SURTCOM 20-01

ITS Technology Usage and Feasibility in Small Urban and Rural Transit

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U.S. Department of Transportation

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April 2020

Acknowledgments

Funds for this study were provided by the Small Urban, Rural and Tribal Center on Mobility (SURTCOM), a partnership between the Western Transportation Institute at Montana State University and the Upper Great Plains Transportation Institute at North Dakota State University. The Center is funded through the U.S. Department of Transportation's Office of the Assistant Secretary of Research and Technology as a University Transportation Center. The Small Urban and Rural Center on Mobility within the Upper Great Plains Transportation Institute at North Dakota State University conducted the research.

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ABSTRACT

Intelligent transportation system (ITS) applications have been widely applied to the highway system, and are being used by an increasing number of small urban and rural transit systems throughout the United States. The objectives of this study were to first, identify what technologies are currently used by small urban and rural transit agencies. Second, investigate the influence of community, agency, and manager attributes on technology adoption. Finally, evaluate the changes in ITS adoption among small urban and rural transit agencies today as compared to 10 years ago.

When comparing technologies usage today to that of 10 years ago (Ripplinger and Brand-Sargent 2010), significant increases have occurred. Traveler information systems (TIS) technology usage has increased from 4% in 2010 to 34% among survey respondents today while electronic fare payment (EFP) increased from 2% in 2010 to 18% today. The largest single technology increase was seen in automatic vehicle location (AVL) usage that was 6% among survey respondents in 2010 and 51% today.

Econometric analysis showed that hiring managers with more education and encouraging them to attend conferences and interact with ITS vendors may influence adoption of technologies by transit agencies. Results did not show that help from state DOTs or transit associations has been effective in encouraging technology adoption. This may suggest that help received, while useful, was not a contributing factor in adopting certain technologies. Finally, results can be used to identify which agencies could potentially benefit from certain technology adoptions.

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1. INTRODUCTION

Advances in computers, telecommunications, and information system technologies have led to the development of a wide range of applications that can improve the efficiency and quality of service for all forms of transportation, including public transit. These intelligent transportation system (ITS) applications have been widely applied to the highway system, and are being used by an increasing number of small urban and rural transit systems throughout the United States.

However, many transit systems are being held back from full implementation of their ITS applications. This is often because of a lack of coordination and an unwillingness to change on the part of transit agencies. Some transit agencies also feel that ITS does very little to increase the efficiency of their operations. Identifying transit systems that have implemented ITS technologies and investigating their ability to coordinate different ITS applications will provide a better understanding of the issues and supply a benchmark for other transit agencies to work toward.

Through this research, transit system operators will become more familiar with ITS choices available to them, and be able to quickly and systematically determine the potential benefits of each technology as applied to their individual operations. This technical assistance is necessary as the United States will see a doubling of its 65 and older demographic by the year 2030. Many members of this older demographic will demand efficient transit service as they switch from driving their own vehicles to relying on public transportation for their mobility needs.

1.1 Objectives

The objectives of this study were to first, identify what technologies are currently used by small urban and rural transit agencies. Second, investigate the influence of community, agency, and manager attributes on technology adoption. Finally, evaluate the changes in ITS adoption today versus 10 years ago. A previous study by Ripplinger and Brand-Sargent (2010) was used to compare technology adoption then to adoption among small urban and rural transit agencies today.

1.2 Organization of Content

The study begins with a literature review including research papers and other applicable materials addressing ITS technologies from multiple perspectives. Following the literature review are results from a nationwide survey conducted within the small urban and rural transit industry. Agency characteristics, ITS transit technology usage, manager practices, and technology deployment changes are all included within this section. An econometric model was also developed to investigate the effect of manager attributes on technology adoption. Finally, an overall summary concludes the study with recommendations based on research findings. The appendix includes the survey instrument used in this research.

2. LITERATURE REVIEW

Intelligent transportation systems (ITS) are systems or technologies used for the management of impedances to safe, secure, responsible, and efficient mobility. ITS refers to the use of techniques, methods, or technologies in different transportation modes to provide innovative services that support informed decision-making for transportation stakeholders. ITS provides safer and smarter transportation services to end-users. The Federal Transit Administration outlines congestion relief and improved economic productivity as some of the early benefits of ITS (FTA 2016).

ITS has become an efficient way of improving transportation system performance, security, and modality. Lately, data collection has improved, leading to an increase in data size and variety (Zhang et al. 2011). The increase in data collection and availability suggests that there is potential for more data processing for different transportation stakeholders. The ITS market is expanding internationally with ITS services and products as the most significant potential in the market in the coming years (Fink 2019). The ITS market is expected to grow substantially over the next few decades, exceeding a value of $38.68 billion by 2020. The benefits of ITS in transportation performance, safety, and efficiency is the primary driver for the projected growth (Hexa Research 2014). The growth could enable multimodal transport through the increased integration of information and communications technology (ICT) systems. The use of vehicular ICT systems could be beneficial in preventing the externalities of growing mobility: fatalities, injuries, pollution, and traffic congestion (Papadimitratos et al. 2009).

USDOT's portfolio has programs, projects, and initiatives that focus on ITS. ITS encompass technology-based systems divided into two categories, intelligent infrastructure systems and intelligent vehicle systems (IVS) (US DOT 2014). IVS typically consist of a variety of sensors, actuators, navigation, and driving systems, communications systems, mission packages, and weapons systems controlled by an intelligent controller (Madhavan et al. 2007). As stated earlier, the primary drivers for IVS adoption are safety and efficiency; the anticipated drawbacks are standardization and interoperability issues.

This report focuses on the adoption and deployment of ITS in small urban and rural communities. The scope of this study is in the use of ITS in small urban and rural transit. The goal of this literature review is to identify ITS technologies in use and to evaluate the challenges faced by transit agencies in implementing/adopting ITS technologies.

HEXA Research (2014) highlighted the use of ICT for travel management emphasizing the benefit of ITS in providing mobility services for transportation disadvantaged travelers or riders through the use of travel management coordination centers (TMCC). Their study identifies the significant steps in planning and designing TMCC systems and outlines key lessons from the Mobility Services for All Americans (MSAA) initiative as they relate to the institutional foundation needed to develop and sustain TMCC. MSAA initiatives aim to improve transportation services and access to employment, healthcare, education, and other community activities through a coordinated effort enabled by various ITS technologies and applications (US DOT 2019a.). TMCCs improve small urban and rural transit through optimal multijurisdictional reservations and scheduling. TMCCs provide seamless transportation services and utilize universal cashless fare payment systems and automated billing to improve transportation services in areas with fragmented transportation services (Jamison et al. 2012). TMCCs improves transportation services through better organization of information for passengers and agencies, across all modes, within one system (US DOT 2019a.).

In a study on the use of ITS for the transportation disadvantaged in rural and small urban communities (NADTC 2006), the authors discuss extensive research and case studies of exemplary programs that have greatly improved transportation for people with disabilities. They assert that ITS can help provide service for people with disabilities in small urban or rural areas, primarily through demand-responsive, coordinated, or flexible services. They highlight that while ITS can provide some benefits, the technologies can be expensive. Hence it is vital to carefully plan for the selection and successful implementation of ITS technology in a way that is most appropriate and cost-effective. The authors identify some challenges facing transit agencies in meeting the requirements of the law and the regulations of communities they serve when implementing solutions. The challenges include:

- limited funding
- limited trip purposes
- client-only transportation
- limited days and hours of service
- lack of long-distance transportation
- high cost of transportation
- need accessible vehicles and equivalent service
- more limited use of advanced technologies
- need for driver training
- lack of information

Stone et al. (2000) studied the provision of decision support for transit stakeholders to select the best ITS for their agencies. The authors describe the functionality of an online service that provides decision support for transit managers and researchers. Although small or rural transit agencies already use computer technologies like spreadsheets, a few of them use technologies for dispatch and scheduling automation, complementing voice radio with digital communications, or tracking vehicles automatically. Note that this study highlighted findings from 20 years ago and technologies have advanced considerably since that time. The authors point out the online decision support service focuses on technology choices for both subscription and demand-responsive paratransit service (as well as fixed-route bus and taxi operators) in small urban and rural areas. Ripplinger and Brand-Sargent (2010) studied the adoption of ITS in small urban and rural transit agencies, and the authors identify some technologies currently used, and investigate the influence of communities, agencies, and managers on technology adoption. The report discusses the implications of these findings to policy and practice.

Middelton et al. (2011) considered the use of ITS in rural work zones, and explored the value of ITS in rural work zones in Texas and termed them “Smart Work Zones” (SMZs). SWZs send data to transportation management centers (TMCs). The study found that rural SWZs offer significant benefits to operating agencies. However, the justification of SWZs is challenging because of the anticipated low reduction in crashes (between 5% or 10%), the low traffic volume, and the duration of work zones during a project’s life cycle.

The USDOT (2005) outlines some of the lessons learned from the experience of several states in implementing ITS for rural transit. They assert that a reduction in the accounting and scheduling time and effort required in planning rural trips is a potential benefit of rural ITS. The fundamental step in implementing ITS in rural transit is in facilitating the adoption of automatic vehicle location (AVL) and mobile data terminal (MDT) systems. These systems can help in establishing reliable communications between rural agencies and their riders. In another study published by the U.S. Government Accountability Office (2016), the DOT discusses the findings from a review of ITS deployment in small urban and rural areas and determine the extent of ITS use among transit providers. The study found the following characteristics for adoption of ITS in some small urban and rural transit agencies:

- next-generation electronic fare payment systems
- smaller transit providers may receive and use grants to invest in more innovative technologies:
- transit providers in niche communities (Universities, Vacation destinations, and border communities in metropolitan areas) are using more ITS
- seventy-five percent of small urban and rural transit providers use ITS through the deployment of security systems

These technologies help many small-urban and rural transit agencies provide mobility to their communities. The adoption of ITS by transit agencies is found to be dependent on the anticipated impact on social welfare. In small urban and rural transit agencies, the higher the operational cost of transit services, the higher the likelihood of ITS adoption. The authors assert that agency managers that attend national meetings, interact with product vendors, and participate in technology training are more likely to adopt ITS. Encouragement from state departments of transportation and the Federal Transit Administration also influences the adoption of technology by transit agencies (Ripplinger and Brand-Sargent 2010).

A USDOT report (2019b.) discussed the benefits of ITS in rural communities and the effort of the USDOT to support ITS in rural areas. Rural transportation systems experience more fatal crashes than urban transportation systems. Given the importance of transportation safety and the commitment of USDOT to reduce traffic crashes, efforts are being made to improve rural mobility safety and efficiency with ITS. The ultimate benefits of ITS are to address safety, mobility, and accessibility. USDOT is funding pilot programs that provide safety in rural communities using the following ITS applications:

- curve speed warning
- work zone warnings
- stop sign gap assistance
- do not pass warning
- emergency staging and Communications

Some of the USDOT pilot programs are:

- Connected Vehicle Pilot Deployment Program
- Mobility Services for All Americans (MSAA)
- Mobility on Demand (MOD)
- Accessible Transportation Technologies Research Initiative (ATTRI)
- Road Weather Research
- Advanced Transportation and Congestion Management Technologies Deployment (ATCMTD) Grants
- ITS Professional Capacity Building (PCB)
- National Rural ITS (NRITS) Conference

In another study by the FHWA (1997), the authors identified and demonstrated cost-effective solutions for rural mobility needs. Solutions identified are methods or technologies that local agencies can implement to meet a local need independent of assistance from state or federal agencies (Figure 2.1). The rural ITS solutions are categorized as follows:

- traveler safety and security
- emergency services
- tourism and travel information services
- public traveler services / public mobility services
- infrastructure operation and maintenance
- fleet operation and maintenance
- commercial vehicle operations

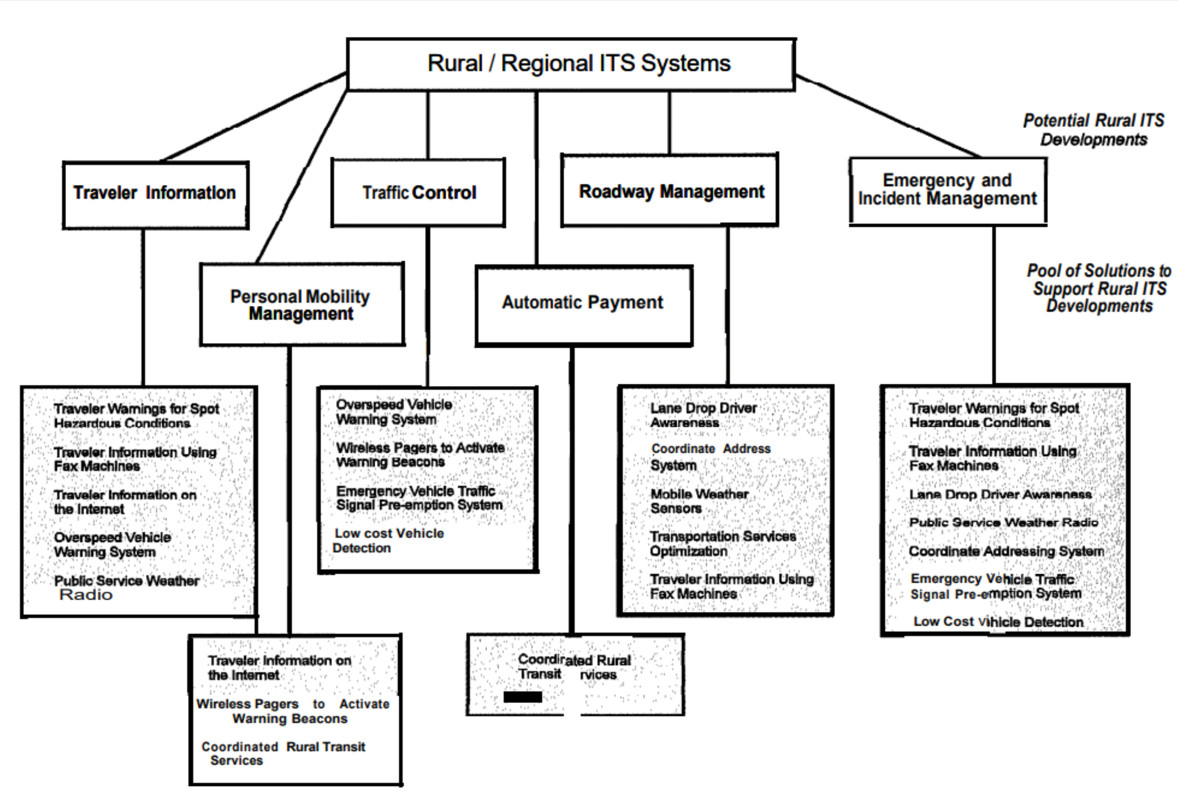

Figure 1. Illustration of Selected Solutions in Overall Rural ITS Development.

Figure 2.1 Proposed Rural ITS Development Solutions

The study found that rural agencies responsible for developing and implementing ITS systems did not perceive them to be “intelligent systems” and this finding is significant as it suggests that ITS implementation is both a “top-down” and a “bottom-up” process (as local agencies take the initiative to design and deploy systems that meet their unique needs).

3. ITS USAGE SURVEY

3.1 Survey Design and Administration

The Small Urban and Rural Center on Mobility (SURCOM) developed an online survey instrument to distribute to transit agency directors. Surveys contained questions regarding technology use by agencies providing transit services in rural and small urban areas. The major goal of the survey was to collect data pertaining to technology adoption at the agency level. A preliminary version of the survey was sent to agency managers and transportation researchers for testing. Changes were made based on reviews and comments. Most of the survey questions were based on previous research at SURCOM conducted by Ripplinger and Brand-Sargent (2010). Developing an updated account of technology adoption was another major goal of the survey, and comparisons can then be made to reflect changes in technology use during the past 10 years.

The survey was distributed nationwide via email to agencies in small urban and rural areas. An email list containing approximately 1,800 valid email addresses was used to contact agency managers. The email list was specific to those agencies receiving either 5311 or 5307 formula grant federal funding. A total of 144 usable surveys were received from the email list, yielding an almost 8% response rate. No incentive was given to potential respondents to complete any questions. A copy of the survey instrument is found in Appendix A.

3.2 Agency Characteristics

Survey participants represented transit agencies from 39 U.S. states (Figure 3.1). Nine states had four or more respondents while the other 30 had between one and three. Figure 3.1 shows that the distribution of states represented most of the country equally. There was similar participation from the southwestern and northeastern states. Only two southwestern and four northeastern states were not represented. One Midwestern state was unrepresented while two states from the southeast and southwest had no respondents. Montana had the most respondents with nine, and North Dakota had the second-most with six followed by Georgia, New Hampshire, and Michigan with five respondents each.

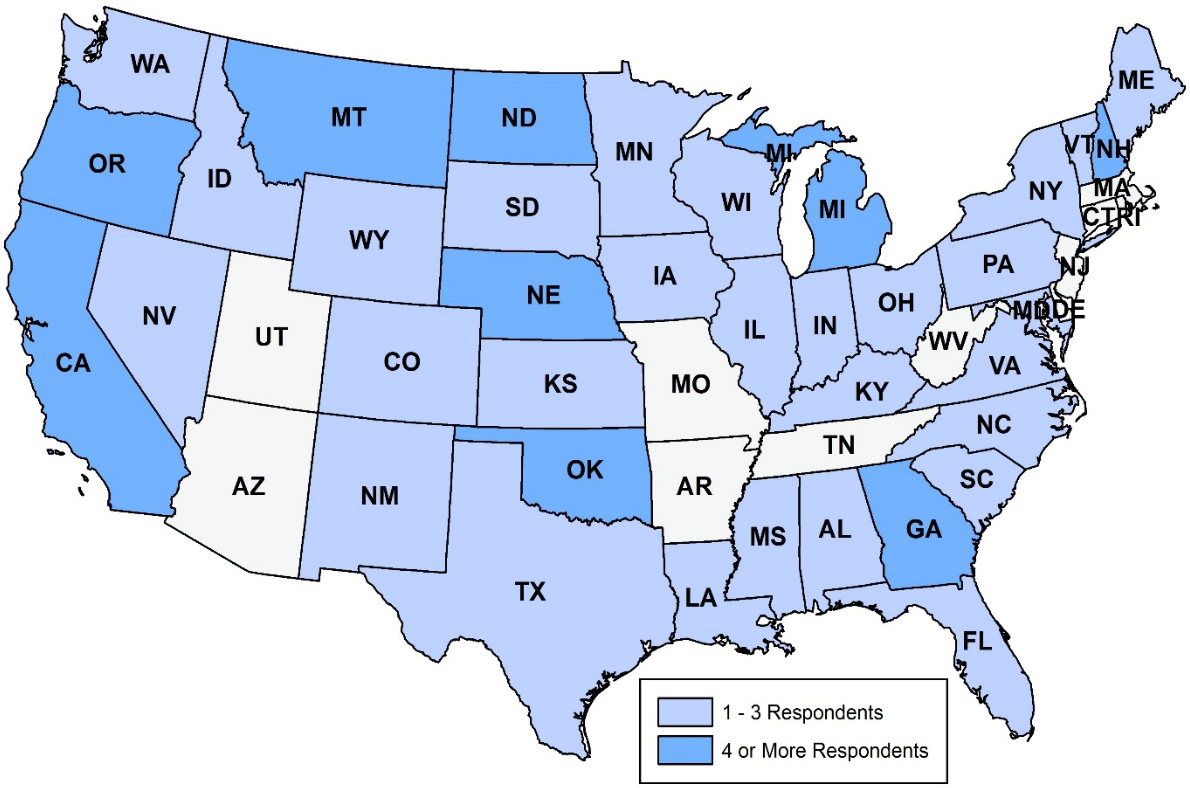

Figure 3.1 Survey Respondents Map

Survey respondents were asked what types of services their agencies provide (Figure 3.2). Demand-response was the most common response, reported by 83% of agencies. Fixed-route service was indicated by 45% of agencies while advanced reservation and intercity bus was indicated by 18% and 11% of agencies, respectively.

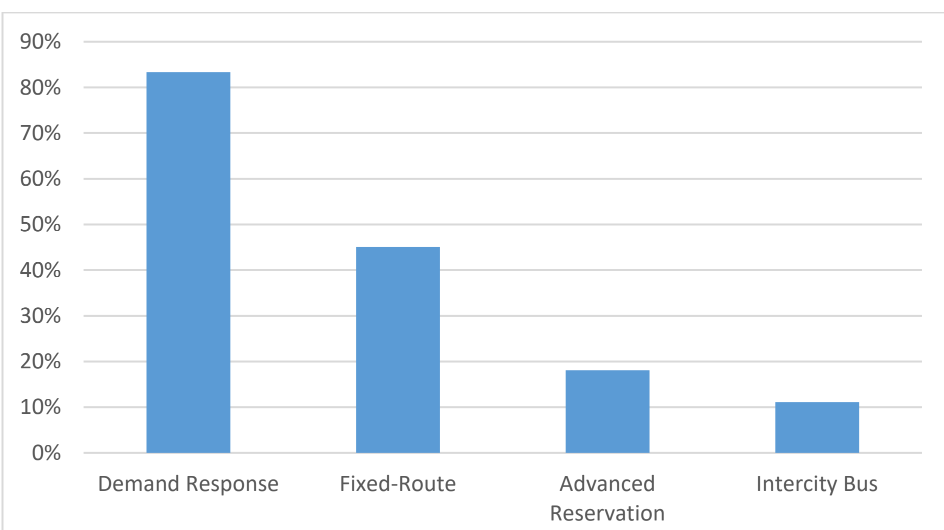

Figure 3.2 Types of Service Provided

Agencies were questioned about their organization type with local government being the most common response with 48% reporting this type (Figure 3.3). Non-profit followed with 35% while only 3% of respondents indicated that their organization was operated for profit.

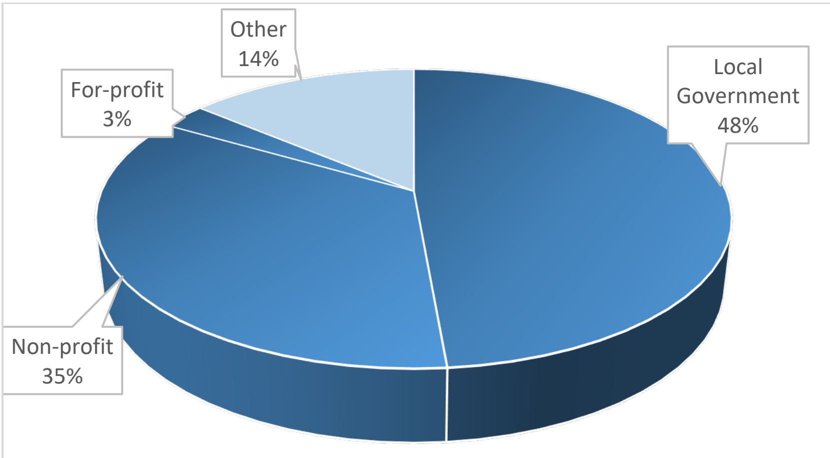

Figure 3.3 Organizational Type

3.3 Transit Technologies

3.3.1 Operations Software

Respondents were asked a series of questions regarding technology use within their agencies. Operations software assists transit agencies by automating and integrating functions and systems. More than 60% of respondents indicated they use operation software packages that include accounting, spreadsheets, and reporting technologies (Figure 3.4). Use of maintenance tracking software was reported by 47% of respondents while 34% indicated they use specialized personnel software. Fourteen percent reported that they do not use specialized operations software.

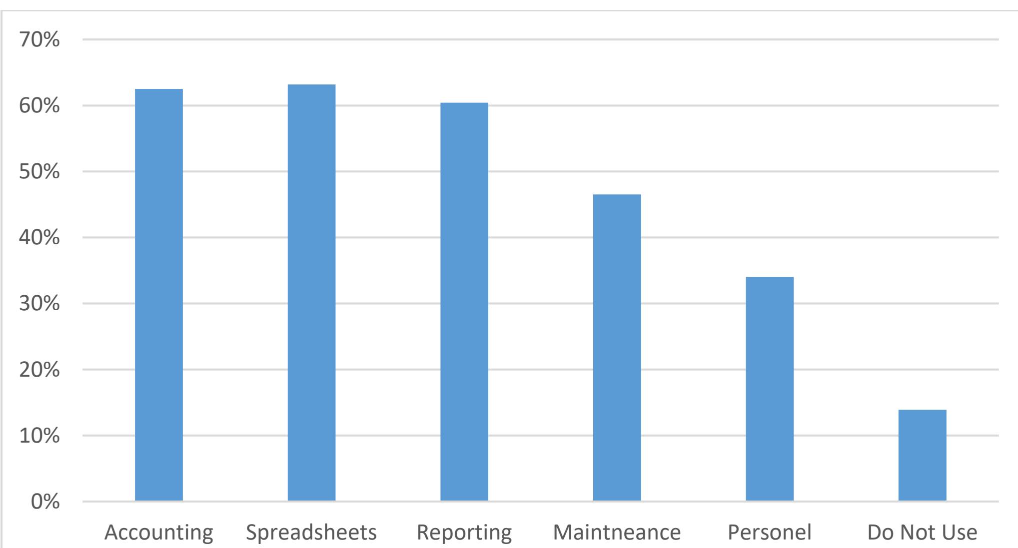

Figure 3.4 Operations Software Use

3.3.2 Geographic Information Systems

Transit agencies were asked about their use of geographic information systems (GIS). GIS is used to collect, manage, and analyze spatial data in a mapping format. In transit, GIS is used for planning and operations. Nearly 50% of respondents indicated that they currently use the technology. Among those respondents, 60% reported using GIS to schedule trips, while more than 50% indicated they use the technology to provide customer information (Figure 3.5). Between 40% and 50% of agencies that use GIS indicated they use the technology for operations, reporting and record keeping, service coordination, service quality monitoring, and trip requests.

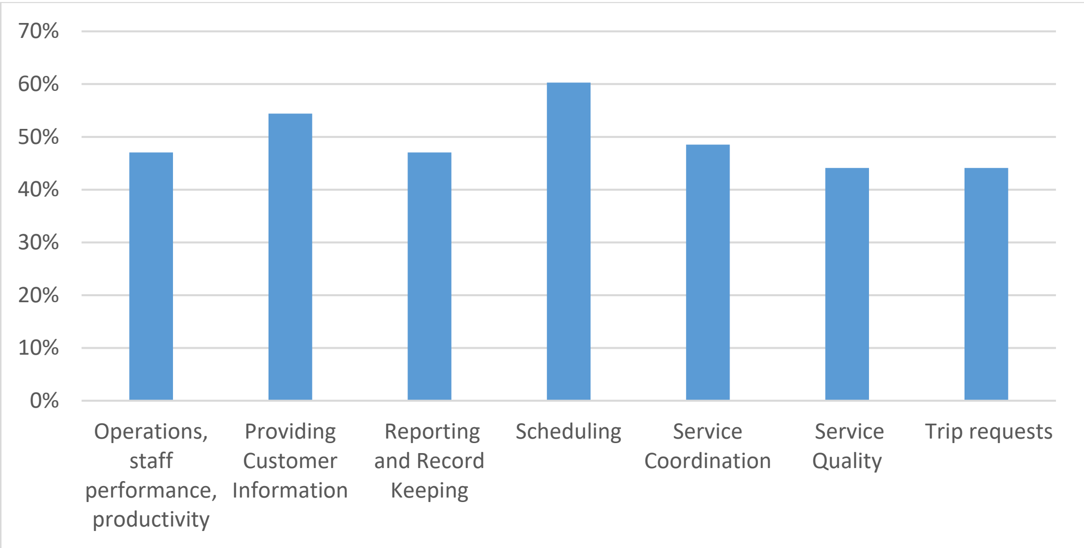

Figure 3.5 Application of GIS Among Agencies that Use GIS

3.3.3 Computer Aided Scheduling and Dispatching Software

Just over 40% of respondents indicated they currently use computer aided scheduling and dispatching software (CASD). The key component of CASD is automating the scheduling and dispatch function of a transit agency. Among those that use CASD, 92% reported using it for dispatching while more than 80% use it for scheduling and trip requests (Figure 3.6). Seventy-five percent of agencies use CADS for reporting and record keeping. Between 60% and 70% of agencies reporting using the software for providing customer information and operations while 50% indicated they use it for service coordination. Finally, 42% reporting using CADS to monitor service quality and fewer than 30% said they use it to monitor safety.

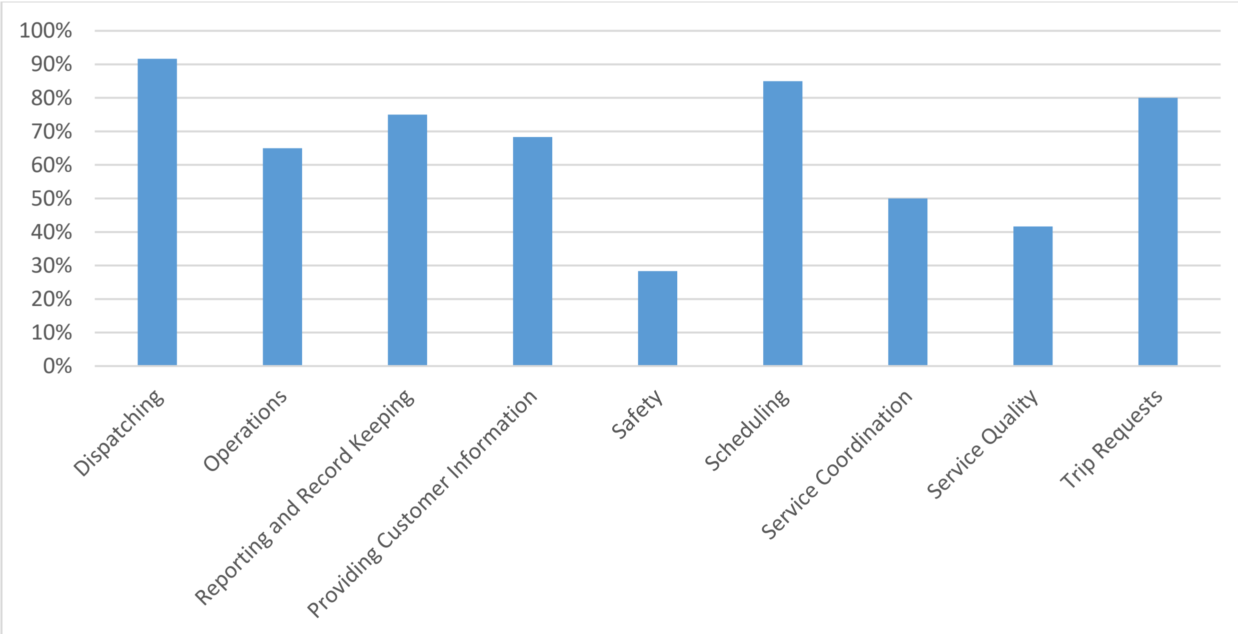

Figure 3.6 Application of Computer-Aided Scheduling and Dispatch Software Among Agenices that Use the Technology

3.3.4 Automatic Vehicle Location

Automatic vehicle location (AVL) allows for the tracking of vehicle location using computerized navigation. More than 50% of agencies reported currently using AVL technology. Of those, 83% indicated they use it to track bus locations, and 75% use it for dispatching (Figure 3.7). Sixty-six percent use AVL for communications while more than half use it to provide customer information and monitor safety issues. Between 40% and 50% also indicated they use the technology for scheduling, service coordination, and to monitor service quality.

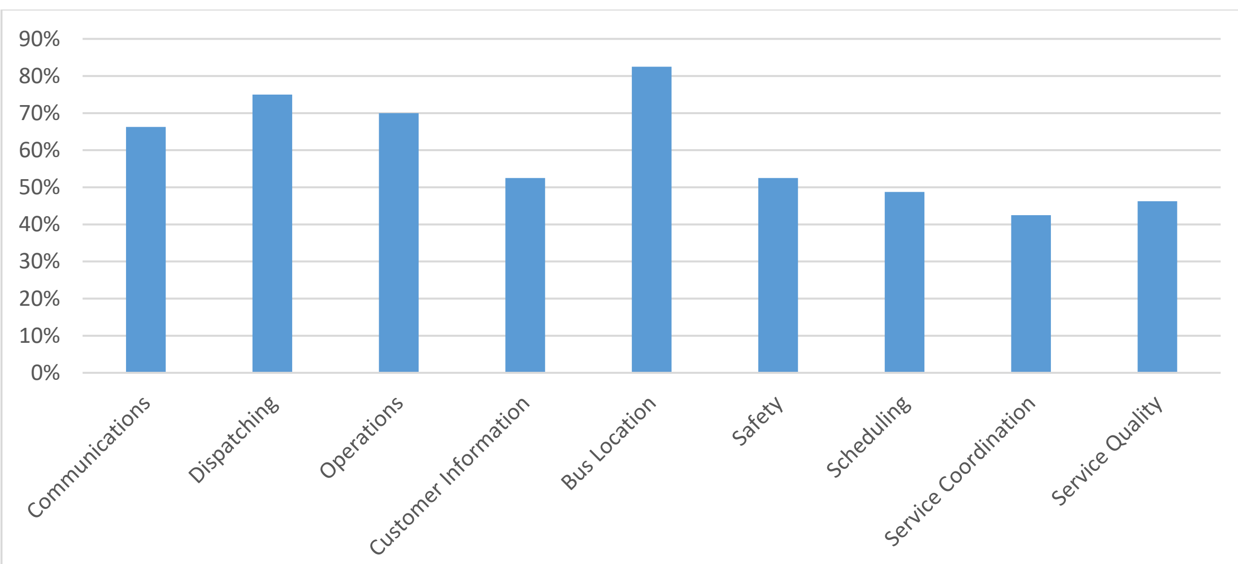

Figure 3.7 Application of Automatic Vehicle Location Among Agencies that Use the Technology

3.3.5 Mobile Data Terminals

Figure 3.8 shows the purposes for which agencies use mobile data terminals (MDTs). MDTs are on-vehicle technology that allow for non-voice communication between driver and agency. More than 45% of agencies indicated they use MDTs, and 80% or more of these reported using them for downloading trip manifests, driver sign-on and sign-off, vehicle location, and for updating schedule changes. Seventy-five percent indicated using MDTs for passenger pick-up and drop-off while roughly 50% to 60% of agencies reported using the technology for emergency communications, driver and operations supervision, and fare determination and collection.

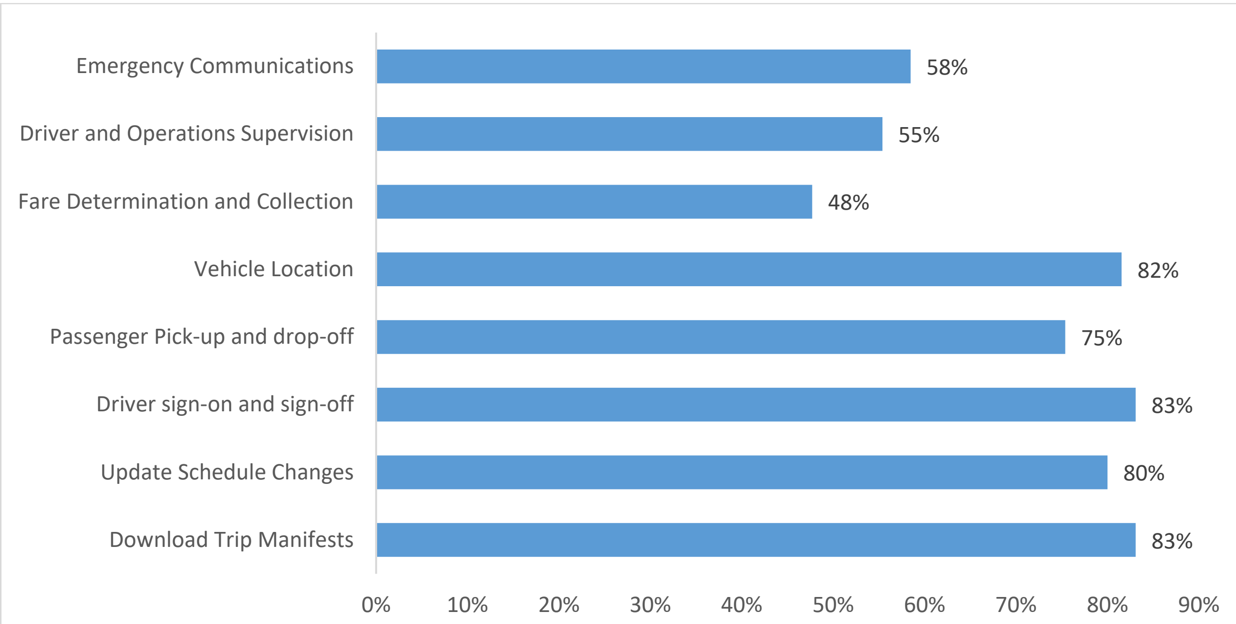

Figure 3.8 Application of Mobile Data Terminals Among Agencie that Use the Technology

3.3.6 Traveler Information Systems

Transit agencies were asked about their use of traveler information systems (TIS). TIS are wide-ranging technologies that provide pre-trip or on-vehicle information. Websites, smartphone applications, and in-vehicle displays are some the the most commonly used TIS technologies. About one-third of agencies indicated they currently use TIS. Eighty-seven percent of agencies that use TIS have an agency website; more than 70% use smartphone applications (Figure 3.9). About two-thirds of respondents indicated they use some form of social media while almost 60% use email to communicate to customers. Between roughly 25% and 40% of those that use TIS indicated they use the technology to communicate to customers via text message, variable message signs, in-vehicle displays, audible annunciators, and automated phone service.

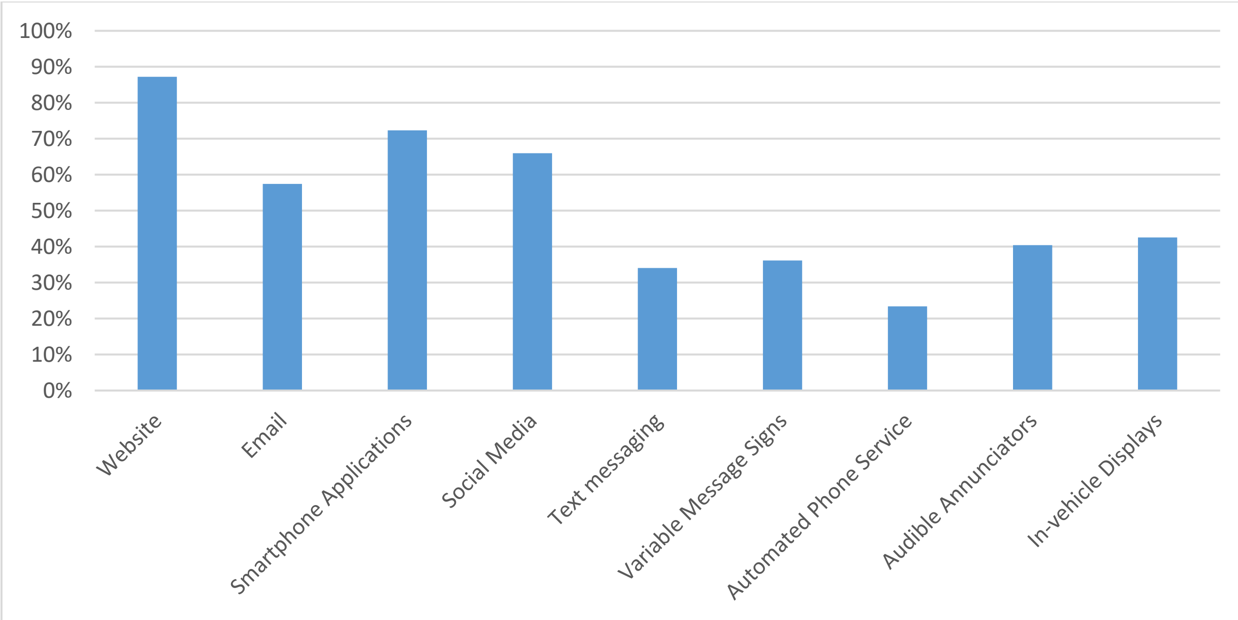

Figure 3.9 Types of Traveler Information Systems Used Among Agencies that Use These Technologies

Figure 3.10 illustrates the type of information provided by TIS systems. Between 60% and 70% of respondents stated that their systems provide estimated arrival times, real-time vehicle location, and static service information. Fifty-seven percent indicated that TIS technologies provide them with trip planning tools information.

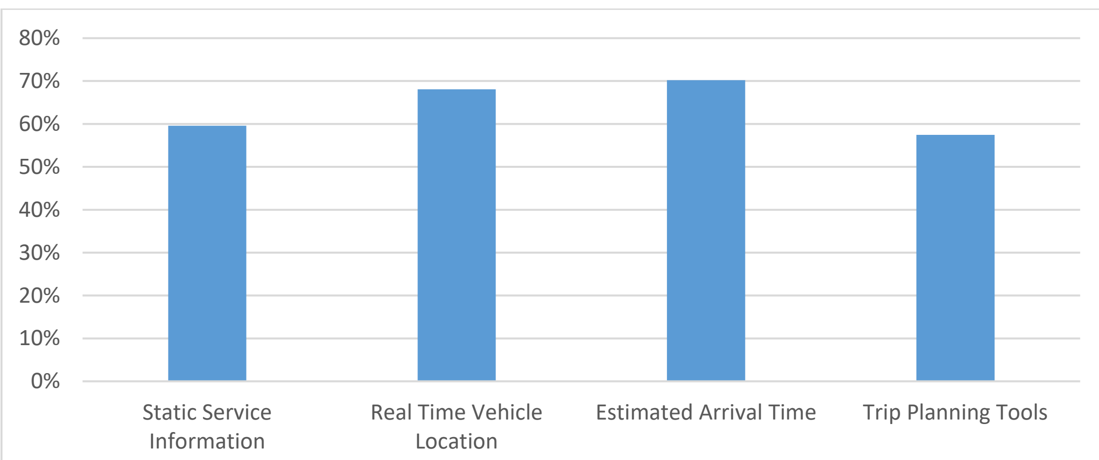

Figure 3.10 Information Provided by Agencies Using Traveler Information Systems

Agencies were then questioned as to what purposes their TIS serve. Almost 90% of respondents reported the technology was used to provide customer information (Figure 3.11). Eighty-three percent indicated it was used to communicate. Seventy percent stated it helped improve service quality while 26% use the technology to assist with trip request processing.

Figure 3.11 Traveler Information System Purpose

3.3.7 Electronic Fare Payment

Transit agencies were then asked about electronic fare payment (EFP) systems. EFP systems simplify the collection and processing of fare payments. Traditionally, they use magnetic stripe cards to reduce or eliminate cash handling. Nearly 20% of respondents indicated they currently use an EFP system with magnetic stripe cards being the most popular system, used by 38% of respondents using EFP (Figure 3.12). Nineteen percent indicated they use either contactless smartcards or mobile ticketing while 15% utilize a smartphone application for their EFP system.

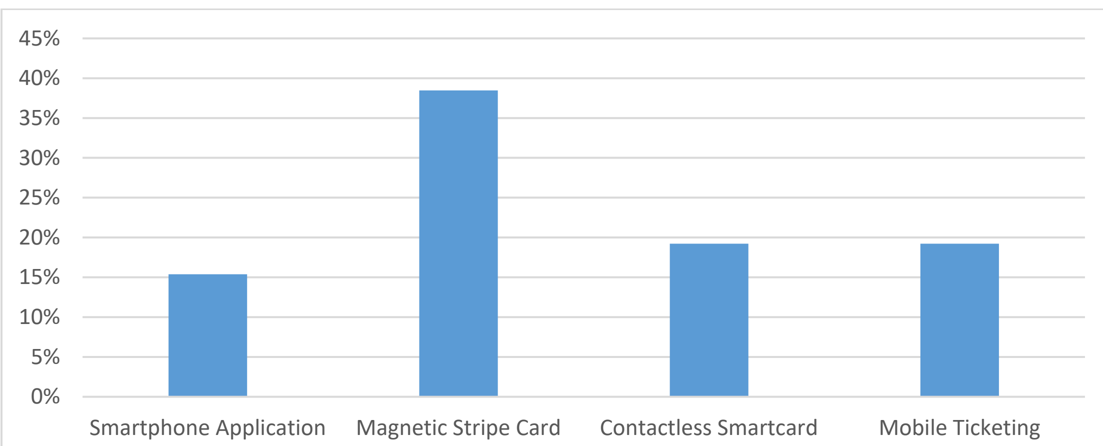

Figure 3.12 Electronic Fare Payment Options Adopted by Agencies That Use Electronic Fare Payment

Agencies were then asked what purpose their EFP system serves. The most common response was fare collection, which was reported by all respondents (Figure 3.13). Seventy-three percent of participants indicated that report and record keeping were the essential purpose of their EFP system with rider and trip information along with fare determination indicated by 38% and 42% of respondents, respectively. Finally, service coordination was considered as a purpose for EFP among 12% of participants.

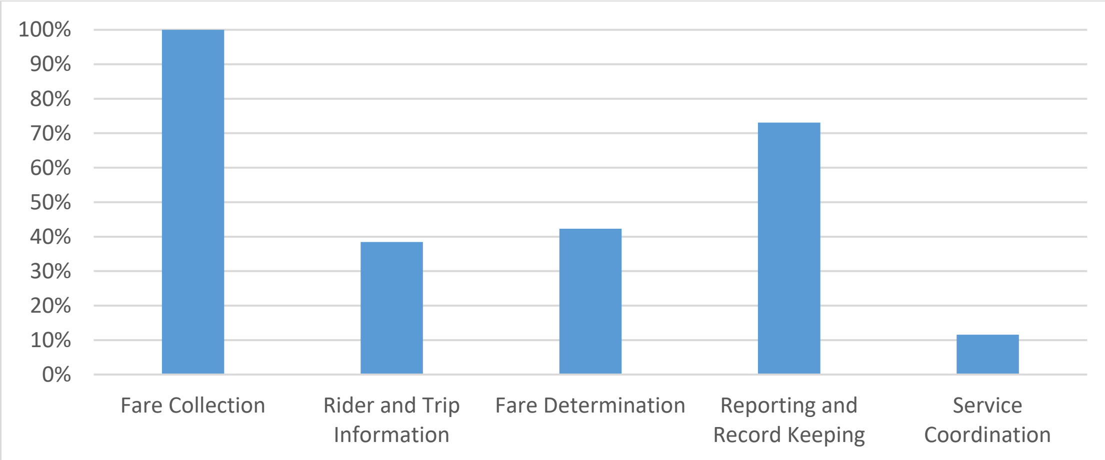

Figure 3.13 Electronic Fare Payment Systems Purpose

3.3.8 Automatic Passenger Counting

Figure 3.14 shows the percentage of respondents who indicated they currently use automatic passenger counting (APC) technology. APC systems count passengers boarding and departing the vehicles. Seventeen percent indicated that they use this technology while 83% do not.

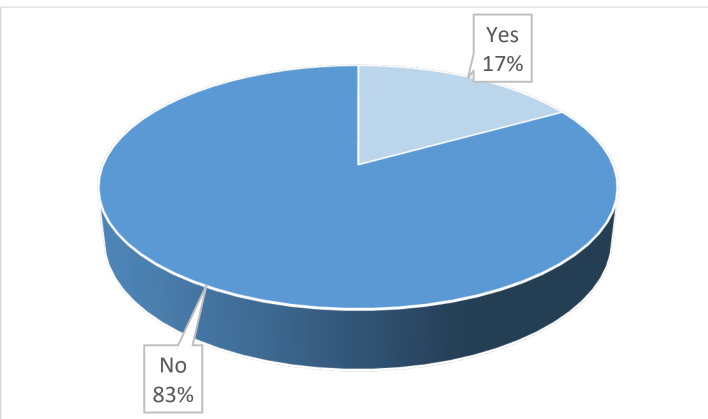

Figure 3.14 Automatic Passenger Counting Technology Use

3.3.9 Transit Security Systems

The next questions pertained to transit security systems. One-half of survey participants indicated they use some form of technology for security purposes. Among these, all but one indicated they use cameras for security, while 51% use audio surveillance. Silent alarms were used by 37% of respondents and concealed microphones by 12%. Finally, 4% of participants indicated they utilize object detection sensors as a form of security for their transit agency.

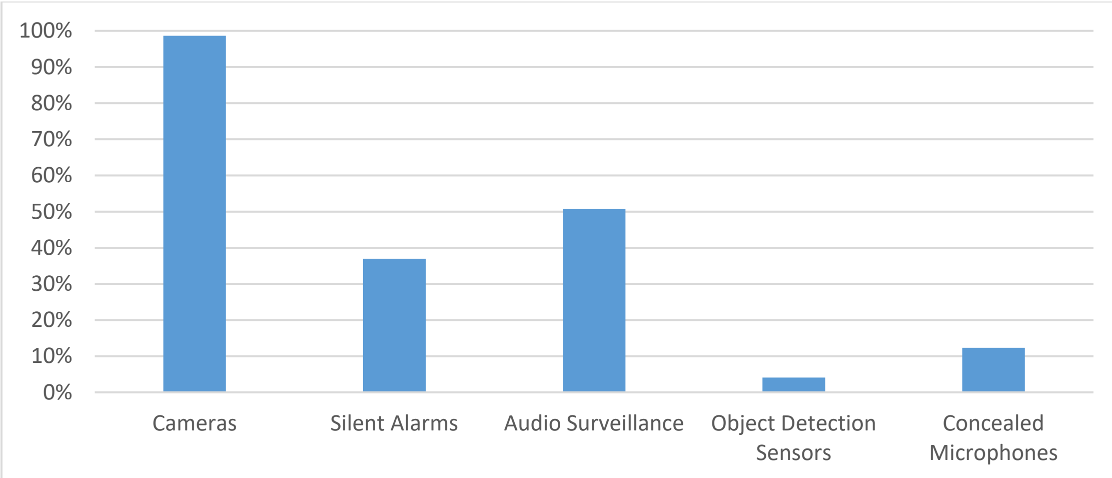

Figure 3.15 Forms of Transit Security Systems Used Among Agencies that Adopted a Security System

3.3.10 Communications Technology

Transit agencies were questioned about their use of communications technology. These technologies are used to communicate voice, text, data, or video. In some rural areas, the lack of communication infrastructure influences what forms of technology can be used. Two-thirds of survey participants indicated they use two-way radios for communication within their agency. Among these, emergency communication (88%) was the most popular response when asked about the purpose of the technology. Seventy-five percent responded they use two-way radios for scheduling changes, and 65% use them to check on vehicle locations. Fifty-seven percent of agencies use this technology for pick-ups and drop-offs while 38% of respondents use this for driver sign-on and sign-off.

Figure 3.16 Two-Way Radio Purpose

More than 40% of agencies indicated they use smart phones for communication. Among these, 75% reported utilizing smart phones for emergency communication while 46% indicated using them for scheduling changes. Thirty-one percent use smart phones for pick-ups and drop-offs, and 22% use them to locate vehicles. Finally, only 12% indicated they use smart phones for driver sign-on sign-off purposes. Transit agencies were also asked about their use of satellite phones in rural areas with only three participants, roughly 2%, indicating they use this technology within their agency. All three agencies indicated they use these phones for emergency communication and operations management.

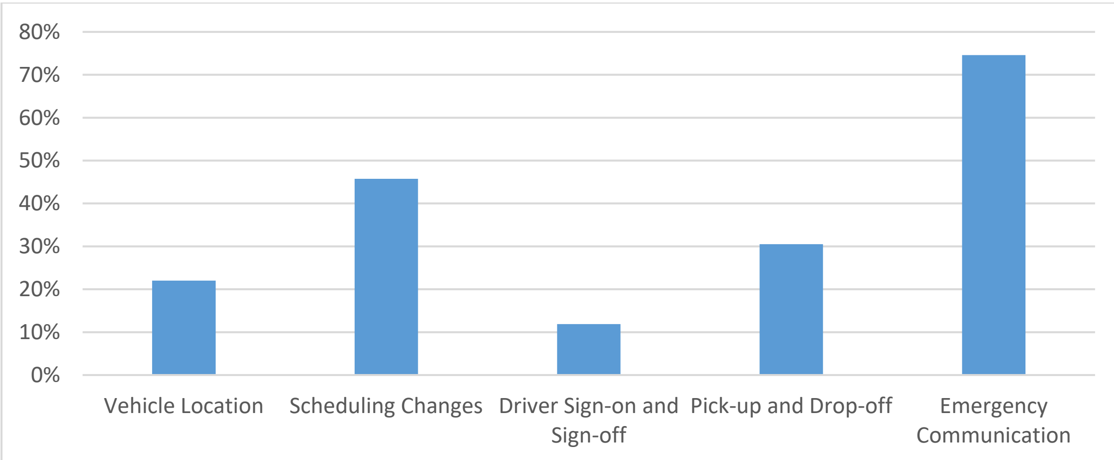

Figure 3.17 Smart Phone Purpose

3.4 Manager Characteristics

Transit agency managers were asked several questions regarding their employment history, education, meeting participation, and communication with technology vendors. First, managers were asked how many years they had been employed in their current position. Less than five years was the most cited response, reported by 35% of managers (Figure 3.18). Twenty percent indicated they had been at their current position for more than 20 years, and 18% have been at their current position for between five and ten years. Seventeen percent said they had spent between 10 and 15 years at their current position while 10% indicated they have served between 15 and 20 years at their current job.

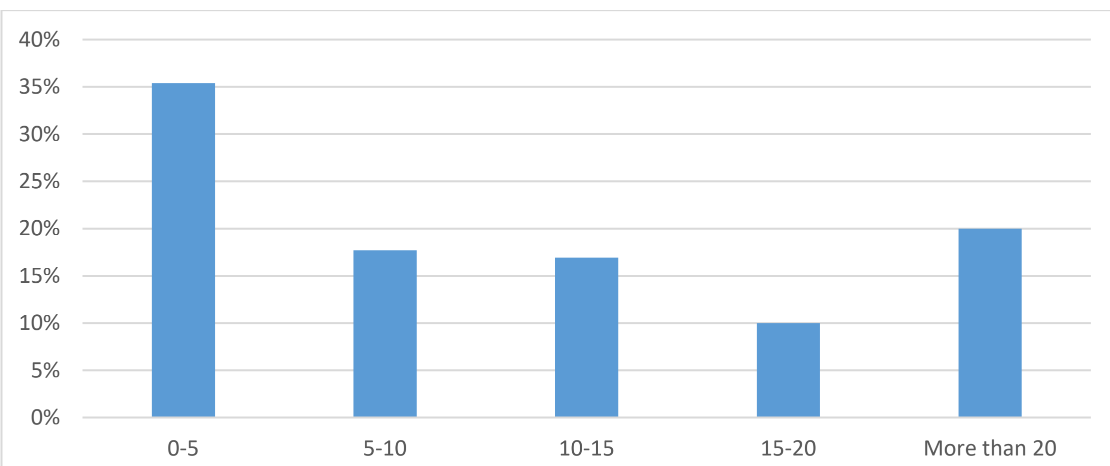

Figure 3.18 Years Managing Current Agency

Managers were then asked how many years they have worked in the transit industry. Thirty-five percent responded they had worked more than 20 years in the industry while 19% indicated they have worked in the industry for either zero to five years or five to ten years, respectively (Figure 3.19). Sixteen percent have worked in the transit industry between 15 and 20 years, and 12% indicated they had been employed within the transit industry between 10 and 15 years.

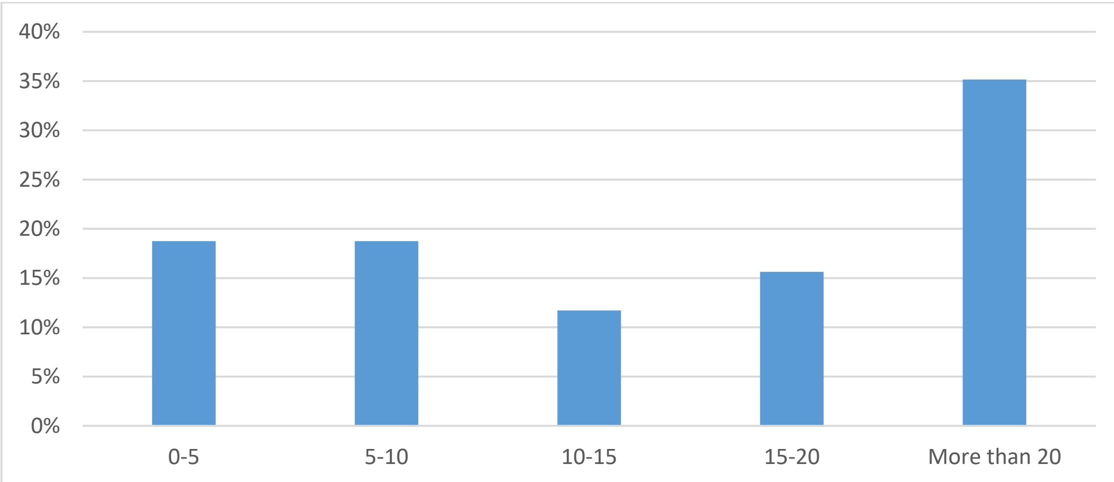

Figure 3.19 Years Working in Transit

Figure 3.20 shows the highest level of education attained by responding managers. About one-third of managers answered that they held a four-year degree, and 29% reported having completed some college. Graduate degrees have been attained by 15% of transit managers surveyed, while 13% have achieved a high school or equivalent education. Finally, 8% have a two-year degree, and one respondent reported completing some high school.

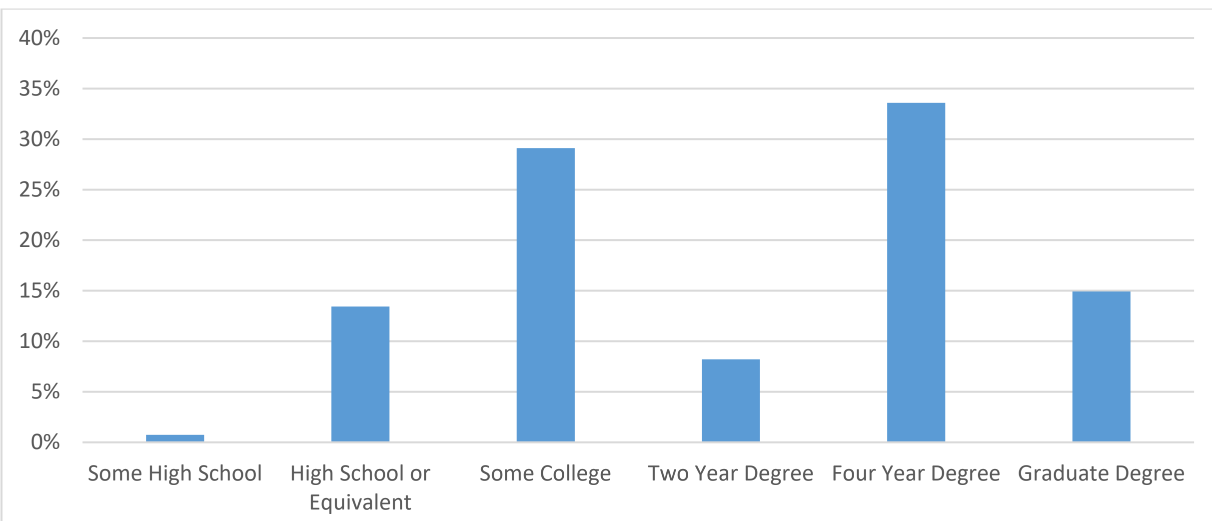

Figure 3.20 Highest Level of Education Completed

Managers were asked about their meeting participation during the past five years at a state and regional level as well as at a national level. Thirty-two percent of responding managers indicated they attended between one and five state or regional meetings during the past five years (Figure 3.21). Twenty-four percent reported attending between 11 and 20 meetings while 19% indicated they attended between six and ten meetings. Finally, 18% said they had attended 21 or more meetings during the past five years, and 8% indicated they had not attended any meetings during that time frame.

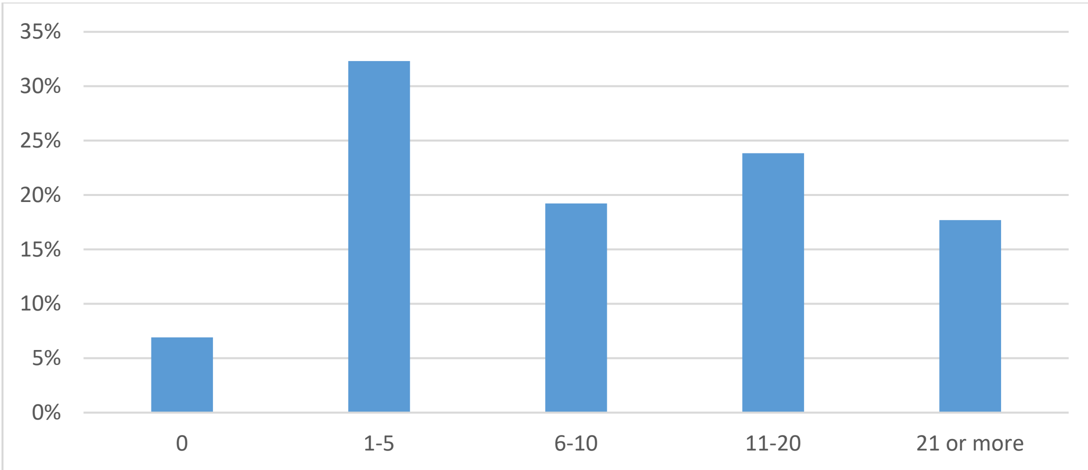

Figure 3.21 Number of State and Regional Meetings Attended During Past 5 Years

National meeting attendance was far less prevalent compared to attendance at the state and regional level. More than 50% of managers indicated they had not attended a national meeting during the past five years (Figure 3.22). Twenty-four percent reported attending between two and five meetings while 17% indicated attending one meeting. Eight percent reported attending six or more meetings during that five-year period.

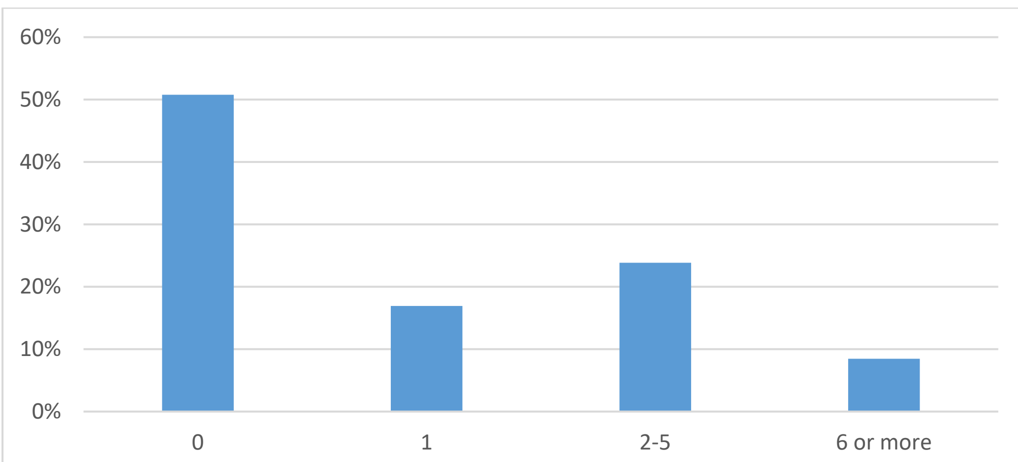

Figure 3.22 Number of National Meetings Attended During Past 5 Years

Transit managers were questioned about the kinds of technology vendors, if any, they visited while attending various conferences during the past five years. The most commonly visited vendor (53%) was those providing operations software (Figure 3.23). This was followed closely by CASD software, transit security systems, vehicle location, traveler information, and electronic fare payment vendors, which were all reported by between 40% and 50% of managers. GIS and MDT vendors were reported to have been visited by 35% and 30% of respondents, respectively, while passenger counting vendors received a 23% response rate among transit managers. Finally, 15% indicated they had not visited any technology vendors during their conference attendance during the past five years.

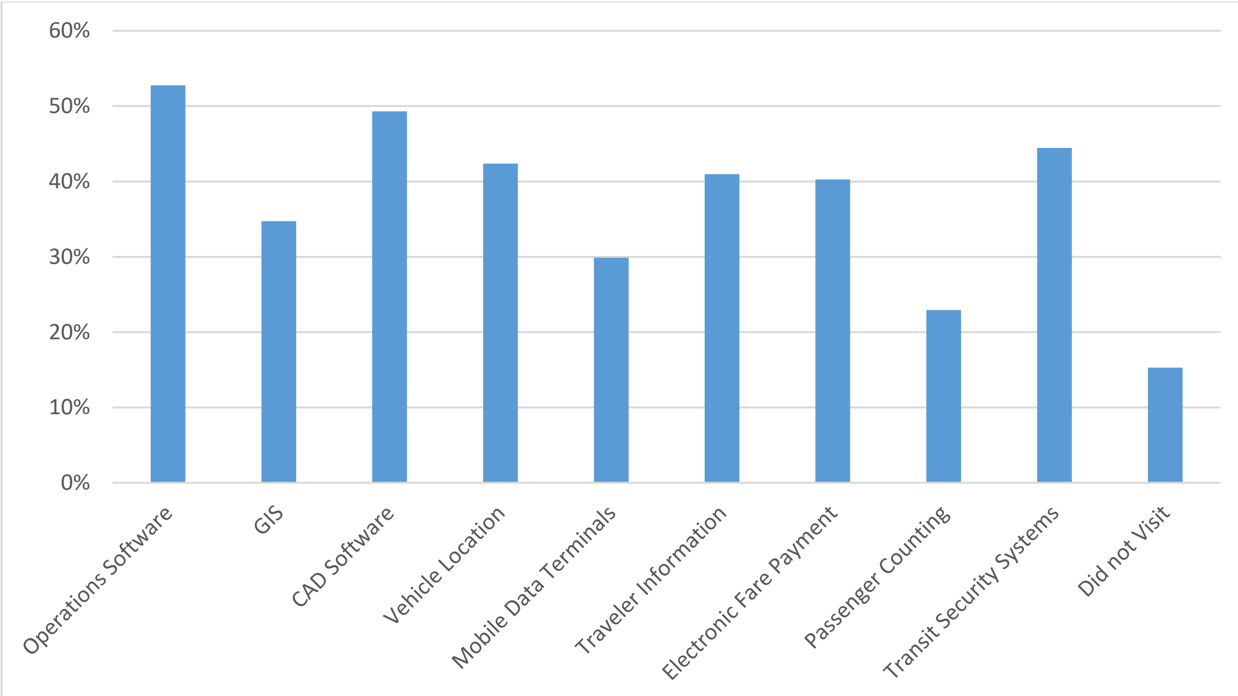

Figure 3.23 Vendors Visited at State, Regional, or National Meetings by Technology Type

Transit agency managers were also asked about technology sessions they attended during conferences over the past five years. Thirty-five percent indicated they attended sessions pertaining to types of technology while 34% responded they had not attended any technology sessions (Figure 3.24). Sessions on technology and coordination were attended by 28% of respondents, and 21% attended sessions related to technology procurement. Technology deployment and technology selection sessions were attended by 17 and 16% of responding managers, respectively.

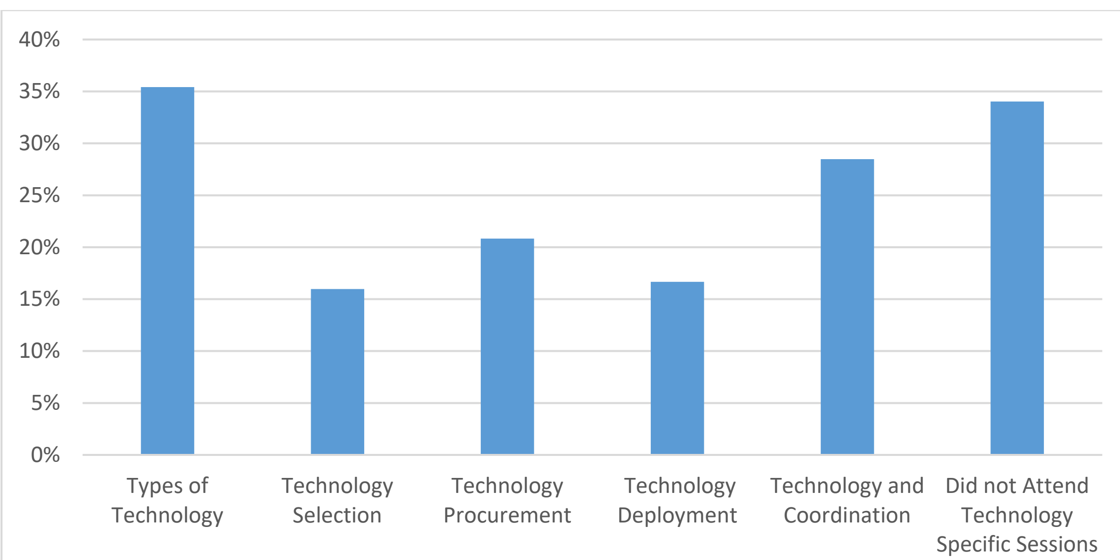

Figure 3. 24 Types of Technology Sessions Attended at State, Regional, or National Meetings

3.5 ITS Support and Adoption

A final survey question asked whether or not the local state departments of transportation (DOT) or local transit associations helped individual agencies with technology procurement or implementation. Sixty percent of respondents indicated that their DOT or transit association does help in these areas (Figure 3.25). In the open-ended question that followed, respondents were asked how DOTs or transit associations help with technology procurements or implementations. Responses included:

- They provide grant funding.
- They provide access to training and vendors.
- They provide financial assistance.
- They help coordinate with developers to implement software.
- If you approach them with a question regarding technology, they will give you their opinion.
- They provide info through National RTAP.
- DOT has been working on proposals from technology vendors that can be used by rural agencies.
- They provide match requirements.
- They secured a statewide contract for the purchase of new technology software.
- They coordinated with Google Transit on a statewide level and aided with implementation.

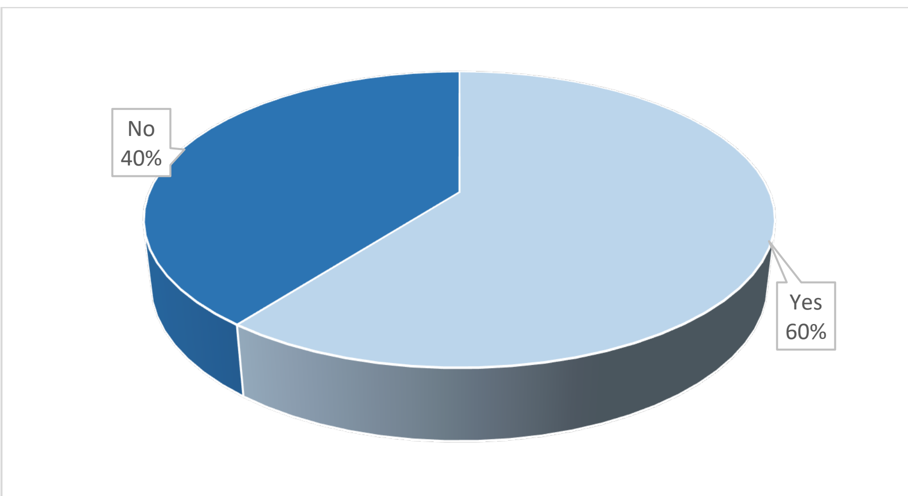

Figure 3.25 DOT/Transit Association Assistance with Technology Procurements

3.6 Trends in Technology Adoption

Technology use has increased significantly during the past 10 years among transit agencies. A study by Ripplinger and Brand-Sargent (2010) first calculated the number of agencies using specific technologies as shown in Figure 3.26 in the 2010 column. The 2020 column shows the specific technology use among survey participants in this current research. All seven of the technologies have seen significant increases in use during the past 10 years. The most prominent increases have occurred in AVL technology which showed an increase from 6% usage in 2010 to 51% today followed by an increase from 9% to 45% in the use ofMDTs. Smart phone use also increased significantly, from 8% to 42%, followed by a usage increase from 4% to 34% in TIS technology. Finally, GIS saw an increase in use from 25% to 49%, and both EFP and CASD saw significant increases in use during the same 10 years.

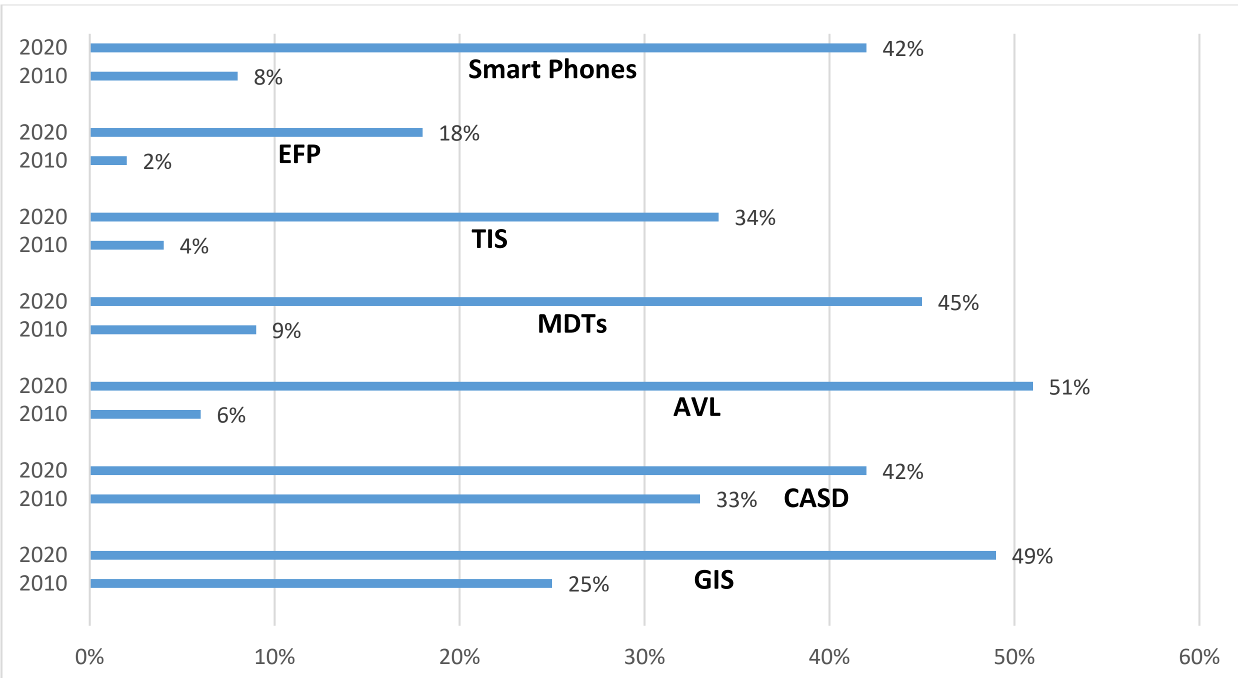

Figure 3.26 Technology use Increases, 2010 to 2020

4. Factors Affecting Technology Adoption

Survey results presented in previous sections provide an understanding of the current state of technology use by rural transit agencies and the trends in technology adoption. It would be useful to understand why some agencies adopt a particular technology and why others do not. Differences in transit agency characteristics or transit manager characteristics could be an essential determinant of technology adoption. This study developed a model to analyze the relationships between transit agency and manager characteristics and technology adoption.

The model follows previous research conducted by Ripplinger and Brand-Sargent (2010). They studied the adoption of AVL, CASD, GIS, and MDT. Their analysis showed that fleet size and ridership were positively associated with technology adoption; and for some technologies, budget, trips per vehicle, cost per trip, non-profit status, and mode were associated with adoption. They also studied the influence of transit manager characteristics and found that for some technologies, the number of years the manager had been working in transit and attendance at national conferences and sessions specifically about technology were associated with adoption. However, results were not consistent between technologies. For example, the longer the manager had been working in transit, the more likely their agency was to have adopted AVL but less likely to have adopted CASD, and there was no relationship with GIS or MDT. They also found that manager education and interaction with vendors at conferences were not associated with technology adoption.

This study updates the work previously Ripplinger and Brandt-Sargent (2010) with new data and an expanded number of technologies. Adoption was modeled for eight technologies: Geographic Information Systems (GIS), Computer-Aided Scheduling and Dispatching (CASD), Automatic Vehicle Location (AVL), Mobile Data Terminals (MDTs), traveler information systems (TIS), electronic fare payment systems, Automated Passenger Counting (APC), and security systems.

4.1 Explanatory Variables

Adoption of each technology was modeled as a function of agency characteristics and manager characteristics, as well as support from the state DOT or transit association.

Agency characteristics that could influence technology adoption include size, modes provided, and agency type. Size could be measured by ridership, fleet size, vehicle revenue miles, vehicle revenue hours, or operating budget. These data are all available from the National Transit Database (NTD). It is hypothesized that larger agencies are more likely to adopt technologies because they have a greater need for thembecause they assist in the management of complex systems, and because those larger agencies are more likely to have the resources to purchase and use them. The modes that an agency operates could also be important, as fixed-route providers may be more likely to adopt certain technologies, and demand-response operators may be more likely to adopt others because of the differences in the characteristics and complexities of operations. For example, adoption of CASD is expected to be related to whether the agency provides demand-response service.

Agency type could also play a role. Most rural transit services are operated by non-profit organizations or local governments, while there are a few for-profit operators, such as intercity bus providers, and other organization types. Non-profit organizations may have different motivations than for-profit firms, which could influence adoption decisions. Non-profits are concerned with the impacts of their decisions beyond the bottom line.

Manager characteristics that could influence technology adoption include education, the number of years the manager has been working in the transit industry, attendance at national meetings and conferences, and interaction with vendors. It is hypothesized that managers with more education, those who were in the transit industry longer, those who have attended more national meetings and conferences, and those who have interacted with vendors at conferences are more likely to adopt technology. It is expected that these managers are more aware of the various available technologies and have studied how these technologies could be beneficial to their operations.

Finally, support from the state DOT or transit association could have a positive influence on technology adoption. The survey asked respondents if their state DOT or transit association helps with technology adoption or implementation. It is hypothesized that those from states with such support are more likely to adopt.

4.2 Model and Data

Binary logit models are used to model the likelihood of an agency adopting a particular technology. The dependent variable in these models is a binary variable indicating whether or not the agency has adopted the technology. Models were run for the eight technologies previously listed.

Because the different measures of size are highly correlated, only one measure of size, ridership, was used in the model. Ridership data for 2018 was obtained from the NTD. Dummy variables were used to indicate if the agency provides a demand-response service and if it provides a fixed-route service (some agencies provide both). A dummy variable was also added to indicate if the agency is a non-profit organization. Information on modes provided and organization type were obtained from the survey.

Manager characteristics included in the model were education, years in the transit industry, the number of national meetings or conferences attended, and interaction with vendors at conferences. Data were obtained from the survey. Education was measured on a 1-6 scale, where 1=some high school, 2=high school or equivalent, 3=some college, 4=two-year degree, 5=four-year degree, and 6=graduate degree. The number of national meetings or conferences attended in the previous five years was used in the model. A dummy variable was used to indicate if the manager had visited with a technology vendor at state, regional, or national transit meetings for the specific technology being considered. For example, the model of APC adoption included a dummy variable indicating if the person had visited with an APC vendor. Finally, a dummy variable was included to indicate if the respondent's state DOT or transit association helps with technology adoption or implementation. Complete data were available for 106 transit agencies. Descriptive statistics for each of these variables are shown in Table 4.1.

Table 4.1 Descriptive Statistics for Model Variables

Variable	Description	Mean	Standard Deviation
GIS use	Equals 1 if GIS was adopted, 0 if not	0.47	0.50
CASD use	Equals 1 if CASD was adopted, 0 if not	0.43	0.50
AVL use	Equals 1 if AVL was adopted, 0 if not	0.60	0.49
MDT use	Equals 1 if MDTs were adopted, 0 if not	0.49	0.50
TIS use	Equals 1 if TIS was adopted, 0 if not	0.32	0.47
EFP use	Equals 1 if EFP was adopted, 0 if not	0.18	0.39
APC use	Equals 1 if APC was adopted, 0 if not	0.19	0.39
Security use	Equals 1 if security systems were adopted, 0 if not	0.56	0.50
Ridership	Annual ridership	415,805	1,011,713
Demand response	Equals 1 if agency operates demand-response, 0 if not	0.87	0.34
Fixed route	Equals 1 if agency operates fixed-route, 0 if not	0.50	0.50
Nonprofit	Equals 1 if agency is a nonprofit, 0 if not	0.35	0.48
Education	Education of manager, measured on 1-6 scale	4.0	1.4
Years transit	Number of years manager has been in transit industry	16.8	11.8
Conferences	Number of national conferences or meetings attended in five years	1.9	3.5
GIS vendor	Equals 1 if visited GIS vendor, 0 if not	0.42	0.50
CASD vendor	Equals 1 if visited CASD vendor, 0 if not	0.58	0.50
AVL vendor	Equals 1 if visited AVL vendor, 0 if not	0.45	0.50
MDT vendor	Equals 1 if visited MDT vendor, 0 if not	0.33	0.47
TIS vendor	Equals 1 if visited TIS vendor, 0 if not	0.30	0.46
EFP vendor	Equals 1 if visited EFP vendor, 0 if not	0.43	0.50
APC vendor	Equals 1 if visited APC vendor, 0 if not	0.25	0.43
Security vendor	Equals 1 if visited security systems vendor, 0 if not	0.50	0.50
State help	Equal 1 if state DOT or transit association provides help, 0 if not	0.58	0.50

4.3 Results

Results are shown in Table 4.2. The table provides estimated odds ratios for adoption of each of the eight technologies. Odds ratios for dummy variables provide a way to compare whether the probability of adoption is the same for two groups of agencies. The odds of an event happening is equal to the probability of it happening divided by the probability of it not happening. An odds ratio is calculated by dividing the odds in group 1 by the odds in group 2. An odds ratio of 1 indicates the event is equally probable for the two groups, while an odds ratio greater (less) than 1 indicates the event is more (less) likely among the first group. For example, in the GIS adoption model, the odds ratio for fixed route is 2.46. This result indicates that the odds of adopting GIS is 2.46 times greater for fixed-route agencies. An odds ratio below 1.0 would have meant they are less likely to adopt. For variables that are not dummy variables, the odds ratio represents the estimated change in the odds of adoption with a one-unit increase in the variable. For example, the odds ratio for education in the GIS model is 1.44, which indicates that as education (measured on a 1-6 scale) increases by one, the odds of adoption increase by 44% (or are 1.44 times greater).

Ridership is a much larger number than all other variables in the model and the change in odds of adoption from a ridership increase of just one trip is minimal. Therefore, ridership was divided by 100,000, which means the odds ratio estimates the change in the odds of adoption with a change in ridership of 100,000 trips.

Table 4.2 Estimated Odds Ratios from Binary Logit Models of Technology Adoption

Explanatory variable	GIS	CASD	AVL	MDT	TIS	EFP	APC	Security
Ridership (100,000s)	1.03	1.04	1.05	1.09**	1.13**	1.09***	1.11***	1.53**
Demand-response	2.00	6.55**	1.71	2.32	1.18	0.62	0.19*	5.27
Fixed-route	2.46*	1.19	2.16	1.02	2.35	3.40	0.67	1.75
Nonprofit	0.48	1.88	0.78	1.12	2.74*	0.33	0.18	0.40*
Education	1.44**	1.18	1.48*	1.35	1.05	2.00**	1.06	1.14
Years in transit	1.00	0.99	1.00	0.98	0.98	1.04	0.99	1.03
Conferences	0.99	1.11	1.36**	1.16	1.16*	0.84	1.28*	0.99
Vendor	1.22	1.77	6.03***	4.71***	3.63**	32.62***	14.15***	1.16
State help	1.50	1.36	2.63*	2.14	0.70	0.32	0.36	2.01

*Statistically significant at the 10% level
**Statistically significant at the 5% level
***Statistically significant at the 1% level

Agency size, measured in ridership, and interaction with vendors at conferences were most often found to be associated with technology adoption. Other variables were found to be statistically significant in some of the models.

Ridership was found to be positively related to technology adoption. This result was found to be statistically significant for five of the eight technologies (MDTs, traveler information systems, electronic fare payment, APC, and security systems). The effect of ridership was most significant for the adoption of security systems.

Agencies that provide demand-response services were found to be more likely to adopt CASD and APC, compared to those that do not provide demand-response. Fixed-route providers are more likely than non-fixed-route operators to use GIS. Non-profit organizations are more likely than others to use traveler information systems and less likely to use security systems.

Among manager characteristics, education appears to have some relationship with adoption. More educated managers were found to work for agencies that were more likely to use GIS, AVL, and electronic fare payment. The number of national conferences attended was also found to be positively related to technology adoption. This result was statistically significant for AVL, traveler information systems, and APC. However, the number of years that the manager has been in transit was not found to have a statistically significant relationship with adoption for any of the technologies.

Interaction with vendors at conferences or meetings was found to have the strongest association with technology adoption. Those who visited vendors were much more likely to use the technology. This positive relationship was found to be statistically significant and substantial in magnitude for AVL, MDT, traveler information systems, electronic fare payment, and APC, though it was insignificant for GIS, CASD, and security systems.

Note that the model does not prove causation. Correlation between the independent and dependent variables do not prove that the independent variable caused the dependent variable. Therefore, the study does not prove that managers visiting with technology vendors causes an increase in technology adoption. A manager may visit a technology vendor because they are already predisposed to the use of technology, or they may have already decided to purchase a technology or have already implemented it and are interested in learning more. Nevertheless, it is possible that interactions with vendors positively influenced adoption decisions.

Finally, help from state DOTs or transit associations had a positive and statistically significant relationship with AVL use, but the relationship was statistically insignificant for all other technologies.

A summary of the statistically significant relationships is shown in Table 4.3.

Table 4.3 Summary of Rural Transit Technology Adoption Relationships

Explanatory variable	GIS	CASD	AVL	MDT	TIS	EFP	APC	Security
Ridership (100,000s)				+	+	+	+	+
Demand-response		+						
Fixed-route	+							
Nonprofit					+			-
Education	+		+			+		
Years in transit								
Conferences			+		+		+	
Vendor			+	+	+	+	+	
State help			+					

+ Statistically significant positive relationship

- Statistically significant negative relationship

4.4 Implications

The analysis identified three manager characteristics related to the use of technology by rural transit agencies: education, attendance at national meetings or conferences, and interaction with product vendors. Results were not consistently found for all technologies, but many of the models showed positive associations. Based on these results, hiring managers with more education and encouraging them to attend conferences and vendor shows may influence adoption of technology by transit agencies. However, this does not guarantee that there will be an increased rate of adoption.

Attendance at national meetings provides transit agency managers with several unique opportunities that may impact technology adoption. These include exposure to new ideas during formal sessions and to specific technology products at vendor shows as well as opportunities to interact and network 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 agencies and to think strategically about organizational and community mobility needs, which is often the first step in innovation and technology adoption.

Interaction with vendors provides transit agency managers the ability to become educated on specific technologies and how they might benefit their agencies. A discussion with vendors does not require that a specific technology project be under consideration.

Results do not provide strong evidence that help from state DOTs or transit associations has been effective in encouraging technology adoption. A statistically significant effect was found for AVL use, but not for any other technology. The lack of an effect could suggest that the help received may have been useful but was not a contributing factor to the adoption decision, or it could suggest the help received was not sufficient.

Results also showed that different types of agencies are more likely to adopt technology. For example, larger agencies are more likely to use most types of technology. They are more likely to find them beneficial. Findings can be used to identify which agencies are more likely to benefit from different technologies. Agencies that would be expected to use a technology but do not could be identified as those that might benefit from adoption. Conversely, agencies could be identified if they use a technology that they are not expected to use based on their characteristics, and they could be studied to determine if and how they benefit from the use of the technology.

5. SUMMARY AND CONCLUSIONS

Intelligent transportation system (ITS) applications have been widely applied to the highway system, and are being used by an increasing number of small urban and rural transit systems throughout the United States. The objectives of this study were to: first, identify what technologies are currently used by small urban and rural transit agencies; second investigate the influence of community, agency, and manager attributes on technology adoption; and finally, evaluate the changes in ITS adoption among small urban and rural transit agencies today as compared to ten years prior.

Levels of adoption of commonly used ITS technologies by transit agencies were found to be between 30% and 50%. For example, geographic information systems (GIS) were being used by nearly half of survey respondents. Automatic vehicle location (AVL) and computer aided scheduling and dispatch (CASD) technologies were being used by a similar number of agencies. Smart phones were used by more than 40% of survey respondents.

When comparing technologies use today to that of 10 years ago (Ripplinger and Brand-Sargent 2010), significant increases have occurred. Traveler information systems (TIS) technology use has increased from 4% in 2010 to 34% among survey respondents today while use of electronic fare payment (EFP) increased from 2% in 2010 to 18% today. The most substantial single technology increase was seen in AVL use, climbing from 6% among survey respondents in 2010 to 51% today.

Econometric analysis showed that hiring managers with more education and encouraging them to attend conferences and interact with ITS vendors may influence adoption of technologies by transit agencies. Results did not show that help from state DOTs or transit associations has been effective in encouraging technology adoption. This may suggest that help received, while useful, was not a contributing factor to adopt certain technologies. Finally, results can be used to identify which agencies could potentially benefit from certain technology adoptions. Agencies expected to use technology that do not can be identified as ones that may benefit from adoption while agencies that adopt technologies, but are not expected to based on their characteristics, could be studied to determine potential benefits from technology use.

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APPENDIX

Intelligent Transportation Systems (ITS) Usage and Feasibility Survey

1). Agency Name ___________________
City, State ______________________
Contact Person _________________
Title ____________________________
Email ___________________________

2). Organization Type
- Non-Profit
- Local Government
- For-Profit
- Other ________________________

3). Type of Service Provided (Check all that apply)
- Demand Response (Dial-a-Ride)
- Fixed-Route
- Intercity Bus
- Advanced Reservation
- Other ________________________

Operations Software
-Operation software include accounting, personnel, maintenance, and reporting software, among others.

4). What types of operations software does your agency currently use? (Check all that apply)
- Accounting
- Personnel
- Reporting
- Maintenance
- Spreadsheets
- Do not use operations software
- Other ___________________

5). Does your agency currently plan to add to or change its operations software in the next 5 years?
- Yes
- No

Geographic Information Systems (GIS)
-GIS software programs provide the capability for displaying and editing geographic information. GIS is often used in conjunction with scheduling and dispatching systems to integrate bus stops, routes, and local street networks.

6). Does your agency currently use GIS technology?
- Yes
- No

7). For what purposes 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 requests
- Other ___________________

8). Does your agency plan to use GIS in the next 5 years?

- Yes
- No

Computer Aided Dispatching and Scheduling (CADS)

-CADS software coordinates trip requests and passenger data along with vehicle and route information to generate efficient demand-response schedules.

9). Does your agency currently use CADS?

- Yes
- No

10). For what purposes does your agency use CADS? (Check all that apply)

- Dispatching
- Operations
- Reporting and Record Keeping
- Providing Customer Information
- Safety
- Scheduling
- Service Coordination
- Service Quality
- Trip Requests

11). Does your agency plan to use CADS in the next 5 years?

- Yes
- No

Automatic Vehicle Location (AVL)

-AVL software tracks the real time location of a vehicle and allows rural agencies to monitor the location of all transit vehicles in the fleet. The most popular form of AVL uses global positioning systems (GPS).

12). Does your agency currently use AVL technology?

- Yes
- No

13). For what purposes does your agency use AVL? (Check all that apply)

- Communications
- Dispatching
- Operations
- Providing Customer Information
- Bus Location and Arrival Time
- Safety
- Scheduling
- Service Coordination
- Service Quality
- Other ______________________

14). Does your agency plan to use AVL in the next 5 years?

- Yes
- No

Mobile Data Terminals (MDTs)

-MDTs are devices used to communicate with the main office. They provide two-way communication and have the ability to upload data during a scheduled route, usually via tablets.

15). Does your agency currently use MDTs?

- Yes
- No

16). For what purpose does your agency use MDTs? (Check all that apply)

- Download Trip Manifests
- Automatically Update Schedule Changes
- Driver sign-on and sign-off
- Passenger Pick-up and drop-off
- Vehicle Location
- Fare Determination and Collection
- Driver and Operations Supervision
- Emergency Communications
- Other ______________________

17). Does your agency plan to use MDTs in the next 5 years?

- Yes
- No

Traveler Information Systems (TIS)

-TIS provide transportation information prior to and during trips. The technology can include websites, email, smartphone applications, text messaging, variable message signs, automated phone service, audible annunciators, in-vehicle displays, customer service lines, automated trip planners, social media, and real time transit and traffic information.

18). Does your agency currently provide traveler information systems (TIS)?

- Yes
- No

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

- Website
- Email
- Mobile/Smartphone Applications
- Social Media
- Text messaging
- Variable Message Signs
- Automated Phone Service
- Audible Annunciators
- In-vehicle Displays
- Other _______________

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

____

21). 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 ______________________

22). For what purposes does your agency provide traveler information systems? (Check all that apply)

- Communications
- Providing Customer Information
- Service Quality
- Trip Request Processing
- Other ______________________

23). Does your agency plan to provide traveler information systems in the next 5 years?

- Yes
- No

Electronic Fare Payment Systems

-Electronic fare payment systems are automated ways of collecting and processing fares.

24). Does your agency currently use electronic fare payment systems?

- Yes
- No

25). What type of electronic fare payment system does your agency use?

- Smartphone Application
- Magnetic Stripe Card
- Contactless Smartcard
- Mobile Ticketing
- Other _______________

26). For what purposes does your agency use electronic fare payment systems? (Check all that apply)

- Rider and Trip Information
- Fare Determination
- Fare Collection
- Reporting and Record Keeping
- Service Coordination
- Other ________________

27). Does your agency plan to use electronic fare payment systems in the next 5 years?

- Yes
- No

Automated Passenger Counting (APC)

-Automated passenger counting is a technology that counts passengers as they board and alight.

28). Does your agency currently use automated passenger counting technology?

- Yes
- No

29). Does your agency plan to use automated passenger counting technology in the next 5 years?

- Yes
- No

Systems

-Security systems include a variety of technologies found both on and off the vehicles including closed circuit cameras, silent alarms, and microphones, among others.

30). Does your agency currently use on-or off-vehicle transit security systems?

- Yes
- No

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

- Cameras
- Silent Alarms
- Audio Surveillance
- Object Detection Sensors
- Concealed Microphones
- Other ________________

32). Does your agency plan to use on-or off-vehicle transit security systems in the next 5 years?

- Yes
- No

Communication Technologies

-Communication technologies provide voice and data communication among drivers, riders, managers and others involved within the agency.

33). Does your agency currently use two-way radios?

- Yes
- No

34). 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 _________________

35). Does your agency currently use smart phones?

- Yes
- No

36). 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
- Other _________________.

37). Does your agency plan to use smart phones in the next 5 years?

- Yes
- No

38). Does your agency currently use satellite phones?

- Yes
- No

39). What does your agency use satellite 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 _______________

40). Does your agency plan to use satellite phones in the next 5 years?

- Yes
- No

Manager Information

-The final section of the survey asks questions regarding manager training.

41). How many years have you been manager at this agency?

____

42). How many years have you worked in the transit industry?

____

43). What is the highest level of education you have received?

- Some High School
- High School or Equivalent
- Some College
- Two Year Degree
- Four Year Degree
- Graduate Degree

44). How many state or regional transit meetings have you attended in the past 5 years?

____

45). How many state or regional transit meetings have you attended in the past year?

____

46). How many national transit meetings have you attended in the past 5 years?

____

47). How many national transit meetings have you attended in the past year?

____

48). At the state, regional, or national transit meetings, what technology vendors did you visit?

- Operations Software
- Geographic Information Systems (GIS)
- Computer Aided Dispatching and Scheduling Software (CADS)
- Automatic Vehicle Location Technology (AVL)
- Mobile Data Terminals (MDTs)
- Traveler Information Systems (TIS)
- Electronic Fare Payment Systems
- Automated Passenger Counting Technologies
- Transit Security Systems
- Did not Visit Technology Vendors
- Other ______________________

49). At the state, regional, or national meetings, what technology specific sessions did you attend?

- Types of Technology
- Technology Selection
- Technology Procurement
- Technology Deployment
- Technology and Coordination
- Did not Attend Technology Specific Sessions
- Other _______________________

50). Does your state DOT/transit association help with technology implementation/adoption?

- Yes
- No