Technology Adoption
by Small Urban and Rural Transit Agencies

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June 2010

Acknowledgements

This research was sponsored by the Federal Transit Administration, United States Department of Transportation, and conducted by the Small Urban & Rural Transit Center within the Upper Great Plains Transportation Institute at North Dakota State University.

The guidance of Jill Hough of the Small Urban & Rural Transit Center and Henry Nejako, FTA Project Manager for the project, are acknowledged.

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ABSTRACT

In this paper, findings from a national survey on technology use by agencies providing transit service to rural areas are presented. The survey collected data on agency use of information and communications technologies, transit-specific technology, as well as characteristics of its manager. The survey targeted organizations that receive Section 5311 funds, a federal grant program, to provide transit service to non-urbanized areas, but that do not provide intercity bus service exclusively. Survey data were joined with financial and operating statistics contained in the recently available Rural National Transit Database (Rural NTD) to allow for further analysis.

An econometric analysis to investigate the impact of community, agency, and manager attributes on technology adoption was conducted using discrete choice modeling techniques. The analysis included modeling the individual adoption of four technologies: Automatic Vehicle Location (AVL), Computer-Aided Scheduling and Dispatch software (CASD), Geographic Information Systems (GIS), and Mobile Data Terminals (MDTs) using binary logit techniques. The joint adoption of technology, specifically CASD software in combination with AVL, GIS, or MDTs, was modeled using a multinomial logit framework. Agency size measured by fleet size, budget, and trips delivered are significant factors that impact the adoption of technology by rural transit agencies. Manager education and experience, attendance at national conferences, interaction with technology vendors, and participating in technology training were also found to be significant.

Results of the survey and analysis have practical implications for policy and practice. They support participation of agency mangers in national conferences and technology-focused training. The results can also be used to determine which agencies might benefit from technology based on community, agency, and manager attributes. Conversely, agencies that do use technology, but are not expected to based on their characteristics, can be identified to determine if and how they benefit from the technologies they use.

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ACRONYMS

APC	Automatic Passenger Counter
APTS	Advanced Public Transportation Systems
AVL	Automatic Vehicle Location
CASD	Computer-Aided Scheduling and Dispachsoftware
DOT	Department of Transportation
DSL	Digital Subscriber Line
EFP	Electronic Fare Payment Systems
FTA	Federal Transit Administration
GIS	Geographic Information Systems
IT	Information Technology
ITS	Intelligent Transportation Systems
MDT	Mobile Data Terminal
NTD	National Transit Database
RFID	Radio Frequency Identification
Rural NTD	Rural National Transit Database
TCRP	Transit Cooperative Research Program
TIS	Traveler Information Systems

1. INTRODUCTION

In this study, the results of a national survey of rural transit agencies on the topic of technology are presented. Data collected by the survey were joined with that in the Rural National Transit Database (Rural NTD) to provide a more complete picture of rural transit agencies and their current use of technology. These data were used to identify the factors that impact the adoption of individual transit technologies by rural transit agencies using discrete choice modeling techniques. The results of the analysis have implications for rural transit policy and practice.

Transit agencies serving rural areas provide a vital link for many Americans. These organizations are the product of the communities they serve with demographics, geography, and economics dictating the services they provide and how they can be best delivered. Rural transit is about more than transporting people. It requires a commitment to safety and continual innovation to increase efficiency so that no feasible trip goes unserved. At the same time, growing demands of discretionary riders require that transit agencies provide high levels and high quality service. To meet the challenges of providing mobility to their community, many rural transit agencies use technology.

The technology used by rural transit agencies include traditional information technology (IT), defined as computer-based information systems, communications technology such as the Internet and cell phones, as well as systems that are unique to transportation and transit. These systems, referred to as Advanced Public Transportation Systems (APTS), assist rural transit agencies in a number of ways, including increasing productivity, capacity, or improving safety. Examples of APTS include software that automates scheduling and dispatching functions and on-vehicle technology that identifies the vehicle's location in real time.

While many agencies have adopted specialized technology, prior to this study there has been no resource that provided a national picture regarding the use of specific technologies by rural transit agencies. Beyond a simple description of the current state of practice with respect to rural transit technology, the absence of data has prevented investigation into what factors influence the adoption of technology. While some agency attributes are outside of its control, such as the region an agency serves, others, such as the participation of agency managers at national conferences or formal technology training, are not. Knowledge of the current use of technology and the attributes that influence technology adoption by transit agencies providing service in rural areas can help guide policy and practice. Agencies that do not currently employ a particular technology but share the characteristics of other agencies that do may benefit from additional information on the costs and benefits of implementation or formal technology training. Conversely, agencies that would not be expected to use technology based on their attributes, but that do, may need to be investigated to the see if and how the technology is beneficial.

In this study, rural transit agencies are defined as those organizations that receive Section 5311 funds to provide service to non-urbanized areas. Organizations that provide only intercity bus service were excluded. These agencies are quite diverse in terms of the types of transportation services they provide and the communities they serve. Some agencies that receive Section 5311 funds also provide service to urbanized areas, those with populations greater than 50,000.

1.1 Objective

The small urban and rural transit technology study has three objectives. The first objective is to identify what technologies are currently used by small urban and rural transit agencies. The second study objective is to investigate the influence of community, agency, and manager attributes on technology adoption. The third project objective is to determine the implications of these findings on policy and practice.

1.2 Outline

The report consists of six sections. The second section describes technologies used by rural transit agencies. The third section describes the study's survey design. Section Four presents the results of the survey. The fifth section presents the results from using discrete choice models to estimate the influence of community, agency, and manager characteristics on technology adoption by rural transit agencies. In the sixth section, the implications of the results of the analysis on policy and practice are presented.

2. RURAL TRANSIT TECHNOLOGY

A number of technologies are used by rural transit agencies to positively impact their service. In this section, these technologies are described to assist those who are unfamiliar or unsure about the definitions of technologies, the functions they provide, and how transit agencies benefit from their use. Similar descriptions were included in the survey to ensure a common understanding of the technology. The technologies listed are far from exhaustive; however, they include most of those typically used by rural transit agencies.

2.1 Communications Technology

Communications technology forms the backbone upon which other technologies rely. Communications infrastructure is used to communicate voice, text, data, or video. In some rural areas, the lack of communications infrastructure dictates what other technologies may be used.

- **Cellular communications** are a long-range phone service that allows voice and data communication over a wireless network. Cellular communications are provided by a cellular carrier and are dependent on local coverage. In the context of rural transit, cellular communications are typically used to communicate operational information.
- **Wireless Local Area Networks** (WLAN) connect devices, such as computers, by sending data from one location to another wirelessly over short distances. In transit, WLAN may be used to communicate between vehicles in a garage or yard with other agency computers.
- **Smart phones** are mobile phones with many of the same capabilities as a computer, including data processing and online mapping. Smart phones can run operating systems, like Windows or Linux, access the Internet, and use e-mail and other software applications as well as provide traditional voice communication.
- **Satellite phones** are a type of mobile phone similar to a cellular phone. However, instead of connecting to terrestrial cellular towers, the phone communicates with orbiting satellites. Consequently, satellite phones provide the ability to communicate in remote areas with limited or no cell reception.

2.2 Transit Operations Software

Transit operations software assists in the operation of transit agencies by automating and integrating functions and systems, including on-vehicle technology. Transit operations software may assist with route planning, scheduling, and vehicle assignments. The most familiar type of transit operations software is Computer-Aided Scheduling and Dispatch software.

2.3 Computer-Aided Scheduling and Dispatch

Computer-Aided Scheduling and Dispatch (CASD) technology provides a number of functions, but the key component is automating the scheduling and dispatch function of a transit agency. Some CASD packages automatically assign trips to vehicle and generate routes. Generated schedules may be disseminated using printed hard copies of driver manifests or be communicated electronically to on-vehicle technology for drivers to access in real time.

Given the amount of information required, and that scheduling and dispatching is a key function of an organization providing demand-response service, CASD has become a core component of most rural transit technology systems. Some CASD packages provide record-keeping and billing capabilities as

much of the information required is already assembled in the CASD database. Other potential benefits of using CASD identified by Kessler include improved accuracy of reservations and the ability to provide real-time customer information.

2.4 Geographic Information Systems

Geographic Information Systems (GIS) are used to collect, manage, analyze, store, and report spatial data using a common set of coordinates. In transit, GIS is used for planning and operations. GIS is often used in combination with CASD software as it provides the ability to schedule trips using road network and other geographic information.

Sutton identified a number of uses and benefits from using GIS in transit. The technology allows for managing and communicating large volumes of data, often in a visually appealing manner. GIS is a useful planning tool as it can contain demographic, economic, and road network information required for travel demand modeling.

2.5 Automatic Vehicle Location

Automatic Vehicle Location (AVL) allows for the tracking of vehicle location using computerized navigation. The actual method used to determine the location can vary; however, the most common method is using Global Positioning System (GPS) technology. GPS collects information generated by orbiting satellites which is then used by on-vehicle technology to calculate location. This information may be used by on-vehicle systems as well as be communicated back to the agency.

Okunieff (1997) recognized the value of AVL in reducing response times to emergency situations, the ease of tracking schedule adherence, and as evidence in managing grievances. Parker (2008) also noted the role of AVL in managing schedule adherence and in reacting to service disruptions as well as its ability to increase situation awareness for dispatchers, coordinating operations, and for security purposes. Data generated by AVL technology can be used for planning as described by Furth, Hemily, Muller, and Stratham (2006).

2.6 Traveler Information Systems

Traveler Information Systems (TIS) are a broad array of technologies that provide pre-trip, wayside, or on-vehicle information. Pre-trip information may include static or real-time information, or trip planning tools. This information may be accessible to users using the Internet or by phone. Wayside technologies include variable message signs, video monitors, or audible announcements while on-vehicle technology includes stop annunciation and variable message signs.

2.7 Security Systems

Security systems include surveillance, sensor, and alarm technology. Surveillance may use video or audio. Many systems also include a recording capability. Sensor technology includes metal detectors and motion sensors. Alarms may be either driver activated or user activated. Security systems may be located on-vehicle, in public areas such as stops or transit stations, or in non-public areas, including yards, garages, or inside buildings.

Nakanishi (2009) cautions against over reliance on technology and the need for evaluation of systems to ensure that they are feasible and effective. Maier and Malone (2001) explore the ramifications of on-vehicle surveillance and its impact on crime prevention, risk management, legality, customer service, and

employee related issues. AVL technology can play a role in transit system safety and security by allowing for monitoring of vehicle location, which can result in reduced response times (Okunieff 1997).

2.8 Electronic Fare Payment Systems

Electronic Fare Payment (EFP) systems facilitate the collection and processing of fare payment. User-side components of electronic fare payment systems may be located on vehicles or transit stops, or be accessible via the Internet.

EFP systems may use dedicated or multipurpose cards. These may rely on magnetic stripe, bar code, or Radio Frequency Identification (RFID) technology. RFID technology, commonly referred to as smart card technology, allow for contactless communication of information.

EFP systems may reduce or eliminate cash handling and corresponding losses. They also facilitate reporting and billing. In many cases they increase the speed of boarding as passengers are not required to pay with coin. EFP systems may assist in tracking ridership and identifying passengers.

EFP systems may result in increased ridership by increasing customer loyalty and facilitate coordination by using a single fare card (Multisystems, Mundle & Associates and Simon & Simon Research and Associates 2003). Fleishman, Schweiger, Lott, et al. (1996) describe the benefits of a multipurpose payment media. These include allowing for seamless regional travel which reduce fare collection costs by transferring the function to financial institutions. Multipurpose cards may improve data collection, revenue reconciliation, and improve customer convenience as well as increase ridership.

2.9 Maintenance Tracking Systems

Maintenance tracking systems may monitor the performance of individual vehicles, assist in managing preventative maintenance programs, and help with managing fleet or parts inventories. Tracking of individual vehicle performance often relies upon on-vehicle technology.

2.10 Automatic Passenger Counting Systems

Automatic Passenger Counting (APC) systems count passenger boardings and departures. Boyle (2008) notes that smaller systems, those with fewer than 250 vehicles, typically use manual methods to collect data. He also noted the impact of APC technology in providing large amounts of timely, high quality, detailed data for managing operations and planning. Furth, Hemily, Muller, and Stratham describe how APC data can be used for planning and managing system performance.

2.11 Mobile Data Terminals

Mobile Data Terminals (MDTs) are on-vehicle technology that allow for non-voice communication between driver and the agency. MDTs may communicate vehicle location, vehicle performance, passenger counts, and other information. MDts are often integrated with on-vehicle technology, including electronic fare payment and AVL systems.

Harman and Shama (2007) identified a number of applications of MDT-communicated data using a survey of urban transit agencies. These include driver time keeping, route and schedule adherence, and fraud prevention and detection. Also noted was the use of MDTs in vehicle status and preventative maintenance.

3. SURVEY METHOD

A survey was designed and deployed to collect information on technology use by agencies providing transit service to rural areas. The primary goal of the survey was to collect accurate, current information on technology adoption. The collection of detailed cost data and data needed to fit the technology adoption models were secondary goals. While a 100% response rate was unlikely, effort was made during the survey design and deployment phases to encourage participants to respond.

Collection of agency level, per unit cost data was determined to come at a significant cost in terms of the rate of response. Many agencies do not have this information readily available, which may require considerable time and effort to assemble. It was estimated that the completion time for the survey would increase from about fifteen minutes to more than an hour for agencies that had recently adopted multiple technologies, if detailed cost information was requested. This amount of time was deemed unacceptable. Consequently, less detailed cost data were requested.

The survey benefited from the recently available Rural National Transit Database, the assistance of state departments of transportation (DOTs), and the low cost of online surveying. The Rural National Transit Database provided a list of target participants, although contact information for organizations still needed to be collected. It is important to note that most, but not all, recipients of 5311 funds report to the Rural National Transit Database. Agencies that also receive 5307 funds to provide service to urban areas may chose to report to the National Transit Database. State DOTs were helpful in providing contact information for agencies that could not be identified through other sources. Many state DOTs contacted subrecipients to encourage them to participate in the survey.

A preliminary version of the survey was sent to select transit agency managers, state DOT staff, and transportation researchers for testing. A frequent comment was the potential for collection of more detailed cost data. Again, this was not requested due to the expected adverse impact on the response rate. Other comments included those related to definitions and wording.

The survey was made available online, in paper form, and by phone. Individuals were initially invited to participate by email. The email invitation informed potential participants of the purpose of the survey and that the results would not be used for marketing purposes. For agencies that did not complete the survey within a two-week time frame a second email was sent. For those agencies that did not respond to the second email within two weeks, a phone call was made to the agency head. Transit managers were asked if they had received the survey; or if they still had the invitation available; or if they would another copy sent, if they would like a paper survey, or if they would like to complete the survey by phone. Only two individuals asked to have paper surveys sent while one was completed by phone. The remaining surveys were completed online.

The survey instrument is included as an appendix to this report. It includes all questions and information provided to participants who completed online, paper, or telephone surveys. The survey asked participants for general agency information, communications technology, and transit technology. Adequate agency information was requested so that survey data could be joined to that in the existing Rural NTD database. This would allow for questions collecting recent financial and operating statistics to be omitted from the technology survey, which would reduce the response time and increase the rate of response. The survey instrument included brief descriptions of each technology to ensure that there was common understanding of the terms used. Transit managers were asked questions about education, work experience, training, and conference attendance. Participants were also asked if they would like to receive the results.

Some participants contacted the research team for clarifications on the survey. The most common question concerned reporting the number of computers used by the agency. Many transit agencies are part of larger organizations, such as city departments. Respondents from these organizations didn't know if they should report the number of personal computers used by their department or the entire organization. Participants were asked to provide information for only their department or that part of their organization that is involved in public transportation.

Some agencies that do not directly provide transit service asked how they should report. Participants wanted to know if they should report for their agency or agencies they partner with that deliver service. These participants were asked to respond for their organization only as they would likely be unable to answer many of the more specific questions for tertiary recipients and to prevent double counting. One individual asked why specific manager information was requested by the survey. They were informed of the reasoning: to serve as variables to determine the role of manager attributes on technology adoption. They were also reminded that they were free to leave any question unanswered.

4. SURVEY RESULTS

The survey results provide the first national picture of the use of technology by agencies serving rural areas. In this section, descriptive statistics from the survey are presented. First agency statistics are presented. Next, use of common Information Technology (IT) is described. In the third part, use of common communications technology is presented. In the fourth section, manager's familiarity and their organization's use of core rural transit technology are presented. The fifth section presents manager background information such as education level and experience. Technology adoption by agency characteristics, such as fleet size, budget, and levels of service, are presented in the final section.

4.1 Transit Agency Characteristics

The survey was completed by 451 agencies located in 45 states. Two tribes, the Citizen Potawatomie Nation and the Navajo Nation, also completed the survey. The number of survey responses by state is presented in Table 4.1.

Table 4.1 Number of Responses by State (N=451)

State	Number of Responses	State	Number of Responses
Alabama	5	**Montana**	7
Alaska	3	**Nebraska**	15
Arizona	8	**Nevada**	1
Arkansas	3	**New Hampshire**	0
California	17	**New Jersey**	5
Colorado	13	**New Mexico**	11
Connecticut	2	**New York**	6
Delaware	0	**North Carolina**	25
Florida	11	**North Dakota**	7
Georgia	19	**Ohio**	14
Hawaii	0	**Oklahoma**	5
Idaho	8	**Oregon**	19
Illinois	14	**Pennsylvania**	12
Indiana	13	**Rhode Island**	0
Iowa	15	**South Carolina**	2
Kansas	33	**South Dakota**	10
Kentucky	8	**Tennessee**	1
Louisiana	7	**Texas**	17
Maine	3	**Utah**	0
Maryland	5	**Vermont**	3
Massachusetts	2	**Virginia**	6
Michigan	23	**Washington**	10
Minnesota	24	**West Virginia**	4
Mississippi	5	**Wisconsin**	16
Missouri	7	**Wyoming**	7

Managers were asked what types of service their agency provides. The most common response was advanced reservation service, which was reported by 61% of agencies, followed by dial-a-ride, which was reported by 51% of agencies. Among agency managers, 39% stated that their agency provides fixed-route service, while 12% stated they provide intercity bus. The number of responses by transportation service provided is presented in Figure 4.1.

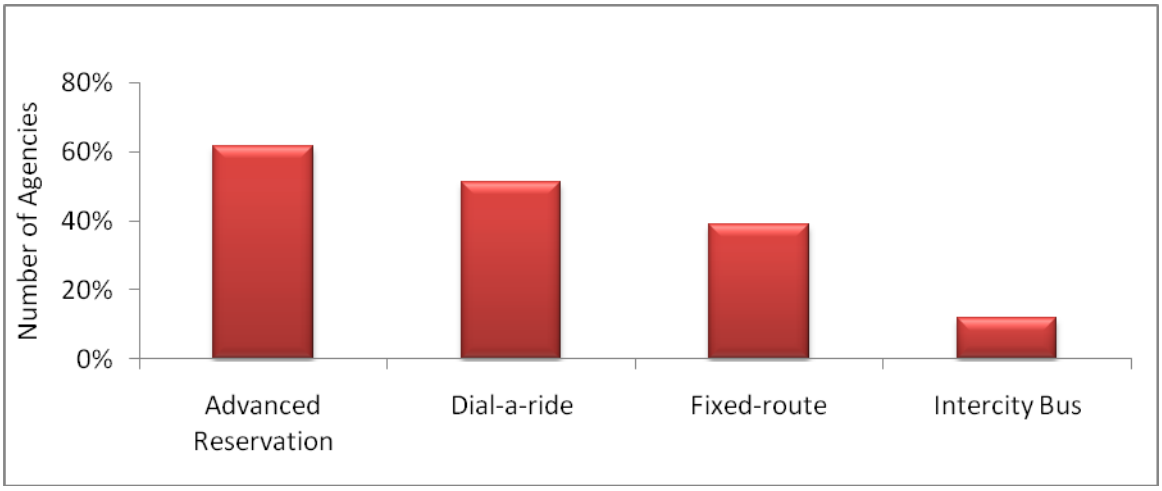

Figure 4.1 Number of Responses by Service Provided (N=451)

Agency managers were asked about their organizational type. Local government was the most common response with 49% of agency managers reporting this type. This was followed by non-profit, which was reported by 40% of survey respondents. Only 2% of agency managers reported that their organization was operated for profit. The responses by organization type are presented in Figure 4.2.

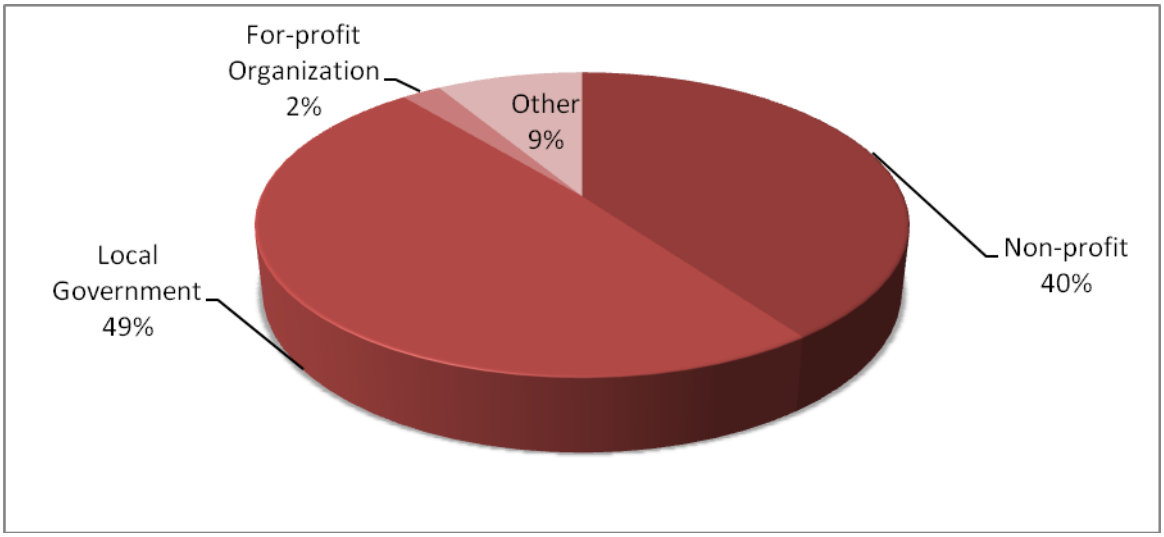

Figure 4.2 Number of Responses by Organization Type (N=451)

4.2 Information Technology

Transit agency managers were asked about their agency's use of information technology. This included questions on use of personal computers, computer servers, Internet access, and source of IT assistance.

4.2.1 Personal Computer Use

The survey asked agency managers about the number of personal computers their organization uses. There was confusion among some agencies that are part of larger organizations on what number to report. For example, city departments or large organizations that have a large non-transportation related function. A determination was made that personal computers used by those departments that had direct interaction with the provision of personal transportation should be included.

Most transit agency managers, 53%, reported that their agency had five or fewer personal computers. The use of 6-10 personal computers was noted by 24% of agency managers. Eight percent of transit agency managers reported that their agency used more than 25 computers. Figure 4.3 presents the number of personal computers used by transit agencies that participated in the survey.

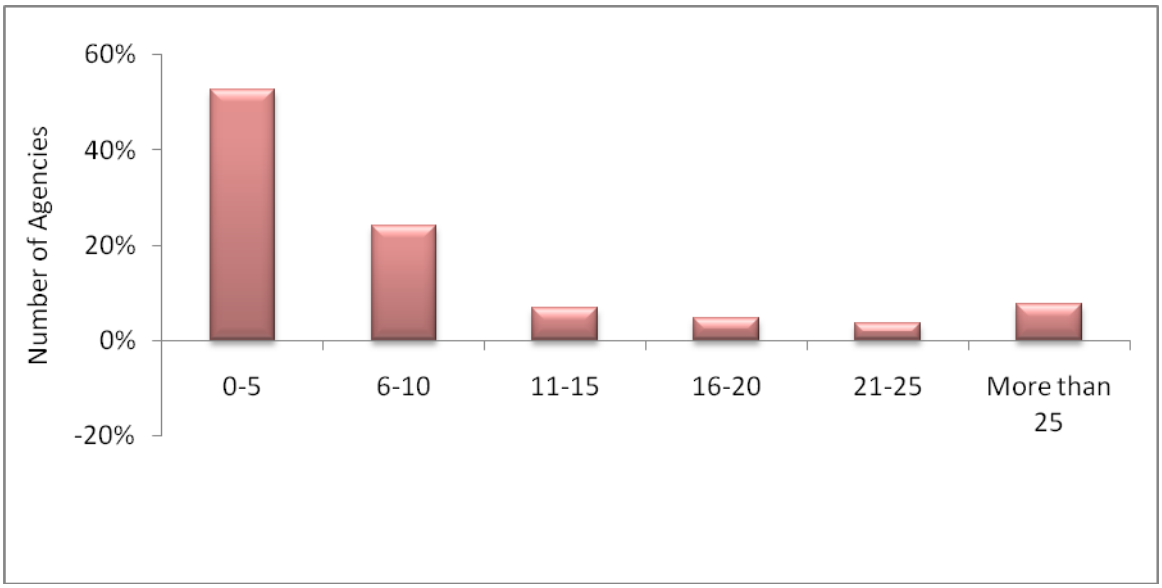

Figure 4.3 Number of Personal Computer Used (N=448)

4.2.2 Computer Server Use

Transit agency managers were asked if their organization used a computer server or servers as part of their organization's information technology infrastructure. Just under 72% of survey respondents stated that their agencies use servers. Of these, 72% stated that their servers are located on site.

4.2.3 Internet Use

Survey participants were asked if their agency has access to the Internet and, if so, what type of connection they have. Nearly all agency managers, 99%, stated that their agency has access to the Internet. Three-fifths of managers stated that their agency uses Digital Subscriber Line (DSL) service, which uses existing telephone lines to transmit data. Cable Internet was reported to be used by 17% of

transit agencies followed closely by wireless service, which was reported by 14% of transit agency managers. Transit agency Internet use as reported by survey respondents is presented in Figure 4.4.

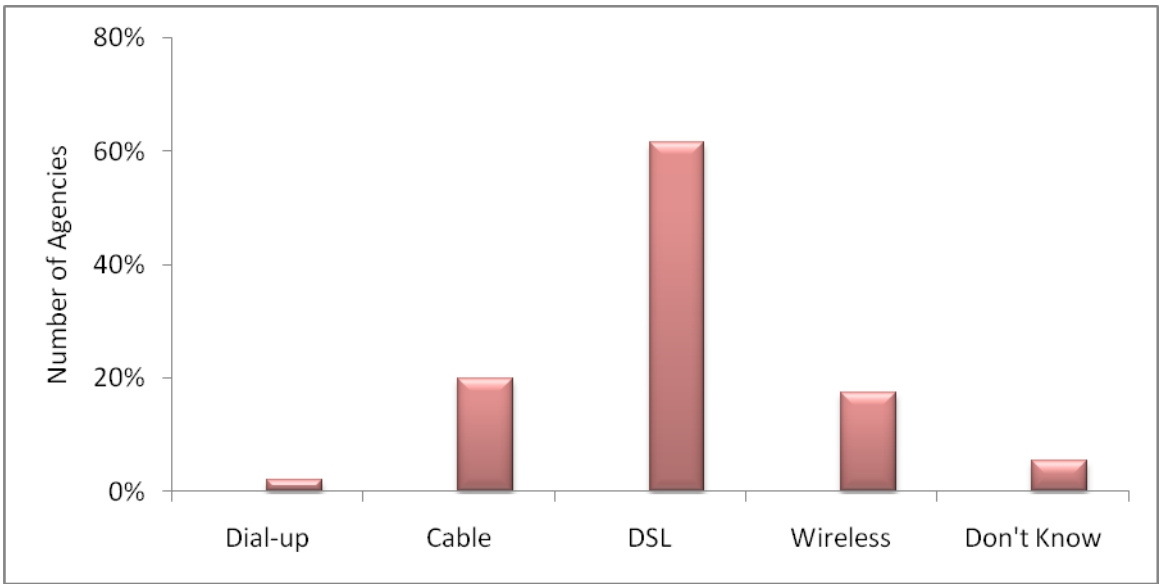

Figure 4.4 Type of Internet Access (N=433)

4.2.4 IT Support

The survey asked transit agency managers about their usual source of technical (IT) support. In-house support was reported by 39% of transit agency managers. The second most common response was third-party support, which was reported by 33% of survey participants. Shared government support was reported by 18% of managers, while 10% of managers said they had no formal, regular source of support. The source of IT support used by responding agencies is presented in Figure 4.5.

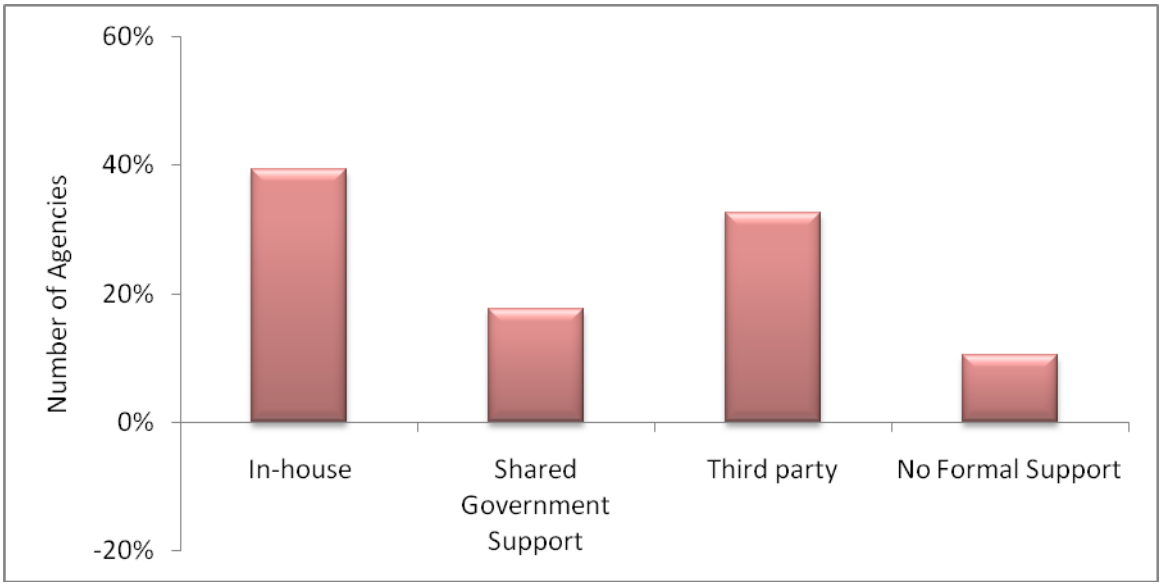

Figure 4.5 IT Support Source (N=417)

4.3 Communications Technology

Transit agency managers were asked about their agency's use of communications technology. This included which technologies - including two-way radios, cell phones, smart phones, text messaging, satellite phones and wireless local area networks - are used. They were also asked what for what purposes each technology are used.

4.3.1 Two-Way Radios

The survey asked participants about their familiarity with and their agency's use of two-way radios. Nearly all participants stated that they are familiar with the technology and 73 percent stated they currently use two-way radios.

Participants were asked about the ownership of the communications infrastructure that they use to communicate. Of these, 59% stated that the agency owns the communications infrastructure; 19% stated that they share public infrastructure; 21% stated that they contract with other entities, public or private, for use of communications infrastructure. Ownership of communications infrastructure is presented in Figure 4.6.

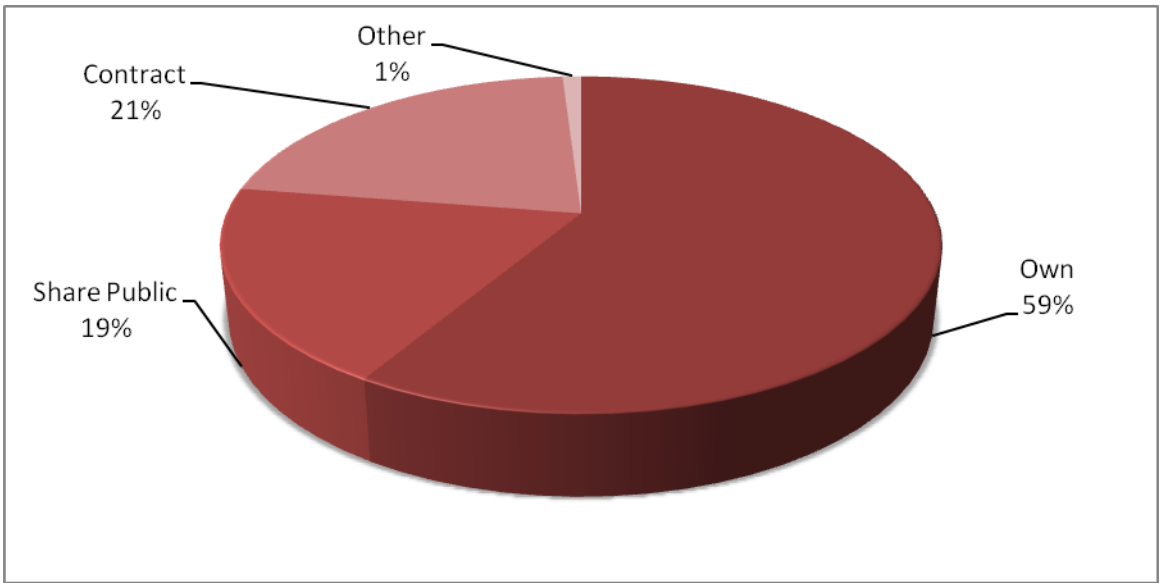

Figure 4.6 Communications Infrastructure Ownership (N=287)

Agency managers were asked what purposes two-way radios are used for. Of these, 86% stated that their two-way radio system is used for emergency communications, 80% use the technology to schedule changes, while 74% use two-way radios to communicate the pick-up and drop-off of riders. About three-fourths of agencies use two-way radios to communicate vehicle location and one-half to communicate driver sign-on or sign-off. Figure 4.7 presents the purposes two-way radios are used by survey participants.

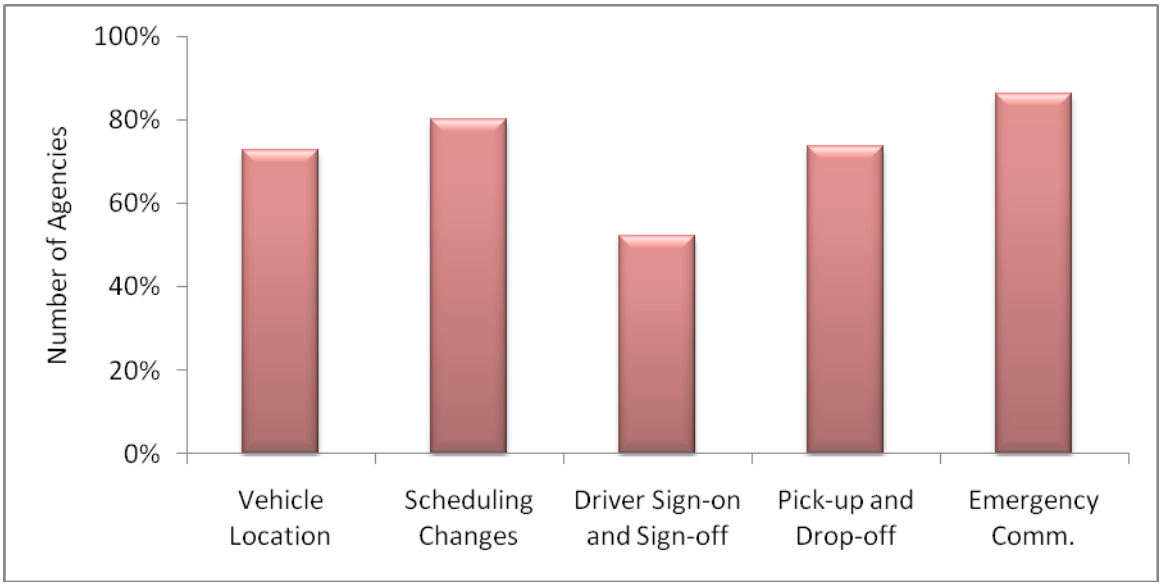

Figure 4.7 Two-way Radio Purpose (N=283)

4.3.2 Cellular Phones

Cellular phone use formed the basis of the next line of questions. Nearly all respondents, 99 %, stated that they are familiar with cell phones and 80% reported currently use them as part of their transportation operation. Twelve percent of agencies that don't currently use cell phone technology plan on doing so in the next five years.

Survey participants were asked what purposes cell phone technology serves in their agency. Of those, 80% stated that cell phones are used for emergency communication. About 60% of agencies use cell phones for scheduling changes and operations management. About half of the agencies that participated in the survey stated that they use cell phones to communicate vehicle location and passenger pick-up and drop-off. Figure 4.8 presents the purposes for which agencies use cellular phones.

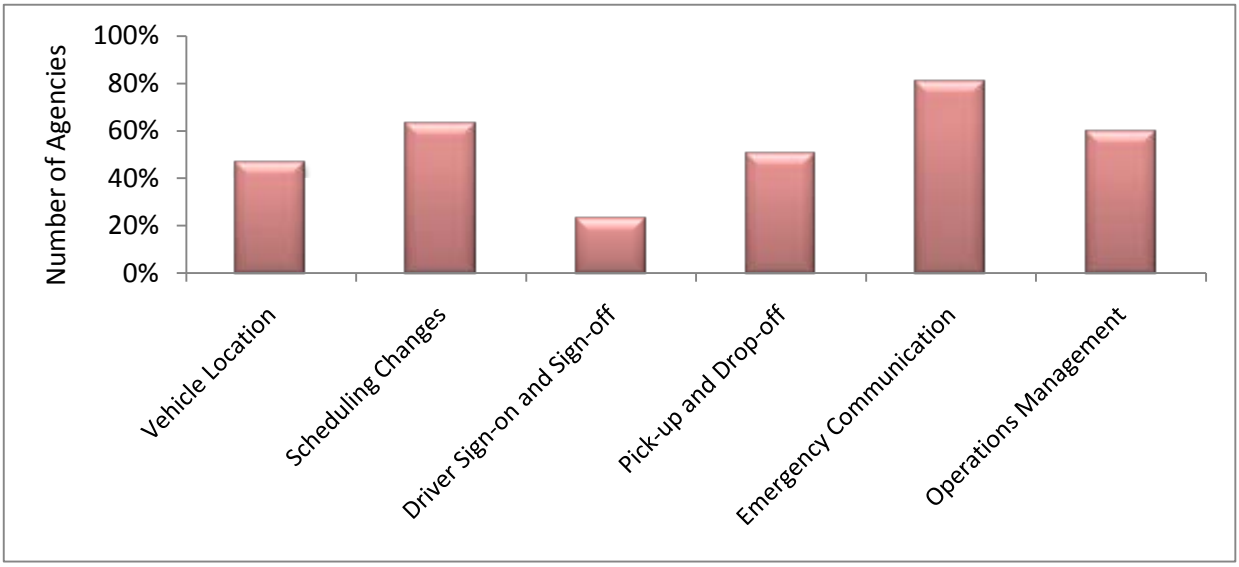

Figure 4.8 Cellular Phone Purpose (N=287)

4.3.3 Smart Phones

Transit agency managers were asked about their familiarity with and their agency's use of smart phones. Among respondents, 73% stated that they are familiar with smart phone technology. However, only 8% of agencies reported currently using them. Eleven percent of those agencies that do not currently use smart phone technology plan to do so within the next five years.

Most agencies, 69%, reported using smart phones to assist in operations management. Fourteen percent stated that they use smart phones for emergency communications. Less than 10% of respondents stated that they use smart phone technology for vehicle location, scheduling changes, driver sign-on and sign-off, or passenger pick-up and drop-off. Purposes for smart phone use are presented in Figure 4.9.

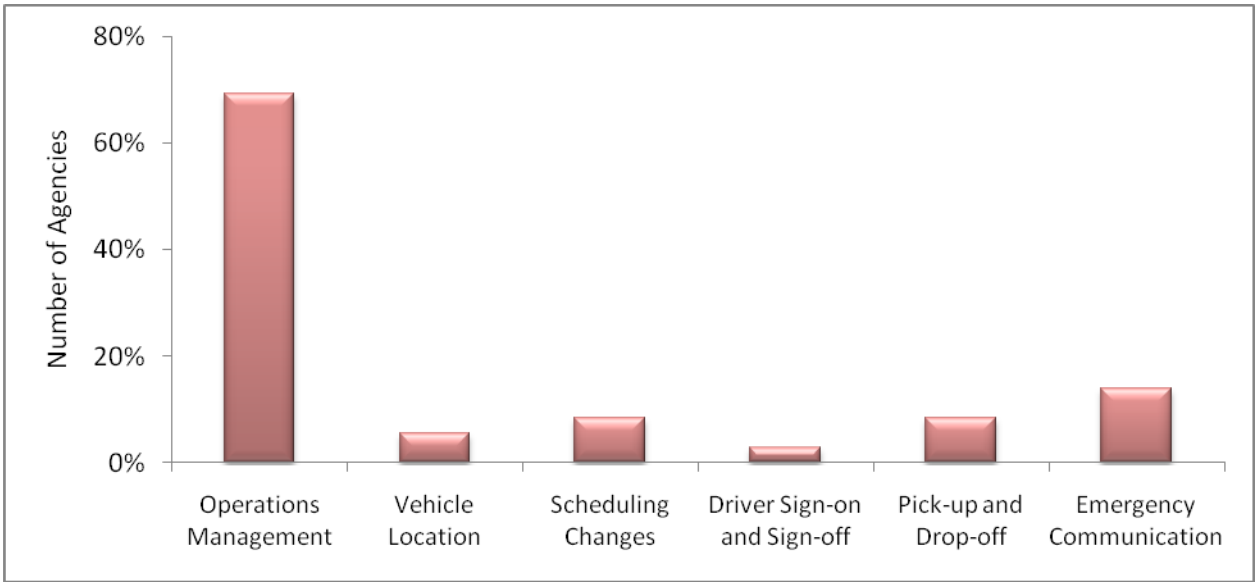

Figure 4.9 Smart Phone Purpose (N=21)

4.3.4 Text Messaging

Nearly all respondents, 97%, stated that they are familiar with text messaging. Twelve percent currently use text messaging as part of the transportation operations. Nine percent of agencies that don't currently use text messaging plan to in the next five years.

Text messaging was reported as being used most often to manage operations. About one-half of survey participants stated that their agency uses text messaging for emergency communications or for scheduling changes. One-fourth of managers stated that text messaging is used to communicate passenger pick-up and drop-offs or vehicle location information. The use of text messaging to communicate driver sign-on and sign-off was reported by 15% of participants. Uses of text messaging capability are presented in Figure 4.10.

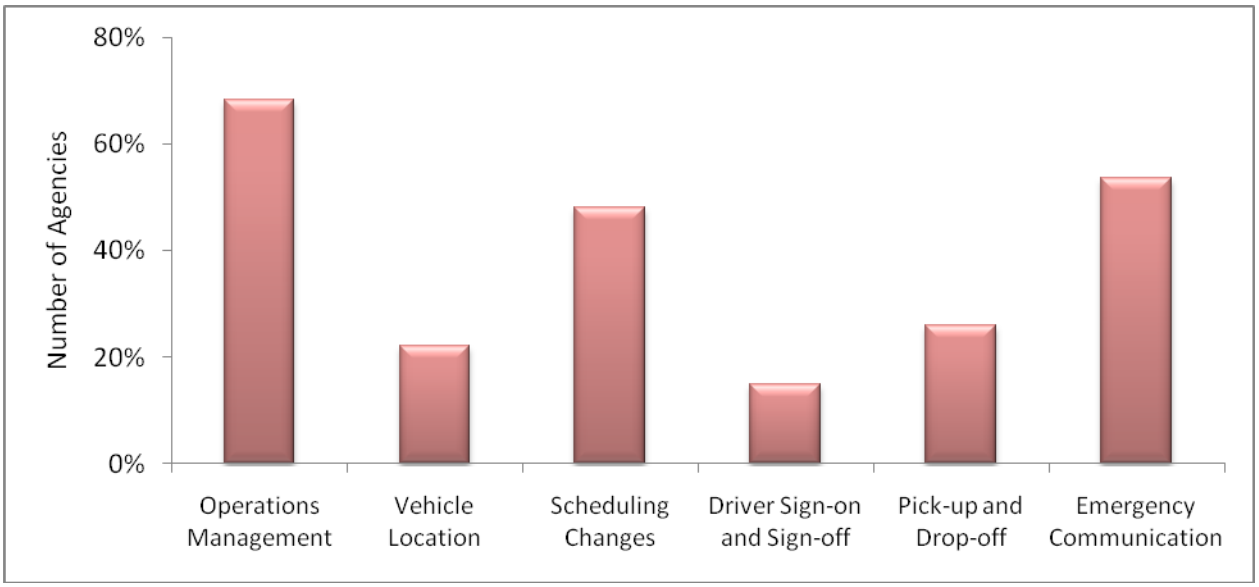

Figure 4.10 Text Messaging Purpose (N=42)

4.3.5 Satellite Phones

The next set of questions concerned the use of satellite telephones by rural transit agencies. About two-thirds of respondents stated that they are familiar with satellite phones. However, only three agencies, less than one percent of all participants, stated that they currently use the technology. Of those agencies that currently do not use the technology, three percent plan to use it in the next five years. All three agencies that have satellite phones use them for emergency communications. One agency uses satellite phones for managing operations.

4.3.6 Wireless Local Area Network

Transit agency managers were asked about their familiarity with and their agency's use of Wireless Local Area Network technology. Two-thirds of survey participants stated that they are familiar with the technology. Twelve percent reported current use of the technology. Eleven percent of the agencies that do not currently use the technology expect to do so in the next five years.

4.4 Rural Transit Technology

Transit agencies managers were asked a series of questions on transit technologies. Questions included those on familiarity, current or planned use, type of functionality provided, and cost.

4.4.1 Transit Operations Software

Most transit managers, 83%, stated that they are familiar with transit operations software. Ninety percent of respondents stated that they use specialized accounting software. Seventy-seven percent stated that their agency uses specialized reporting software. Use of maintenance software was reported by 57% of managers, followed closely by 53% who stated their agency used specialized personnel software. About 18% of transit agency managers reported their agency does not used specialized operations software. Figure 4.11 presents the number of agencies that reported the use of specialized operations software.

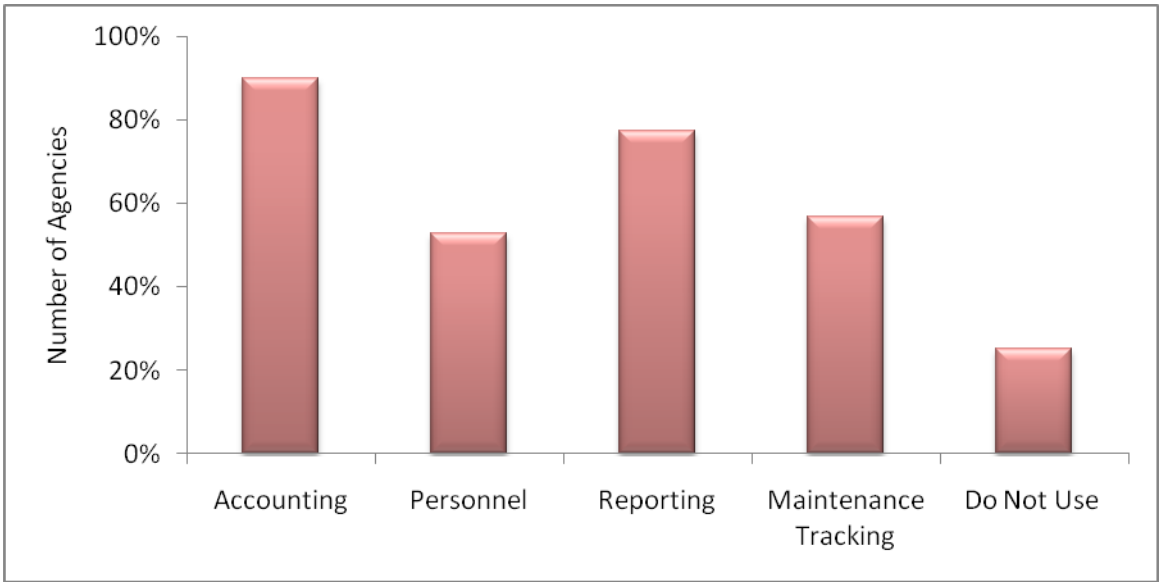

Figure 4.11 Operations Software Use (N=331)

4.4.2 Use of Spreadsheet Software to Manage Operations

Transit agency managers were asked if they used spreadsheet software to manage some part of their systems operations. Eighty-four percent responded 'yes'. Of these, 97% stated they used spreadsheets to manage reporting and record keeping functions. Fifty-nine percent use spreadsheets to assist in scheduling, the same percentage that use the technology for managing cash handling and maintenance tracking. Fifty percent of agency managers stated they use spreadsheets to maintain customer information the same that use it to manage daily operations. Uses of spreadsheets by rural transit agencies are presented in Figure 4.12.

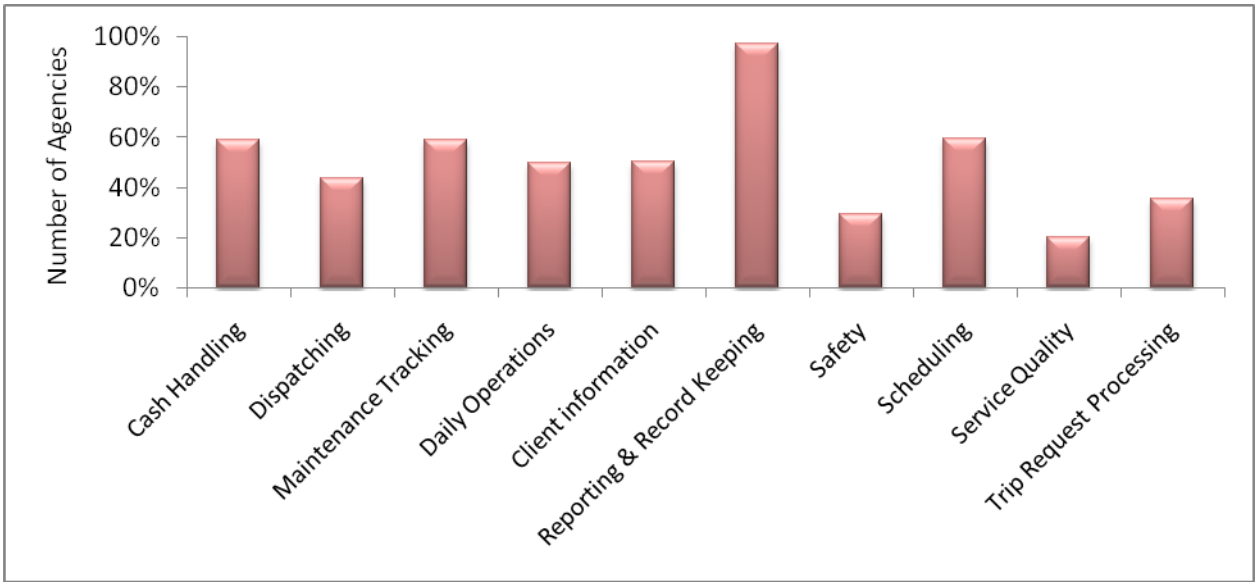

Figure 4.12 Spreadsheet Use (N=341)

4.4.3 Geographic Information Systems

Transit managers were asked about their familiarity with and their agency's use of Geographic Information Systems (GIS). Seventy-eight percent of respondents stated that they are familiar with GIS. Twenty-five percent of the agencies currently use the technology. Somewhat surprisingly, of those managers that do not already use GIS, more than 43% expect their agency to do so in the next five years. Managers were asked how their agency uses GIS. Seventy-two percent stated their agency uses GIS to schedule trips. Fifty-six percent of agencies use GIS to assist with operations followed closely by 52% that use GIS for service coordination and 51% that use GIS for reporting and record keeping. The number of agencies that reported their type of use of GIS is presented in Figure 4.13.

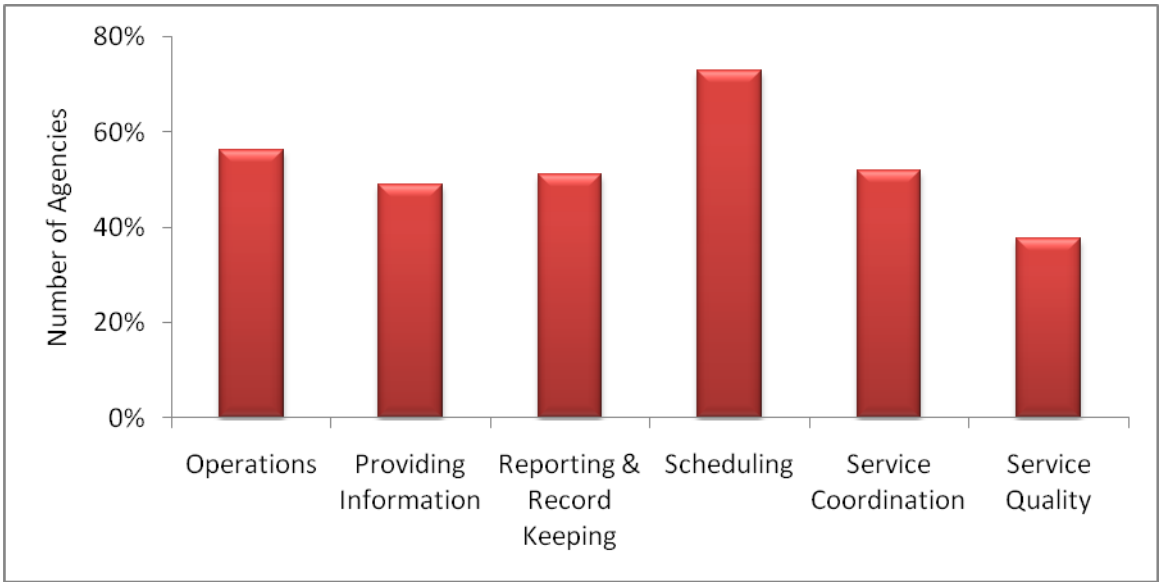

Figure 4.13 Geographic Information System Use (N=96)

Managers of agencies that have implemented GIS technology since the beginning of 2008 were asked about the upfront cost of implementation. Costs ranged from $0 to $400,000 with an average cost of $62,021. The median cost of implementing GIS technology was $33,000.

GIS costs are presented in Table 4.2. Like other rural transit technology systems, advanced GIS require hardware and software with high fixed costs. Consequently, the average cost per vehicle for small systems is significantly higher than for larger systems. Also, the small sample size results in outliers having a significant impact on some calculated measures. This issue is magnified because the agencies are classified by fleet size.

Table 4.2 Geographic Information System Reported Costs

# of Vehicles	Number of Agencies	Low	High	Average	Median	Cost per Vehicle
1 to 5	9	$ 1,500	$ 400,000	$ 104,400	$ 55,000	$ 44,100
6 to 10	7	$ 1,000	$ 100,000	$ 32,900	$ 20,000	$ 4,600
11 or more	11	$ 0	$ 250,000	$ 63,400	$ 50,000	$ 3,600
All	27	$ 0	$ 400,000	$ 133,337	$ 50,000	$ 6,500

4.4.4 Computer Aided Dispatching and Scheduling Software

Most agency managers, 81% of those responding, stated they are familiar with CASD software. About one-third stated their agency currently uses CASD software. For those that do not, 46% expect to within the next five years.

The most common function provided by CASD software as reported by survey respondents was report generation. Seventy percent of agency managers stated their software provided manual routing and scheduling capabilities while 49% stated their software had automated routing and scheduling capabilities. Billing functionality was reported by 61% of agency managers followed by automated client management was reported by 59% of managers. Fifty-five percent of survey respondents stated their CASD software accommodates automated trip requests. CASD functionality as reported by agency mangers is presented in Figure 4.14.

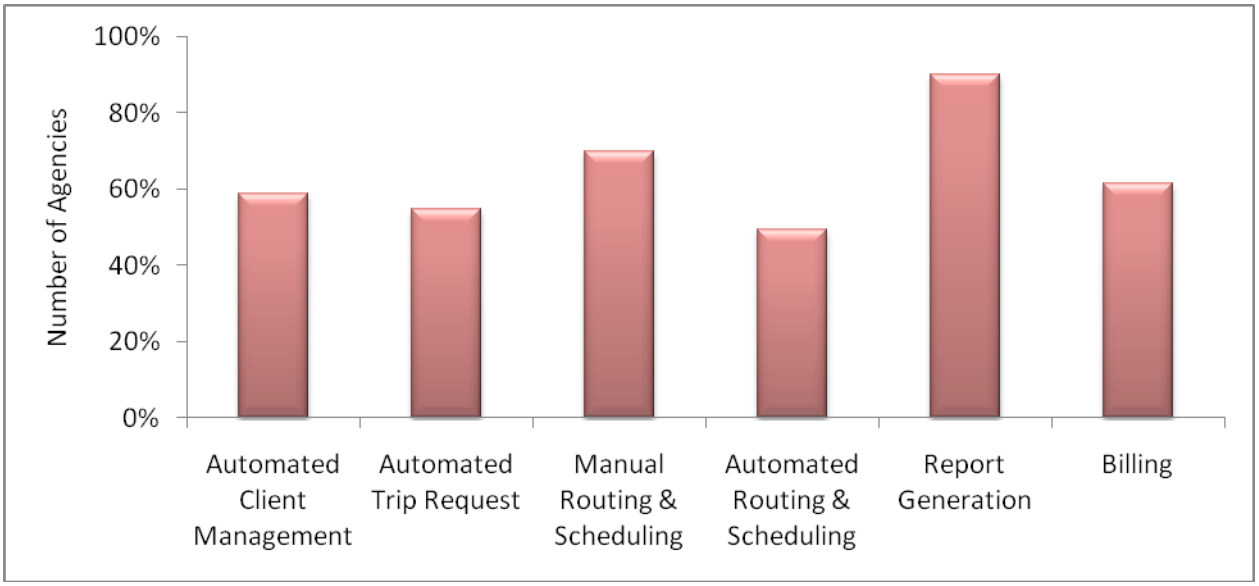

Figure 4.14 Computer-Aided Scheduling and Dispatch Software Functions (N=136)

Agency managers were asked what uses their CASD software serve. Ninety percent stated they use their software for scheduling; 88% stated they use the software for reporting and record keeping. Use of software for trip request processing was reported by 80 % of survey respondents. Sixty-nine percent stated they use the software for managing information and just less than half for coordinating service. Forty-three percent of managers use CASD software for operations and just under a third for managing service quality. The responses to agency use of CASD software use are presented in Figure 4.15.

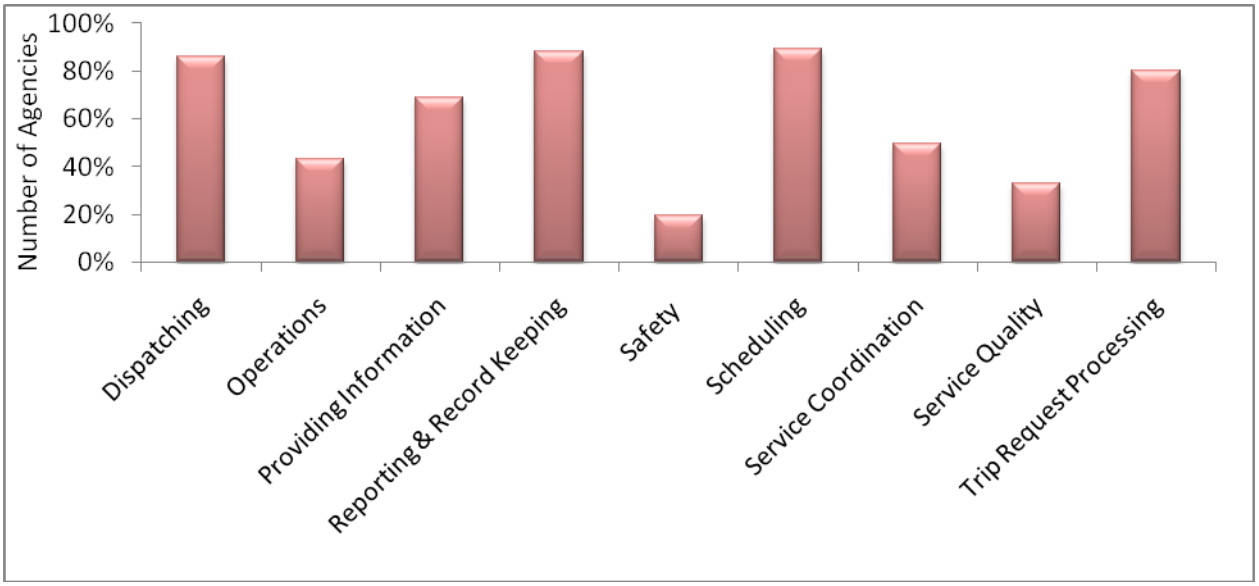

Figure 4.15 Computer-Aided Scheduling and Dispatch Software Use (N=136)

Cost data on CASD software implementation were collected by the survey. Costs of implementation since the beginning of 2008 ranged from $0 to $200,000 with an average cost of $57,868. The median cost of CASD implementation was $52,500.

The costs of CASD software implementation are presented in Table 4.3. As with GIS, the high fixed costs of CASD result in a higher per vehicle cost for smaller agencies.

Table 4.3 Computer-Aided Scheduling and Dispatch Software Costs

# of Vehicles	Number of Agencies	Low	High	Average	Median	Cost per Vehicle
1 to 5	8	$ 0	$ 200,000	$ 61,200	$ 42,500	$ 22,200
6 to 10	3	$ 0	$ 50,000	$ 25,000	$ 12,500	$ 3,500
11 or more	7	$ 6,000	$ 100,000	$ 68,000	$ 93,000	$ 4,800
All	18	$ 0	$ 200,000	$ 57,900	$ 52,500	$ 6,500

4.4.5 Automatic Vehicle Location

Transit agency managers were asked about their familiarity and agency's use of Automatic Vehicle Location (AVL) technology. Eighty percent of respondents stated they are familiar with AVL. Only 6% of managers stated their agencies currently use AVL technology. However, 45% of those agencies that don't currently use the technology expect to do so in the next five years.

Survey participants were asked for what purposes their agencies use AVL. The most common response was for dispatching, which was reported by 90% of respondents. This was followed by driver communications at 74% and to monitor service quality at 70%. About 50% of respondents reported that their agencies use AVL technology to manage customer information, for safety, or to coordinate service. The purposes for using AVL technology are presented in Figure 4.16.

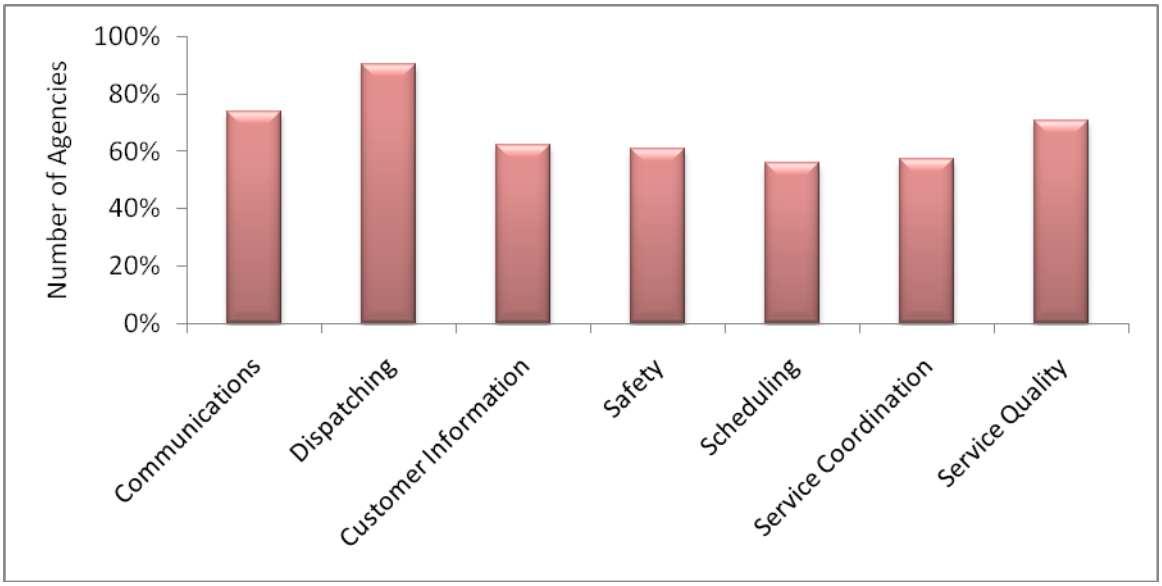

Figure 4.16 Automatic Vehicle Location Purpose (N=61)

Managers of agencies that have implemented AVL since the beginning of 2008 were asked about the upfront cost of implementing the technology. The costs ranged from $0 to $325,000 with an average cost of $74,779. The median price of implementing AVL technology was $50,000. The reported costs of implementing AVL technology is reported in Table 4.4. As with GIS and CASD, the cost per vehicle is significantly higher for small agencies primarily due to high fixed costs of implementation.

Table 4.4 Automatic Vehicle Location Costs

# of Vehicles	Number of Agencies	Low	High	Average	Median	Cost per Vehicle
1 to 5	3	$ 50,000	$ 50,000	$ 50,000	$ 50,000	$ 19,400
6 to 10	4	$ 10,000	$ 139,100	$ 68,000	$ 33,000	$ 9,400
11+	7	$ -	$ 250,000	$ 59,800	$ 12,000	$ 2,300
All	14	$ -	$ 250,000	$ 60,100	$ 50,000	$ 4,500

4.4.6 Mobile Data Terminals

Mobile Data Terminals (MDT) was the subject of the next line of questions. Sixty-four percent of respondents stated they are familiar with mobile data terminal technology. Only 9% of agencies reported currently using MDT technology. However, of those that do not, nearly 31% expect to use the technology in the next five years.

Rural transit agencies reported that MDTs are most often used to identify vehicle location or passenger boarding and drop-off with 84% of participants reporting those uses. Eighty-one percent stated that MDTs are used to have drivers sign on and off for service. Seventy-six percent report using the technology to update schedule changes while 69% use them to issue electronic trip manifests, the same number that use the technology for emergency communications. About three-fifths of the agencies that reported stated they use the technology to supervise drivers and operations or fare determination and collection. Uses of MDT technology are presented graphically in Figure 4.17.

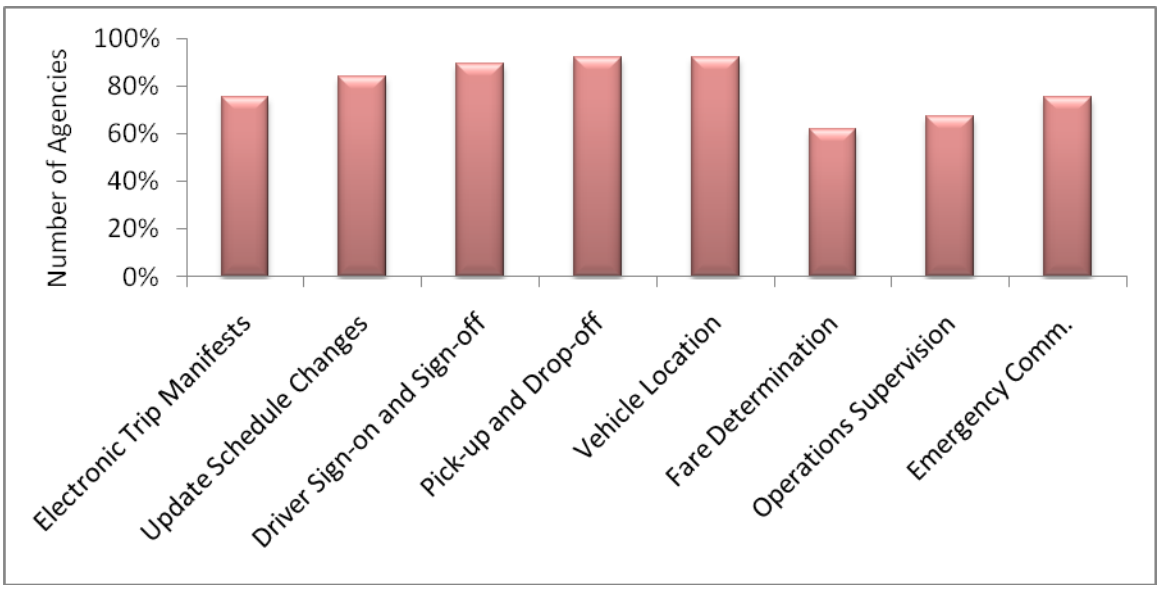

Figure 4.17 Mobile Data Terminal Purpose (N=37)

Agencies were asked about the cost of the implementing MDT technology. The costs ranged from $0 to $325,000 with an average cost of $85,833. The median cost of implementing the technology was $40,000.

4.4.7 Traveler Information Systems

Transit agency managers were asked about their familiarity with and agency's use of Traveler Information Systems (TIS). Forty-three percent of managers stated they are familiar with them. However, only 4% currently use them. Of those that do not, 20% expect to in the next five years. Most of the agencies that have a traveler information system, 87%, have an agency website. Forty-one percent reported having in-vehicle displays. Twenty-nine percent of agencies reported having variable message signs while 23% have automated phone service or audible annunciators. Seventeen percent of reporting agencies stated they deliver traveler information via text messaging. Figure 4.18 presented the types of Traveler Information Systems used by rural transit agencies.

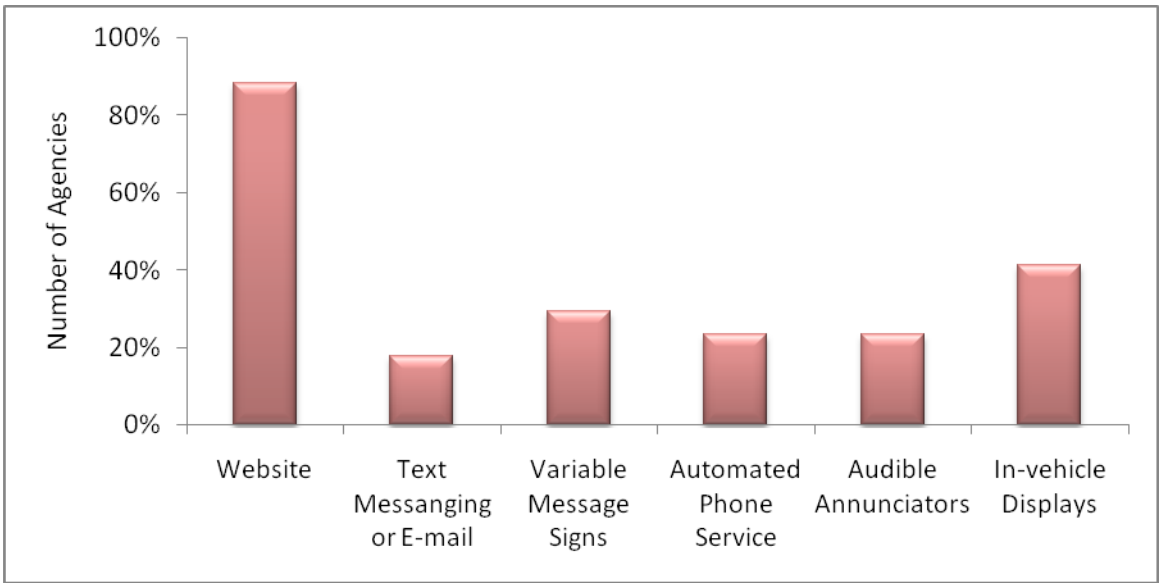

Figure 4.18 Types of Traveler Information Systems (N=17)

Agency managers were asked what type of information their traveler information system provides. Seventy-six percent stated that their system provides static service information. Just more than half of agencies stated that their systems provide estimated arrival times or other trip planning tools. Eighteen percent of agencies reported that their traveler information system provides real-time vehicle information. Figure 4.19 presents the types of information provided by Traveler Information Systems used by rural transit agencies.

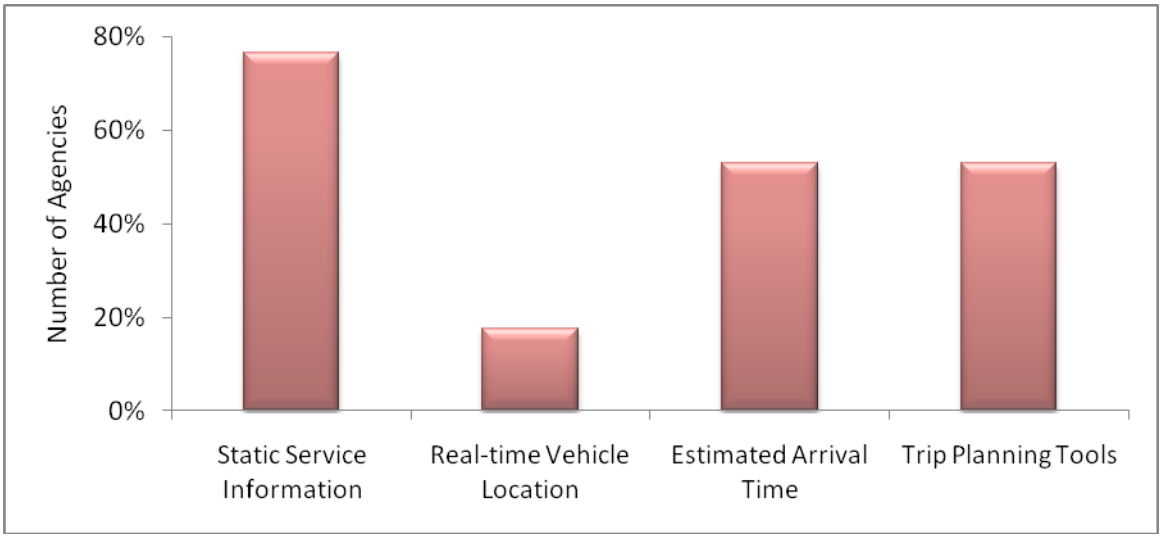

Figure 4.19 Traveler Information Systems Information Provided (N=17)

Agency managers were also asked what purposes their organization's Traveler Information System serves. Eighty-eight percent of agencies reported the technology was used to provide customer information. Sixty-four percent stated it was used to improve service quality. Just less than 60% of respondents stated they use the technology to communicate, and about one-third use the technology to assist in processing trip requests. Figure 4.20 presents the purposes served by Traveler Information Systems.

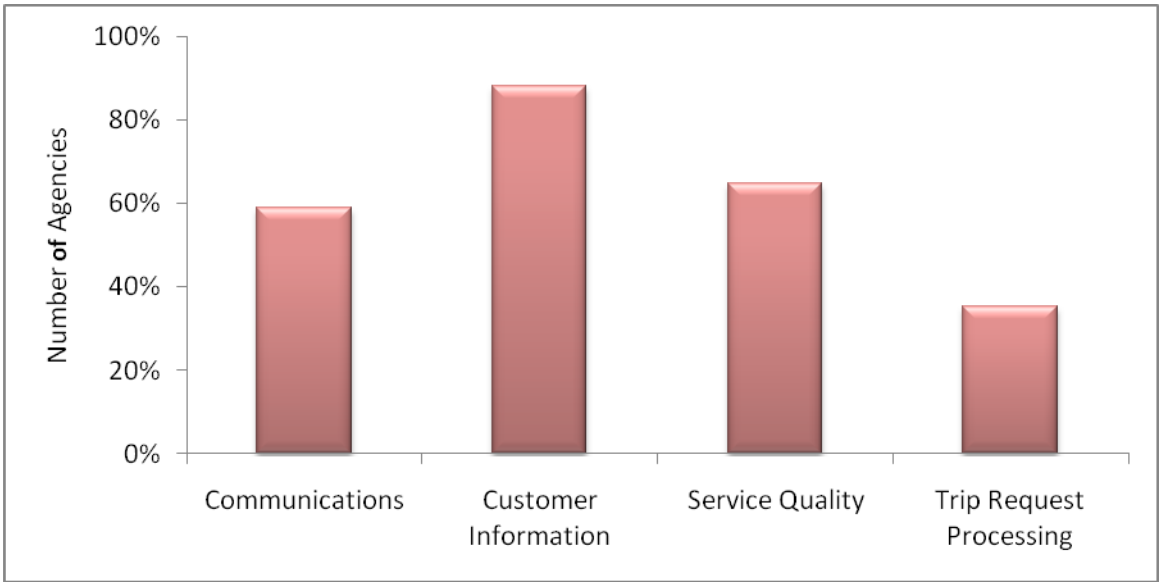

Figure 4.20 Traveler Information System Purpose (N=17)

4.4.8 Electronic Fare Payment Systems

Electronic Fare Payment (EFP) systems was the subject of the next set of questions. About two-thirds of respondents stated they are familiar with electronic fare payment systems. However, only 2% of agencies stated they currently use EFP. Of those that do not, 21% expect to within the next five years. Of the agencies that use EFP, all use magnetic stripe technology, 25% use smart card readers, and 12% use barcode readers.

Managers of agencies that use EFP were asked what purposes the technology serves. The most common response was fare collection which was reported by 88% of participants. Seventy-five percent of participants stated their agency uses the technology for reporting and record keeping. Rider and trip information was reported by 63% of participants. Fare determination was reported by 38% of agencies. Billing and service coordination was reported by one-fourth of respondents. Figure 4.21 presents the purposes served by Electronic Fare Payment systems.

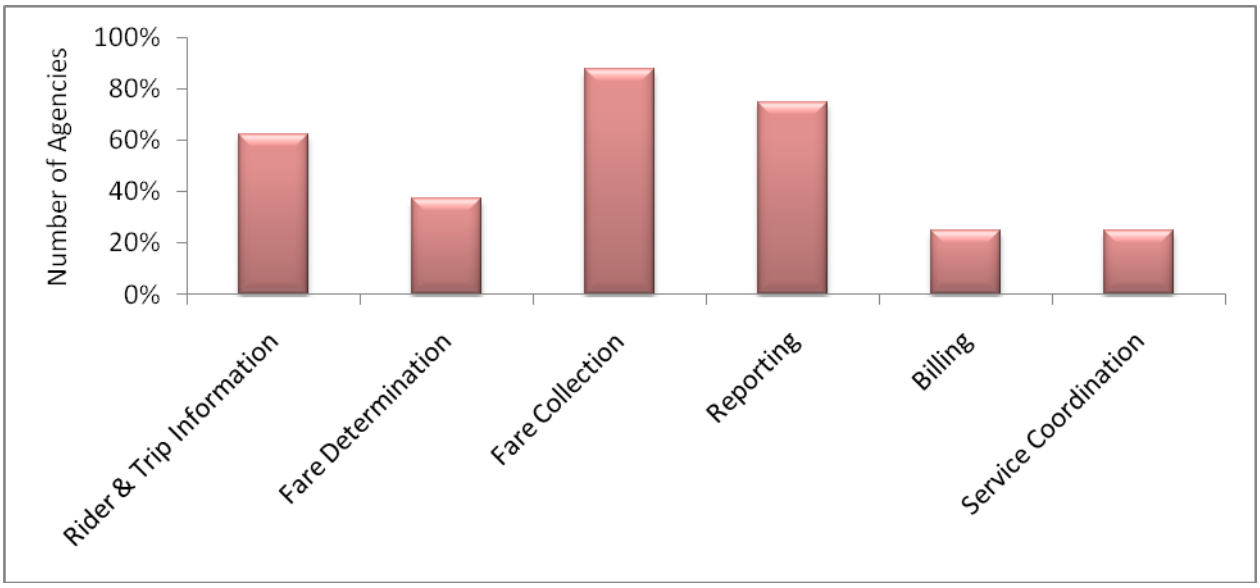

Figure 4.21 Electronic Fare Payment Systems Purpose (N=8)

4.4.9 Advanced Passenger Counting Technology

Transit agency managers were asked about their familiarity with and their agency's use of Advanced Passenger Counting (APC) technology. Forty-three percent of respondents stated they are familiar with APC. Only ten agencies, 2% of all that responded, currently use the technology. Of those that do not, 15% expect to do so within the next five years.

4.4.10 Transit Security Systems

Transit security systems technology was the subject of the next line of questions. Seventy-four percent of agency managers responding to the survey are familiar with transit security systems. One-fifth of agencies that responded currently use security system technology. Thirty percent of those agencies do not expect to within the next five years.

Agencies were asked what type of security systems they used. The most commonly reported technology was cameras, which was reported by 95% of agencies that use security systems. Thirty-nine percent of agencies reported using audio surveillance and one-fifth reported using silent alarms. Use of closed

circuit television was reported by 15% of agencies that participated in the survey. Eight percent reported the use of object detection sensors and 6% reported the use of covert microphones. The types of transit security systems used by rural transit agencies are presented in Figure 4.22.

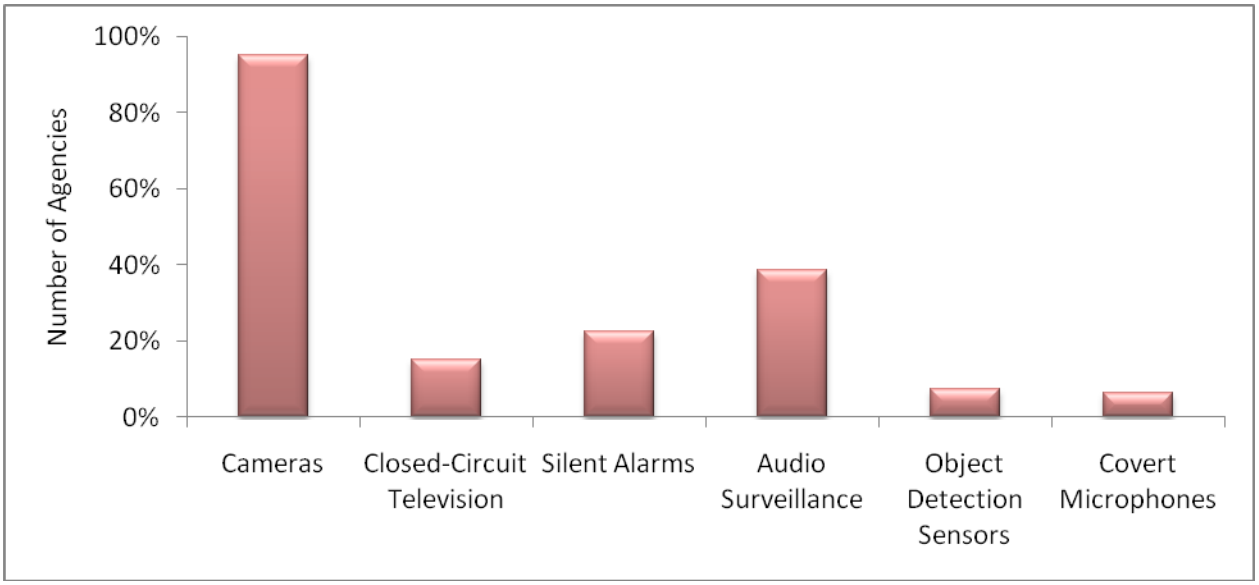

Figure 4.22 Types of Transit Security Systems Used (N=80)

The survey asked agencies that have implemented transit security systems since the beginning of 2008 about system costs. Costs ranged from $0 to $280,863 with an average cost of $75,282. The median cost was $21,000. The cost of transit security systems is presented in Table 4.5. Like other transit technology, the per unit cost of transit security systems is higher due to fixed costs. At the same time, some of the transit security systems for which costs are reported are not vehicle based, making the measure misleading.

Table 4.5 Transit Security System Costs

# of Vehicles	Number of Agencies	Low	High	Average	Median	Cost per Vehicle
1 to 5	9	$15,000	$280,900	$92,200	$67,400	$52,500
6 to 10	1	$10,000	$10,000	$10,000	$1,700	$1,100
11+	8	$1,000	$100,000	$23,400	$900	$900
All	18	$1,000	$280,900	$75,200	$21,000	$4,400

4.5 Transit Agency Manager Characteristics

Agency managers were asked a series of questions about their employment history, education, participation in meetings, and interaction with technology vendors. The objective was to identify what characteristics of technology adoption decision makers played in the choice of technology.

4.5.1 Employment History

Transit agency managers were asked how many years they had been employed by their current agency. The most common response was less than five years, which was reported by about 40% of respondents. This was followed by 5 to 10 years, which was reported by about one-fourth of managers. Seventeen percent of managers reported having worked at their current agency between 10 and 15 years while 7%

reported having worked between 15 and 20 years. Fifteen percent reported having worked for the same agency for more than 20 years. The number of years survey participants have managed their current agency is presented in Figure 4.23.

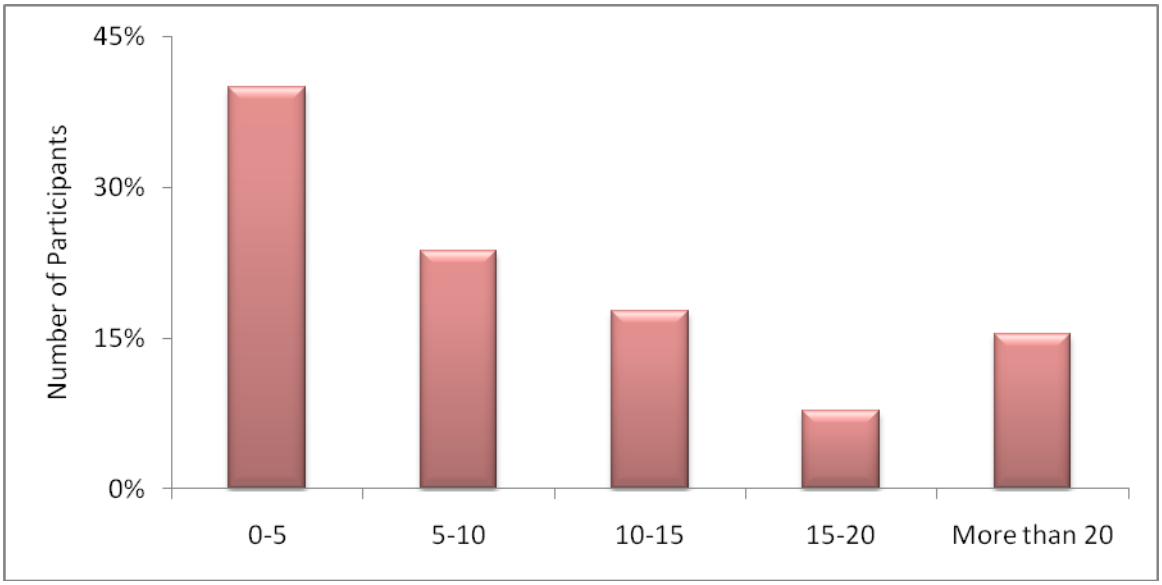

Figure 4.23 Number of Years Managing Current Agency (N=385)

Transit agency managers were asked how many years they had been employed in the transit industry. The most common response was more than 20 years, which was reported by 29% of participants. The next most commonly reported responses were between 0 and 5 years, which was reported by 23% of participants. Twenty percent of participants stated that they had worked 5 to 10 or 10 to 15 years, respectively. Ten percent stated that they had worked in the industry between 15 and 20 years. The number of years transit agency managers reported having worked in the field are presented in Figure 4.24.

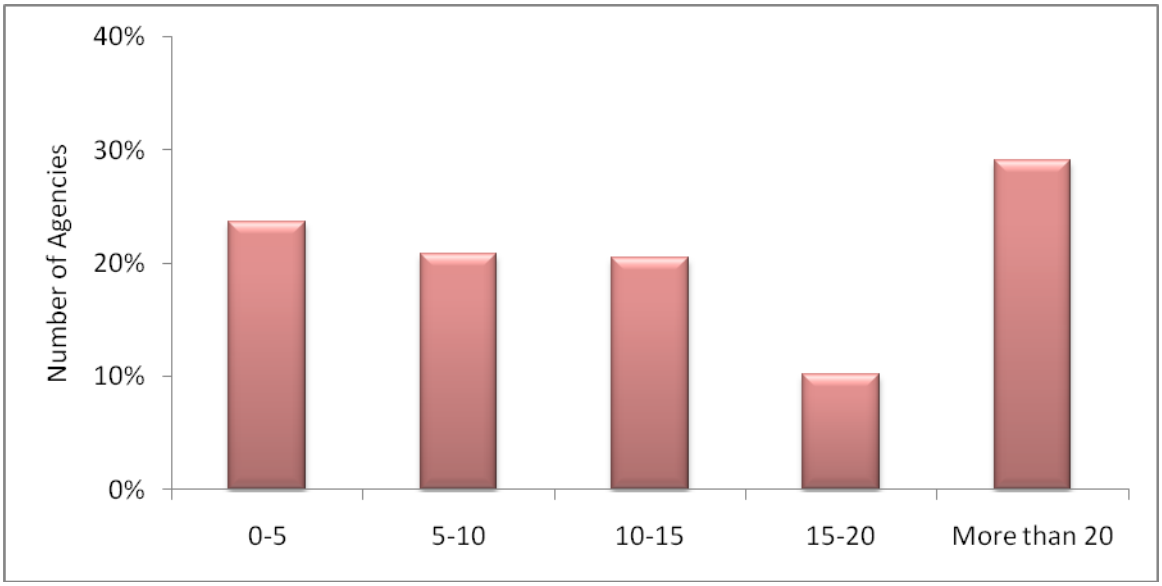

Figure 4.24 Number of Years Working in Transit (N=385)

4.5.2 Education

Transit agency managers were asked the highest level of schooling they had completed. Of the 402 survey participants that answered the question, 30% stated they had completed a four year degree while one-fourth stated they had completed some college. One-fifth stated they had completed a post-graduate degree. Ten percent stated they had completed a two-year degree, while 14% had completed high school or a high school equivalent. The highest level of education completed by survey participants is presented in Figure 4.25.

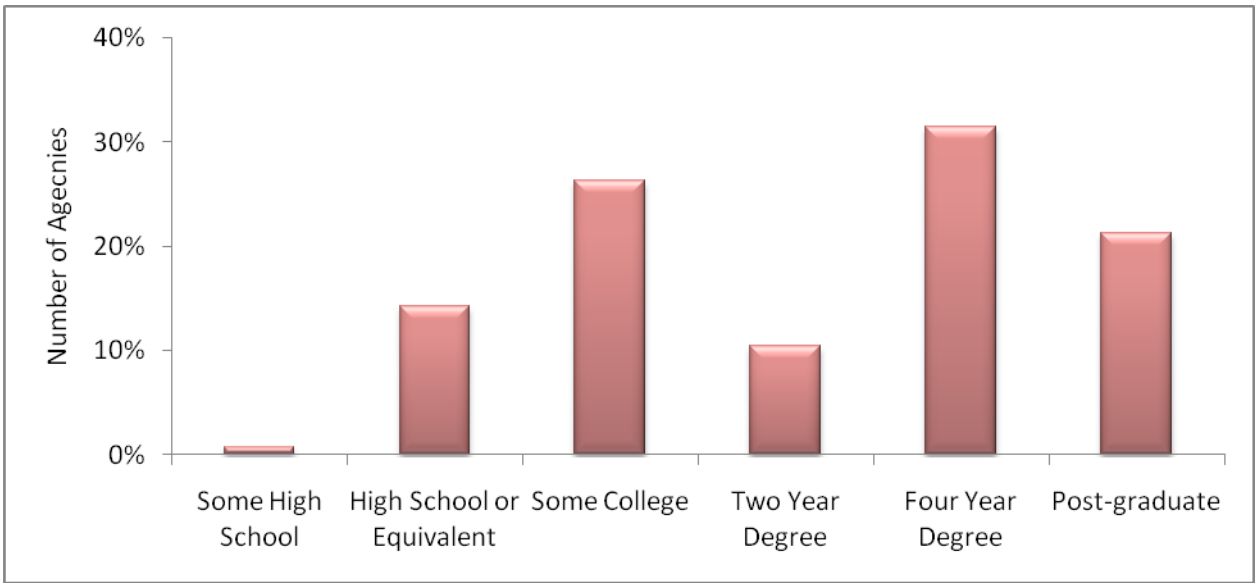

Figure 4.25 Highest Level of Education Completed (N=385)

4.5.3 Meeting Participation

Transit agency managers were asked about the number of state or regional meetings they had attended in the past year. Fifty-five percent stated they had attended from two to five meetings. Twenty percent stated they had attended one meeting. Twelve percent reported having attended no meetings in the past year, while 8% reported having attended six to ten meetings. Six percent reported having attended 11 or more meetings. The number of state and regional meetings attended by agency managers in the past year is presented in Figure 4.26.

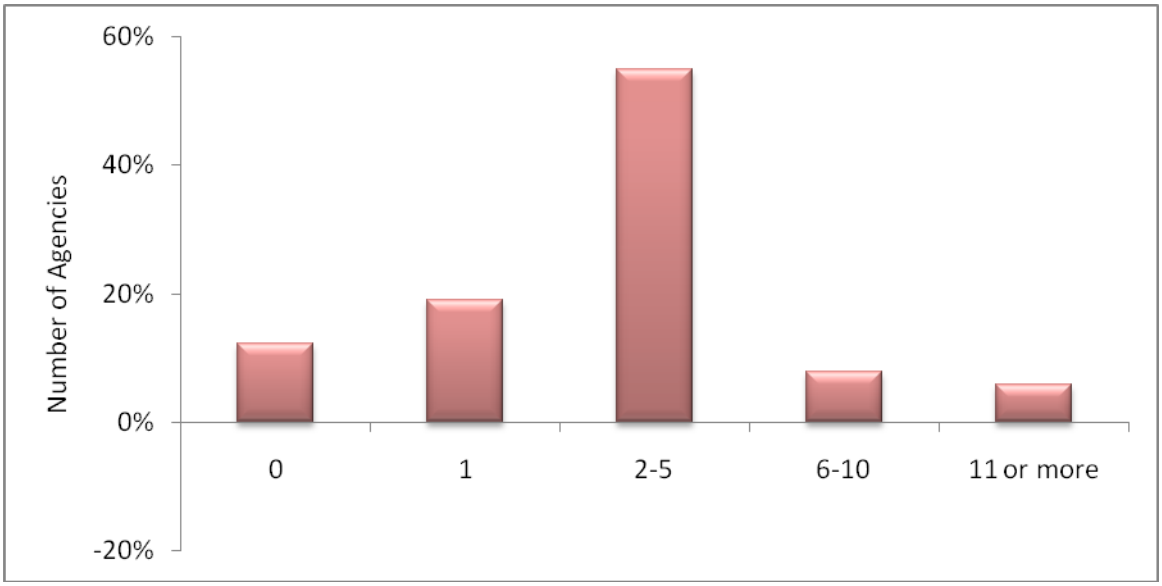

Figure 4.26 Number of State and Regional Meetings Attended (Past Year) (N=391)

Agency managers were also asked the total number of state and regional transit meetings they had attended in the past five years. Thirty percent reported having attended between one and five meetings while 25% reported having participated in between six and ten meetings. Twenty-one percent reported having participated in between 11 and 20 meetings. Seventeen percent of transit agency managers stated they had attended 21 or more meetings in the past five years. Seven percent stated they had not attended any meetings. Figure 4.27 presents the number of state or regional meetings agency managers have attended in past five years.

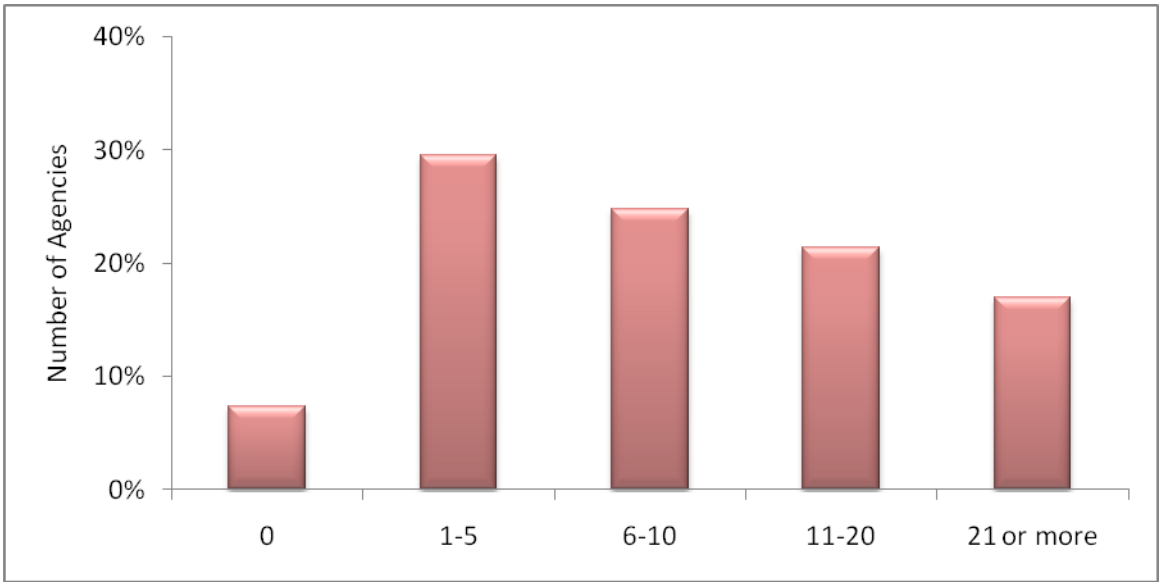

Figure 4.27 Number of State and Regional Meetings Attended (Past 5 Years) (N=383)

Managers were asked the number of national meetings they had attended in the past five years. Fifty-five percent stated they had not attended a national meeting. Eighteen percent stated they had attended one while 22% stated they had attended between two and five. Six percent reported that they have attended six or more national meetings in the past five years. Figure 4.28 presents the number of national meetings attended by transit agency managers in the past five years.

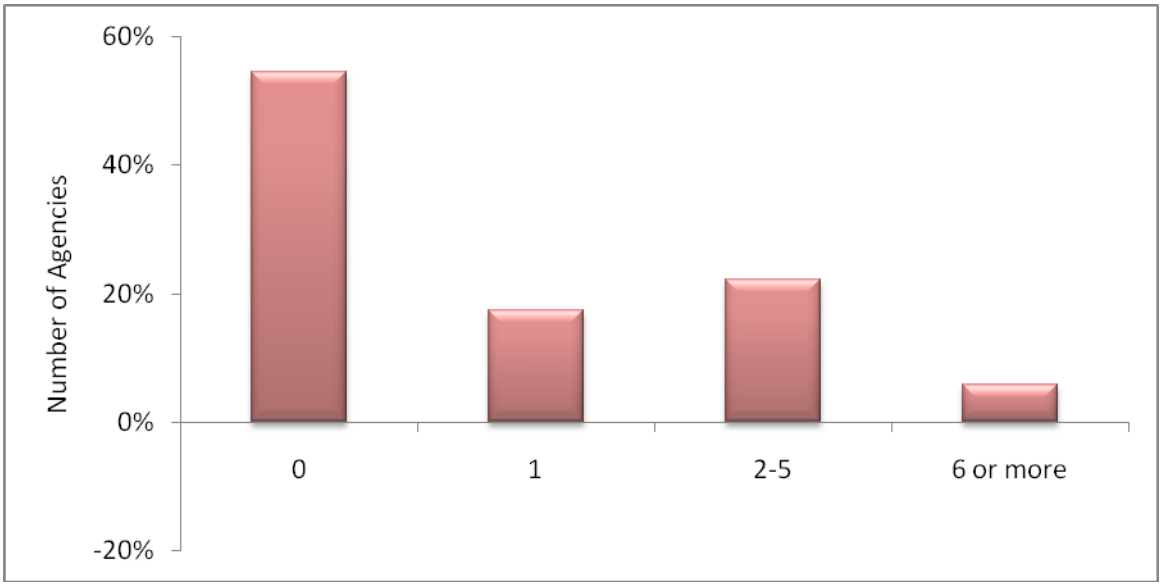

Figure 4.28 Number of National Meetings Attended (Past 5 Years) (N=400)

Transit agency managers were asked what types of technology vendors, if any, they had visited with when attending any state, regional, or national meetings within the past five years. The most commonly reported vendor being visited were those providing CASD software, which was reported by 62% of respondents. This was followed closely by operations software, which was reported by 59% of participants. Forty-six percent of participants stated they had met with GIS vendors, the same percentage that reported meeting with AVL vendors. Thirty-nine percent of managers stated they had met with transit security system vendors. About one-third of managers stated they had met with mobile data terminal vendors. One-fourth stated they had not visited with technology vendors when attending state, regional, or national meetings in the past five years. EFP system vendors had been visited by 28% of managers. Traveler Information System vendors had been visited by 19% of managers. Only 15% of managers reported having visited with advanced passenger counting technology vendors. Figure 4.29 presents the number of transit agency manager visits to vendors at meetings by technology.

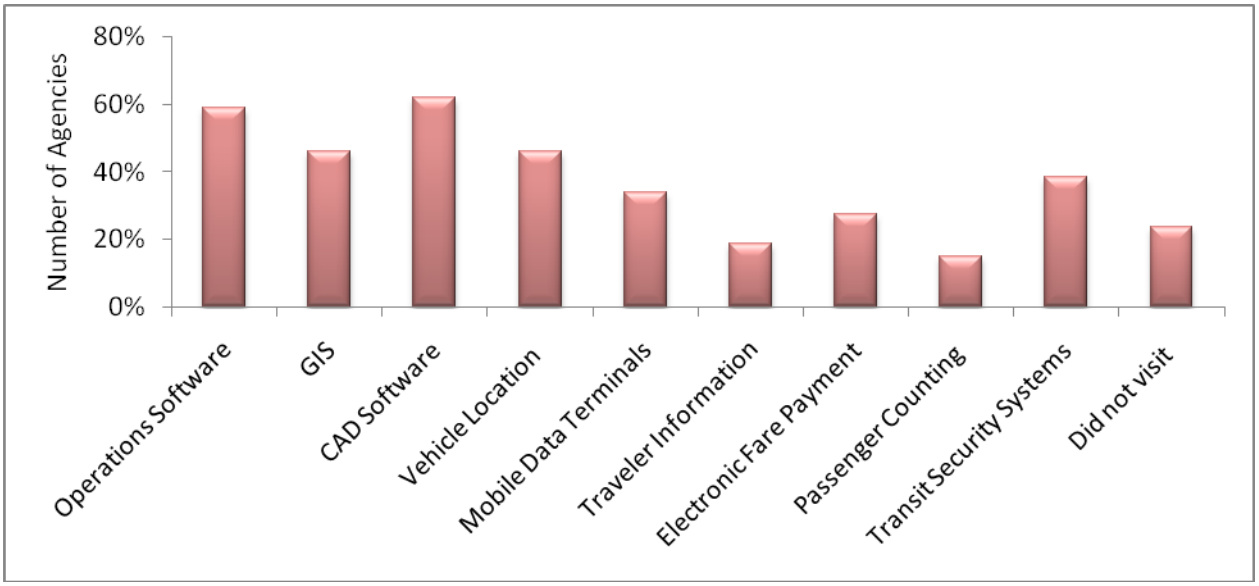

Figure 4.29 Vendors Visited at State, Regional, or National Meetings by Technology (N=426)

Transit agency managers were asked what technology sessions they had attended at state, regional, or national meetings within the past five years. Forty-four percent of managers stated they had not attended a technology session. One-third stated they had attended a session on the types of technology available. Twenty nine percent attended a session on technology and coordination. Sessions on technology procurement were attended by 17% of managers while 14% stated they had attended a session on technology selection. Eleven percent reported they had attended a session on how to deploy technology. Figure 4.30 presents the number of agencies that have attended technology sessions at meetings by type in the past five years.

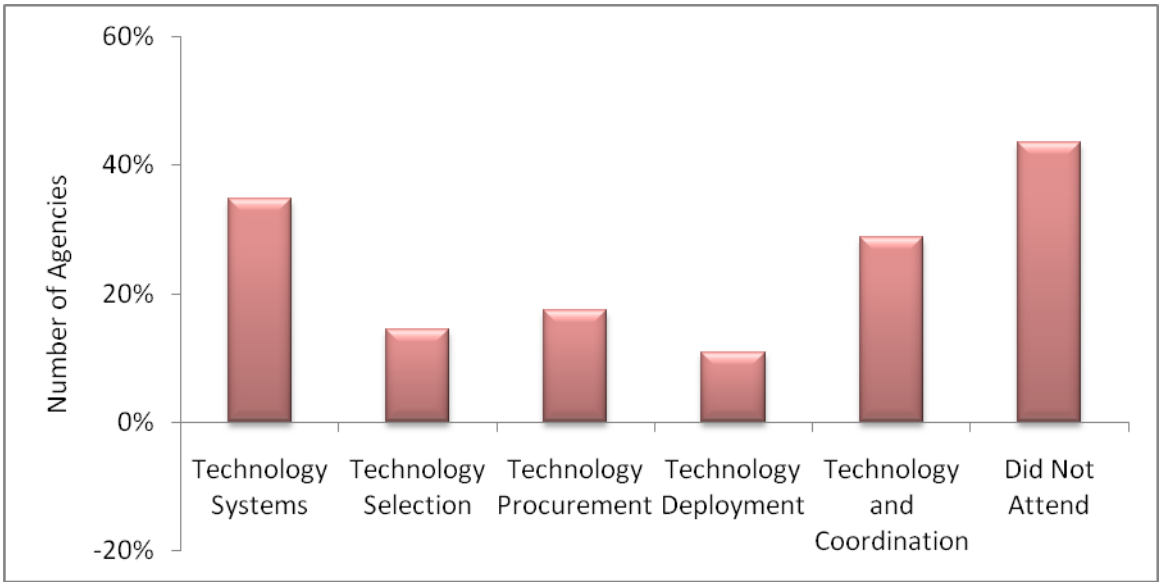

Figure 4.30 Technology Sessions Attended at State, Regional, or National Meetings by Topic (N=426)

4.6 Use of Multiple Technologies

Most agencies that participated in the survey reported using more than one technology. Table 4.6 presents the use of two technologies as conditional probabilities. The probability of technology in each row of the table is conditional on the technology in a corresponding row. For example, the probability of an agency using GIS technology given that it uses operations software is .27, while the probability that an agency uses operations software given that it uses GIS is .9. While there are more than 80 combinations, some are noteworthy. The probability that an agency uses MDT technology given that it uses CASD software is .21. However, 82% of agencies that use MDTs also use CASD software.

Table 4.6 Multiple Use of Core Rural Transit Technologies

	Operations Software	Geographic Information Systems	Computer Aided Dispatching & Scheduling	Automatic Vehicle Location	Mobile Data Terminals/ Computers	Traveler Information Services	Electronic Fare Payment Systems	Advanced Passenger Counting	Transit Security Systems	Total
Operations Software	1.00	0.27	0.37	0.17	0.09	0.04	0.02	0.02	0.21	369
Geographic Information Systems	0.90	1.00	0.57	0.49	0.32	0.06	0.05	0.05	0.36	111
Computer-Aided Dispatching & Scheduling	0.95	0.43	1.00	0.31	0.21	0.07	0.03	0.04	0.30	146
Automatic Vehicle Location	0.94	0.82	0.68	1.00	0.55	0.06	0.08	0.11	0.55	66
Mobile Data Terminals/Computers	0.92	0.92	0.82	0.95	1.00	0.08	0.05	0.11	0.53	38
Traveler Information Services	0.88	0.44	0.63	0.25	0.19	1.00	0.13	0.06	0.50	16
Electronic Fare Payment Systems	1.00	0.75	0.63	0.63	0.25	0.25	1.00	0.25	0.63	8
Advanced Passenger Counting	0.90	0.60	0.60	0.70	0.40	0.10	0.20	1.00	0.50	10
Transit Security Systems	0.92	0.48	0.52	0.43	0.24	0.10	0.06	0.06	1.00	84

Most agencies reported the use of more than one type of communications technology. Table 4.7 presents the multiple use of communications technology as conditional probabilities. For agencies that use two-way radios, 73% also use cellular phones. Ninety percent of agencies that used WLAN technology also use cell phones.

Table 4.7 Multiple Use of Communications Technology

	Two-way Radios	Cell Phones	Smart Phones	Text Messaging	Wireless Local Area Network	Satellite Phones	Total
Two-way Radios	1.00	0.73	0.06	0.12	0.14	0.01	302
Cell Phones	0.67	1.00	0.09	0.15	0.14	0.01	329
Smart Phones	0.58	0.94	1.00	0.65	0.39	0.00	31
Text Messaging	0.70	0.98	0.40	1.00	0.40	0.00	50
Wireless Local Area Network	0.80	0.90	0.24	0.39	1.00	0.02	51
Satellite Phones	1.00	1.00	0.00	0.00	0.33	1.00	3

4.7 Technology Adoption by Agency Characteristics

Anecdotally, larger, more complex transit agencies would expect to benefit from technology adoption. Given the nature of transit, size may be measured by level of service, fleet size, or budget. While this information was not collected by the survey, it is available in the Rural National Transit Database, with which the technology survey dataset was joined. These relationships between agency size and technology adoption were formally tested for four technologies, the results of which are presented in the next section. Figure 4.31 presents the percentage of agencies that adopted technologies based on the number of vehicle-miles of service the agencies provides. Figure 4.32 presents the number of agencies that adopted technologies by the number of trips provided, Figure 4.33 by fleet size, and Figure 4.34 by budget. For most technologies, the larger the agency, as measured by one of the four measures, the more likely it is that a technology is used. The one exception is security systems, where the smallest agencies are more likely to use the technology. There is a noticeable jump in the use of spreadsheets and CASD software for agencies that provide more than 30,000 trips per year. The relationships between agency size and technology adoption will be investigated more rigorously in the next section.

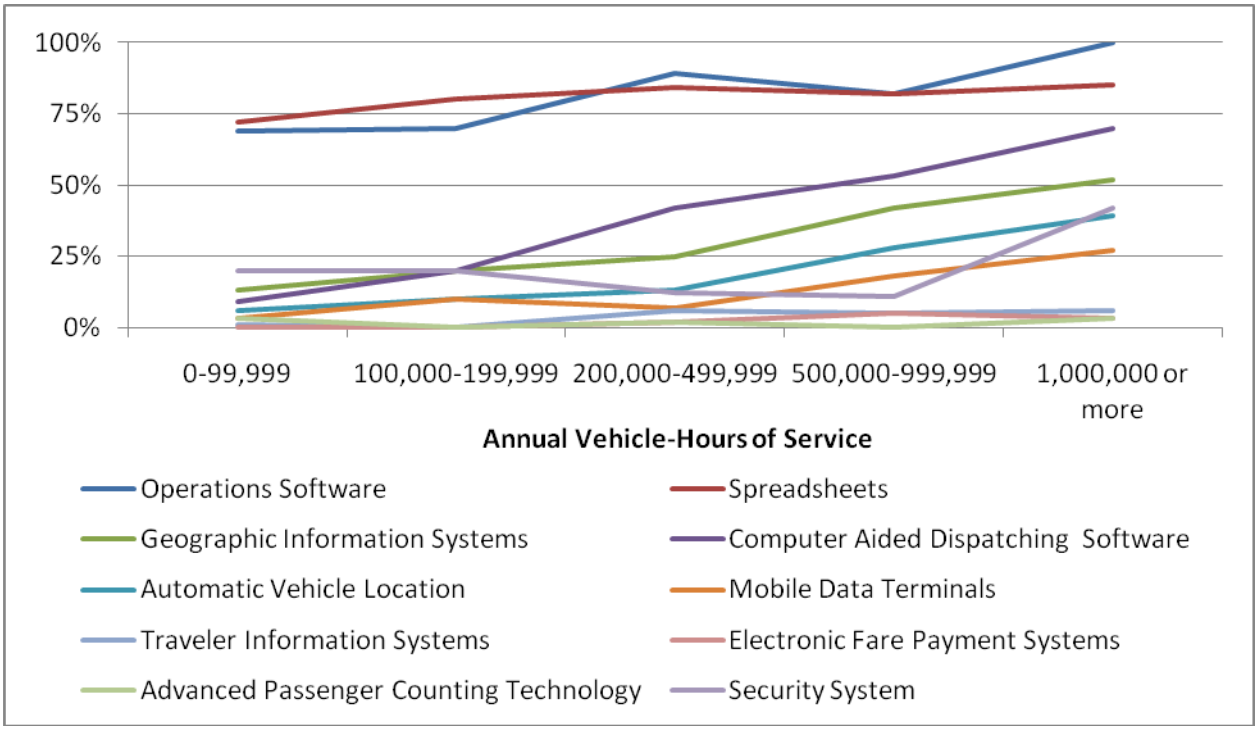

Figure 4.31 Technology Adoption by Agency Vehicle-Hours System

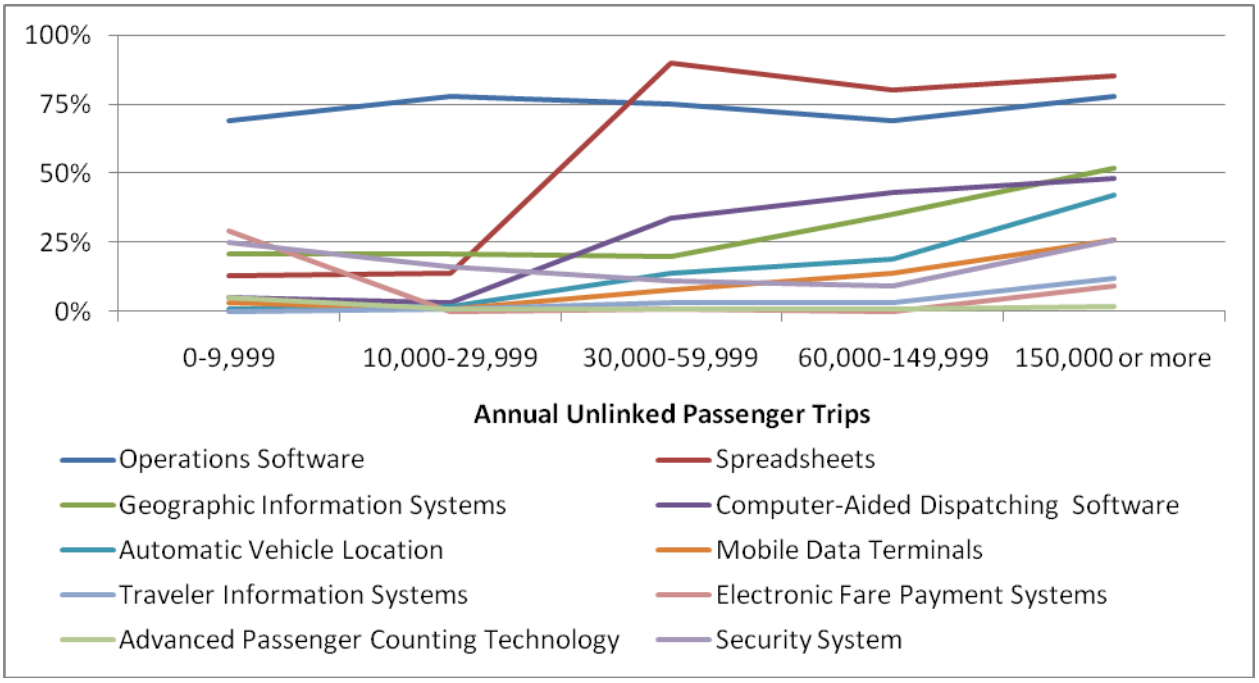

Figure 4.32 Technology Adoption by Agency Ridership

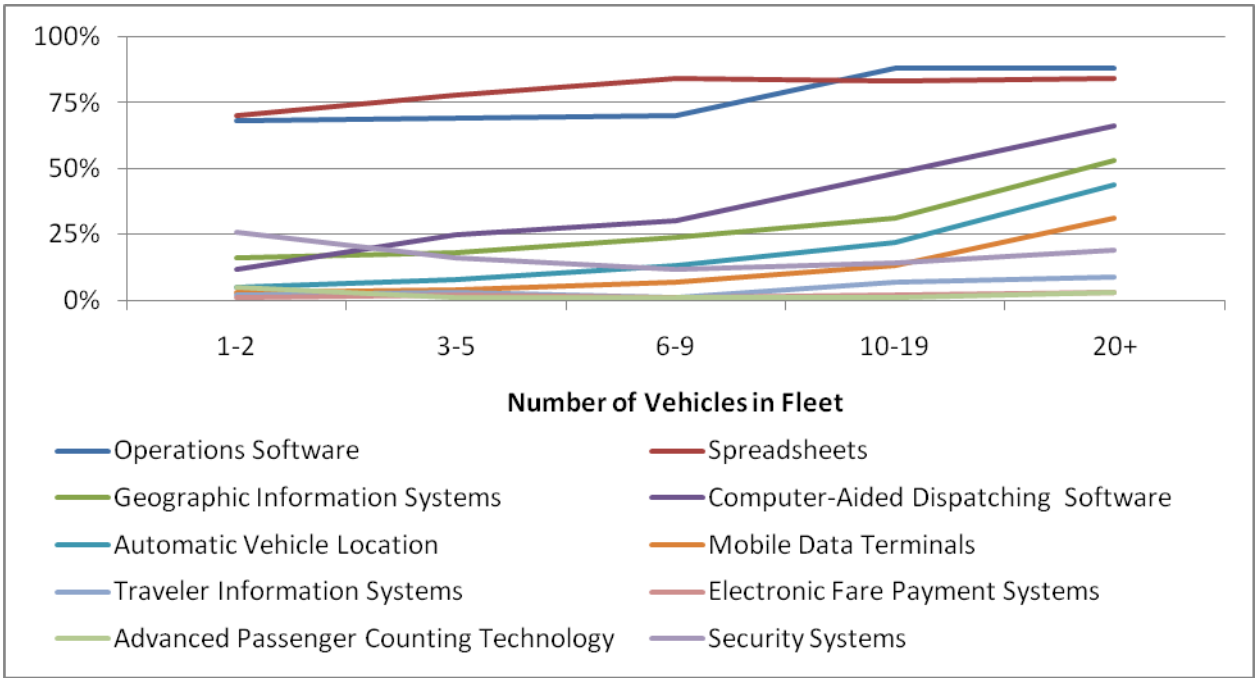

Figure 4.33 Technology Adoption by Fleet Size

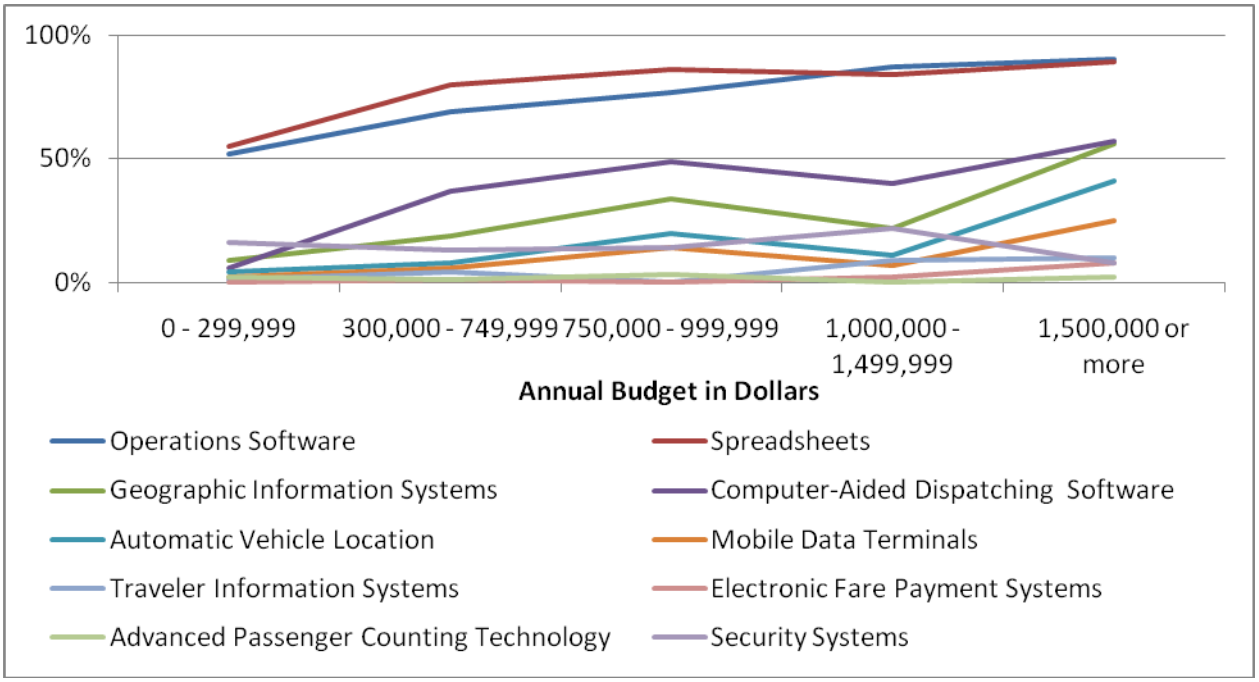

Figure 4.34 Technology Adoption by Agency Budget

5. FACTORS AFFECTING TECHNOLOGY ADOPTION

Descriptive statistics, such as those presented in the previous section, provide an understanding of the current state of technology use by rural transit agencies. However, additional analysis is required to determine the complex relationships among agency, community, and manager attributes and technology adoption by rural transit agencies. This is important from a practical standpoint as technology use varies tremendously among apparently similar agencies providing transit service to rural areas.

In this section, attributes affecting technology adoption by small urban and rural transit providers are modeled. Adoption of four individual transit technologies − Automatic Vehicle Location, Computer-Aided Scheduling and Dispatch software, Geographic Information Systems, and Mobile Data Terminals - are modeled using a binary logit framework. Joint adoption is considered for combinations of CASD software and AVL, MDTs, or GIS using multinomial logit.

5.1 Economics of Technology Adoption

Established economic frameworks and tools from the field of technology adoption can be used in our case with some modification. These changes are necessary to accommodate the fact that most transit agencies are not for-profit firms and thus are concerned with the impacts of their decisions beyond the bottom line. These changes modify the framework, but have no impact on the method of analysis or the findings.
We assume that transit agencies make the decision to adopt technology based on its impact on social welfare. Social welfare, W, is a function of consumer surplus, which is affected by various factors, X, and the technology employed by the transit agency, τ, and the profits of the agency, which are affected by another set of factors, Z, and technology, τ, as shown by (1).

$$W_i = CS(X,\tau) + \pi_i(Z,\tau) \qquad (1)$$

Suppose that there are two types of technology that are being considered for adoption. The transit agency will make one of four decisions: j=1 when no technology is adopted, j=2 when the first technology is adopted, j=3 when the second technology is adopted, or j=4 when both technologies are adopted. This decision can be modeled as a discrete choice

$$D_{ij} = \begin{cases} 1 & if\ W_{ij} = \max(W_{i1}, W_{i2}, W_{i3}, W_{i4}) \\ 0 & otherwise \end{cases}$$

where i=1,….,n and j=1,….,4.

The decision can be modeled using a logit function. A binary logit framework can be used when there is a single technology under consideration or multinomial logit when there is more than one technology. In our example, the probability that the ith transit agency makes the jth choice can be written as a multinomial function

$$\Pr(D_{ij} = 1 | X, Z) = e^{Z_i\beta_{z,j} + X_i\beta_{x,j}} \Big/ \sum_{j=1}^{4} e^{Z_i\beta_{z,j} + X_i\beta_{x,j}}.$$

5.2 Modeling Considerations

Econometric modeling requires that a number of concerns and considerations be addressed. This includes decisions being made prior to fitting models as well as those that impact the interpretation of results. In this case, special emphasis is placed on the issues of causation in addition to common concerns about explanatory variables.

5.2.1 Explanatory Variables

A number of explanatory variables were considered as potential determinants of technology adoption. These attributes fall into three categories: community, agency, and manager attributes. The sign of parameters was expected to be the same for each technology considered, while the relative magnitude might differ.

The sole community variable considered was the location of the organization as identified by region. Region I in the model includes states in FTA Regions I, II, and III. Region II consists of states in FTA Regions IV and V while Region III consists of the remaining western states.

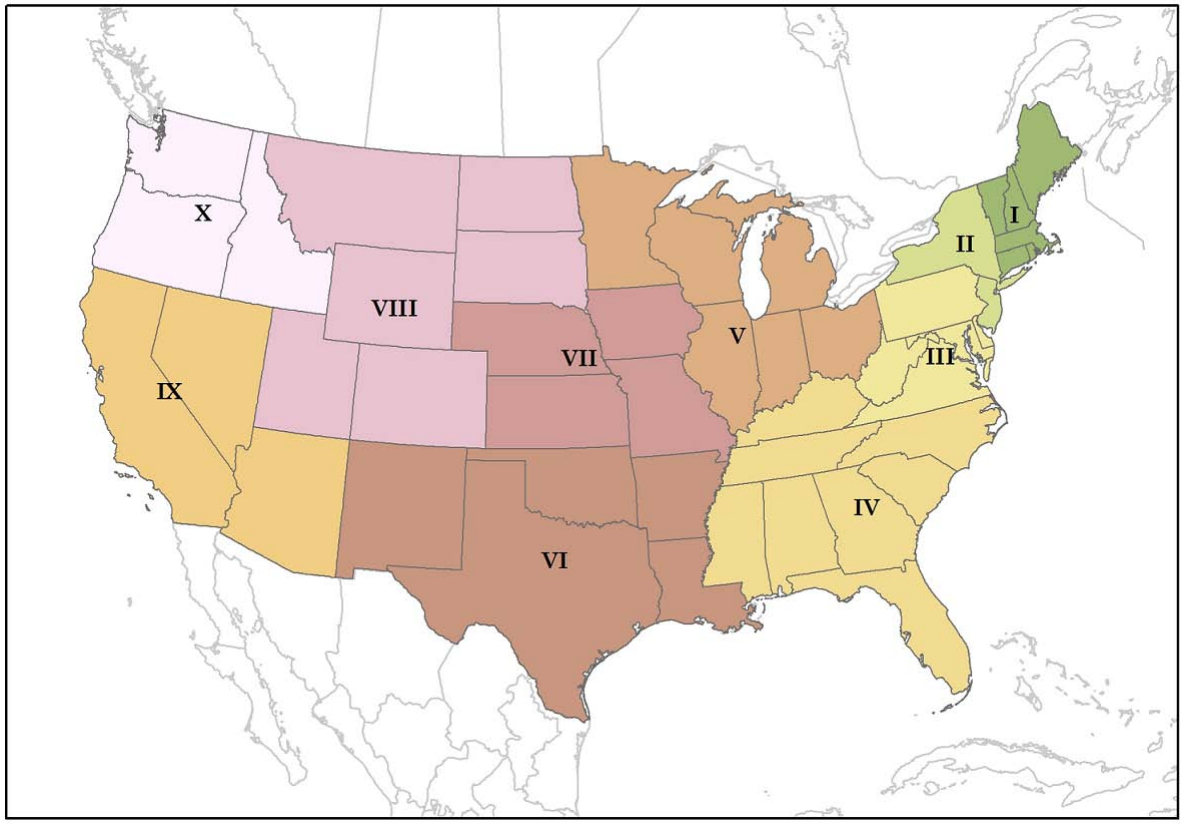

Figure 5.1 FTA Regions

Agency attributes include measures of system size, cost effectiveness, service type, and organization type. System size was measured by four variables: annual number of unlinked trips, vehicle-hours of service, fleet size, and budget. It is hypothesized that larger agencies are more likely to use technology as they assist in the management of complex systems. Cost efficiency was measured by cost per trip and cost per hour of service as reported to the Rural NTD. It is hypothesized that agencies with high costs of service

will be more likely to more likely to use technology and many technologies help improve the efficiency of service delivery.

Service type was measured using a dummy variable for demand-response service. It is hypothesized that agencies providing demand-response service will be more likely to use technology due to the complexity of the service. Organization type was measured using a dummy for those agencies organized as non-profits.

Manager attributes include education, years working in the transit industry, and the number of years managing their current agency. Also considered were attendance at national meetings, interactions with vendors, and participation in technology sessions. It is expected that all manager attributes will be positively correlated with technology adoption.

5.2.2 Causation and Cross-Sectional Data

As with many econometric models, there is often confusion with causality. That is, correlation between independent and dependent variables doesn't prove that the independent variable causes the dependent variable. For example, an agency with a manager that attends technology training may be positively related to use of AVL technology. This may be improperly interpreted as training resulting in technology adoption while the use of technology may result in an increase in the likelihood of a manager attending training.

There is an additional issue with the timing of decision and causality. Our data set consists of cross-sectional data with values from a single point in time. For example, an agency with a large fleet may use CASD software. However, it may be the case that the agency had a smaller fleet prior to technology adoption which allowed it to increase the number of vehicles in service that it could later efficiently utilize.

5.2.3 Logistic Regression and Odds Ratios

Odds ratio estimates are presented for each of the models as parameter estimates for logit models. Odds ratios can be interpreted as the estimate in the change of the likelihood of technology adoption from a one unit increase in the respective variable.

5.3 Adoption of Individual Technologies

Adoption of individual transit technologies by agencies serving rural areas is modeled using a binary logit framework. Four technologies are considered: Automatic Vehicle Location, Computer-Aided Scheduling and Dispatch software, Geographic Information Systems, and Mobile Data Terminals.

5.3.1 Automatic Vehicle Location

The relationship between agency, community, and manager attributes on the adoption of AVL technology was modeled using binary logit. Odds ratio estimates from the model are presented in Table 5.1.

Table 5.1 Automatic Vehicle Location Adoption Odds Ratio Estimates

	Odds Ratio
Fleet Size	1.04*
Annual Ridership	4.31**
Cost/Trip	1.01**
Non-Profit Status	3.07**
Manager Education	1.31
Transit Years	1.01*
Technology Session Attendance	.725
Interaction with Vendors	.184
National Conference Attendance	.862*

* Significantly different from zero at the 10% level
**Significantly different from zero at the 5% level

The longer the transit agency manager has worked in the industry the more likely that their agency uses AVL. This may be due to an understanding of the operational needs of their organization and the benefits AVL would provide. Managers who attend national conferences are less likely to work for an agency that uses AVL. An increase in the size of the agency in terms of either fleet size or number of trips results in an increased use of AVL. Agencies organized as non-profit agencies are much more likely to use technology. Agencies with high costs per trip are slightly more likely to use AVL.

5.3.2 Computer-Aided Scheduling and Dispatch Software

Factors affecting the adoption of CASD software are modeled using a binary logit model. Estimates of odds ratios from the final model are presented in Table 5.2.

The more educated and longer a manager has worked in transit the less likely they are to use CASD software. This may due to technology aversion by older workers or a better understanding of transit operations and a resistance to adopt unhelpful technology. Countering this is the odds ratio estimate for the number of years the respondent has managed their current agency.

Table 5.2 Computer-Aided Scheduling and Dispatch Software Adoption Model Estimates

	Odds Ratio
Fleet Size	1.05*
Annual Ridership	1.53**
Demand-Response	.43**
Manager Education	1.05
Years Working in Transit	.97**
Interaction with Vendors	.84
Technology Session Attendance	.94
National Conference Attendance	1.43
Region 2	1.61*

* Significantly different from zero at the 10% level
**Significantly different from zero at the 5% level

Agencies with large fleets or that provide a high number of trips are more likely to use CASD software. Agencies providing demand-response service are less likely to use CASD software. The more vehicle hours an agency provides the more likely they are to use CASD. The higher the cost of providing an hour of service the more likely transit agencies are to use the technology. However, the more trips provided per hour the less likely they are to use CASD. Agencies in Regions I and II, which corresponds to FTA Regions III, IV, and V, are more likely to use CASD software.

5.3.3 Geographic Information Systems

Odds ratios for factors influencing the use of GIS by rural transit agencies were estimated using a binary logit model. The estimates of these values are presented in Table 5.3.

Table 5.3 Geographic Information Systems Adoption Odds-Ratio Estimates

	Odds Ratio
Fleet Size	1.03**
Budget	2.48**
Trips/Vehicle	1.03**
Cost/Trip	.933**
Non-Profit Status	.295**
Number of Agency Computers	1.02**
Manager Education	1.21
Years Working in Transit	1.00
Technology Session Attendance	2.31**
Interaction with Vendors	.619
National Meeting Attendance	1.18
Region 3	.538*

* Significantly different from zero at the 10% level
**Significantly different from zero at the 5% level

Agencies with managers that have attended sessions on technology are much more likely to use GIS. Larger agencies in terms of fleet size and budget are also more likely to use GIS. Agencies that have a large number of personal computers or high capacity utilization, measured by the number of trips delivered per vehicle, are more likely to use GIS. NPOs are much less likely to use GIS than others. This may due to the high rate of use of GIS by governments. A number of transit agencies are organized as departments of local governments. In some cases, these governments may have in-house GIS expertise. Surprisingly, agencies with low costs per trip are more likely to use GIS. Agencies in Regions 2 and 3, which corresponds to FTA Regions IV, V, VI, VII, VIII, IX, and X, are less likely to use GIS.

5.3.4 Mobile Data Terminals

Individual adoption of MDTs is modeled using a binary logit. Only one variable, fleet size, was found to be statistically significant. The larger an agency is in terms of vehicles the more likely it is to adopt MDTs. The odds ratio estimates from modeling the adoption of MDTs by rural transit agencies are presented in Table 5.4.

Table 5.4 Mobile Data Terminals Adoption Odds-Ratio Estimates

	Odds-ratio
Fleet Size	1.08**
Budget	1.54
Manager Education	.915
Years Working in Transit	.988
Interaction with Vendors	.791
Technology Session Attendance	1.791
National Meeting Attendance	.723

* Significantly different from zero at the 10% level
**Significantly different from zero at the 5% level

The results of the four models of individual rural transit technology adoption are presented in Table 5.5.

Table 5.5 Rural Transit Technology Adoption Summary Table

	AVL	CASD	GIS	MDT
Fleet Size	+	+	+	+
Annual Ridership	+	+		
Budget			+	o
Trips/Vehicle			+	
Cost/Trip	+	o	-	
Non-Profit	+	o	-	
Demand-Response		-		
Number of Agency Computers			+	
Manager Education	**o**	o	o	o
Years Working in Transit	+	-	o	o
Technology Session Attendance	o	o	+	o
Interaction with Vendors	o	o	o	o
National Conference Attendance	-	o	o	o
Region 2		+		
Region 3			-	

+ Statistically significant positive correlation
- Statistically significant negative relationship
Statistically insignificant relationship

5.4 Joint Adoption of Rural Transit Technologies

Multinomial logit techniques allow the investigation of joint adoption of multiple technologies. Joint adoption is considered for combinations of CASD software and AVL, MDTs, or GIS. While measures of agency size were significant, few other variables were found to significantly impact the joint adoption of transit technology.

5.4.1 Joint Adoption of Computer-Aided Scheduling and Dispatch Software and Automatic Vehicle Location

Odds ratios estimates from modeling the joint adoption of CASD software and AVL were calculated using multinomial logit techniques. Agencies with large fleets or that deliver high numbers of trips are more likely to use CASD software or AVL individually or in combination with one another. Managers who interact with vendors are less likely to use AVL technology. CASD software and AVL adoption odds ratio estimates are presented in Table 5.6.

Table 5.6 CASD and AVL Joint Adoption Odds Ratio Estimates

	CASD*	AVL	CASD & AVL*
Trips	1.53**	2.62**	3.00**
Vehicles	1.06**	1.073**	1.09**
Transit Years	.991	1.02	.955
Education	1.08	1.04	1.03
Vendors	.61	.20**	.85
Sessions	1.48	3.26	.538
National Meetings	1.45*	1.25	1.04

* Significantly different from zero at the 10% level
** Significantly different from zero at the 5% level

5.4.2 Joint Adoption of Computer-Aided Scheduling and Dispatch Software and Geographic Information Systems

Odds ratios for the joint adoption of CASD software and GIS were estimated using multinomial logit methods. Agencies that provide large numbers of trips are more likely to use GIS or GIS and CASD, but not CASD alone. At the same time, agencies with large fleets are more likely to use CASD or GIS and CASD, but not GIS alone. Managers that attend technology sessions are more likely to have GIS. This is logical as successful use of GIS requires a certain level of technical sophistication which may either result in an interest or need to attend technology sessions. The estimated odds ratios for the joint adoption of CASD and GIS are presented in Table 5.7.

Table 5.7 CASD and GIS Joint Adoption Odds Ratio Estimates

	CASD	GIS	CASD & GIS
Trips	1.19	1.43**	2.62**
Vehicles	1.06**	1.02	1.05*
Transit Years	.979	1.02	.983
Education	1.03	1.45	1.10
Vendors	.57	.75	1.34
Sessions	1.78	3.23**	.655
National Meetings	1.14	.489	1.39

* Significantly different from zero at the 10% level
** Significantly different from zero at the 5% level

5.4.3 Joint Adoption of Computer-Aided Scheduling and Dispatch Software and Mobile Data Terminals

The odds ratios from modeling the joint adoption of CASD software and MDT were also estimated. The larger an agency in terms of annual unlinked passenger trips and fleet size the more likely they are to use the technologies individually or in combination with one another. In addition, more educated rural transit agency managers are more likely to work for agencies that use MDT. The estimated odds ratio for this effect is relatively large, but only significant at the 10% level. Model estimates for the joint adoption of CASD software and MDT are presented in Table 5.8.

Table 5.8 CASD and MDT Joint Adoption Odds Ratio Estimates

	CASD	MDT	CASD & MDT
Trips	1.51**	2.31*	2.10**
Vehicles	1.05**	1.14**	1.10**
Transit Years	.986	1.09	.967
Education	1.26	17.4*	.709
Vendors	.690	2.12	1.56
Sessions	1.38	999	.459
National Meetings	1.34	.001	.990

* Significantly different from zero at the 10% level
** Significantly different from zero at the 5% level

6. IMPLICATIONS FOR POLICY, PRACTICE, AND FURTHER RESEARCH

The results of the econometric analysis have significant implications for rural transit policy and practice. While some factors that impact technology adoption cannot be controlled, others, including activities of rural transit agency managers, can. Encouragement of these activities by state or federal program administrators or self-motivation by managers who know which activities to participate in may influence the adoption of technology. At the same time, knowledge of agency attributes that affect technology implementation can serve as a basis to identify which agencies might benefit from technology adoption. Conversely, the analysis can assist in identifying agencies that are not expected use technology but do. While the study was successful in meeting its primary goal of identifying current technology use by rural transit agencies and a secondary goal of determining factors that influence technology adoption, it did not collect detailed cost information. This remains an ongoing industry need.

6.1 Transit Agency Manager Activities

The econometric analysis identified three manager activities that influence technology by rural transit agencies: attendance at national meetings, interaction with product vendors, and participation in technology training. Encouragement by state departments of transportation and the Federal Transit Administration may influence adoption of technology by transit agencies. Of course, agency managers themselves can take initiative and pursue these activities independently. However, this does not imply that there will be an increased rate of adoption.

Attendance at national meetings provides transit agency managers with a number of unique opportunities that may impact technology adoption. These include exposure to new ideas in formal sessions and to specific technology products at vendor shows as well as interacting and networking with other transit agency managers from across the country. Perhaps most importantly, national meetings provide the opportunity for attendees to step away from the day-to-day operational demands of their agency and think strategically about organizational and community mobility needs, which is often the first step in innovation and technology adoption.

Interaction with vendors, be it at national meetings, on-site, or remotely, provides transit agency managers the ability to become educated on specific technologies and how they might benefit their agency. A discussion with vendors does not require that a specific technology project be under consideration. Guidance on effectively interacting with technology vendors is available from a number of sources and is occasionally the subject of sessions at state or national conferences.

Participation in formal training may provide managers with knowledge of concepts, tools, and processes necessary to successfully adopt and use technology in their rural transit agency. The National Transit Institute in partnership with the Small Urban & Rural Transit Center provides a two-day course on implementing rural transit technology that covers these topics. Shorter training opportunities on specific areas are often provided at state or national transit conferences.

6.2 Differences in Adoption

The econometric analysis identified factors that impact technology adoption by rural transit agencies. These findings can be used to determine which agencies might benefit from technology based on community, agency, and manager attributes. Conversely, agencies that do use technology, but are not

expected to be based on their characteristics, can be identified to determine if and how they benefit from the technologies they use.

For example, the analysis found that larger agencies, as measured by fleet size, are more likely to use technology. However, some agencies with large fleets use relatively little technology, while some small agencies use a number of technology systems. Individual investigation of each of these agencies will likely provide a better understanding of the decision to implement technology and the benefits that result.

6.3 Need for Additional Research

While the project survey collected a large amount of data on technology use by rural transit agencies, it did not request detailed agency level cost or benefit data. This was done to avoid a lower response rate that was expected to result from asking for detailed information. However, the survey did ask participants to report if their agency had recently implemented technology. A follow-up survey of these agencies that requests costs, including those per unit, and benefits may be worthwhile. At the same time, more thorough case studies that provide a more complete understanding of the context in which the adoption decision was made and a thorough collection of benefits and costs would also be beneficial to the industry.

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APPENDIX: SURVEY INSTRUMENT

1. General Information

*** Agency Name**

*** Address**

*** City, State**

*** Contact Person**

*** Title**

*** E-Mail**

*** Type of Service Provided (Check all that apply)**

- ☐ Advanced Reservation
- ☐ Dial-a-Ride
- ☐ Fixed-Route
- ☐ Intercity Bus
- ☐ Other (please specify)

*** Organization Type**

- ○ Non-Profit Organization
- ○ Local Government
- ○ For-Profit Organization
- ○ Other (please specify)

2.

The next section of this survey asks questions regarding core technology use and the functions of the technology used within your transit agency. It addresses current and future use of core technologies.

3. General Technology

*** How many personal computers does your agency have?**

A server is a computer on a network that manages network resources including data and programs. Any user connected to the server can store and run files saved on the server.

*** Does your agency use a server(s)?**

- ◯ Yes
- ◯ No
- ◯ Don't Know

4. Server Location

*** Where is/are your server(s) located?**

- ☐ On-site
- ☐ Remote
- ☐ Don't know
- ☐ Other (please specify)

5. Internet

*** Does your agency have an Internet connection?**

- ◯ Yes
- ◯ No

6. Connection type

What type of connection is it?

- ☐ Dial-up (Using a modem, the pc dials a number to connect to a network. Low speed connection.)
- ☐ Cable (A cable modem provides internet access that operates through cable television lines. Very fast access.)
- ☐ DSL (An alternate telephone line is connected to premises. This connection does not tie up phone lines as dial up does and is always on. Higher speed connection.)
- ☐ Wireless (Using radio frequency bands to connect, this connection can be accessed anywhere; it's always on. Speeds vary based on connection.)
- ☐ Don't know
- ☐ Other (please specify)

7. IT support

*** Where does your agency receive IT support from? (Check all that apply)**

- [ ] In-house
- [ ] Shared government support
- [ ] Third party
- [ ] No formal support
- [ ] Other (please specify)

8. Operations Software

Operations software is a broad family of technologies that encompasses spreadsheets and databases as well as accounting, personnel, and maintenance software. Accounting software can process accounting data. Personnel software can process payroll, benefits and personnel data. Maintenance software organizes vehicle inventory, maintenance, and repair data. Reporting software helps generate reports with specific data included. Operations software has the capability to connect, upload and share data with other software and technologies.

*** Are you familiar with operations software?**

- ◯ Yes
- ◯ No

*** Does your agency currently any use operations software? (Check all that apply)**

- [ ] Accounting
- [ ] Personnel
- [ ] Reporting
- [ ] Maintenance tracking
- [ ] Do not use operations software
- [ ] Other (please specify)

9. Operations Software applications

*** For what purpose(s) does your agency use operations software? (Check all that apply)**

- [ ] Accounting
- [ ] Personnel management
- [ ] Maintenance tracking
- [ ] Record keeping
- [ ] Reporting
- [ ] Other (please specify)

10. Spreadsheets

*** Does your agency use spreadsheets to manage agency operations?**

- ◯ Yes
- ◯ No

11. Spreadsheet purpose

*** For what purpose(s) does your agency use spreadsheets? (Check all that apply)**

- [ ] Cash handling
- [ ] Dispatching
- [ ] Maintenance tracking
- [ ] Operations, staff performance, productivity
- [ ] Maintaining customer information
- [ ] Other (please specify)
- [ ] Reporting and record keeping
- [ ] Safety
- [ ] Scheduling
- [ ] Service quality
- [ ] Trip request processing

12. Operations Software future use

*** Does your agency currently plan to change or add operations software in the next five years?**

- ◯ Yes
- ◯ No

13. GIS

Geographic Information Systems (GIS) are computer software programs that provide database management capabilities for the display and editing of geographically-referenced information. This software can integrate bus stops, routes, transit facilities, and the area street network to increase efficiency. GIS is often used in conjunction with advanced scheduling and dispatching systems.

*** Are you familiar with Geographic Information Systems (GIS) technology?**

- ◯ Yes
- ◯ No

*** Does your agency currently use GIS technology?**

- ◯ Yes
- ◯ No

14. GIS purpose

*** For what purpose(s) does your agency use GIS technology? (Check all that apply)**

- ☐ Operations, staff performance, productivity
- ☐ Providing customer information
- ☐ Reporting and record keeping
- ☐ Scheduling
- ☐ Service coordination
- ☐ Service quality
- ☐ Trip request process
- ☐ Other (please specify)

*** Was the technology adopted after January 1, 2008?**

- ◯ Yes
- ◯ No

15. GIS cost

*** What was the total cost in dollars associated with implementing geographic information systems? (e.g., software, hardware, development, training, labor)**

Please describe any unique conditions or circumstances that impacted the cost of implementing GIS.

16. GIS future use

*** Does your agency currently plan to use GIS in the next five years?**

- ◯ Yes
- ◯ No

17. CADS

Computer Aided Dispatching and Scheduling (CADS) software coordinates trip requests, passenger data, vehicle information, and route information to generate efficient schedules for demand-response services. This technology is also capable of customer registration, reservations, scheduling, dispatching and monitoring.

*** Are you familiar with computer aided dispatching and scheduling software?**

- ◯ Yes
- ◯ No

*** Does your agency currently use computer aided dispatching and scheduling software?**

- ◯ Yes
- ◯ No

18. CADS purpose

*** What functions does your computer aided dispatching and scheduling software have? (Check all that apply)**

- ☐ Automated client management
- ☐ Automated trip request
- ☐ Manual routing and scheduling(software assists schedulers who construct routes and schedules from trip requests)
- ☐ Automated routing and scheduling (algorithm generated output)
- ☐ Report generation
- ☐ Billing
- ☐ Other (please specify)

*** For what purpose(s) does your agency use computer aided dispatching and scheduling software? (Check all that apply)**

- ☐ Dispatching
- ☐ Scheduling
- ☐ Operations, staff performance, and productivity
- ☐ Service coordination
- ☐ Providing customer information
- ☐ Service quality
- ☐ Reporting and record keeping
- ☐ Trip request processing
- ☐ Safety
- ☐ Other (please specify)

*** Was this technology adopted after January 1, 2008?**

- ○ Yes
- ○ No

19. CADS cost

*** What was the total cost in dollars associated with implementing computer aided dispatching and scheduling software?(e.g., software, hardware, development, training, labor)**

Please describe any unique conditions or circumstances that impacted the cost of implementing computer aided dispatching and scheduling software.

20. CADS future use

*** Does your agency currently plan to use computer aided dispatching and scheduling software in the next five years?**

- ○ Yes
- ○ No

21. Automatic Vehicle Location

Automatic vehicle location (AVL) software tracks the real time location of a vehicle and allows rural agencies to monitor the location, actual or approximate, of all transit vehicles in the fleet. The most popular form of AVL uses global positioning systems (GPS), which is a series of satellites that emit signals. The satellite sends signals to vehicles equipped with GPS receivers. To use AVL, a vehicle must have the means to transmit data back to a central dispatch location.

*** Are you familiar with automatic vehicle location (AVL) technology?**

- ◯ Yes
- ◯ No

*** Does your agency currently use AVL technology?**

- ◯ Yes
- ◯ No

22. AVL purpose

*** For what purpose(s) does your agency use AVL technology? (Check all that apply)**

- ☐ Communications
- ☐ Dispatching
- ☐ Operations, staff performance, productivity
- ☐ Providing customer information
- ☐ Other (please specify)
- ☐ Safety
- ☐ Scheduling
- ☐ Service coordination
- ☐ Service quality

*** Was the technology adopted after January 1, 2008?**

- ◯ Yes
- ◯ No

23. AVL cost

*** What was the total cost in dollars associated with implementing automatic vehicle location technology? (e.g., software, hardware, development, training, labor)**

Please describe any unique conditions or circumstances that impacted the cost of implementing AVL.

24. AVL future use

*** Does your agency currently plan to use automatic vehicle location technology in the next five years?**

- ◯ Yes
- ◯ No

25. MDTs/ MDCs

Mobile data terminals (MDT) are computerized devices used to communicate with the central office. They provide two-way text based communication and have the ability to upload data during a scheduled route. Mobile data computers (MDC) are similar to MDTs. MDCs are on board computers generally equipped with a touch screen. A MDC has the capability for two-way communications, electronic manifests, maps and directions, vehicle tracking and in-vehicle financial transactions. MDCs have a LCD screen, internal GPS receiver, wireless network modem, smart card reader, magnetic stripe reader, and various other features.

*** Are you familiar with Mobile Data Terminals (MDTs) and Mobile Data Computers (MDCs)?**

- ◯ Yes
- ◯ No

*** Does your agency currently use MDTs or MDCs?**

- ◯ Yes
- ◯ No

26. MDT/ MDC purpose and adoption

*** For what purpose(s) does your agency use MDTs or MDCs? (Check all that apply)**

- ☐ Download electronic trip manifests
- ☐ Automatically update schedule changes
- ☐ Driver sign-on and sign-off
- ☐ Passenger pick-up and drop-off
- ☐ Other (please specify)
- ☐ Vehicle location
- ☐ Fare determination and collection
- ☐ Driver and operations supervision
- ☐ Emergency communications

*** Was the technology adopted after January 1, 2008?**

- ◯ Yes
- ◯ No

27. MDT cost

*** What was the total cost in dollars associated with implementing Mobile Data Terminals and/or Mobile Data Computers? (e.g., software, hardware, development, training, labor)**

Please describe any unique conditions or circumstances that impacted the cost of implementing Mobile Data Terminals and/or Mobile Data Computers.

28. MDT future use

*** Does your agency currently plan to use MDTs/ MDCs in the next five years?**

- ◯ Yes
- ◯ No

29. Traveler Information Systems

Traveler information systems provide transportation information prior to and during transportation. This technology can range from customer service lines to automated trip planner and real time transit and traffic information. This information generally has multiple access points including at the passenger's home or work, at transit stops, and in vehicles.

*** Are you familiar with traveler information systems?**

- ◯ Yes
- ◯ No

*** Does your agency currently provide traveler information systems?**

- ◯ Yes
- ◯ No

30. Specific TIS

*** What traveler information services do you provide? (Check all that apply)**

- [ ] Website
- [ ] Text messaging and/or e-mail
- [ ] Variable message signs
- [ ] Automated phone service
- [ ] Audible annunciators
- [ ] In-vehicle displays
- [ ] Other (please specify)

If your agency has a website, please provide the address.

*** What information does your agency's traveler information systems provide? (Check all that apply)**

- [ ] Static service information
- [ ] Real time vehicle location
- [ ] Estimated arrival time
- [ ] Trip planning tools
- [ ] Other (please specify)

*** For what purpose(s) does your agency provide traveler information systems? (Check all that apply)**

- [ ] Communications
- [ ] Providing customer information
- [ ] Service quality
- [ ] Trip request processing
- [ ] Other (please specify)

*** Was the technology adopted after January 1, 2008?**

- ( ) Yes
- ( ) No

31. TIS cost

*** What was the total cost in dollars associated with implementing traveler information systems? (e.g., software, hardware, development, training, labor)**

Please describe any unique conditions or circumstances that impacted the cost of implementing traveler information systems.

32. TIS future use

*** Does your agency currently plan to provide traveler information systems in the next five years?**

- ◯ Yes
- ◯ No

33. Electronic Fare Payment Systems

Electronic fare payment systems are automated ways of collecting and processing fares. There are different ways this technology can be used. One way is through barcoded cards. These cards assign a specific barcode to each customer and are read by a barcode reader. This information must then be sent to a computer for decoding. Magnetic stripe cards allow information to be stored on a band of magnetic material which is swiped through a reader. Smart cards come in different formats including the contact, contactless, and combi-card. The contact card requires contact with a reader to use, while the contactless card can be used by passing by the reader. The combi-card combines the function of both the contact and contactless card. It has two separate chips or a chip capable of both functions.

*** Are you familiar with electronic fare payment systems?**

- ◯ Yes
- ◯ No

*** Does your agency currently use electronic fare payment systems?**

- ◯ Yes
- ◯ No

34. Specific EFPS

*** What type of electronic fare payment system does your agency use?**

- [ ] Barcode card
- [ ] Magnetic stripe card
- [ ] Smart card
- [ ] Combi-card

*** For what purpose(s) do you use electronic fare payment systems? (Check all that apply)**

- [ ] Rider and trip information
- [ ] Fare determination
- [ ] Fare collection
- [ ] Reporting and record keeping
- [ ] Billing
- [ ] Service coordination
- [ ] Other (please specify)

*** Was the technology adopted after January 1, 2008?**

- ○ Yes
- ○ No

35. EFPS cost

*** What was the total cost in dollars associated with implementing electronic fare payment systems? (e.g., software, hardware, development, training, labor)**

Please describe any unique conditions or circumstances that impacted the cost of implementing electronic fare payment system technology.

36. EFPS future use

*** Does your agency currently plan to use electronic fare payment systems in the next five years?**

- ◯ Yes
- ◯ No

37. APC

Advanced passenger counting is a technology that counts passengers as they board. This information can then be uploaded to computers for processing and planning.

*** Are you familiar with advanced passenger counting technology?**

- ◯ Yes
- ◯ No

*** Does your agency currently use advanced passenger counting technology?**

- ◯ Yes
- ◯ No

38. Specific APC

*** Was the technology adopted after January 1, 2008?**

- ◯ Yes
- ◯ No

39. APC cost

*** What was the total cost in dollars associated with implementing advanced passenger counting technology? (e.g., software, hardware, development, training, labor)**

Please describe any unique conditions or circumstances that impacted the cost of implementing automatic passenger counter technology.

40. APC future use

*** Does your agency currently plan to use advanced passenger counting technology in the next five years?**

- ◯ Yes
- ◯ No

41. Security

Security systems include a wide variety of technologies found on and off the vehicles including silent alarms, microphones, and closed circuit television cameras. This type of system allows for the transit vehicle to send distress calls to a base station for transportation situations to be monitored.

*** Are you familiar with transit security systems?**

- ◯ Yes
- ◯ No

*** Does your agency currently use on- or off-vehicle transit security systems?**

- ◯ Yes
- ◯ No

42. Specific security

*** What methods does your agency use for security? (Check all that apply)**

- ☐ Cameras
- ☐ Closed circuit television
- ☐ Silent alarms
- ☐ Audio surveillance
- ☐ Object detection sensors
- ☐ Covert microphones
- ☐ Other (please specify)

*** Was the technology adopted after January 1, 2008?**

- ◯ Yes
- ◯ No

43. Security cost

*** What was the total cost in dollars associated with implementing transit security systems? (e.g., software, hardware, development, training, labor)**

Please describe any unique conditions or circumstances that impacted the cost of implementing transit system security technology.

44. Security future use

*** Does your agency currently plan to use on- or off-vehicle transit security systems in the next five years?**

- ◯ Yes
- ◯ No

45.

The next section addresses the use and functions of communication technologies within your agency.

Communications technology provides voice and/or data communication between the drivers, agency, customers and others involved in transit. This technology can range from voice radio to a much more complex system that combines various communications technologies.

46. Two-way Radios

Two-way radios allow voice communication by connecting multiple wireless devices to a central base station.

*** Are you familiar with two-way radios?**

- ◯ Yes
- ◯ No

*** Does your agency currently use two-way radios?**

- ◯ Yes
- ◯ No

47. Radio Infrastructure

*** Does your agency own the communication infrastructure or contract for its use?**

- ◯ Own
- ◯ Share public infrastructure
- ◯ Contract
- ◯ Other (please specify)

*** What does your agency use two-way radios for? (Check all that apply)**

- ☐ Vehicle location
- ☐ Scheduling changes
- ☐ Driver sign-on and sign-off
- ☐ Pick-up and drop-off
- ☐ Emergency communication
- ☐ Other (please specify)

48. Cellular Phones

Cellular communications are a long range phone service that allows voice and data communication over a wireless network. Cellular communications are provided through a cellular carrier and are dependent on local coverage.

*** Are you familiar with cellular communications?**

- ◯ Yes
- ◯ No

*** Does your agency currently use cellular phones?**

- ◯ Yes
- ◯ No

49. Cellular Phones purpose

*** What does your agency use cellular phones for? (Check all that apply)**

- [ ] Vehicle location
- [ ] Scheduling changes
- [ ] Driver sign-on and sign-off
- [ ] Pick-up and drop-off
- [ ] Emergency communication
- [ ] Operations management
- [ ] Other (please specify)

50. Cellular Phones future use

*** Does your agency currently plan to use cellular phones in the next five years?**

- ◯ Yes
- ◯ No

51. Smart Phones

Smart phones are mobile phones with many of the same capabilities as a computer such as data processing and online maps. They can run complete operating software, like Windows or Linux, and are able to run the internet, e-mail and other applications as well as phone capabilities. Examples include Blackberry, Apple iPhone, and Palm Pre.

*** Are you familiar with smart phones?**

- ◯ Yes
- ◯ No

*** Does your agency currently use smart phones?**

- ◯ Yes
- ◯ No

52. Smart Phones purpose

*** What does your agency use smart phones for? (Check all that apply)**

- [ ] Vehicle location
- [ ] Scheduling changes
- [ ] Driver sign-on and sign-off
- [ ] Pick-up and drop-off
- [ ] Emergency communication
- [ ] Operations management
- [ ] Other (please specify)

53. Smart Phones future use

*** Does your agency currently plan to use smart phones in the next five years?**

- ◯ Yes
- ◯ No

54. Text Message

Text messaging allows individuals to send brief messages between mobile phones and cell networks. Originally only for text, this technology has evolved to be able to send photos, video, and sound.

*** Are you familiar with text messaging?**

- ◯ Yes
- ◯ No

*** Does your agency currently use text messaging?**

- ◯ Yes
- ◯ No

55. Text Message purpose

*** What does your agency use text messaging for? (Check all that apply)**

- [ ] Vehicle location
- [ ] Scheduling changes
- [ ] Driver sign-on and sign-off
- [ ] Pick-up and drop-off
- [ ] Emergency communication
- [ ] Operations management
- [ ] Other (please specify)

56. Text Message future use

*** Does your agency currently plan to use text messaging in the next five years?**

- ◯ Yes
- ◯ No

57. Wireless Local Area Network

Wireless Local Area Network (WLAN) connects with a device such as a computer or Personal Digital Assistant (PDA) to send text and other information from one location to another over a wireless internet network.

*** Are you familiar with WLAN?**

- ◯ Yes
- ◯ No

*** Does your agency currently use WLAN?**

- ◯ Yes
- ◯ No

58. WLAN purpose

*** What does your agency use WLAN for?**

- [ ] Vehicle location
- [ ] Scheduling changes
- [ ] Driver sign-on and sign-off
- [ ] Pick-up and drop-off
- [ ] Emergency communication
- [ ] Operations management
- [ ] Other (please specify)

59. WLAN future use

*** Does your agency currently plan to use WLAN in the next five years?**

- ◯ Yes
- ◯ No

60. Satellite Phones

Satellite Phones are a type of mobile phone very similar to a cellular phone. Instead of connecting to cell sites or towers, the phone transmits signals and connects with orbiting satellites.

*** Are you familiar with satellite phones?**

- ◯ Yes
- ◯ No

*** Does your agency currently use satellite phones?**

- ◯ Yes
- ◯ No

61. Satellite Phones purpose

*** What does your agency use satellite phones for?**

- [ ] Vehicle location
- [ ] Scheduling changes
- [ ] Driver sign-on and sign-off
- [ ] Pick-up and drop-off
- [ ] Emergency communication
- [ ] Operations management
- [ ] Other (please specify)

62. Satellite Phones future use

*** Does your agency currently plan to use satellite phones in the next five years?**

- ◯ Yes
- ◯ No

63.

The final section of the survey asks questions regarding manager training with a focus on regional and national meetings.

64. Manager Information

*** How many years have you been manager at this agency?**

*** How many years have you worked in transit?**

*** What is the highest level of education you have received?**

- ◯ Some high school
- ◯ High school or high school equivalent
- ◯ Some college
- ◯ Two year degree
- ◯ Four year degree
- ◯ Post graduate

*** How many state or regional transit meetings have you attended in the past FIVE YEARS?**

*** How many state or regional transit meetings have you attended in the PAST YEAR?**

*** How many national transit meetings have you attended in the past FIVE YEARS?**

*** How many national transit meetings have you attended in the PAST YEAR?**

*** At the state, regional or national transit meeting(s) what technology vendors did you visit? (Check all that apply)**

- [ ] Operations software
- [ ] Geographic information systems
- [ ] Computer aided dispatching and scheduling software
- [ ] Automatic vehicle location technology
- [ ] Mobile data terminals/mobile data computers
- [ ] Traveler information systems
- [ ] Electronic fare payment systems
- [ ] Advanced passenger counting technology
- [ ] Transit security systems
- [ ] Did not visit technology vendors

*** At the state, regional or national meeting(s) what technology specific sessions did you attend?**

- [ ] Types of technology
- [ ] Technology selection
- [ ] Technology procurement
- [ ] Technology deployment
- [ ] Technology and coordination
- [ ] Did not attend technology specific session
- [ ] Other (please specify)

65. Thank you.

Thank you for completing the survey. Your help is greatly appreciated.

If you have any questions or concerns about the survey, feel free to contact David Ripplinger at (701) 231-5265 or by e-mail at david.ripplinger@ndsu.edu.

A report presenting the findings of the survey will be available in Fall 2009. Would you like to receive an electronic copy of the report when it is completed?

- ◯ Yes
- ◯ No