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THE BENEFITS OF AUTONOMOUS PODS FOR THE FIRST/LAST MILE AND THEIR POTENTIAL IMPACT ON TRADITIONAL MODES OF PUBLIC TRANSPORT

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Abstract

The transport industry is evolving rapidly, and new technologies are emerging every day, including autonomous vehicles. Autonomous vehicles are a promising technology for bridging the gap for first/last mile connections of public transport journeys, however, their potential benefits in providing efficient and reliable transportation solutions and their impact on traditional modes of public transport still need to be explored. This paper investigates the potential benefits of autonomous vehicles and their integration with traditional public transport modes. Additionally, the paper examines the potential infrastructural elements required for their introduction from two aspects. The first aspect is the user, which considers stops and designated road surfaces, while the second aspect is the operator, which considers service stations, depots and charging stations. Moreover, the use of autonomous vehicles can also significantly impact traditional modes of public transport, such as trains and buses. While these modes of transport have their own advantages, they often need help to provide a door-to-door service, leaving the first/last mile of the journey uncovered. Autonomous vehicles can bridge this gap, reducing the reliance on traditional modes of transport and potentially leading to a more integrated and seamless transport system. Overall, this paper highlights the potential of the introduction of autonomous vehicles for the first/last mile of public transport journeys and the way it enhances the overall efficiency and convenience of the transport.

1. INTRODUCTION

Creating a sustainable transportation system is a fundamental imperative for urban areas worldwide. Such a system not only improves the quality of life but also reduces pollution and offers a multitude of significant advantages [1]. However, designing an efficient and sustainable public transport system for low-density areas has proven to be a difficult task, primarily due to the substantial operational costs involved. In many cases, public transport relies on government entities to provide financial support through subsidies. However, despite diligent efforts, accessibility remains a persistent challenge, particularly in rural areas. This persistent "poverty of access" leaves many without viable public transport options, underscoring the critical importance of addressing the first/last mile gap [2]. Autonomous pods (APs) have the potential to reshape mobility and have the potential to address some of the unique transport challenges, especially in rural areas where the first/last mile issue is prominent. This paper is dedicated to investigating the role of APs in addressing complex transportation issues, particularly in rural areas, by exploring their prospects, benefits, and associated challenges.

This paper aims to explore the integration of APs into public transport systems, focusing on mitigating the first/last mile challenge, particularly in low density areas with limited access to public transport. The significance of addressing the first/last mile transportation challenge extends beyond mere convenience and accessibility. It represents a crucial step toward constructing sustainable, efficient, and inclusive urban and rural transport systems for the future. This research assesses the feasibility and potential benefits of APs, emphasising their transformative potential in addressing this critical transportation issue. By underscoring the importance of tackling the first/last mile challenge, this study contributes to the development of sustainable, efficient, and inclusive urban and rural transport systems.

2. POTENTIAL ADVANTAGES AND IMPACTS OF AUTONOMOUS PODS

The initial reports, studies, and trials of the usage of APs, have shown that, if adequately designed, APs do have the potential to fill the gap of the first/last mile where public transport service is limited. For example, a study done in the Finnish capital of Helsinki, has shown that, if introduced, APs could increase the population living in the 30-minute travel time area from the city centre by 36% [3]. The transportation model for Singapore has shown that the introduction of fully autonomous pods, integrated with traditional public transportation modes, could increase public transportation ridership, and switch the modal split towards more sustainable modes, which, in turn, could decrease congestion by 36,9% on congested road links in peak hours [4]. A study undertaken in the USA, in Arlington, Texas has shown that, although the initial investment for APs is substantially higher than for fossil fuel-powered vans, the non-existent driver costs, as well as the lower price of electricity compared to fossil fuels, implies that, over time, the investment would pay off and that APs are a cost-effective solution over a longer period [5].

Theoretical assumptions suggest that integrating APs into the public transport system can expand coverage, enhancing accessibility and attractiveness. An improved modal split might also reduce air pollution. The lower price of electricity compared to fossil fuels, no driver costs would imply that higher frequency could be achieved without a substantial impact on operational costs [5, 6]. Also, such conditions imply that the service could be available during most of the day, or non-stop. For example, the Heathrow Pod operates 22 hours a day [7]. Moreover, autonomous services offer greater on-demand flexibility compared to traditional public transport modes, and they easily integrate with Mobility as a Service (MaaS).

In addition, the users of past/current pilots and practical examples of the system are satisfied with the system and feel safe using it. During the Sohjoa Last Mile pilot project, most users rated the quality of the service as 5 (on a scale of 1 to 5). In terms of safety during operation, the most common grade was 7 (on a scale of 1 to 7), although a lot of users also rated their safety as 5 or 6. This pilot included tests with and without a professional supervisor. Around 75-80% of users expressed feeling safe without a supervisor. Most users intended to use the service for the first/last mile of their trip, provided the pod's speed increases while still ensuring safety, and that they would use the service for distances of up to 5 kilometres [8, 9].

In addition to their potential advantages in enhancing accessibility and mobility, APs also hold promise in significantly reducing environmental impacts. As these vehicles operate on electric power, they offer an eco-friendly alternative to traditional fossil-fuel-powered vehicles. This shift towards electric drive not only reduces greenhouse gas emissions but also helps improve air quality, particularly in urban areas. APs align with sustainability goals by promoting cleaner transportation options, making them a key component of future urban mobility systems. By addressing the environmental aspect, APs can play a crucial role in mitigating the adverse effects of climate change and improving the quality of life in urban environments.

3. POTENTIAL CHALLENGES FOR IMPLEMENTATION

While the benefits of such a service are evident, addressing challenges is essential for improved efficiency and safety. To address these concerns, the GATEway project has been run in London, United Kingdom. During the project, an extensive four-week-long public trial in a real-world urban environment was conducted. The trial was strategically located in the Greenwich Peninsula, specifically along the Thames Path, due to its complex environment with frequent interactions between pedestrians, cyclists, and vehicles. Within this context, the project deployed driverless pods equipped with sophisticated technology including sensors, cameras, lasers, and cutting-edge software algorithms. These technological advancements allowed the driverless pods to navigate the complex environment safely and efficiently, showcasing their capabilities in a dynamic and demanding urban environment [10]. This implies that potential safety concerns can be dismissed if adequate technology is applied. However, an issue that is yet to be tackled is the assistance to people with disabilities. A human could easily assist people and recognise when a ramp should be lowered, while driverless vehicles cannot assist such users in an adequate way. Addressing this issue is of great importance.

Another issue which current APs are facing is the low operating speed. Citizens who used the service during the Sohjoa Last Mile pilot project said that, to start using the service daily for the first/last mile of their trip, the average speed should be higher than it is now. The average travel speed of pods used in the pilot was around 7 km/h, with the maximum speed being below 20 km/h, which was the case in another related study as well [9-11]. In comparison, buses in mixed traffic usually have travel speeds between 12 and 20 km/h [1]. However, to operate at such speed, adequate technology must be applied to ensure safe operations.

Personal safety on board is another challenge which needs to be overcome. A certain portion of users of APs have noted that the lack of presence of a driver made them feel uncomfortable in case of potential robbery, assault, or any kind of criminal activity in the vehicle. Also, both users and partners of the Sohjoa Last Mile pilot project said that additional measures must be taken for users not to press stop buttons or similar buttons, to test the technical limits of the pods. The same concerns were noted for other road users and their potential wish to test the pods, a behavior which could be dangerous for both passengers and other road users [8, 9].

Communication between the pod and other road users must be clear and easy to understand. Generally, studies have shown that other road users are wearier of autonomous pods, than those inside of them. During the Sohjoa Last Mile pilot project in Tallin, 33,3% of other road users said that a driverless pod makes them feel unsafe, while 25% said that they are not sure if they feel unsafe [8]. Also, around 24% of other road users in Tallin said that they did not completely understand that the pod has safely stopped and is planning to remain stopped until all pedestrians have safely crossed the road. Both audio and visual signals must exist, which will provide road users with information about the pod’s next move [8, 9].

Additionally, there may be a need for updated regulations and legal frameworks to govern the operation of APs on public roads. Establishing clear guidelines for insurance and liability allocation is crucial to ensure the protection of passengers, pedestrians, and other road users. Additionally, regulatory agencies must develop comprehensive safety standards and certification processes specific to APs, considering their unique characteristics and autonomous operation.

4. INFRASTRUCTURE INTEGRATION AND DESIGN CONSEDIRATION

Infrastructural elements for APs can be divided into two groups: infrastructural elements from the aspect of the user (designated stops and dedicated lanes), and infrastructural elements from the aspect of the operator (service and charging stations and depots).

Regarding APs stops, two methods have been considered: a system with fixed stops and an on-demand system, with no fixed stops. Although an on-demand system is more convenient for users, it is far more complex to organise for the operator and can be confusing for elderly users and people with disabilities, who sometimes prefer fixed stops at locations which are familiar to them. If fixed stops are designed, they should include displays with key information: when a vehicle is coming, and if it is an on-demand service, and not a fixed schedule one. Also, the display should include a way to request a vehicle, while including key data, such as the trip duration, price, etc. Alternatively, a method used during the Sohjoa Last Mile pilot project can be applied – dedicated bus stops included a QR code, inviting the users to use a web application to request a vehicle [9]. If the service is on-demand location wise, some authors recommend passenger pooling – a system where a few passengers request the service at proximity from each other, and the system arranges an optimal meeting point for all these users. Additionally, regarding the construction of dedicated lanes for autonomous pods, three aspects should be considered – how much will a dedicated lane improve the travel speed of the pod, does the pod have a fixed route which it uses or is it an on-demand service location wise, and is the ridership and the frequency of pods high enough to justify such an investment.

Running APs as a service involves several infrastructure considerations. Currently, APs operate under various schemes, some relying on segregated infrastructure while others function without fixed tracks. Notable examples include the Heathrow Pod in the UK and the Suncheon Wetlands SkyCube in South Korea, which operate on dedicated segregated infrastructure [7, 12]. In contrast, vehicles in Masdar City, Abu Dhabi, and Capelle aan den Ijssel, the Netherlands, navigate flat tracks based on virtual routes, utilising external reference points for positioning [13, 14]. All these systems are powered by batteries, ensuring emission-free operations, with recharging occurring either at maintenance facilities or dedicated stations. These systems operate on demand, 24 hours a day, backed by staffed emergency support. Each element of the system communicates with each other in real-time and is controlled through distributed telecommunication control systems.

Key infrastructural and design elements should be considered, such as data utilisation, cybersecurity measures, improved accessibility provisions, enhanced safety protocols, an operational center, charging infrastructure, and a maintenance system for vehicle servicing. The new infrastructure could explore innovative funding models, such as public-private partnerships, for infrastructure development.

5. INTEGRATION WITH PUBLIC TRANSPORT

APs have the potential to be used for the first/last mile of a trip. The International Association of Public Transport (UITP) has recognised that APs are best suited for this role [15]. UITP also claims that different types of autonomous vehicles, including APs, could reduce the usage of passenger cars by 80% [16].

Integrating APs into traditional public transport systems requires careful consideration of aspects such as geographic reach, communications systems, scheduling synchronization, and fare structure alignment. Key enablers for this integration include advanced smart ticketing systems that facilitate contactless payments and dynamic pricing models to incentivise off-peak usage. Furthermore, these systems promote multimodal integration, enabling passengers to effortlessly switch between different modes of transportation with a single ticket. Real-time data sharing is identified as essential, supporting efficient fleet allocation, proactive maintenance, and accurate demand forecasting. To optimise AP performance, data-sharing systems must prioritise user privacy, scalability, and data accuracy. By addressing these aspects, we can ensure the successful integration of autonomous pods, reshaping mobility and enhancing the overall transport experience for users.

Additionally, the authors of a study done for Helsinki, Finland, claim that, if APs are used for the first/last mile in many parts of a city and the area is well covered by the system, it can decrease the travel time of the traditional mode, which is, in this case, the trunk line, while the pod lines serve as feeder lines. The reduction of travel time can be achieved by grouping the feeder lines at one trunk line stop, instead of many feeder lines serving many different trunk line stops. Therefore, since the entire area is well served by autonomous pods, the number of stops on the trunk line can be reduced without reducing the coverage area, with feeder lines integrated with the trunk line at the same location. The lower number of stops therefore reduces travel time on the trunk line. A prerequisite for this system is the acceptable travel speed of pods [5].

6. CONCLUSION

In conclusion, the introduction of APs for first/last-mile public transport journeys present a significant opportunity to deliver efficient and sustainable transport solutions. Their potential benefits, including enhanced accessibility, improved efficiency, cost savings, and environmental advantages, position them as an attractive option for bridging gaps within traditional transport systems, thereby contributing to more sustainable and balanced urban and rural environments. However, successful integration demands careful consideration of infrastructure elements from both user and operator perspectives. Furthermore, the potential impact on traditional modes of transport should not be underestimated, as APs can serve to complement and potentially reduce reliance on these modes. Overall, APs have the potential to enhance the overall performance of public transport, creating a more integrated and efficient system accessible to everyone. The promising potential of APs in improving transport accessibility underscores the value of a flexible, on-demand, door-to-door service in addressing current barriers to transport and improving access to essential amenities and opportunities. Nevertheless, several challenges must be addressed before introducing autonomous infrastructure into the transport ecosystem, including technological and cost uncertainties, along with the need for extensive implementation research to understand the full spectrum of requirements for deploying and maintaining autonomous pods while developing workforce skills. Ensuring the safety of passengers and road users through advanced technology is of paramount importance, while maintaining travel speed.

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