Transit Automation Technologies: A Review of Transit Agency Perspective—Executive Summary

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Abstract

While the automobile industry is transitioning towards automation, the transit industry in the United States has recently begun investigating automation in transit operations. This study identified various U.S. transit industry uses of automation technologies and conducted a national survey of transit agencies in rural, small-urban, and urban areas to gather input about aspects of bus transit automated technologies and their implementation. Results provide improved understanding of the opportunities, advantages, and challenges for implementing bus automated transit technologies.

Introduction

Transit agencies in the United States have recently begun piloting and testing various automated transit technologies in their operations. While various levels of transit automation technologies are currently available, and with more advanced versions likely to be on the market soon, it is important to identify and understand these technologies in the context of transit agencies' needs. Data and feedback gathered from transit agencies can serve as a valuable resource for vehicle manufacturers, planners, and policy makers to better design automated transit vehicle technologies that can effectively meet the needs of transit agencies and, ultimately, transit riders. In this this study, we initially identified various transit industry practices with regard to automation technologies in the United States, and then conducted a national survey with transit agencies in rural, small-urban, and urban areas to gather input about various aspects involved with bus transit automated technologies and their implementation. A total of 258 responses were received from U.S. transit agencies: 157 from rural, 67 from small-urban, and 34 from urban transit agencies. While the findings from this study are primarily based on transit agencies' survey responses, it has to be noted that agencies responded based on their knowledge about automation in transit industry, which can be limited.

Awareness of Transit Automated Technologies

Some transit agencies were knowledgeable about bus transit automated technologies such as Society of Automotive Engineers (SAE) levels of automation, FTA's Strategic Transit Automation Research (STAR) plan, ongoing advanced driver assist systems (ADAS), and low-speed fully automated shuttle implementations. This knowledge comes as a result of these transit agencies having explored various automation technologies or made plans for implementation in their operations. However, fewer transit agencies in rural areas or small communities were knowledgeable about automation technologies available for implementation in their operations.

Interest in Transit Automation Technologies

Once relevant automation technologies are ready to be deployed, 30% of rural agencies, 54% of small-urban agencies, and 89% of urban agencies believe transit vehicles with automated functions would be beneficial for conducting transit operations (Figure 1). Safety was mentioned as a top contributor for all

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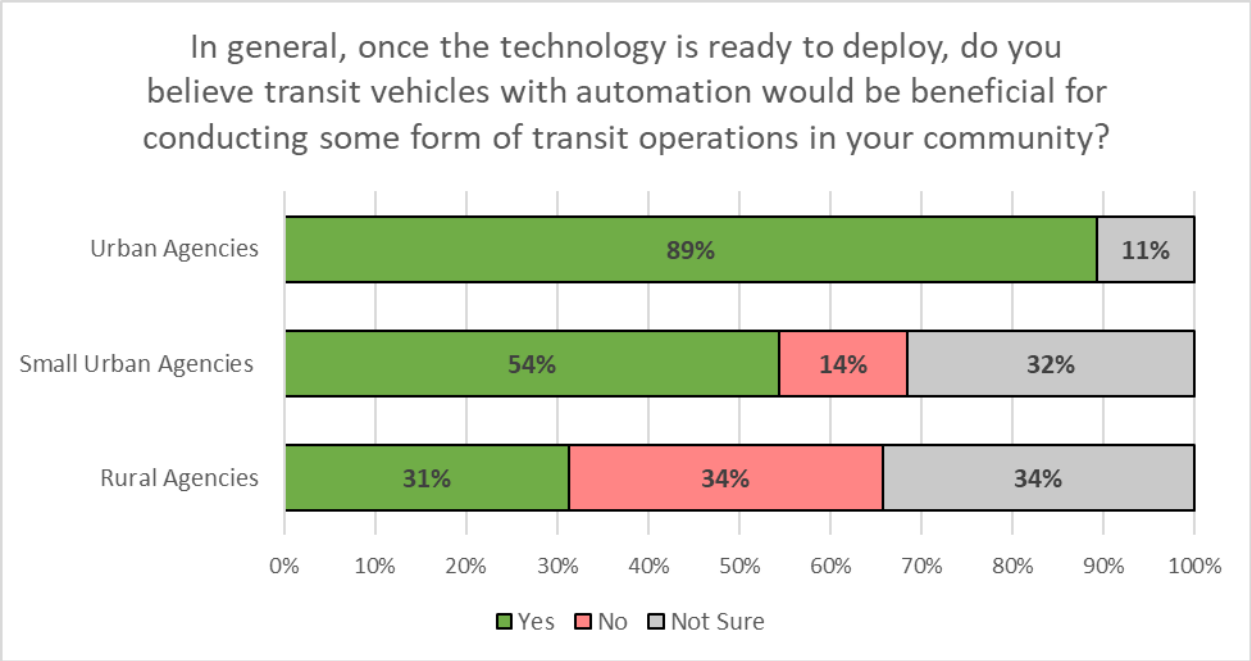

Figure 1. Benefit of Transit Automation in Conducting Some Form of Transit Operations

categories of transit agencies in justifying their belief that that transit vehicles with automated functions would be beneficial for their transit operations. Additionally, there are unique reasons for each type of transit agency to believe that automated functions could be a benefit in their operations. Some specific reasons rural and small-urban transit providers believe transit automation technologies would be beneficial include: 1) transit agencies face challenges in finding qualified drivers, and automated transit vehicles could reduce the need for trained personnel; 2) automation functionalities could help vehicles park closer to curbs, making it easier for riders to get on and off buses; 3) automated transit vehicles have the potential to create more efficient and reliable service; 4) automated transit vehicles have the potential to provide cost-efficient services to people living in low-density and remote areas; and 5) automated transit vehicles have the potential to reduce transit operating costs.

Similarly, some specific reasons urban transit agencies believe transit vehicles with automation features would be beneficial are that they could maintain more efficient schedules, serve as efficient vehicles in sustainable transit systems, operate in narrow lanes, etc. Most urban and small-urban transit agencies indicated they would choose first to introduce some level of automation within traditional fixed-route services. Reasons for better applicability of these technologies to fixed-route services include: 1) service being consistent, minimizing possible accidents; 2) stops are located in fixed locations, making it easier to plan the service; 3) lanes could be narrowed for exclusive bus operations, if needed; 4) there is potential to increase service levels without the need for additional drivers; and 5) fixed-route is comparatively the easiest service to automate in general. Rural transit agencies mostly indicated they would introduce some level of automation for demand response services, as this is the service commonly available in rural communities, and they prefer to introduce some level of automation to their existing services rather than introduce new services.

Low-Speed Fully Automated Shuttles

Five responding transit agencies (one small-urban and four urban) currently operate or have plans to operate fully automated shuttles in the near future. More than 80% of rural and small-urban transit agencies are not interested in operating fully automated shuttles in the near future. However, a few rural and small-urban transit agencies were curious to learn about the automated shuttle's potential for operations in their rural communities. In contrast, urban transit agencies are actively exploring fully automated shuttles for potential operations now or sometime in the future. While traditional bus transit services are not favored for automated shuttle operations, services such as downtown or business park circulators, shuttles on

Table 1. Top Five Potential Transit Service Applications for Fully Automated Shuttles in Rural, Small-Urban, and Urban Areas

Rank	Rural Areas	Small-Urban Areas	Urban Areas
1	Downtown or business park circulator	Downtown or business park circulator	Feeder bus service/ first-mile last -mile shuttles
2	Shuttles on university campus	Shuttles on university campus	Downtown or business park circulator
3	Filling service gaps and serving low density areas	Circulator bus service	Circulator bus service
4	Shuttles on hospital campus	Feeder bus service/ first-mile last -mile shuttles	Shuttles on university campus
5	Circulator bus service	Filling service gaps and serving low density areas	Shuttles at airport

university campus, and circulator bus services are best-use cases for fully automated shuttles in any type of community (Table 1).

Timeline and Procurement

While most of the transit automation technologies listed in the survey were not popular among transit agencies for implementation in the next 10 years, some of the technologies most favored by transit agencies for implementation in the near future include collision avoidance, curb avoidance, and lane-keep-assist (Table 2). All of these technologies can be characterized as advanced driver assistance systems (ADAS) and have the potential to enhance vehicle operation and safety. In general, as transit system size increases, demand increases for various transit automation technologies, as shown in Table 2.

Some of the potential challenges that transit agencies face when procuring transit vehicles with some level of automation include: 1) funding for procuring expensive vehicles with automation features, 2) public acceptance, 3) reliability of technology, 4) pushback from transit and local unions, 5) hiring and training qualified operators, 6) lack of availability of fully ADA compliant vehicles among higher SAE level qualified transit vehicles, 7) uncertainty about insurance and liability requirements, and 8) available existing transit fleet with useful service life.

In addition to the challenges previously listed, additional challenges faced by small-urban transit agencies include: 1) transit agencies are not willing to risk being early adopters of automated technologies, and 2) advanced transit technologies are out of their reach financially as they currently cannot fund basic transportation services and infrastructure.

Challenges also faced by rural transit agencies include: 1) cannot incorporate automated technologies unless state agencies are interested in these technologies; 2) lack of relevant technical capabilities (Wi-Fi, GPS, cell service, etc.,) to accommodate automated technologies; 3) lack of infrastructure (such as curbs, lane markings, etc.,) to accommodate automated technologies; 4) existence of

Table 2. Timeline for Transit Agencies to use Various Transit Automation Technologies

Automation Technology	Rural Agencies		Small-Urban Agencies		Urban Agencies	
	next 5 yrs	5-10 yrs	next 5 yrs	5-10 yrs	next 5 yrs	5-10 yrs
Precision docking	11.4%	19.0%	14.9%	29.8%	10.7%	32.1%
Narrowlane/shoulder	12.6%	21.8%	16.3%	30.6%	17.8%	57.1%
Lane-keep-assist	29.7%	42.6%	34.6%	55.8%	53.6%	78.6%
Platooning transit vehiclesautomation	7.2%	14.4%	10.2%	18.4%	17.8%	39.0%
Curb avoidance	2.9%	43.6%	44.2%	63.5%	53.6%	75.0%
Collision avoidance	41.9%	51.4%	61.5%	65.4%	75.0%	85.7%
Maintenance yard operations	6.3%	11.4%	14.0%	16.0%	35.7%	46.4%
L4/L5 Vans/Busses	4.5%	10.2%	5.8%	11.7%	17.8%	42.8%

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unique rural community natural barriers such as mountainous terrain, potential for adverse weather conditions such as snow, ice, etc.; 5) lack of successful automated transit implementation examples in rural communities; 6) concerns especially from older riders about not feeling confident and safe with automated technologies; and 7) lack of knowledge among transit agency personnel about automated technologies and available vehicles with automated functions.

Conclusions

This study gathered input from U.S transit agencies in rural, small-urban, and urban areas to understand transit agencies' interest in implementing various automated transit technologies and identify opportunities, challenges, and research needs.

Transit agencies believe transit vehicles with all SAE levels (1 to 5) can promote safety. However, because safety of higher levels of automated transit vehicles (4 and 5) has not been extensively researched in all sizes of communities and various types of environments, there are concerns and unanswered questions among some transit agency respondents about the technology's effectiveness, reliability, and performance. In general, transit agencies believed that transit vehicles in level 1-3 can improve safety, while vehicles in levels 4 and 5 could be cost efficient by reducing operator expenses and have the potential to operate throughout the day if needed for increased service levels. While levels 4 and 5 do not need to have a driver, transit agencies feel that the vehicles would still need an operator or agent to provide focused customer support and monitor the operating environment. The need for an operator or agent is observed to be much more important if level 4 or level 5 vehicles had to provide ADA paratransit or demand -response type of services.

Most rural transit agencies are comparatively less aware about the specifics of various transit automation technologies and are not knowledgeable about potential advantages, concerns, and opportunities of automation features to their agencies. As transit agency system size increased to include more urban systems, awareness and demand for using various transit automation technologies was observed to increase.

Agencies that operated fixed-route services thought that fixed-route transit would be a best-use case for deploying some level of automated technologies to their operations to help assist the driver with alerts/warnings and improve safety with features such as collision avoidance technologies, curb avoidance, lane keep assist, etc. Fully automated shuttles or transit vehicles in the SAE level 4 or 5 categories have some interest among transit agencies, preferably in simpler circulator routes with fewer conflicts. Examples may include downtown circulators, university shuttles, hospital campus shuttles, airport shuttles, parking shuttles, etc. Most transit agencies in smaller communities (rural and small-urban) are not interested in adopting fully automated shuttles or transit vehicles in SAE level 4 and 5 categories until they witness successful demonstrations of such services in similar-sized communities.