract for a fare collection system upgrade	Annual cost of customer service contract is $1 million.
WMATA MetroAccess	Paratransit Scheduling and Dispatching and Automatic Vehicle Location Systems	$3,000 per vehicle (for AVL, GPS, MDT)	$20,000 licensing fee for the entire system
WMATA Metrobus	Metrobus Vehicle-Component Monitoring (VCM) System	$4,500 per vehicle	
WMATA Metrobus	Electronic Fareboxes for SmarTrip	$20 million	fleet of 1600 buses
WMATA Metrobus	Metrobus On-Board Video Cameras	$8,000/vehicle	5 cameras per vehicle
WMATA Metrobus	Metrobus - Automated Annunciator System	$12,000 per vehicle	
MWCOG/WMATA Metrobus/VDOT	Transit Signal Priority in U.S. 1 Corridor	$200,000	for detectors/readers at intersections in main line flow only at 25 intersections and emitters for 25 vehicles; Detectors/readers - $5,200 per intersection including installation; emitters - $1,100 per bus excluding installation.

Agency	System	Cost	Comments
WMATA Metrobus	New SmarTrip Compatible Fareboxes	$20 million	For 1,600 buses; cost associated with SmarTrip actually only 5-15% of cost
WMATA Metrobus	SmarTrip Regional Customer Service Clearinghouse	$19.96 million	For 5 year service period and 1 year start-up including capital and operating (Capital is $7.8 million; Operating is $12.1 million)
WMATA	RideGuide and IVR System	$880,000 plus in house efforts	Original RideGuide web version required 3 person-months of effort. IVR costs were $680,000 for hardware, software, programming and integration plus $200,000 for Trapeze scheduling software.
WMATA	Scheduling and Dispatching System for Bus and Rail	$6.3 million	
Northern Virginia Bus Operators	New SmarTrip Compatible Fareboxes	$5 million	
City of Fairfax (CUE)	Annunciators	$200,000	For 12 buses; the first six purchased in 1998 will be upgraded at an additional cost of $75,000
City of Fairfax (CUE)	NextBus	$160,000	Nine buses and nine signs, including power connection
VRE	Train Brain	$5,000	Initial cost ($5,000) as the vendor was interested in demonstrating the program; annual license fee of several thousand dollars. This system utilizes information from the AVL system, the cost of which is identified below.
VRE	AVL and IVR	$1.2 million	

Agency	System	Cost	Comments
Arlington County	NextBus	$100,000	Includes MDTs for 9 buses and 9 dynamic message signs; operating costs are an additional $2,000 per month
Arlington County	Paratransit computer assisted scheduling and dispatching system	$200,000	
Arlington County	CommuterPage Mobile Services	$30,000	
Arlington County	Mobile Commuter Store	$240,000 per vehicle	
Montgomery County	Ride On AVL System	$4 million	For 236 vehicles; in addition, the County spent $1 million to upgrade fixed end communications infrastructure
Montgomery County	Real Time Arrival Information	$58,000 for equipment	$20,000 at each transit center and $8,000-$9,000 per bus stop location. The system was developed in house and staff hours for programming and integration are not included in this estimate.
Montgomery County	Transportation Management Center (now Public Safety Communications Center)	$30 million for construction work at new center incluiding all technology/equipment	At an existing leased building
PRTC	E-mail Alerts	$5,000	To establish system and integrate with their website.
PRTC	SaFIRES	$5.0 million	

Additional Information on Projects Not Selected for Detailed Interviews

MWCOG: Commuter Connection Program Information:

Commuter Connection Program Information is an Internet program to assist commuters to get to their work fast, safely, and efficiently. It provides a host of information on various modes of travel as well as on various travel options. It also provides updates on construction activities and transit service disruptions. The objectives of the program are to reduce commuters' travel times while increasing their safety.

Visitors to the web site can click on a number of links to get information on carpooling, van pooling, guaranteed ride home, transit, construction activities, and teleworking.

MWCOG: ITS as a Data Resource Study

This study completed in 2001 recommended a follow-up project – the Regional Integrated Transportation Information System (RITIS), which is described below.

MWCOG: Regional Integrated Transportation Information System (RITIS):

Regional Integrated Transportation Information System (RITIS) was scheduled to commence in 2003 and conclude in 2006. It will be the design and development of a system to take data from a variety of real-time sources and fuse this data as a source of both real-time and archived data. This project does not contemplate delivery of this information to the public. This project was a recommendation of the prior study of ITS as a Data Resource, completed by MWCOG in 2001.

MWCOG: Metropolitan Washington ITS Strategic Plan:

Metropolitan Washington Management, Operations, and ITS (M&O/ITS) Strategic Plan was completed in 2001. In developing the strategic plan for ITS, MWCOG wanted to achieve a larger benefit across the region through examining and planning to incorporate ITS advances, and to ensure the effective integration and interoperation of transportation management systems. Therefore, the strategic plan looks at the question of M&O/ITS from two approaches: first, from individual components of ITS, and secondly, from the integration and interaction of the various ITS components in the endeavor of M&O.

The strategic plan addresses the following ITS systems components:

- Arterial Management
- Commercial Vehicle Operations
- Data Sharing
- Electronic Fare Payment and Toll Collection
- Freeway Management
- Highway Railroad Crossings
- Incident Management
- Regional Communications Coordination
- Regional Traveler Information
- Safety and Emergency Response Management
- Transit Management

MWCOG: Metropolitan Washington Regional ITS Architecture:

Computer Sciences Corporation (CSC) and its partner, PB Farradyne (PBF), were contracted in August, 2000 to perform an analysis of potential electronic voice, data, and video information exchange for and between regional ITS applications throughout the MWCOG / TPBNCR region. Originally, the project work plan called for developing a Proof of Concept to demonstrate the validity of the regional architecture. However, the MWCOG / TPBNCR ITS Architecture Working Group chose to focus on the development of the regional architecture, and scaled back the Proof of Concept task. The final scope of this project was to:

- Develop a regional ITS architecture. The architecture provides an opportunity to examine and look at potential interconnects – it does not commit stakeholders and agencies to implementation.
- Examine regional ITS application interface alternatives.
- Develop alternative Proof of Concept projects that could lay the groundwork for future ITS integration among MWCOG / TPBNCR jurisdictions.

The regional architecture has been closely coordinated and developed with the on-going development of the Maryland Statewide and VDOT NOVA District ITS Architectures. The MWCOG / NCRTPB ITS Architecture Working Group is working to place the regional architecture into a regional transportation planning practice. Furthermore, as the regional architecture is a "living document", the MWCOG / NCRTPB ITS Architecture Working Group is working to develop processes that will result in on-going maintenance of the regional architecture and conformance to the national ITS Architecture.

The Metropolitan Washington Area ITS Architecture provides the framework to enable the following: data archiving; emergency/incident management; traveler information; traffic management; transit management; electronic toll collection; and parking management.

The Metropolitan Washington Area ITS Architecture was drafted in 2002.

MWCOG (TPB),VDOT, MD SHA, DCDOT, WMATA: Partners-in-Motion and 511:

Partners-in-Motion

In 1997, TPB joined the Virginia Department of Transportation and many other transportation agencies around the region to form the "Partners In Motion" consortium to provide regional advanced traveler information. VDOT contracted on behalf of this partnership with the Battelle Memorial Institute and SmartRoute Systems to build a traveler information system for the region. This system was developed and offered to the public under the "SmarTraveler" name, including a web site and a free-of-charge telephone service. Battelle and SmartRoute Systems envisioned a system that would become self-supporting through the sale of advertising and services above and beyond the free Internet and telephone services. Unfortunately, since the July 1998 launch of the Washington area SmarTraveler service, revenues have not been able to cover costs, and the contractors discontinued in mid-December 2002. This is part of a national overall trend that advanced traveler information systems (ATIS) have not proven to be self-sustaining on a business level in the private sector marketplace. It seems that if the public sector finds benefits from ATIS and wants it, there will have to be some form of subsidy.

One of the problems with SmarTraveler has been getting quality information from public agencies. It is not worth providing data that is of poor quality and clearly there is no market to sell data of poor quality. Once data of sufficient quality is available from the public sector, the private sector may have a greater interest in stepping in to repackage data and provide it to the public in a value-added manner. As a result, the regional sponsors of Partners-in-Motion have decided to invest in data fusion rather than renew subsidies for SmarTraveler. (See RITIS project above.)

VDOT: 511 Implementation:

The Commonwealth of Virginia has established a statewide 511 information system that currently provides "messages" and is not interactive. While there are other regions in Virginia (Shenandoah Valley) that have operating 511 systems, the metropolitan region of Northern Virginia is expected to be later in the implementation process due to its complexity.

DCDOT: 511 Implementation

DCDOT has obtained a grant from USDOT to begin planning implementation of a 511 system for the region. This planning study, to be performed by a consultant, was scheduled to start during 2003.

WMATA: SAP-ITS Communication Enhancements

This project is part of the System Access/Capacity Program. The project is designed to improve communications and customer service. The project includes four ITS projects:

- Improved communications links between Bus Central Control and bus supervisors
- Developing automatic capacity notification signs at parking facilities
- Providing on-line information to WMATA customer service personnel
- Developing a Regional Customer Service Center with local jurisdictions.

WMATA: Automatic Train Control/Power System

This project for FY 2002-2007 includes the following Metrorail improvements as part of the Infrastructure Renewal Program:

- Train communications upgrade
- Public address systems replacement
- Rehabilitation of Automatic Train Control (ATC) equipment
- Rehabilitation of A/C, TPSS and TPS equipment
- Traction power switchgear rehabilitation
- A/C power control system
- Uninterruptible Power Supply (UPS)/Battery System

The project includes design, procurement and installation of all communications equipment including stations, yards and shops and the rehabilitation and replacement of electrical systems, circuit breakers, switchgear and automatic train control equipment. The purpose is to replace obsolete and worn out systems that have largely been in place for 25 years in order to ensure system reliability and integrity.

WMATA: Orbital AVL & Motorola Radio Communications System:

This IRP project includes a new radio system to provide a complete radio communications system for bus, rail, maintenance and transit police. The new radio system would provide above and below-ground communications. It will have a feature to call all buses. The goals of the project are to ensure reliability of the system and replace outdated and outmoded equipment. Benefits are expected for schedule adherence, response to problems and incidents. As of August 2003, 500 vehicles have been equipped with AVL and MDT units. It is anticipated that the entire fleet will be retrofitted with the new AVL/MDT system by the end of 2003.

The cost for this project is estimated to be about $4 million. WMATA plans to use the AVL system for response to problems, and as an operations/supervisory tool. The procured system will also provide silent alarm capabilities. The AVL does not have CAD functionalities as it will not be interfaced with a scheduling system.

WMATA: Metrobus Scheduling System:

WMATA is planning on acquiring a state-of-the-art scheduling system in the near future for its bus fleet and for Metrorail. Funding has already been made available for this system, and procurement is anticipated to take place in 2004. Once the proposed scheduling system is in place, the new AVL system would be utilized to its maximum potential (i.e. schedule adherence, CAD functionalities, etc.). The proposed scheduling system will include scheduled times for each and every bus stop and not just major stops/timepoints. The cost of the bus and rail scheduling and dispatching system is $6.3 million.

WMATA: Camera Surveillance:

WMATA has installed cameras in Metrorail stations. The cameras point to the cashiering area only and are not generally monitored. In case of an incident, camera tapes can be pulled for review. The only location that has a 24/7 monitored surveillance camera is at Addison Road parking garage.

WMATA: In-Vehicle Signage for Information:

New rail cars are to be equipped with in-vehicle signage.

WMATA: Feasibility Study of AVL

This study was a follow-on study to the 2000 WMATA ITS Strategic Plan and was prepared by the same consultant, Capital Transit Consultants. It defined some medium to high level technical requirements for AVL deployment, that were successfully used by WMATA in the procurement phase.

WMATA: Collision Avoidance Systems on Buses:

WMATA has been interested in equipping their buses with collision avoidance systems in order to reduce their accident-related costs (service disruption, insurance claims, and repairs). However, this project was assigned a lower priority in the ITS Plan and it has not moved forward.

WMATA: Parking Lot Availability Information:

WMATA provided “Lot Full” information via electronic dynamic message signs at garage entrances. The system was reportedly about 99% accurate on a single day basis, however, errors in the calculation of parking availability accumulate from day to day causing the system to be less reliable. Hence, WMATA has turned off the signage and is about to study in installing a PC-based system that recalibrates either midday or overnight and thus improve accuracy of data.

Once more funding becomes available, WMATA plans to provide garage parking availability on the website and on DMSs.

WMATA Transit Customer Information System (TCIS) Plan

This study was a follow-on study to the WMATA ITS Strategic Plan and was prepared by the same consultant, Capital Transit Consultants. Information access technologies identified in the conceptual design of candidate solutions (Task 4 report dated August 2001) include:

- Passenger information display systems (PIDS) (this project has been implemented)
- Dynamic message signs
- Enunciation systems (bus and rail)
- Display monitors
- Information kiosks
- Internet website

TCIS solutions identified include:

- Remote access information center
- Non-vehicle voice and display systems
- In-vehicle systems
- Information kiosks
- Broadcast information systems

Specific recommendations are made for each including identifying target markets, technologies, implementation issues and demonstration approaches. The study included interviews with representatives of local and regional transit as well as others around the nation.

WMATA/VDOT: Sharing CCTV Information from VDOT:

The purpose of this project was to improve safety and security at parking facilities by reducing crime incidents. VDOT was to locate/direct their highway cameras as to also cover Metro parking lots. This project was carried out for a while. Although the project was not very active during the period of this study, the latest information indicates that a contract will be awarded to a vendor in December 2003 and that the project will last about four to six months.

WMATA Intelligent Transportation Systems (ITS) Plan – Phase 1

This plan, developed by WMATA staff in October 1999, is reported to be out-of-date and is superseded by subsequent ITS Plan documents. Therefore the details of the plan are not presented here but just some background on approach to the problem taken at that time.

The purpose of the plan was to develop an approach to identify and evaluate major components of ITS related to WMATA's transit services and to recommend a series of strategic actions WMATA should undertake in the next five to ten years. The ITS Plan was viewed as a key element of WMATA's Information Technology Plan. The ITS Strategic Plan addressed those investments that directly impact service delivery including safety, operating efficiency and passenger information. The plan prioritized investments and identified next steps. The recommendations were developed taking into account other planning efforts in the region such as the ITS Element of the Northern Virginia Draft 2020 Plan, the Dulles Corridor Technology Task Force, SmartMover, and MWCOG planning efforts.

The identified goals of the WMATA ITS program were:

A. Customer Service

- Quality and accessibility of passenger information
- Improved service reliability
- Decreased travel times

B. Passenger and Employee Safety and Security

- Vehicles
- Passenger facilities

C. Operating Efficiencies

- Reduce costs
- Efficient use of scarce resources
- Redeployment of resources where possible

The plan also incorporated five principles:

- Leadership (as the regional transit agency)
- Compatibility with other elements and expandability
- Interoperability (with other transit and traffic systems in the region
- Simplicity of procurement (use of off-the-shelf products)
- Incremental growth

Recommended actions steps included:

- Evaluation of ongoing procurement in light of ITS needs
- Inventory of inter-operability requirements
- Analysis of costs and state of the art technology
- Development of an implementation plan
- Budget development

WMATA: ITS Strategic Plan – Phase 2

The WMATA strategic plan issued in December 2000 identified ten projects (actually groupings of one or more actions). These projects included:

1. Safety and Security:
   a. vehicle and facility security surveillance (specifically identified were phasing in at selected bus terminals, extending use of video lead from station manager kiosk and remote transit security stations to the Rail Operations Control Center, and integrating bus mayday systems with AVL)
   b. maintenance monitoring and remote vehicle diagnostics
   c. in-vehicle signage
   d. parking facility security.
2. Collision Avoidance/Obstacle Detection:
   a. conducting a demonstration project
   b. monitoring the development of control systems and applicability to WMATA
3. Emergency Response:
   a. implementing AVL and integrating it with communications systems
   b. developing and implementing of pre-defined response plans
   c. developing LAN and WAN
4. Automated Passenger Counters (APCs):
   This focused on buses.
   a. preparing and implementing plan and data processing infrastructure
   b. demonstrating real-time use of data
   c. monitoring the state of practice for rail
5. Customer Trip and Travel Information:
   This included pre-trip, in-vehicle and broadcast information.
   a. integrating transit and traffic information
   b. developing trip estimation algorithm
   c. developing media and formats
   d. comparing with systems used by other transit agencies
6. Operations Data Traveler Information:
   This included in terminal and wayside information, on-board electronic destination signs and automated public address systems.
   a. implementing rail station kiosks
   b. providing CCTV for bus operations control center
   c. coordinating bus departures from rail stations
   d. developing data content and format

7. Automatic Vehicle Location (AVL)
   WMATA was already employing Clever Devices AVL-GPS for enunciation. This item addressed AVL for other purposes.
   a. furnishing customer service with real-time information
   b. assessing technologies
   c. developing data processing systems
8. Electronic Fare Payment:
   a. multiuse smart card (implementing for bus, offering "best value fare calculation, demonstrating common card for transit, tolls and parking in the region, analyzing usage data)
   b. parking facility electronic payment
9. Parking Facility Availability and Navigation (to available spaces):
   a. implementing technology to automate garage availability determination
   b. displaying availability on signs and other media
   c. displaying navigation information
10. Systems Architecture and Integration:

Items 2,4 and 9 were identified as moderate priority while all the others were high priority. Three special independent studies were conducted on items 5, 6 and 7. Note that the Plan included a logical and physical architecture that referenced the national architecture

George Mason University/VDOT: Public Perception and Elected Officials Reaction to ITS:

This project addresses public perception and elected officials' reaction to intelligent transportation systems in the greater Washington area. The scope of work (still under development as of late 2002) addressed the following areas:

- *Traveler attitudes towards transportation in the National Capital Region*: This project will survey user attitudes towards transportation needs in the greater Washington area, with a focus on the uses of integrated intelligent transportation systems. The survey will assess what users expect from the management and operations of the region's surface transportation system, and, in particular, how ITS can contribute to a seamless movement of passengers throughout the region. The objective is to support transportation agencies in the region in their effort to become more customer-oriented and responsive to the public.
- *Attitudes of elected officials in Northern Virginia towards ITS evaluation.* This project will examine how local officials in Northern Virginia, both elected and appointed, evaluate intelligent transportation systems. Such officials are often the decision-makers as to whether ITS technologies will be deployed, yet anecdotal evidence suggests that these decision-makers often do not find useful the evaluation information developed by professional transportation analysts and by the ITS community. To take just one example, current ITS evaluation methodology tends to judge a technology's cost-effectiveness by national standards, yet local officials may consider the out-of-state experiences to be of very little value. This research will

employ an “expert interview” methodology, with in-depth interviews of some 50 elected and appointed officials from Northern Virginia.

- *Motorist attitudes towards travel time information on I-66:* One application of ITS in Northern Virginia that is under consideration by the Virginia Department of Transportation is the dissemination of information about travel times along interstate highways, and, in particular, along the stretch of I-66 between Manassas and the Capital Beltway. VDOT is most immediately interested in whether forecast travel times should be posted on variable message signs, but is also interested in the possible dissemination of travel times on the internet, radio and cable TV. This project will study the attitudes of motorists towards the value of travel time information, both in general, and particularly along I-66 from Manassas to the Beltway. The research methodology will be the use of a few focus groups to get a general understanding of public attitudes and to help clarify what questions should be asked in the formal survey. Then a formal survey will be carried out and analyzed, with conclusions and recommendations presented to VDOT.

Arlington County: Information Kiosks (DMSs):

As part of a Partners-in-Motion project, they installed information kiosks (really DMS) at 4 bus stops on Moore Street, which provide canned LED messages based on pre-input schedule (headway) information only. The system is not interactive and is not real-time. It tells you the scheduled arrival of the next two buses for the appropriate direction. This was done in mid 2000.

Loudoun County: Bus Biz E-mail Alert:

The Loudoun County Commuter Bus Service has a communication tool called "Bus Biz" which allows passengers to receive e-mail messages from the County regarding bus service. These e-mails alert riders to bus service changes such as delays in the schedule, re-routing of stops, subcontractor equipment issues, etc. Passengers interested in receiving the "Bus Biz," simply send an e-mail message to requesting the addition of their names to the existing “Bus Biz” list.

City of Alexandria: Signal Upgrade

Alexandria has recently upgraded its signal system. Although the primary purpose was not to install TSP, Alexandria has built in capability for future TSP; that is, upgrade included fiber optics that will accommodate future installation of TSP. Alexandria has no immediate plans for TSP projects. The City expressed the need for a common architecture for TSP in the region and the need for interoperability for the many bus operators in the region.

City of Alexandria: SmarTrip Fareboxes

Like the other local Virginia operators, DASH will be a participant in the SmarTrip bus program, Installation of the SmarTrip fareboxes will occur after Metrobus testing and installation are completed.

City of Alexandria: In-vehicle Stop Annunciators

Four DASH buses have Digital Recorder bus stop enunciators installed. There have been problems with them and they are reported to not be in operation.

City of Alexandria: Other Planned Transit ITS Projects:

The City of Alexandria is planning on acquiring some ITS technologies for its transit fleet. It is anticipated that by 2005, the City will equip part of its bus fleet with an AVL system. Also, by 2005, the City is planning on having an automated telephone information system, 511 telephone system, real-time information system (via pagers, PDAs, and Internet), and equipping their buses with smart card readers.

City of Fairfax: Transit Signal Priority and SmarTrip Farebox:

Like other areas in the region, City of Fairfax is interested in implementing several transit ITS technologies for its CUE bus service. The City is interested in implementing transit signal priority system and an APC system. These two projects are planned for the near future but are not funded. Keeping up with the rest of the region, City of Fairfax is planning on acquiring SmarTrip fareboxes for its bus fleet.

City of Fairfax: Automated Stop Announcements:

City of Fairfax currently has an automated stop announcements system that is deployed on all twelve buses. The manufacturer is Luminator and the system was acquired for the first six buses in 1998 as part of their new bus purchase. The other six old buses were replaced during August 2003 and the new buses also are equipped with a Luminator system. The cost of the systems was $200,000; the systems on the first six buses will be upgraded at an additional cost of $75,000.

Fairfax County: Automatic Passenger Counters:

Fairfax County uses two contractors to run their fixed route connector service: First Transit and Yellow Transportation. Two of the buses run by Yellow Transportation are equipped with APCs. The units were provided by Urban Transit Associates (UTA) and are simply part of a test.

Fairfax County: Scheduling Software:

Fairfax County has acquired Trapeze scheduling software for its Connector (fixed route) and FASTRAN (paratransit) operations. The system was fully operational by summer 2003.

Fairfax County: Community Resident Information Services (CRiS) :

CRiS kiosks are located at 25 different locations providing users with a wealth of information. The kiosks are interactive and allow the users to get information on various transportation modes, renew vehicle registration, pay taxes, and many other options.

The County's kiosk project is known as Community Resident Information Services (CRiS). Located at County Libraries, public buildings, shopping malls and other locations, each kiosk contains the following features:

- Touch screen activation
- Audio
- Full motion video
- Color graphics
- Still pictures/photographs

- Laser printer
- Information pages
- e-services
- Telephone
- Frequently asked questions
- Index

The Fairfax County Electronic Multimedia Kiosk is a regional program in partnership with other public and private sectors. CRiS provides the public with responsive and flexible alternatives for obtaining information and services. CRiS also allows Residents to conduct business with the government at convenient locations and times.

This program comprises information from various County agencies and other partners such as Metro (Bus and Rail), Virginia Railway Express, State DMV, Schools, C.O.G., City of Fairfax, Town of Warrenton, Fairfax Fair Corporation, Inova, EDA, NVRC. Many additional jurisdictions are in the planning stage for having information content added to CRIS. The program also delivers Services that include:

- Paying taxes
- Renewing vehicle registration
- Subscribing to publications
- Registering to be a child care provider
- Inquiring housing wait list status
- Scheduling special collections for trash pickup
- Scheduling/canceling inspection requests
- Inquiring permit/plan/inspection status
- Applying for current county and school jobs

VRE: IVR Phone Information:

VRE also offers delay information via its 1-800 IVR phone system where more detailed announcements are voice recorded and disseminated. This system has a hierarchy of information. If a train is 10 minutes late or more, the phone line would state "there is a delay on the ___ line"; to get more specifics, the caller can select the line or train number and listen to the more detailed message.

VRE: Communication/Fare Collection System

VRE procured fare collection system enhancements in 2000. VRE will introduce new ticket vending machines, an honor system for deferred cash payments and fare media purchases on account. VRE may choose to equip their TVMs to read WMATA SmarTrip cards since VRE is expected to be a participant in SmarTrip in the future. It is our understanding that interoperability is an issue since VRE selected a vendor other than Cubic.

VDOT: Tysons Area ITS Support:

Beginning in 1994, Fairfax, Prince William, and Loudoun Counties Virginia deployed a system to connect approximately 700 signalized intersections with central control. The system used leased telephone lines to communicate with a central control room. In the control room, operators monitored traffic conditions at intersections and retimed signals as necessary. The staff attempted to effectively manage the arterial transportation network by optimizing signal timings, improve traffic progression, and reduce environmental impacts. The optimization process was also used to create a database that can be used in for planning, design, and operational activities.

During the month of May 1999, optimization of the system in the Tysons Corner area of Virginia was completed. Annual savings to motorists traveling the network were estimated at about $20 million. Stops were reduced by approximately 6% (saving $418 thousand), system delay decreased by an estimated 22% ($18 million), and fuel consumption improved by an estimated 9% ($1.5 million). Total annual emissions for CO, NOX, and VOC were decreased by an estimated 134,600 kilograms.

VDOT: NOVA Smart Travel ITS Architecture:

In May 2002, VDOT completed the NOVA Smart Travel Program. In order to maximize the effectiveness and efficiency of this program, the NOVA ITS Architecture was developed which details the interconnection of VDOT facilities and stakeholders, and describes the flow of information between these agencies and VDOT NOVA. The architecture program included a comprehensive outreach effort to garner involvement, input, and consensus from stakeholders.

The VDOT-championed architecture process emphasized elements such as development of an "Asset Baseline" to catalog infrastructure and communications assets; a robust Stakeholder Outreach program; and development of a Communications Plan that guides implementation of the architecture. Outreach Report - identifies the regional stakeholders, and documents the outreach process and coordination effort required to verify aspects of the NOVA ITS strawman architecture and create regional compatibility among the NOVA ITS and Washington, D.C. and Maryland ITS architectures.

System Architecture - documents the iterative system architecture development process, presents the NOVA ITS system architecture in logical and physical formats, relates the NOVA ITS architecture to the National ITS Architecture, and provides guidance for using the system architecture in the project planning and development process.

Communications Plan - documents the communications plan development process and its relationship to the Outreach and System Architecture efforts, translates the system architecture interconnects and information flows into stakeholder communications requirements, presents related communications infrastructure, evaluates various communications technologies, and provides recommendations on investing in communications to support the system architecture.

In addition to the above reports, the project also includes the future publishing of an interactive Internet web site for the distribution of System Architecture and Communications Plan information. Also, a major component of the Communications Plan is the creation of an ITS asset and communications infrastructure database, and development of an enhanced web-based (initially a VDOT Intranet application) Geographic Information System (GIS) for managing the assimilated data.

VDOT: NOVA Smart Strategic Plan:

This Intelligent Transportation Systems (ITS) Strategic Plan is the culmination of more than four years of planning and policy development establishing the statewide vision and direction for ITS in Virginia. The Strategic Plan is a dynamic document that will be updated periodically. In each update, the plan will cover a ten-year horizon. This Strategic Plan provides planning-level information for the purpose of informing the public and transportation constituencies about the proposed transportation technology program in Virginia, which is known as the Smart Travel program. In addition to a description of the types of systems and services the Virginia Department of Transportation (VDOT) plans to implement, the plan identifies the roles of VDOT and the private sector in deployment. The VDOT role is further described in terms of the responsibilities of the different organizational and planning boundaries - statewide, regional, corridor and District – as they relate to the planning, operation, and maintenance of the various systems and services.

This Strategic Plan provides an overview of the Smart Travel program and its goals, and provides the reader with an overall vision for how technology can improve transportation in Virginia. Finally, it details the specific activities underway in various key areas including telecommunication, software development, operations, incident and emergency management, and research.

VDOT: NOVA Smart Travel Program:

The Virginia Department of Transportation's (VDOT) Smart Travel Program unifies the ITS applications of all transportation modes and levels of government under one umbrella concept—Smart Travel. The Smart Travel Program provides the needed coordination for effective development of ITS systems.

NOVA's Smart Travel Program helps ensure that the ITS installed today has the capability designed into the original systems for future expansion as it is usually difficult to modify technology systems after implementation. It envisions the future transportation service needs, including the geographic and functional needs, and envisions complete ITS systems to meet those needs. The NOVA Smart Travel Program can be described as ten inter-related systems that work together. Like pieces in a puzzle, the ten systems are related and form the complete picture of Smart Travel in NOVA. The ten systems are: planning and policy; surface street management; freeway management; freeway management; incident management; multi-modal support; customer service; communications; traveler information; asset management; payment system. NOVA's Smart Travel Program was completed in December 1999.

VDOT: Regional Payment Systems Study

In September 2000, a Regional Payment Systems partnership Action Plan was prepared for VDOT by Volpe National Transportation Systems Center and Multisystems. In addition to regional smart card acceptance for transit, the report also considered the integration of other types of transportation and non-transportation payment applications, including integration with SmarTag, parking, taxi, airport ground transportation and paratransit.

The report recommends an implementation strategy for linking with non-transit payments in the region including 1) further market research to quantify the extent to which smart card acceptance through transponders would benefit Smart Tag facilities, 2) retaining a separate prepaid account capability to support Smart Tag facilities outside the Northern Virginia region, if integration is pursued, and 3) pursuing the benefits expected from implementing a system like that described in the 1999 Smart Access proposal made jointly by regional transportation agencies to FTA for a field operational test of smart cards. The study endorses proceeding with a clearinghouse for regional payment accounts, incorporating the Smart Access approach for a first phase where all partners need to accept the same payment medium. As we understand it, the clearinghouse project that WMATA is undertaking (described as a separate project) is starting with the transit agencies.

DCDPW: Transpass Public Parking Smart Card

A demonstration called TransPass was envisioned of a smart card on-street parking program in DC, involving about 2,000 meters and 10,000 cardholders an possibly an off-street facility. The demonstration was to last 6-9 months. It was envisioned in various plans that TransPass could also be integrated with regional payment efforts such as SmarTrip. The VDOT Volpe study however noted that DC on-street parking meters have a proprietary system smart card reader that is not compatible with the Cubic system used in SmarTrip. It appears that this type of integration is a longer range goal for SmarTrip.

Dulles Corridor Task Force: Dulles Corridor Rapid Transit Project Technology Implementation Plan (late 1999):

Planning for new transit services in the Dulles Corridor has been a multi-year, multi-agency effort. The Task Force developed a five-phase implementation plan for new services. Phase 1 (1999-2000) was to involve express bus service and new routes. Phase 2 (2001-2002) was to involve enhanced express bus service (more routes). Phase 3 (2003-2005) would involve the implementation of Bus Rapid Transit. (BRT typically involves implementation of one or more ITS systems.) Phase 4 (2006-2009) would involve extending Metrorail to Tysons Corner. Phase 5 (beginning 2010) would involve extending Metrorail to Reston/Herndon, Dulles Airport and Routes 606 and 772 in Loudoun County.

The Dulles Corridor Task Force Technology Task Group was formed to develop a technology plan and includes NVTC, VDRPT, VDOT, WMATA, Fairfax and Loudoun Counties, the Metropolitan Washington Airports Authority, The Washington Airport Task Force and the Dulles Area Transportation Association. PB Farradyne was engaged to prepare a Technology Implementation Plan for the project.

The plan develops several implementation concepts for transit in four groups and identifies when they would be implemented:

- Traveler information package
  - Transit vehicle tracking (AVL and CAD including GPS, in-vehicle logic unit, MDT, central/ITS planning/multimodal coordination hardware and software) (Phase 2-3)
  - Parking facility information (DMS at facility and highways, detectors and controller, server)(Phase 2-3)
  - Wayside/in-station traveler information (DMS or display monitors, server, software) (Phase 3-4)
  - In-vehicle information (DMS, enunciator, central recording station) (Phase 3-4)
- Electronic Payment Package
  - Electronic fare payment (to be coordinated with regional EFP) (fareboxes, turnstiles, TVM, central hardware and software, clearinghouse) (Phase 3-4)
  - Parking facility electronic payment (transponder reader, smart card reader, camera, central hardware and software, clearinghouse) (Phase 3)
- Security/Safety Package
  - On-board transit security (CCTV camera, silent alarm and microphone) (Phase 3)
  - Transit facility security (CCTC cameras, video monitors, central video switcher and controller) (Phase 3-4)
  - Parking facility security (CCTV cameras, video monitors, central video switcher and controller) (Phase 3) (note: Herndon Monroe already has CCTV cameras)
- Operation Package
  - BRT station lane access control (vehicle transponder, reader, gate assembly) (Phase 3)
  - BRT precision docking system (Phase 3)
  - Transit vehicle mechanical safety monitoring and maintenance (Phase 3)
  - Traffic signal priority study for corridor (based on findings of current regional study; should include pre-study, installation, operation and evaluation of TSP in the corridor) (Phase 2)
- Emergency Response (for the transit operator) (includes GPS, MDT for police vehicles and central hardware and software) (Phase 3)

For each concept, the plan identifies the specific systems, costs and benefits.

It was recommended that other applicable concepts, considered either to be technologically immature or of lower priority, be monitored to determine whether they should be implemented in the corridor:

- Enhanced driver vision system

- In-vehicle signing
- Collision avoidance systems (lateral and longitudinal warnings or controls, and driver safety monitoring)
- Automated passenger counters
- Platform screen doors
- Personal Rapid Transit
- Automated highway/rail system
- Pre-crash restraint

The plan also identifies 10 major coordination concepts to be implemented by other that directly relate to transit as well as several additional concepts less directly related to Dulles transit services. The Plan also indicates in which phases they would be implemented.

According to the plan, broadcast traveler information, interactive traveler information (personal information access), transit trip itinerary planning, and transit fixed route software would be implemented in Phase 1 (express bus). Incident management systems would also be implemented by others in Phase 1. Traffic information dissemination, interactive kiosks, probe data collection and lane control would be implemented in Phase 2 (enhanced express bus). Freeway ramp and interchange metering with queue jumping would be implemented by others in Phase 2. Electronic toll collection and regional traffic control would be implemented in Phase 3 (BRT). By Phase 3, all of the primary transit concepts would be implemented. In addition, five other concepts would be implemented by others (intersection safety warning, emergency response, demand response transit software, road weather information system and emissions monitoring and management). By Phase 4 (Rail), it is envisioned that intersection collision avoidance and traffic prediction and demand management would be implemented by others.

On December 19, 2002 the Virginia Commonwealth Transportation Board (CTB) endorsed extending Metrorail from West Falls Church to Route 772 in Loudoun County. With the CTB's approval of Metrorail as the Locally Preferred Alternative, DRPT will now seek FTA approval to start preliminary engineering. The Final EIS for the Dulles Corridor Rapid Transit Project is scheduled for completion in 2003 The decision to move directly to rail implementation and to bypass the BRT phase may have significant impacts on the implementation of the technology plan. To our knowledge, none of the concepts recommended the Table 3 of this report.