



Impacts of Emerging Transportation Technologies on Urban Mobility and Public Transportation Systems

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Abstract. Today, new transportation technologies are emerging as a result of higher education levels and more talented people. The rapid development of contemporary technology has led to significant advancements in various aspects of the whole society, while the two main considerable ones are about the urban mobility and the public transportation systems. Innovations such as Low Traffic Neighborhoods (LTNs), the Internet of Vehicles (IoV), and Autonomous Cars (AC) are at the forefront of this transformation. These technologies promise to enhance urban sustainability by reducing traffic congestion, creating smart transformation, improving safety, and minimizing environmental impacts. LTNs, for instance, aim to create safer and more livable urban environments by restricting through-traffic and encouraging alternative modes of transportation such as walking, cycling, and public transit. This could effectively reduce the emission of toxic or greenhouse gasses and lower the amount of private traffic flow on roads. The IoV connects vehicles, infrastructure, and users, optimizing traffic flow and enabling new services like Usage-Based Insurance (UBI), which is a kind of car insurance that promotes responsible driving behavior since its premium is installed depending on this. Meanwhile, Autonomous Cars represent a paradigm shift in personal and public transportation, offering the potential to drastically reduce accidents and improve mobility for all, including those with disabilities. In addition, autonomous vehicles are also a famous and recognized symbol of the new era of smart cities. However, these innovations also present challenges, including public acceptance, regulatory hurdles, and potential disruptions to existing transportation systems. How can these difficulties be breached at a time when the will of the public and the true utility and sophistication of the technologies become more highly valued? This paper provides a comprehensive analysis of these emerging technologies, discussing their potential benefits, challenges, and the broader implications for the future of urban environments.

Keywords: Urban mobility, Transportation, Technology.

1 Introduction

Urban mobility is a cornerstone of modern urban planning, directly affecting economic vitality, environmental sustainability, and quality of life. With increasing urbanization, cities face growing challenges related to traffic congestion, air pollution,

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and inadequate public transportation infrastructure. In response, innovative solutions such as Low Traffic Neighborhoods (LTNs), the Internet of Vehicles (IoV), and Autonomous Cars (AC) have emerged. This paper explores these innovations, evaluating their impacts and potential to transform urban mobility.

The transformation of urban transportation systems is a critical aspect of sustainable development in the modern era. As cities worldwide experience rapid population growth and urbanization, the demand for efficient, safe, and environmentally friendly transportation solutions becomes increasingly urgent. Traditional transportation models, which heavily rely on fossil fuels and contribute to congestion, pollution, and traffic accidents, are no longer viable in a world striving to meet sustainability goals and reduce carbon footprints. In this context, emerging technologies like Low Traffic Neighborhoods (LTNs), the Internet of Vehicles (IoV), and Autonomous Cars (AC) are stepping in as potential game changers that can redefine urban mobility and public transportation.

The introduction of LTNs marks a pivotal shift in how urban planners approach city design, aiming to create spaces that prioritize people over vehicles, thereby enhancing the quality of life for residents. On the other hand, the IoV represents the next step in leveraging connectivity and digitalization to transform transportation networks, enabling real-time data sharing among vehicles, infrastructure, and users. This not only optimizes traffic management but also opens up opportunities for innovative services, such as Usage-Based Insurance (UBI) and predictive maintenance, which can enhance safety and efficiency. Meanwhile, Autonomous Cars have emerged as a symbol of futuristic urban living, promising to revolutionize personal mobility by offering a safer, more accessible, and eco-friendly alternative to conventional vehicles.

While these innovations are promising, they are not without their challenges. Public acceptance, regulatory frameworks, ethical concerns, and the potential displacement of existing jobs in the transportation sector are pressing issues that need to be addressed. This paper aims to delve deeper into how these technologies can contribute to sustainable urban development, examining their advantages, the obstacles they face, and the strategies required to integrate them into our cities effectively. By exploring the transformative potential of LTNs, IoV, and AC, we can gain insights into how the future of urban transportation might unfold, reshaping the way we live, work, and travel.

2 Low Traffic Neighborhood (LTN)

2.1 Definition and Implementation

Low Traffic Neighborhoods are urban areas designed to minimize through-traffic by implementing traffic calming measures and filtered permeability. The primary goal of LTNs is to create safer, quieter, and more livable environments by encouraging walking, cycling, and public transport use over private car travel.

LTN is implemented in two separate areas of the UK, Cowley (Temple Cowley, Church Cowley and Florence Park) and East Oxford (Divinity Road, St Clement's and

St Mary's). The LTN in Cowley is planned to be implemented initially in 2021, whilst the LTN in East Oxford is planned to be implemented initially in May 2022 through an Experimental Traffic Regulation Order (ETRO), which will be trialed for a period of 18 months.

2.2 Impacts

The impact of the LTN program on local cities is clear from the local news in the UK. They can be seen in three broad areas: air quality, traffic flow, and public attitudes towards the program.

The LTN program has a positive and complementary effect on the improvement of air quality. --- In an article titled Evaluation of low traffic neighborhood (LTN) impacts on NO₂ and traffic [1], the authors used data provided by Islington Council for the period July 2019 to February 2021 to assess the impact of LTN implementation on NO₂. They used a DID approach to estimate the effects of the LTN intervention, taking into account time fixed confounding effects as well as other confounding effects such as site location. Based on the estimated effects, we find that the implementation of LTN resulted in a reduction of 8.9% and 5.7% in average NO₂ emissions at the boundary and interior sites, respectively, compared to the exterior control sites. Even though these numbers may seem small, even small changes in airborne NO₂ data can be very beneficial to people's occupancy and health. In addition, the LTN program also discourages the amount of traffic flow among the urban regions. At the same time, in the previously mentioned paper Evaluation of low traffic neighborhood (LTN) impacts on NO₂ and traffic, Xiuleng Yang et al. emphasized that compared to the external control site, the internal site significantly reduced traffic by 58.2% and the boundary site by 13.4%. Moreover, there are also other articles that describe the reduction of intra-city traffic due to the establishment of LTNs: The Impact of 2020 Low Traffic Neighborhoods on Levels of Car/Van Driving among Residents: Findings from Lambeth, London, UK by Anna Goodman et al published on June 7, 2023, has also contained relevant research [2]. It was noted that between 2020 and 2023, the total number of valid parking permits increased by 9.0% within the LTN; 8.7% near the LTN; and 10.1% within the control zone. The before-and-after change in average past-year driving for residents living within the LTN is -0.7 km/day (from 20.3 km/day to 19.6 km/day), compared to +0.6 km/day (from 20.4 km/day to 21.0 km/day) for those living within the control area. This corresponds to a differential effect of -1.3 km/day between the LTN and the control area, or a relative decrease of 6.4%. What's more, BBC, the most authoritative local news platform in the UK, also published regular news and provided the latest information about the LTN program between 2021 and 2024. From the newscasts, however, we can learn that the attitude of the local population towards the cloud LTN program is not that ideal. In one of the earliest BBC news reports on LTN, published in 2021, mentioned that hundreds of people were involved in protests against the LTN program. By February 2023, thousands of people had joined protests in Oxford, with activists gathering on Broad Street to oppose the city's low-traffic neighborhoods (LTN) and traffic filters [3]. It wasn't just a simple demonstration in the street, as

bollards and fences used to implement the LTN scheme in different areas were crushed, vandalized, and even burned by residents. Figures obtained by The Guardian under the Freedom of Information Act show that the capital's Low Transport Neighborhood (LTN) infrastructure has suffered over £850,000 worth of damage since 2020. Vandals have cut cables, damaged cameras and push them into the air, smashed or removed bollards, and defaced signage. Hackney Council had the most expensive repairs with almost £400,000 spent. As a result, people's access to transportation has been greatly reduced due to the partial closure of roads caused by the LTN project. The number of opponents of the LTN project has only increased over the years, and the prejudice and anger of those opponents of the LTN project leads to criminal acts of destruction of public property.

2.3 Consequences

The main goal of local governments in setting up LTNs is to reduce the traffic flow and speed of vehicles near residential areas, and at the same time to improve air quality, reduce air pollution, and encourage the public to use public transportation instead of private cars. From the perspective of urban mobility and urban public transportation, LTN has largely changed the travel patterns and travel habits of most residents, but it is obvious that this is not a positive change for the masses, but rather a restriction on the freedom of travel, which has brought traffic inconvenience to their lives. As a result, urban mobility deserves to be reduced. However, when people are less likely to use private transportation, they will be more inclined to go to public transportation to get around. Therefore, the use of public transportation increased after the LTN was implemented.

3 Internet of Vehicles (IoV)

3.1 Definition

Internet of Vehicles (IoV) is an open network system based on the synergy of people, vehicles and environment. It senses and calculates large-scale static and dynamic information about people, vehicles, network communications and road traffic infrastructure through advanced information communication and processing technologies, and ultimately realizes the deep integration of people, vehicles and the environment. It enriches personal automobile life, improves the efficiency of transportation, improves the level of urban services and reduces social operation costs [4].

3.2 Usage - Based Insurance (UBI)

Usage-Based Insurance also usually called Pay-As-You-Drive (PAYD). PAYD is a non-traditional, new-age affordable car insurance with relatively low premiums as it pays the policyholder based on the number of kilometers he drives the car. This

means that the policyholder pays the premium based on the distance he/she drives the car. UBI is a new type of car insurance concept derived from IoV, which flexibly utilizes the real-time monitoring system in IoV to develop a well-established insurance model. Since IoV tends to be a huge topic that can be difficult and complicated to analyze detailly. Here, UBI will be analyzed as a representative case of IoV.

UBI is usually categorized into three types:

- Pay-As-You-Drive (PAYD): Insurance costs are based on the total mileage driven, incentivizing reduced vehicle use and promoting public transport.

- Pay-How-You-Drive (PHYD): Premiums are determined by driving behavior, encouraging safe driving practices through monitoring and feedback.

- Manage-How-You-Drive (MHYD): Insurance adjustments are made based on real-time driving data, offering personalized risk assessments and rewards for safe habits.

To sum up, UBI premiums are charged based on the miles driven by the driver or the driving behavior of the driver. Therefore, UBI not only helps buyers save more money than buying regular car insurance, but also effectively reduces the traffic flow in the inner city and decreases the probability of traffic accidents. According to Innovative insurance schemes: pay as/how you drive [5]. Dimitrios I. Tselentis et al. contended that PAYD can enable each household to reduce up to \$ 270 per vehicle insurance contributions to be paid. It is said that if drivers were charged per kilometer, they would have an extra incentive to drive less. They also consider that the reduction of vehicle would be around 8%, a figure which is equivalent to \$50-60 million due to reduced harmful effects on driving. The above reduction would also reduce carbon dioxide emissions by 2% and oil consumption by about 4%. Nichols and Kockelman (2014) showed that the average vehicle will be driven less by 2.7% (237 mileage reduction per year). Despite of saving money for the consumers, undern this kind of brand-new insurance system, the rate of traffic accidents can be effectively reduced. Since each car removed from traffic reduces both its opportunities of causing an accident and of being the target of a crash caused by another vehicle, as a result, the rate of multi-vehicle accidents is also decreased [6]. Also, many authors such as Edlin, Ferreira and Minikel found out that the mileage driven and risk of having accidents are positively correlated.

3.3 Consequences

UBI is beneficial to consumers of the insurance since it aids to save money for the users, while it also achieves lower car accident rate and guarantees a safer daily driving for all of the users. In term of urban mobility, the number of vehicles is reduced from the traffic since people are willing to spend less money on the premium of UBI, which means that the condition of traffic congestions would be greatly improved. People are provided more convenience to access to various places of cities. Also, since users keep their driving behavior appropriate, an improvement in urban mobility can be witnessed. On the other hand, the usage of public transportation would increase since users of UBI are motivated to drive less of their cars by the

lower premiums. As an alternative choice, people would choose to take more public transports.

4 Autonomous Cars (AC)

4.1 Definition

Autonomous cars, or self-driving vehicles, represent a paradigm shift in personal and public transportation. These vehicles utilize advanced artificial intelligence, machine learning, and sensor technologies to navigate complex environments with minimal human intervention. Recent advancements have enabled autonomous vehicles to perform various driving tasks, including lane-keeping, adaptive cruising, and automated parking. Companies like Tesla, Waymo, and Uber are at the forefront of developing and testing self-driving technologies, aiming to make them safe, reliable, and accessible.

4.2 Capabilities

An article titled Understanding autonomous vehicles: A systematic literature review on capability, impact, planning and policy. from Asif Faisal et al. mentions that the autonomous vehicles are supposed to be both operational privately and commercially [7]. Also, they pointed out several benefits and flexibility of the private AC compared to the original private vehicles: For example, the ACs are available for every member in a whole family at the same time. Furthermore, they also maintained that commercial ACs are expected to be operated as taxi, buses and cargo services. In this case, self-driving technology is likely to act as an update and replacement of these regular vehicle services. The authors also contended that the mobility of people is regarded to be safer, more sustainable and convenient nowadays, since human driver will be totally replaced for all driving tasks in some or all roadway and environmental conditions. In this case, the ACs will have the capability to perform 5 fundamental functions—localization, perception, planning, control, and management.

4.3 Impacts

The full automation of automobiles has had a major impact on traffic safety. It has been reported that speeding, distracted driving and other human factors account for 93% of all crashes [8]. When automated driving is widely used, a large portion of these crashes can be addressed at the root cause. And autonomous driving also means more comprehensive, smarter driving technology. As a result, traffic congestion can be avoided directly through better fleet management [9]. Reducing traffic congestion will benefit not only self-driving car drivers but also other drivers. While a significant increase in the number of self-driving car users may exacerbate traffic congestion, traffic conditions could also be improved by optimizing vehicle operations and reducing collisions and delays. At the same time, the spread of autonomous driving

could also put in place improvements in everyone's ability to get around, enabling differently-abled people to use transportation and increase their independence. For example, the blind, people with disabilities and people who are too young to travel can have their independence, social connections and life experience enhanced [10]. However, not all of the masses have full faith in self-driving cars. The Guardian has reported on a number of crashes caused by self-driving cars due to malfunctions or errors in the system's judgment. These accidents have caused some people to remain distrustful, critical or even pessimistic towards ACs or AI. As a result, many people are still tending to drive their own cars in familiar ways, even though the human factor is responsible for 93 percent of car accidents.

4.4 Consequences

Self-driving cars have come into the public eye along with many emerging technologies of artificial intelligence. With the aid of such intelligent research and development, more people are eligible and capable of using cars as a mode of transportation independently. Also, lower accident rates give people more confidence to move around the city. As a result, people's mobility in the city is greatly enhanced. On the other hand, the proliferation of self-driving cars will reduce the need for public transportation. More people are willing to rely on technology in order to achieve a higher level of quality of life. As a result, traditional public transportation is more likely to be forgone.

5 Conclusion

According to the contexts mentioned above, the three samples of innovative transportation technology have their own influences on urban mobility and public transportation system respectively. In conclusion, the integration of emerging transportation technologies such as Low Traffic Neighborhoods (LTNs), the Internet of Vehicles (IoV), and Autonomous Cars (AC) presents both opportunities and challenges for urban mobility and public transportation systems. LTNs have shown potential in improving air quality and reducing traffic flow, though they have also sparked significant public opposition due to perceived restrictions on personal freedom and mobility. The IoV, particularly through innovations like Usage-Based Insurance (UBI), offers a promising way to incentivize reduced vehicle use and enhance traffic safety, contributing to more sustainable urban environments. Autonomous Cars, while still in development, promise to revolutionize personal and public transportation by improving safety and accessibility, though concerns about their reliability and impact on traditional public transport persist.

Overall, these technologies are reshaping urban mobility in complex ways, requiring careful consideration of their broader social, economic, and environmental impacts. As cities continue to evolve, it is crucial to balance technological advancements with the needs and concerns of the population to ensure a more sustainable and inclusive urban future.

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