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THE RISE OF LOW-SPEED AUTOMATED VEHICLES: A TRANSPORTATION REVOLUTION

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ABSTRACT

Over the past decade, there has been substantial progress in the development of automated driving technologies. Although conventional vehicles and services have received considerable attention, automated driving technologies also present opportunities for nontraditional vehicle types and use cases. Several manufacturers have focused on developing a new category of vehicles called low-speed automated shuttles. In today's world, autonomous technology has experienced continuous growth, as companies prepare for the future. In the context of global suburbanization and an aging population, low-speed autonomous vehicle systems are being developed to provide transportation services within urban areas. Companies are working to enhance the navigation capabilities of these vehicles to navigate the complex scenarios of inner-city environments, facilitating the movement of people within urban settings. This paper further explores the development of autonomous technology and its benefits for the future. It also examines how companies are working to transform today's transportation system through autonomous navigation. The analysis delves into the driving forces behind this innovative technology and the advantages of autonomous transportation. Additionally, the paper defines the design and characteristics of low-speed autonomous vehicles, discusses the major players and their motivations, and outlines the deployment strategy. It also considers the common challenges and provides suggestions for mitigating them.

KEYWORDS: Autonomous, Low speed Mobility, Artificial Intelligence, Vehicle navigation, Computer vision.

INTRODUCTION

The quality of life in metropolitan cities is largely defined by the design and development of public transportation facilities, which are closely tied to the social fabric of the community. Any city lacking proper transportation infrastructure is like a ship adrift, directionless and going nowhere. Human drivers' decisions during the driving process are influenced by numerous factors - they are not always focused solely on the task of driving, and often fail to maintain safe following distances or obey traffic signals and signs (Iclodean et al., 2020). Autonomous vehicles can bring about positive changes in the transportation sector by eliminating human errors. These vehicles utilize the full potential of artificial intelligence. Automation is a systematic process of data selection, processing, transformation, and decision-making, which is the core capability of artificial intelligence. The transportation industry, being one of the fastest-growing sectors, is transitioning to the next level - autonomous vehicles that rely heavily on artificial intelligence (Tsai et al., 2019).

Automated vehicles are a transformative technology with the intent of improving surface transportation. They offer convenience, better productivity, and easy accessibility, particularly for older adults and people with disabilities. The benefits of automated vehicles are still emerging, including savings from reduced crashes, travel time, and fuel usage, as well as parking benefits. Recent research estimates the annual benefit of automated vehicles at around $2,000 per vehicle, and up to $5,000 when the costs of crashes are fully accounted for (Transportation, 2021) (Fagnant and Kockelman, 2017).

One particularly interesting development within the automated vehicle sector is the emergence of low-speed automated shuttles. These innovative transportation solutions may also be referred to by various other names, such as automated taxis, automated buses, automated minibuses, automated pods, robotaxis, and automated vehicles for last-mile connectivity. While low-speed automated shuttles share many similarities with other automated vehicles, Low-Speed Automated Vehicles (LSAVs) possess unique characteristics in terms of their design, service delivery, and operational framework (Zhou et al., 2021).

According to a recent report by the USDOT Volpe Center, over 260 low-speed automated shuttle demonstrations and pilots are currently being planned, completed, or are ongoing across North America, Asia, Africa, Oceania, and Europe (Cregger et. al., 2018) and according to the report, some features of low-speed automated shuttles were highlighted including

- **Fully automated driving:** Vehicles are intended for use without a driver or operator on board.
- **Restricted Operational Design Domain:** Operation is intended for protected and less complicated environments.
- **Low Speeds:** Service is generally limited to 25 mph or lower, with cruising speeds around 10 to 15 mph.
- **Shared Service:** Vehicles are designed to carry the weight of 4 to 15 passengers, including unrestrained passengers and standees.
- **Shared right-of-way:** Vehicles share the right-of-way with other road users, either at designated crossing locations or along the right-of-way itself (Cregger et. al., 2018).

The usage of low-speed automated shuttles transcends into different industries and sectors including government, academia, and the private sector.

The low-speed automated shuttles are being implemented to serve as first-mile and last-mile transportation solutions, providing connectivity to major transit systems, as well as circulating within urban centers and transporting individuals within confined, controlled environments such as university campuses, parks, and commercial districts (Winter et al., 2020) (Harper et al., 2016). Ongoing developments in artificial intelligence, sensing technology, and autonomous driving capabilities have enabled the emergence of these innovative low-speed transportation solutions.

1. Benefits of Low-Speed Automated Shuttles

There are numerous benefits of low-speed automated shuttles, although they have not been widely quantified, these benefits include,

- The facilitation of understanding and acceptance by introducing the public and internal staff to autonomous vehicles.

- Provision of new solutions or replacement of costly first-last mile vehicles.

- Lower fuel consumption compared to privately operated vans and vehicles, as low-speed automated shuttles are often electric vehicles that produce zero direct emissions and have more efficient energy consumption profiles than traditional internal combustion engine vehicles.

- Increased access and mobility for residents, particularly those unable to drive due to age or disability (Cregger et al., 2018).
- Low-speed automated shuttles provide a more cost-effective alternative for urban delivery, especially in densely populated areas. Furthermore, the National Highway Traffic Safety Administration and the U.S. Department of Transportation have recognized various benefits of these shuttles, such as enhanced safety, improved mobility, reduced emissions, and boosted economic competitiveness (Gurumurthy et al., 2020) (Winter et al., 2020) (Whitmore et al., 2022) (Fagnant & Kockelman, 2014).
- Reduced labor cost since there is no need to employ a driver and lower maintenance cost compared to traditional transit vehicles (Fagnant & Kockelman, 2014) (Winter et al., 2020) (Gurumurthy et al., 2020) (Harper et al., 2016).
- Reduced operational cost since there is lower capacity and the vehicles are fuel-efficient.

2. Present Challenges and Potential Solutions with Low-Speed Automated Shuttles

The transportation sector is faced with a lot of challenges, especially considering the present advancements in technology. Chief amongst the challenges are the first-last mile gaps within the industry. Low-speed automated shuttles solve this problem by creating feeder service to existing high-capacity transit. Other challenges and potential solutions are highlighted below.

Table 1: Challenges and potential solutions.

Transportation challenge	Potential low-speed automated shuttle solution
First and last mile gaps	Feeder service to existing high-capacity transit
The expense of operating low-volume transit routes	Smaller vehicles without drivers
Cost of paratransit trips and flexibility for passengers who must book rides in advance	Automated paratransit

The solutions offered by low-speed automated shuttles may prove to be more cost-effective and customizable than human-operated feeder services. Additionally, they may be more responsive to changes in demand compared to human-operated paratransit. Low-speed automated shuttles can provide a more flexible and efficient transportation option, potentially reducing operational costs through the elimination of driver labor and the use of smaller, more fuel-efficient vehicles. These shuttles can also be more easily adapted to changing ridership patterns, allowing transit agencies to better match supply with dynamic demand. Compared to traditional paratransit services that require passengers to book rides in advance, automated shuttles may offer a more on-demand and responsive solution, improving accessibility and convenience for users.

3. LSAVs Characteristics

US department of transportation has published a report on Low-Speed Automated Shuttles-State of the Practice. In this section, we will focus on the vehicle and service characteristics of the LSAVs, according to the report.

a. Vehicle characteristics

The low-speed automated shuttle concept encompasses a range of small (typically 4-15 passengers), low-speed (typically with a top speed around 25 mph with cruising speeds around 10 mph) automated shuttles. Vehicles share similar sensor configurations, relying upon combinations of cameras, radar, lidar, ultrasonic sensors, and GPS(Cregger et al., 2018). Most of these shuttles are also electric vehicles. While they are designed to operate without a driver, during testing and early deployments, most low-speed automated shuttles use an on-board attendant who is able to take control of the vehicle in the event of an emergency or system failure. Typical characteristics of such vehicles are, passenger capacity 10-15, weight is 6000-7000 lbs, top speed is 20-25 mph, range is 30-60 miles(Cregger et al., 2018) (Transportation, 2021). The below figure shows the currently available examples of LSAVs of Local Motors, EasyMile and Navya.

EZ10 by EasyMile **ARMA by Navya** **OLLI by Local Motors**

Figure 1: Low speed automated shuttles (Antonialli, 2021).

Most of the vehicles considered in this category follow a similar physical format, with low-floor, high-roof bodies allowing seating for half of passengers and an open standing area for the other half. Figure 1 shows a few examples of low-speed automated shuttles currently available and being used in pilots and demonstrations. Definitely, the implementation of

LSAVs will require to change the current infrastructure of the mobility like Infrastructure Assessment and Modification, Infrastructure-based Communication and Sensors, Localization, On-Board Attendants and Remote Intervention, Accessibility. The below figure shows the currently available examples of LSAVs of Local Motors, EasyMile and Navya Websites.

b. Service Characteristics

Several service characteristics of low-speed automated vehicles have been discussed, including a few broad categories of service

- **Passenger or Freight**: While most demonstrations have focused on passenger transportation service, there have been small freight delivery demonstrations.

- **Fare payment**: As the study was focused on demonstrations, fare considerations were not a primary concern. However, a more detailed study would be required to fully understand the impact of fares on ridership for these services. The demonstration nature of the services may have prevented charging fares, which could impact the number of passengers boarding (Xi-an et al., 2013)(Zhou et al., 2021).

- **Integration with other transportation services**: Many demonstrations are operated in areas where there are no existing transportation services (e.g., traditional bus), due at least in part to the desire to avoid labor conflicts. Transit agencies have begun to explore the use of low-speed automated shuttles and to consider their potential in a full-service fleet (e.g., Wiener Linien in Vienna). Switzerland’s Post Bus Smart Shuttle is an exception, being operated and liveried as part of a transit fleet.

- **Service design**: Shuttle service varies by where the shuttle can go (i.e., routes and stops), when it is available (i.e., service frequency), and whether it can react to real-time needs of users (i.e., fixed schedule or on-demand). Based on these variables, three major service models emerge: Circulator service, on demand connector service, point to point service.

LITERATURE REVIEW

There has been an increase in vehicle autonomy within the past several years. Out of many factors, environmental concern and human safety are the key driving factors. Since most of the population use some form of vehicle that emit emissions into the environment, there has been a strong push towards the implementation of autonomous vehicles(Singh & Saini, 2021). It is important to understand the future of our climate and what is being implemented. These rules and guidelines that are being set in place by the government, are what companies needy to comply with. It is the foundation of their validation system. It shall be a goal of the State that 100 percent of in-state sales of new passenger cars and trucks will be zero-emission by 2035(Advanced Clean Cars II, 2022). It shall be a further goal of the State that 100 percent of medium- and heavy-duty vehicles in the State be zero-emission by 2045 for all operations where feasible and by 2035 for drayage trucks(Iclodean et al., 2020)(ZEV Strategy, 2019). It shall be further a goal of the State to transition to 100 percent zero-emission off-road vehicles and equipment by 2035 where feasible(EXECUTIVE DEPARTMENT STATE OF CALIFORNIA, n.d)(The 2022-23 Budget: Zero-Emission Vehicle Package, 2022)(Governor Newsom’s Zero-Emission by 2035 Executive Order, 2021).

The development of the technology for low-speed automated shuttles has seen more demonstrations and piloting been conducted throughout Europe compared to other regions. Most of the projects in the area of low-speed automated pilots and demonstrations have occurred in Germany and France within Europe with other countries like Finland, Netherlands, Norway, Switzerland, and the United Kingdom making efforts as well. There have also been notable efforts in this domain seen in Asia with much of the activities seen in countries like Japan, Taiwan, and Singapore(Iclodean et al., 2020)(Cregger et al., 2018)(Wu et al., 2010).

This section gives us a breakdown and literature of researches on low-speed automated shuttles and literature on projects on low-speed automated shuttles in the US and Europe.

1. Literature on Academic Research

Dong et. al. (2017), in their academic study, expressed results from a stated preference survey carried out on transit bus riders in Philadelphia on their willingness to ride driverless buses. Mixed-logit modeling was implemented to examine the relationship between passenger types and willingness to ride driverless buses with or without an onboard safety attendant. Generally, results show that younger riders and males are more willing to ride a driverless bus.

EasyMile (2017), a vehicle manufacturing company, released a document, which was an assessment report for the off-road path LSAV testing in Arlington, Texas. The document consists primarily of maps, drawings, and charts with an overview, requirement, and analysis of the chosen site and path for the vehicle in the city of Arlington pilot project.

The FTA 2018 plan for the future of automated technology integration in public transport describes the FTA research plan for automated technologies. The plan specifically addresses level 4 automated conveyor applications, including those used for servicing circular conveyors and feeder bus services. It also defines the use of on-demand transport services for applications that buses can also help with, such as first and last mile, ADA transit, and shared journeys on request. Transportation authorities can use the FTA plan to align their plans and goals with national plans and goals (FTA report, 2018).

The FHWA has published an eight-module primer on traffic calming measures and information, which is publicly available. The second module of this FHWA resource focuses on safety, emphasizing the role of traffic calming in reducing vehicle speeds. Module 2 contains background information on tariffs, reasons for traffic brakes, and other traffic topics. This resource highlights the importance of using low-speed vehicles in certain situations(Speed Management: Reference Materials - Safety, 2021).

Nuro took an approach, a voluntary form of safety self-assessment recommended by the US Department of Transportation. Nuro is an LSAV manufacturer whose vehicles are only designed for the transport of goods and not for passengers. The VSSA includes standard elements of the company's vision, vehicle specifications and technologies, safety test methods, operational design field specifications, and high-level policy considerations.

As a sponsor of the Las Vegas Phase-I LSAV pilot project in downtown Las Vegas, AAA distributed a survey to users. The survey asked participants to rate their experience on a scale of stars, whether they would recommend the service to friends, and their understanding of emergency vehicle protocols before and after the journey. Additionally, the survey allowed for open-ended feedback. The document indicates a very positive response from users. However, the AAA did not examine the perspectives of individuals who chose not to participate in the pilot project.

The Mcity Shuttle Driver Case Study provides an overview of the Mcity Driver Shuttle test conducted on the University of Michigan campus. The experiment involved studies of human behavior and autonomous vehicle techniques. Navya LSAV pilots on the University of

Michigan campus were part of the project. The report also includes recommendations for others interested in implementing similar services. Key insights include: setting specific project goals, engaging stakeholders early, exploring legal, regulatory, and insurance options, identifying operational environment constraints, conducting thorough testing, thoroughly training safety conductors, anticipating challenges, developing an incident-response plan, and establishing data needs early on (University of Michigan, 2018).

TuSimple, a new and emerging company, is working on implementing self-driving truck technology. In addition to self-driving trucks, they are also in the business of deploying the technology they develop. TuSimple collaborates with original equipment manufacturers like Navistar and TRATON to create the Autonomous Freight Network. Their self-driving technology utilizes LiDAR, radar, and high-definition cameras to provide the vehicle with a comprehensive 360-degree awareness. This allows the self-driving vehicle to navigate successfully in both day and night conditions. Besides vehicle navigation, the technology also features lane centering and efficient throttle control.

2. Literature on OEM initiatives

In December 2014, the United Kingdom announced its interest in funding three automated vehicle projects, including the GATEway Project, which focused on testing low-speed automated shuttles on the Greenwich Peninsula. The British companies that developed this four-passenger shuttle were Westfield Sportscars and Heathrow Enterprises (GATEway, 2018). The LSAV operates on a 2.1-mile fixed route and can travel at a speed of up to 10 mph. The GATEway project includes not only the shuttle trial, but also testing of automated urban delivery vehicles, remote monitoring and intervention systems, accessibility features, and simulation capabilities.

Contra Costa Transportation Authority (CCTA) made an announcement in 2015 about their testing of low-speed automated shuttles at GoMentum Station, which was a military base in Concord that was converted to a closed test facility for the automated vehicle. With their initial testing at the station, they used two EasyMile EZ10 shuttles, and in March 2018, CCTA started off their shuttle testing in mixed traffic along a stretch of road (CCTA, 2015).

The ParkShuttle has been operational since 1999 (Van, 2016). The ParkShuttle service connects the Rivium business park to a bus and subway station. Starting in 2006, the system began using six second-generation 2getthere shuttles to provide service to five stations along a 2.0-km route. In 2016, the city of Capelle aan den IJssel announced plans to further extend the system. The plan is for six new 2getthere shuttles to be operational on the current route by summer 2019, and in 2020, the route will be expanded to include a longer route that crosses public roads with mixed traffic (Lohmann, 2017).

General Motors has been involved in autonomous technology development for several years, with a focus on using autonomous vehicles for public transportation. Cruise, a San Francisco-based company owned by GM, operates slow-moving, self-driving cars that navigate some of California's busiest streets. The design of these vehicles was inspired by the Chevy Bolt. Cruise's next self-driving model, the Cruise Origin, will feature state-of-the-art autonomous technology, with no steering wheel or mirrors, centered entirely around full autonomy (Fridman et al., 2019).

Google has a startup for an autonomous corridor from Ann Arbor to Detroit through a company called Cavnue. In October, it was announced that the first-of-its kind connected corridor in southeast Michigan (Michigan project 2021). It will be starting with a feasibility project and was selected by the Michigan Department of Transportation to “bring together technology and infrastructure to create a connected corridor improving safety, congestion, accessibility, and other benefits for the state” (Michigan project 2021). This is a very exciting endeavor for the city of Ann Arbor as it is the home to U of M and leader in technological advances. Some partners included in the project are Michigan’s state government and the City of Detroit, Ford, U of M and others. The corridor will be a Connected and Automated Vehicle Corridor between downtown Detroit and Ann Arbor (Michigan project 2021). This project will yield more safety for motorists by allowing roadways to handle more cars due to the autonomous vehicles being able to ride closer together (Winston, 2021).

Apple is planning an investment in research and development, testing and acquisition in autonomous driving technology. Currently, Apple 70 self-driving vehicles on the road in California for building a transportation network. In January 2019, Apple has cut down more than 200 employees for restructuring for their self-driving car initiative, Project Titan(Clements & Kockelman, 2017) (Apple Cuts 200+ Employees From 'Project Titan' Autonomous Car Team, 2019). After five months, Apple confirmed that it had acquired Drive.ai, a self-driving startup that is backed by more than $77M in funding and was valued at $200M in 2017. This move appears to be an effort to get its own autonomous vehicle efforts back on track for Apple.

German automaker Audi has made big promises about its plans for autonomous and electric vehicles. The brand has said it plans to spend close to $16B on self-driving and sustainable tech by 2023. Those efforts were primarily being undertaken by Autonomous Intelligent Driving (AID), Audi's self-driving technology outfit, first launched in 2017. The operation, which is based in Munich and claims more than 200 employees, had 12 autonomous vehicles on public roads in its home city in 2018(Ajao & Oludamilare, 2023)(Rick et al., 2019).

During CES 2016 event, BMW showed autonomous i8 concept, since then BMW has begun aggressively pushing its autonomous strategy. In July 2019, the company announced a partnership with another German automaker, Daimler. The companies agreed to commit 1,200 technicians to the task of developing new autonomous systems with the goal of getting them on the road by 2024(Singh & Saini, 2021)(Iclodean et al., 2020). But this collaboration ended less than a year later. The complexities and expenses of building a joint tech platform proved to be larger than the duo expected. Munich Based BMW is pursuing many different partnerships with other OEMs as well. BMW announced the partnership and collaboration with intel and Mobileye in 2016, later Chrysler and Magna joined this partnership in 2017. The partnership is planning to create an open standard based platform for bringing autonomous car to the market, aiming to roll out the first car on road, BMW iNEXT by 2021(Panchal & Wang, 2023).

In 2015, Ford announced the plan for smart and autonomous mobility plan. As part of its 10-year autonomous vehicle plan, Ford is steadily increasing its fleet and currently has around 100 autonomous test vehicles. It has pioneered the testing of self-driving cars in environments including snowy weather and complete darkness. The company has committed to roll out highly autonomous vehicles within pre-mapped areas, including Austin, Texas, by 2021. In April 2019, CEO Jim Hackett confirmed that timeline but stated that the vehicles' applications would be "narrow," and that the automotive industry "Overestimated the arrival of autonomous vehicles(Transportation, 2021)(Singh & Saini, 2021)." In June 2019, Ford announced the opening of a new research center in Tel Aviv focused on self-driving technologies including sensors, in-vehicle monitoring, and cybersecurity. Israel is evolving into a major hub for self-driving technology, with Intel, Continental, Samsung, Daimler, and General Motors also making investments or setting up shop in the country.

TESLA was initially leading the self-driving technology, CEO Elon musk announced in 2015 that "the future of fully autonomous vehicles and it is 2 to 3 years away and up to 5 years needed for regulatory approvals". Tesla changed the plan and pushed its Autopilot software update to appropriately equipped Model S vehicles in October 2015, allowing auto-steering, lane changing, and parking features (Winkle, 2022) (Iclodean et al., 2020). Tesla's deployment strategy and messaging were criticized following a series of crashes and its first Autopilot-driven fatality in the summer of 2016, although the NHTSA's official report was favorable towards Autopilot and did not find a safety defect.

Toyota changed their plan from its 2014 claims that they would not develop a driverless car on public safety grounds. The Japanese automaker has made an announced at CES 2020 a determined plan to build a city to test its self-driving and smart technology as well as robot-assisted living. Toyota CEO Akio Toyoda said, "With people, buildings, and vehicles all connected and communicating with each other through data and sensors, we will be able to test AI technology, in both the virtual and the physical world, maximizing its potential." The city can accommodate around 2,000 people, and will be located in the foothills of Mount Fuji. Toyota is planning to start work and building the city is expected in 2021 (Hoffman, 2020) (Deren et al., 2021) (Zerza & Park, 2020).

METHODOLOGY

The report and research literature identified in this work are a combination of different methods that includes document tracking of both international and domestic project demonstrations, deployments, studies, and pilots for low-speed automated shuttles. The method is described below

1. Project Tracking

This work involved aggregating information from publicly available literature, media sources, and websites on both international and domestic deployments of low-speed automated shuttles. Extensive research has been conducted on the subject of slow-speed automated vehicles, covering various stages of development. The information presented in this article is based on and extracted from the study of scientific papers and journals.

2. Use Case Analysis and OEM publications

A set of use cases served as a framework for analyzing the technology of low-speed automated shuttles, including their impacts, challenges, and potential solutions. Nearly every OEM is vying to develop autonomous vehicles. During this process, OEMs release updates on the current development status of AVs through press releases, and this article provides information on the development status, future plans, and capital investments of most major

OEMs. Many OEMs, such as Ford, GM, Tesla, and Toyota, are leading the developmental activities in this area. Toyota, for instance, has built a separate town to test its autonomous vehicle technologies.

RESULTS

Based on the various research, deployments, piloting, and demonstrations, several key technologies have emerged as essential for low-speed automated shuttles. These include automotive radar, LiDAR, image sensors or cameras, ultrasonic sensors, GPS/INS, dead reckoning, absolute localization, SLAM, V2X communication, and sensor fusion.

Successful development of low-speed automated shuttles in our research cases requires focus on approximately four key areas

- Environmental sensing/perception
- Mapping and localization
- Planning, control, and decision making
- Application of Artificial Intelligence.

The implementation of fully automated, slow-speed vehicles can transform today's mobility, promising radical changes in terms of safety, economic and social benefits, efficiency, convenience, and mobility.

1. Safety: The safety benefits of fully autonomous vehicles are dominant. Automated vehicles can significantly contribute to reducing fatalities and injuries caused by human errors, as surveys indicate that around 95% of road crashes are due to human negligence and errors. Therefore, the adoption of automated vehicles has the potential to save the lives of drivers, passengers, bicyclists, and pedestrians.

2. Economic and Societal benefits: Low-speed autonomous vehicles will contribute significant economic and societal benefits by largely reducing road crashes. According to a study by the National Highway Traffic Safety Administration, motor vehicle crashes in 2010 cost $242 billion in economic activity, including $57.6 billion in lost workplace productivity, and $594 billion due to loss of life and decreased quality of life from injuries. Eliminating the vast majority of these motor vehicle crashes could erase these substantial costs.

3. **Efficiency and Convenience:** Generally, traffic congestion on roads is primarily due to crashes caused by human errors. Removing the human factor and having roads filled with automated vehicles could enable them to cooperate and smooth traffic flow, reducing congestion. A study by the USDOT found that in 2014, Americans spent an estimated 6.9 billion hours in traffic delays, cutting into time at work or with family, while also increasing fuel costs and vehicle emissions.

4. **Mobility:** In today's fast-paced world, mobility is a fundamental human need. People must commute daily for work, school, business, family, and leisure activities. Individuals of all ages, including the elderly and those with disabilities, rely on transportation, so automated vehicles present new mobility options for millions across the globe. In the United States alone, there are currently 49 million people aged 65 and older, and 53 million people with some form of disability.

CONCLUSION

This report systematically highlights the leading companies advancing research and progress in the autonomous driving sector. It also provides insights into the trends and research on the application, potential, and prospect of low-speed automated shuttles. Autonomous vehicle technology has made significant advancements, enabling some companies like ParkShuttle to confidently roll out low-speed automated shuttles with careful considerations to design, operational ability, safety measures, remote support, and software redundancy. The development of LSAVs comes with numerous benefits, as highlighted in this report. These include lower gas usage, a more cost-effective method of urban delivery, reduced labor and operational costs, among others. Autonomous shuttle buses and slow-speed vehicles for public passenger transport utilize ever-evolving technology, which requires years of testing and validation before replacing large-scale public transport using traditional buses.

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