

Future Studies of Urban Transportation: A Qualitative Perspective on the Future Image of Transportation Systems

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Abstract

This paper deals with future studies of urban transportation, emphasizing its qualitative aspects. Consideration will be given to the significant developments and transformations of technology and information networks in the cities and their impacts on the urban transportation modes, including subway, bus, taxi, walking, and cycling. In the context of future studies, the digital landscape and the concepts of smart and virtual cities will be discussed. Also, the key factors and effective elements contributing to the formulation and processing scenarios for each sector will be explained. Additionally, the upcoming challenges and obstacles will be scrutinized in more detail. Finally, based on the key findings, four strategies should be adopted in urban transportation, including but not limited to the development of human-centered transportation, increasing the use of smart transportation, expansion of public transportation, and development of information technology and electronic communication systems to establish new modes of transportation in line with the other developments of human societies.

Keywords: Future Studies, Intra-City Transportation, Transportation Systems, Advanced Technologies, Smart Cities, Strategy, Servicing, Electrification and Automation

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1. Introduction

Innovations in information and communication technologies and their application in the mass production and consumption of intelligent and automatic public vehicles will transform the transportation and human mobility in the future cities. This meta-informational reform would lead to the integrated travel without severely impacting the intra-city transportation planning. Through smart systems and applications installed in the self-driving public vehicles, online information will be transferred to the users continuously so that the citizens' mental perceptions will shift towards a centralized transfer experience, resulting in a significant reduction in the waiting time. Due to the rapid changes in the transportation sector, the future of public transportation is unclear. The history of transportation and public transportation is directly connected to the technological advancements and economic and governance trends, all of which are currently working. The Transportation Network Companies (TNCs) that provide shared rides and the eventual introduction of automated vehicles have the potential to significantly transform the private travel, particularly in the urban areas, and public transit. Automated vehicles could lower the travel expenses for those who desire to have the car, and pick up and drop off other passengers on their way to their destination. Therefore, it is timely and important to discuss the future of public transportation and put the stakeholders in a position, so that they could help to shape that future [Polzin, 2018].

Enoch (2019) initiated a future-gazing project to explore how people might travel in the year 2045 and foresee the future of the urban transportation system. He explained that the level of automation and urban density are the main dimensions to assess the future of urban transportation systems (Figure 1). As a result, four scenarios explain the future of urban local transportation systems, including high-density urban areas with partial automation, high-

density urban areas with full automation, low-density urban areas with partial automation, and low-density urban areas with full automation.

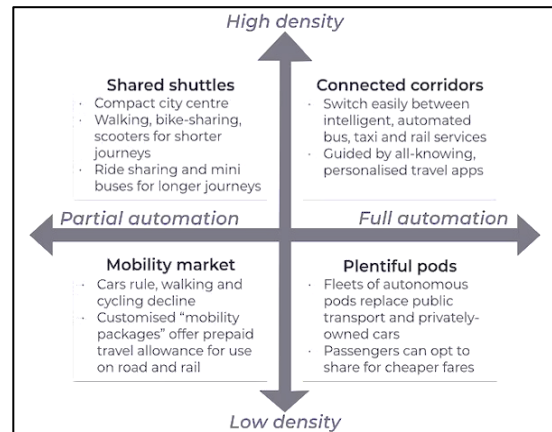


Figure 1. Four possible futures for public transportation [Enoch, 2019]

In Figure 1, the first axis considered automation –on the one hand, vehicles are still being driven, much like today (partial automation). On the other hand, they're driverless (full automation). The second axis is related to how dense cities could become –a future where the population is more dispersed (like Los Angeles) and the other, where it is concentrated at a higher density (more like Hong Kong). With these axes in mind, Enoch envisioned four possible futures for the public transportation, which could be implemented in the cities worldwide.

Transportation is an important part of the urbanization worldwide. It is crucial to develop sustainable transportation systems to have multiple developments and avoid linear developments. As a matter of fact, sustainable urban transportation plans aim to admit the mobility needed for the different sectors, improve the quality of life, and create interconnected transportation systems that integrate the infrastructure, services, information, and economic methods based on productivity and efficiency. However, sustainable transportation methods should include infrastructure, vehicles, and exploitation, and stakeholder participation is a fundamental principle in sustainable transportation planning.

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Studies on various modes of transportation integrated with social justice and the use of technology are essential to configuring the future of transportation systems.

The main purpose of this paper is to plan the future evolution of urban transportation systems with an emphasis on technology. The dominant research model is divided into several parts according to the type of system. The first part states the principles and foundations of future research on intra-city transportation. The authors tried to describe them to the readers as a new approach. The following sections discuss the future of the railways, taxi, and bus systems, respectively. Throughout their discussion, the rapid developments in providing better services in the cities of the world with the aim of a better life in the technological-digital world are mentioned. Finally, the challenges, obstacles, and inhibiting factors that exist in setting up the transportation systems for tomorrow's cities are briefly introduced.

2. Methodology

When conducting any future study project, one should first look for suitable answers to the following questions and then choose the method:

- 1- What kind of information is necessary to achieve a goal? (For example, trend analysis is very suitable for determining the information in a specific field).
- 2- Are the methods compatible with the thought and culture of the society? (For example, do people spend the necessary time to answer Delphi questionnaires?)
- 3- Who are the relevant specialists, and how is their knowledge obtained? (Can small specialized groups be formed easily with a brainstorming method?)
- 4- What is the ability to influence the next plans? (For example, a communication network can be formed among people using the Delphi method.)

Considering the general view of this paper and not focusing on a specific case study, this study

aimed to explain transportation systems and their future by relying on the document-library studies. Emphasizing the future researches and its various methods, a qualitative approach has been taken into consideration. Furthermore, identifying, classifying, and extracting the concepts based on the study of texts forms the main structure of this research. Therefore, it is a qualitative study.

3. Foundation of Future Studies on Intra-City Transportation

Future studies enable the decision-makers and urban transportation planners to think beyond the frameworks and constraints and consider a wider range of possible future events. Since many issues and aspects of transportation are multidimensional, and their change process does not follow a linear and specific pattern, relying solely on the quantitative and statistical studies or point predictions is ineffective for investigating and planning. As a result, more advanced methods and tools are necessary to investigate the trends in the transportation developments.

These methods or tools should help the managers and planners to gather as much information as possible on the future trends in the influential components or issues which are raised. They should also properly recognize the existing or emerging trends on the various aspects of transportation. Furthermore, these tools should enable the development of comprehensive, realistic, and adaptable applications that fit the urban culture and have the capabilities of the modern world. Future studies that optimally interact with the living quasi-organisms known as transportation provide an appropriate response to the needs of the urban transportation sector.

Future studies enable the transportation planners to anticipate the future and avoid passive conditions by expanding their horizon of vision and thought. It also helps them to identify changes in the patterns at the early

stages of planning and targeting the transportation and devise the sustainable solutions accordingly. The transportation managers and planners can act with a scientific understanding of the development process in various fields. Getting help from the future studies, they can plan and formulate the appropriate scenarios for the intelligent intervention in building a desirable future, which is the ultimate goal of transportation management.

It also helps the decision-making managers of transportation in the cities to develop the new skills to face the declining role of the traditional value systems with a sense of responsibility, understanding, and more attention to the rapid changes. They could identify the points of change in the technologies and management patterns of this sector and design a suitable structure for implementing more informed and prudent policies when facing the complex new challenges.

Huge revolutions in the last few decades have dramatically changed the traditional ways, especially in the domain of communication leading to the creation of a completely new culture, with changes in the language and behavior. As a result, new players enter the transportation sector and consumers are more interested in their transportation options.

Internet and cell phones have changed the way we live, leading to the rapid development of assistive technologies such as fast switching, mobile broadband, widespread use of smartphone, self-healing distributed wireless and mobile networks, proximity and location technologies, nanotechnologies, and motion control, mobile and minuscule power supplies, new user interfaces and experiences. These innovations are gradually penetrating the urban transportation, and future research can help the transportation managers and planners to be prepared for these changes [Greene, et al. 2022].

The lack of access to transportation hampers people's ability to fully participate in our

society. Canitez (2018) emphasized the importance of transportation as a human rights issue. He stated that discrimination against the non-drivers was tolerated more than discrimination against other marginalized groups, such as people with disabilities or sexual minorities.

The intra-city transportation has been divided into two private/ individual and public categories. Private transportation, usually known as passenger cars, is an important aspect of the intra-city transportation planning. Future research on this domain should focus on the type and frequency of use, technology, energy consumption, safety, and cost-effectiveness. The use of private cars is influenced by the culture of urban society and the availability of public transportation. Promoting less use of the private cars has become a priority in recent years due to the environmental concerns, air pollution, and traffic issues.

Moreover, the studies on the private cars as one component of the intra-city transportation have addressed the-competition of car manufacturers in the era of globalization. Car manufacturers aim to build more adaptive and technologically advanced vehicles to reduce the traffic, increase the clean fuel use, and implement smart and digital systems. Therefore, one of the most important aspects of the intra-city transportation is its interdisciplinary nature, which includes the advanced technologies and individual and social characteristics in cities.

Public transport systems are critical to the mobility and development of urban communities, as they facilitate the daily movement and transportation among places of residence and work, as well as other activities [Bierstadt et al, 2014]. The urban public transport (UPT) systems have a significant role in reducing traffic congestion, providing alternative means of transportation to reduce the reliance on automobiles, and promoting sustainability for the overall quality of urban life [Boccaletti, Bianconi and Criado, 2014].

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Figure 2 shows the main transportation activists in the UPT systems:

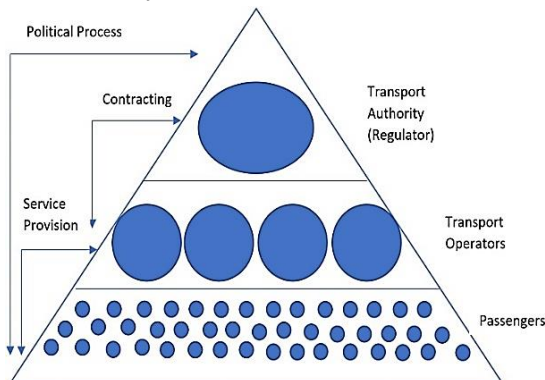


Figure 2. Main transportation activists in the UPT systems [Canitez, 2018]

UPT systems are complex and multidimensional, including the social, economic, political, technological, and organizational aspects. The role of institutions plays a crucial role in shaping the governance models that are chosen for the UPT. The institutional structure of the UPT systems includes both informal elements, such as habits, traditions, customs, and norms, and formal components, such as laws, property rights, and regulations [Williamson, 2000]. Effective policies and strategies require a comprehensive examination of the relationships between these aspects and the actors involved in the system, including the government, operators, and passengers.

As a transportation regulator, the government has a supervisory role in managing the intra-city transportation systems while the executive agencies provide services to the passengers. The interdependence of actors who provide transportation services requires an institutional framework that clearly defines the roles, interests, and actions in intra-city transportation and avoids using inappropriate models and patterns. The governance structures, contractual practices, and support methods are among the organizational issues in urban transportation management that directly affect the performance of UPT systems and future studies.

In developing countries and urban areas where rapid urban growth and the resulting transportation problems are common, a weak institutional environment makes it necessary to consider the institutions in the UPT analysis [Canitez, 2018]. The urban transportation phenomena, such as travel behavior, transport demand, and investment decisions could be effectively explained by aggregating the behavior of transportation actors. [Schwanen, et al. 2012]. Figure (3) displays the institutional levels in the UPT based on the related theories.

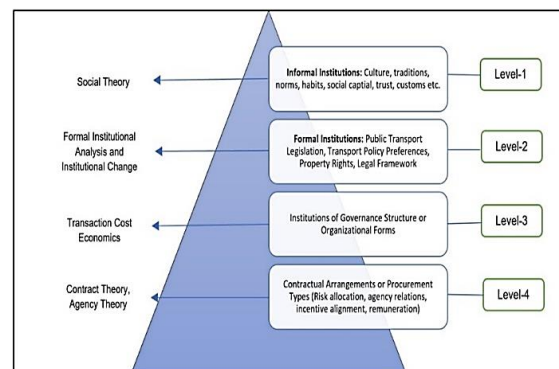


Figure 3. Institutional levels in the UPT [Williamson, 1998]

Many researchers in the domain of urban transportation management and organization consider the institutional framework to be a decisive factor in the future of intra-city transportation. Urban (public) transportation is the basis of integrated development to access service centers on the various social, cultural, economic, administrative, medical, and judicial domains. Therefore, building a favorable future for the citizens' comfort is very important, and future studies, as a relatively new science, prepare practical scenarios related to modern intra-city transportation using new methods and provide them to urban decision-makers and managers.

Considering the institutional framework and the key objective of foundations for intra-city transportation, technologies such as Urban Air Mobility (UAM), Automated Vehicles (AVs) and Unmanned Aircraft Systems (UAS) are expected to change the way people travel and

how businesses operate in all sectors in the near future.

In addition to vehicle-based travel, the advanced communication technology has already had a significant impact on the cities. New urban mobility services will continue to emerge and integrate, including the innovative ride-hailing and ride-sharing applications, as can be seen in Figure (4). The key principle of mobility operations for a smart city will be to optimize mobility connectivity, achieving seamless and efficient transportation for its residents.

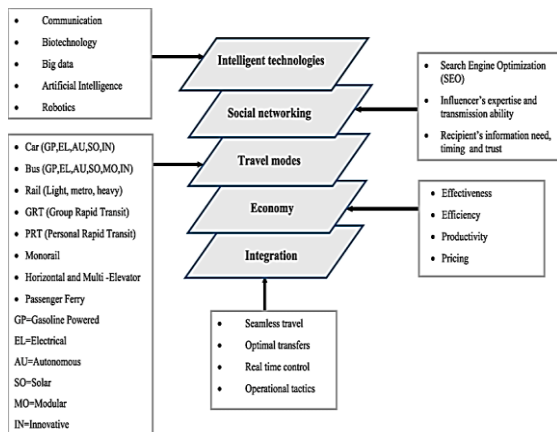


Figure 4. Five layers of elements essential for having an impact on the future urban transportation [Ceder, 2020]

Future studies have highlighted the potential of intelligent transportation systems, including ITS and AV technologies, to significantly improve the efficiency and service level of existing transportation systems [Ceder, 2020]. In recent years these advanced technologies have been used to improve the safety, efficiency, and reliability of transportation systems, providing great opportunities for future transportation studies. Scenario planning is a fundamental method that can be used for intra-city transportation planning for the public and private sectors, using ITS data to create a comprehensive database that considers intra-city transportation performance and demand patterns.

By exploring and normalizing the intra-city transportation systems, future studies can shape

the future generation of urban transportation systems and their impact on the daily life by considering the key technological factors such as social networks, biotechnology, nanotechnology, robotics, artificial intelligence, and electric and solar vehicles.

These studies can open a new research path for the optimization models in urban transportation, including the socio-cultural, economic, and environmental features in the city as a specific spatial territory and the visualization of information production and digital systems in the transportation. They can also consider the nature of quantitative and qualitative data and path-selection behaviors.

Future studies can help transportation managers to examine transportation problems more comprehensively by integrating planning based on fixed perspectives, benefiting from the consensus and consultation of experts inside and outside their group, and continuous and up-to-date city management. They can pay attention to the future and what the result of today's actions would be, and they can develop a culture of hope for the future by depicting the desirable futures in the cities and having comprehensive participation in their programs.

3.1. Foundation of Future Studies on Intra-City Transportation

Nowadays, metro systems have grown in popularity around the world, and the first metro line was built in London in 1860. Metro systems are now used in more than 200 cities in 56 countries. They are preferred in cities with heavy traffic due to their reliability, speed, and high passenger capacity. A well-designed and managed metro system can also contribute to the long-term sustainable growth of the city. As a result, several second-tier cities are considering building their first metro system, while major cities like London, New York, Tokyo, and Beijing are planning to expand their existing metro systems [Lu, et al. 2016; Bao, 2018].

Some studies consider all the relevant factors when considering the effects of the urban metro,

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and it seems that in this step, they seek to achieve at least three main goals: a) strengthening and improving the transportation network using technologies; b) noticeable reduction in traffic volume and c) saving time. In the study of the city's future metro, its ability to change the distribution of nodes in the inner city road network, the level of vulnerability of the transportation network, and its topology are all important considerations.

The normal complex network method, which treats all transportation links as the same, often leads to incorrect results because it is insufficient to entirely understand the connections among the networks using different transportation methods. The intra-city transportation networks cannot be reduced to a layer of nodes and links. Therefore, the recent advances in the multilayer networks theory have made the transportation networks the prime candidates for this strategy [Kurant, et al. 2007; Buldyrev, et al. 2010; Boccaletti, et al. 2014]. By incorporating the layered interactions, the multilayer networks provide a strong theoretical framework for understanding the interdependence of the transportation networks [Rodrigue, 2020]. Due to the increasing urbanization and the physical expansion of cities, transportation networks such as the metro and subway have become more important than ever. Locating the railway lines in the cities along with the protection of infrastructures and using the latest technologies for smartening the underground transportation systems will change the appearance of the cities, and future studies will seek to realize these utopias of tomorrow with scientific planning and investment.

Paying attention to the interaction between socio-economic relations and exchanges is necessary. This is used to highlight the importance of metro and to activate its role in the future urban plans. In the future scenarios of the urban metro, it is considered as a means of social communication –given the alarming

growth of individualism - and industry, energy, and road links.

Future studies seek to develop planning strategies and approaches for transportation systems equipped with advanced technologies. Also, they try to prepare the fundamental solutions in the form of a scenario, and achieve a desirable future for public transportation and for the transportation issues, congestion, and waste of time and energy in the daily trips. These scenarios are derived from the drivers and key factors in the performance of the metro system and turning it into the most efficient system. Future studies will evaluate the future performance of the mass transportation system in terms of ease, speed, safety, and timely transportation of urban residents. Urban areas provide various options for transporting people and goods, including walking and cycling on internal roads and using urban highways, metro, and regional railway networks. Based on the previous studies, there are several classifications of public transportation systems. Future studies of the metro system in cities show its importance in solving the future problems of public transportation as the most flexible transportation system. This flexibility should be sought in the metro's advantages, such as speed, high safety, capacity, low operating cost, and longer hours of service. Undoubtedly, the metro systems will be one of the most attractive means of intra-city transportation in the future, especially in terms of saving time.

Given the importance of metro systems, which are considered as one of the pillars of development in the cities and the primary driver of domestic travel and activities in urban transportation planning, and given the effort to review the existing public transportation networks and systems in the cities as an important step to extract the key factors and continuous evaluation and ensuring the stability and performance of the mentioned system with the increase in the urban population, in the coming years we will see the massive traffic on

the roads; however, we can make sure that the current roads cannot withstand that traffic.

Due to its high capacity and high energy efficiency, the railway can be the best option to carry this traffic. Therefore, the creativity of engineers has led to several alternatives to the old railway method, the most important of which are Maglev and Hyperloop. Magnetic levitation, or maglev, uses magnetic power to keep the train suspended on the rails. These rails are designed to be as straight as possible. The force of attraction between the electromagnets in the vehicle and the ferromagnetic rails lifts the vehicle, while the other electromagnets hold and guide the train on the rails. This technology model was designed in Germany and is currently used to connect Shanghai Airport to the city center at the speed of 430 km/h hour [Qadir, et al. 2021].

However, Japan is the largest user of Maglev and is focused more on its expansion and development [Sakamoto, et al. 1997]. Moreover, for centuries, superconducting magnetic levitation technology has been of interest to engineers, and it has recently been granted permission to use this technology between the two cities of Osaka and Tokyo from 2027 [Zhao and Shen, 2019]. This train travels 500 kilometers in one hour between these two cities. Unlike the Shanghai system, the technology used in these rails uses stronger superconducting magnets and a guidance system based on the repulsive forces.

While Maglev is technically feasible, its commercial utility is uncertain due to the high initial cost of building such lines. For example, the system used in Japan costs the government more than 72 billion dollars [Chi and Li, 2017; Zhao and Shen, 2019]. Furthermore, its disadvantages include the lack of connectivity between the existing and new rail lines and high energy consumption during construction and travel. These drawbacks have raised many concerns among engineers and policymakers about the transportability of Maglev.

Hyperloop is a fascinating concept as it allows you to travel inside the containers at the speed of 1,220 km/h. This conceptual design consists of a tube with a small void created underneath. An electric compressor fan at the opening of these chambers continuously pushes the high-pressure air from front to back. When the linear motor is started using this method, a layer of air is created under the chamber. Batteries and solar energy will fully power this system. Hyperloop is intended to connect Los Angeles to San Francisco and it can also connect cities hundreds of kilometers apart. Of course, this plan cannot be implemented in all parts of the world due to the need for a flat surface. Of course, it should be noted that if the hyperloop systems come true, they will be independent of the railways.

Another type of rail transportation is Cable Propelled Transit (CPT). It is a transportation technology that uses steel cables to transport people and goods in the non-motorized vehicles and cabins [Tischler and Mailer, 2019]. Their operating system (as shown in the Fig. 5) operates in two modes "reversible" and "sequential and continuous" [Perschon, 2011].

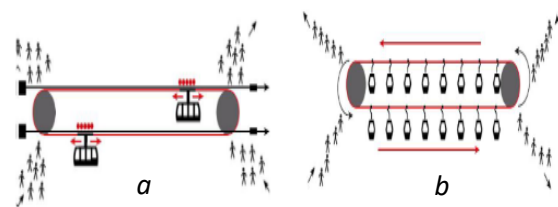


Figure 5. Operating systems of CPT: a) reversible, b) sequential and continuous [Perschon, 2011]

The advanced cable transportation systems are easily adapted to the urban environment and they are the most popular method of transportation among the tourists in the cities. Medellin, Caracas, Rio de Janeiro, Portland and New York (America), Singapore and Hong Kong (Asia), London, Bolzano, Koblenz (Europe), Constantine, Skikeda, and Tlemcen (Africa) are the most famous cable transportation systems that are used today with the first options for the future development with

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the new technology [JACOBS, et al. 2016; Oxfam, 2021].

Their main quality features include comfort, low noise, less waiting time, and reliability. It should also be noted that it can be used by pedestrians, disabled people, and even cyclists. The future of this type of transportation system based on the technical characteristics and urban spaces is aimed at its faster implementation which results in significant time savings. This system is driverless with low maintenance and repair costs.

Tram is another type of rail transportation system. The tram moves on the street rails and can be both intra-city and inter-city. This system is usually lighter and shorter than the regular trains and metros and it works by pantograph. Considering the experiences of different countries, including Turkey and America, the tram can be considered "light rail transportation [Cao, 2019]. With a medium displacement capacity and more than a century of development, transformation, and evolution, light rail transportation is still one of the most advanced and successful public transportation technologies of today and the future of the world's cities. The light rail transportation trains are shorter than the metro trains, and constructing a dedicated track separate from the traffic flow is optional. Light rail transport wagons move easily in the twists and turns of the track, and there is no need for signaling and train monitoring systems.

In short, along with population growth and the development of urban areas and regions, urban areas face complications such as reduced ease of access, longer travel time, air pollution, wear and tear of vehicles and roads, congestion, etc. Therefore, the use of public transportation systems has become increasingly important. Considering the mentioned complications and the necessity of ease of access and the use of appropriate, useful, and safe vehicles for intra-city and inter-city traffic, it is necessary to use fast, efficient, and high-capacity public transportation. Transportation system and

network structure of each city provide a specific ceiling for all types of travel traffic, especially in its central area at any given time.

The increase in the volume of facility users in the time range of excess capacity brings consequences such as increased delay time, poor performance and inefficiency of the vehicle, increase in accidents and violations, noise, and air pollution. Every year, the aforementioned consequences cause significant financial and life losses for the citizens. Finally, one should rely on the urban railway, which has proven its speed and efficiency over time. Of course, the economic and cultural benefits should also be considered when evaluating the benefits of using urban railways. The experiences of the cities' rail transportation systems show that the urban railway has left many benefits in the daily life of the citizens, which include:

- Increasing the speed of movement and safe traffic;
- Avoiding traffic jams;
- Saving fuel consumption and reducing air pollution;
- Reducing the number of accidents;
- Contributing to the economic growth and sustainable development;
- Reducing tensions and stresses caused by traffic;
- Increasing the possibility of moving people and, as a result, the possibility of access to remote urban areas;
- Attention to the environmental issues;
- Eliminating the additional costs of widening the roads.

3.2. Future Studies of Bus System in the City Transportation

For decades, public buses have had a constant transportation landscape. Today, most bus services operate as they did in the early 1900s. They work on fixed timetables and routes based on the 'just in case principle.' In other words, the informal contract between the bus and the rest of the world still exclaims, "I'll do this route at

this time, only if you need me." This approach was absolutely necessary before mobile phones and instant communications - it was the only practical option. The just-in-case model has effectively instilled the notion that bus services should strive for strict predictability. Passengers get good service if the bus runs within its timetable [Liftango, 2021].

One of the most effective ways to prevent the climate crisis is using public transportation instead of driving. To encourage its use, we should ensure that every urban resident has access to safe, affordable, and frequent public transportation within a 10-minute walk of their home [C40-Cities, 2022]. Mobility is steadily increasing in the urban areas and along the busy corridors. At the same time, the demand in the suburbs and the low-density regions has decreased. Transparent decision-making is needed to deal with these developments as effectively as possible [Government of the Netherlands, 2019].

There are many types of bus transportation systems, including road/rail systems (such as electric trolley systems). Also, there are several types of dedicated rail systems, such as subways. The three basic types of road bus systems are:

- Buses that work in the general traffic without priority,
- Buses with limited priority, such as bus lanes and traffic signals.
- Buses that work on the dedicated infrastructure, such as bus routes, with minimal interaction with the general road traffic [IEA, 2002].

Emphasis on future studies of the intra-city bus system would encourage personal vehicle use. According to this view, implementing an advanced pedestrian BRT system for cities may require keeping the road space away from other vehicles. Even if the BRT line is given more road space, it will improve the traffic flow. Two points should be considered: a) the departure of buses from the crowded areas and b) increasing the bus speed.

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Based on the strategies obtained from the future research scenarios, these two factors are critical for several reasons:

1. Providing improved services, including applied and digital technologies, and thus encouraging the passengers to use the bus more;
2. Increasing the income for the public institutions;
3. Aerobus system and turning it into a multipurpose vehicle, especially with transportation and tourism functions;
4. Being cost-effective.

The approach of future studies for the intra-city bus system includes a special approach to the different technologies and propulsion systems which could make an important contribution to saving energy and improving air quality through the use of alternative fuels such as clean diesel, green fuel, and also reducing harmful gases' emission such as carbon dioxide. Despite producing high pollutant emissions such as nitrogen oxides and particulate matter, diesel engines are popular worldwide for their fuel efficiency, excellent durability, and low maintenance requirements. With significant advances in engine technology, new diesel systems that could control pollutants have been developed for buses in recent years.

Future transportation studies, especially heavy vehicle systems such as buses, would pay more attention to the smart and digital engines whose primary fuel consumption would be electric energy, solar energy, and hybrid and green fuels. However, one of the most important challenges for the bus systems is that many of them in third-world and developing countries are old and have very poor maintenance and repair processes. Although proper maintenance of these buses' engines may be the most cost-effective way to reduce particulate matter, implementing such measures requires special regulations due to the bureaucracy that governs these countries. At the same time, even if the engines of the mentioned buses are healthy and do not produce any pollutants, compared to the

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volume of gases produced by the other cars, they cannot play a role in reducing pollution. As a result, special scenarios are critical for using the clean fuel.

Another significant aspect of the future of urban bus systems is the use of special technologies and the production of driverless buses that would be guided and routed using applications and artificial intelligence. Scenarios of the impact of driverless buses on future urban transport networks and their role in mobility, safety, urban environment, and economy are among the sensitive issues in future research on the intra-city bus system and policies.

The main operational basis of the urban bus system is public transportation, which shows users' desire for efficient and inclusive mobility. Passengers need to be able to move quickly and smoothly in their daily lives. The quality of life would be improved with the intra-city bus transportation system equipped with a smart network.

One of the key criteria is digitization and networking, both of which are needed for a new and advanced transportation system that seems to be oriented toward the user's needs. People prefer to use these buses instead of driving their cars because the smart and new system of urban buses, with an emphasis on driverless driving, is very attractive. Such an advanced system with special digital booking apps would be available for next-day use and easy and safe travel. However, there are challenges in using the advanced technologies for future buses.

Despite the high emission levels of pollutants such as nitrogen oxides and particulate matter, diesel engines are used worldwide for their fuel efficiency, durability, and low maintenance requirements. New diesel systems for buses that could control pollutants have been developed with the significant progress of engine technology in recent years. When envisioning urban bus transportation scenarios for future cities, remember that media and public interest in autonomous buses would be dominated by

the prospect of widespread deployment of highly automated, driverless vehicles.

The transportation network and intra-city bus are multifaceted structures that enable continuous movement in certain routes with high reliability and the most advanced smart systems and new technologies. They would play an important role in reducing traffic and pollution, and the polluting gases would also be involved. Policymakers, practitioners, urban planners, and managers should note that infrastructure and transportation systems such as smart buses would undeniably impact the quality and efficiency of the economy and the well-being of citizens in the future urban world, which would face the explosive growth of its population.

3.3. Future Research on the Taxi System in the Urban Transportation

Vehicle automation has accelerated rapidly over the past ten years due to technological advances. Autonomous vehicles (AVs), driverless or self-driving vehicles, are advanced vehicles that can navigate existing roads, routes, and environments without human assistance [Fagnant and Kockelman, 2013]. Fully autonomous vehicles are expected to provide significant benefits such as reducing traffic congestion, reducing car accidents, improving fuel efficiency, and reducing negative environmental impacts [Bierstadt, et al. 2014]. The adaptability of taxi services has contributed to their explosive growth and global industry adoption. However, the industry has been facing very difficult conditions recently. Due to the new technology and intense competition, traditional taxis have been forced to change their services to stay in business in urban mobility [Enel, 2021].

Vehicle automation has increased as a result of technological advancements. Taxis are commonly used as a supplement to public transportation in developing countries due to the inadequate public transportation systems that rely on buses or trains. These taxi services may offer shared rides or low-cost single-

passenger options for people with limited financial resources who do not have their own cars. In the developing countries, the taxi industry is often unregulated.

Future studies on the taxi system in transportation applications are based on the flexible activities of taxi vehicles on fixed routes and fixed schedules and responding to real-world demands to provide more attractive services to passengers/customers using new technologies. Since passengers may not have a choice, one possible scenario for urban taxis is to eliminate the operating costs of the scheduled services.

As mentioned earlier, unmanned taxi vehicles with remote control, equipped with artificial intelligence and a cashless payment system, will revolutionize the taxi industry in the near future, which can be seen as a transportation system in a meta-information city.

The emergence of these new transportation network companies (TNC) shows how working conditions may change significantly, forcing drivers to adapt their work practices accordingly [Zade and O'Neill, 2016]. The taxi industry is already under pressure from the gig economy models, such as the proliferation of transportation services facilitated by mobile technologies such as Uber or Lyft [Taschler, 2015]. As a result of digitization and automation, many industries have experienced fundamental and destructive changes; some products have become extinct, and thousands of jobs have been lost [Davidson and Spinoulas, 2015; Ford, 2015; Frey and Osborne, 2017].

Experts believe that shared autonomous vehicles have the potential to replace traditional taxis [Burns, 2013; Litman, 2022] because they provide the same service at a lower cost [Sakamoto et al. 1997]. While members of the taxi industry are confident that "the profession of taxi driver will not disappear, but will redefine itself" [Pakusch, 2020], future studies will seek this redefinition to provide better and more attractive services, taking into account the

possible consequences of job loss for the taxi drivers.

Three types of autonomous driving are currently at various development and testing stages: autonomous public transportation, private autonomous vehicles, and shared autonomous vehicles [Stevens, et al. 2016]. The first two changes describe the technological advances in the traditional modes of transportation. Integrating self-driving technology in self-driving buses, trains, and autonomous shuttle buses will expand public transportation options. SAVs, on the other hand, are the most radical of the three, representing not only a technological innovation through automation but also a social innovation through ride-sharing [Fagnant and Kockelman, 2014]. SAVs are fully autonomous vehicles that can be summoned via an application, travel to the user's location, and transport them to their destination without the need for the ownership or the responsibility of driving. This transportation mode is often called "driverless taxis" [Pakusch, et al. 2020]. However, one of the main points in this section is the concepts of ride-hailing, ride-sourcing, and taxi services. Taxi services provide individual, usually door-to-door service to the general public, mostly at a local level [International Road Transport Union, 2013]. They are the vital components of the multimodal public transportation system, especially in rural and urban areas.

Previously, taxi services were the main source of ride-hailing services [Remix Primer Series, 2021]. On the one hand, online transportation services now include hiring private drivers who transport passengers to their desired locations. Drivers employed by certain companies can benefit from the unlimited trips [Ryan, 2022]. On the other hand, ride-hailing negates some of the apparent benefits of reducing traffic and environmental impacts [Ecolane, 2022]. Also, ride-sourcing is a digital platform used by private car owners to provide on-demand door-to-door transportation services to users

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[Ashkrof, et al. 2020]. Ride-sharing services have changed travel patterns and will continue to influence urban mobility in the coming years. Despite the growing market for on-demand mobility, little empirical research has been conducted on the operational elements of ride-sourcing systems [Oh, et al. 2022].

Future research sees the era of the human worker as a transitional stage for the automated implementation of shared autonomous vehicles and services, especially taxis. This helps to better understand how future technology in autonomous vehicles will evolve, as well as how it may influence the urban environment and citizens. It also considers the city's economic and revenue-generating aspects by examining the technology of self-driving cars and the driving forces that undoubtedly affect it. Future studies have simulated the automated routing by anticipating the new and updated applications for ride-sharing services and driving in self-driving vehicles, as well as exploring all aspects and possibilities, including the safety and reliability of the unmanned and shared vehicles to facilitate innovative and efficient transportation in the future, regardless of the human role. The simulation of SAVs for the scenario writing considers the new concepts of mobility in public transportation as a suitable and responsive solution for future urban needs. Undoubtedly, traditional transportation systems will not be able to compete in the future and will be destroyed by the introduction of new technologies and automatic guidance systems for public passenger cars.

3.4. Future Research on the Obstacles to the Development of Intra-City Transportation

Urban transportation for future development, like many other components, faces challenges that apply to future transport development research, and these challenges are fraught with uncertainty. If decision-making is considered a system, the goal is to find the best option, and its components include the decision makers,

available options, and direct constraints in terms of the forces and drivers. Then, as the environment becomes unknown, the effects of the environment become more apparent because the system's behavior becomes more uncertain and uncertainty increases; however, as the environment opens up, the constraints are better known, and the options become more specific. As a result, the behavior of the system is determined.

Considering the major and challenging obstacles in the development and future study of urban transportation systems, it should be noted that with the continued dispersion of the cities and changes in the residential patterns, the cost of building and operating (intelligent) transportation systems will increase. Along with the urban expansion, there is more reliance on private cars, and in the dense parts of metropolises, due to the density and uses, modernization and smartening of the public transportation systems require very high costs that require investment. It may be difficult to make decisions based on the risks involved. Due to the increasing reliance of future cities on private cars and the decrease in demand for public transportation, the costs of public transportation network reconstruction must be compensable.

Because of the fierce competition between the automobile companies and the use of advanced technologies that provide various advantages to private cars, the demand and willingness of citizens to use cars is increasing, and this issue will question the economic importance of public transportation in the coming years due to the increase in costs and payment of heavy subsidies. As a result, future studies for the development of intra-city transportation (especially public transportation) are faced with a paradox that, on the one hand, makes the use of advanced and attractive public transportation technologies inevitable in today's digital age, and, on the other hand, with the increase in population and the physical expansion of cities, the volume of car use will increase

significantly. The evidence shows that the car will be the first means of transportation in the future.

Although public transport serves and aims to provide services to all citizens and has undeniable advantages from various perspectives, two factors are important and highly influential on decision-making: 1) political motivations and 2) competition. Although public transportation typically belongs to the government, the service provision is politically motivated and provides limited economic returns. Even though private companies run the transportation systems, they heavily depend on government subsidies, even in advanced capitalist economies such as the United States and Canada, where most cities are based on a transit-oriented approach and private cars and reflect the legacy of the Fordism movement. As a result, the lack of competition in the public transportation system hampers service delivery and detracts from its primary goal of equal access for all.

There are many challenges in the development and future of urban transportation. Public transportation systems are not designed to serve the sparsely populated urban areas. As urban activities become more decentralized, public transportation becomes more difficult and costly. Metros, trams, and railways are fixed infrastructure systems that, despite technological advances, lag behind the cities as dynamic entities in terms of speed, facilities, and safety. In other words, as cities undergo spatial transformation, travel patterns with such transportation systems must be updated or become obsolete. In the last two decades, with the expansion of the airport network and providing significant benefits on the one hand, as well as the expansion of special urban and intercity highways and providing facilities for private car owners on the other hand, the use of railways in Turkey has reached their lowest level and the railway station in cities like Istanbul is on the verge of permanent closure.

Public transportation systems are often not connected to the terminals or the other modes of transportation. This makes it difficult to transfer passengers from one system to another. As a result, passengers' desire for direct communication and demand for a cost-effective service network become incompatible. As mentioned earlier, competition car companies make cheap, and public road transportation systems face fierce competition, and they are likely to fail in the future despite technological advances. This competition includes convenience, reliance on the car, and construction and maintenance costs.

Railway systems are always expensive to build, operate, and maintain, depending on factors such as regulations and congestion. Also, the construction companies, consulting companies, and labor unions cannot be ignored as the stakeholders of these systems. However, far from being inadequately monitored, even these stakeholders seek higher rents under the pretext of improving public transportation infrastructure, especially underground networks such as metros. The construction and development of the metro require more financial and human resources and thus will benefit more people, which contradicts the trend of increasing reliance on private cars.

In recent decades, public transportation systems have replaced distance-based fares with fixed-fare systems, decreasing the volume of trips, especially short trips, accompanied by user dissatisfaction. Information systems are considered forward-looking in future research and planning in general because they allow transportation systems to return to the fair condition of determining fares (such as smart cards).

However, more costs are spent on the public system due to the change in the consumption pattern and the fierce and unequal competition between private car manufacturers and public vehicles. At the same time, this system does not perform properly due to the everyday conditions. Conditions such as labor demands

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sometimes lead to widespread strikes and are associated with work defects.

Subsidies are often used to repay past debts, and in practice, little financial credit has been left to improve the performance or develop the infrastructure. Based on a forward-looking approach that extracts and processes the drivers, uncertainties, and key factors to formulate the scenarios, public transportation agencies are forced to reassess their budgets through an unfavorable combination of higher fares, payment arrears, and termination of employment contracts.

From the point of view of future studies, the urban public transportation systems face another development challenge. Increased fluctuations in energy prices (fossil fuels such as oil and petroleum derivatives) create uncertainty in the operating costs (the property and transportation fleet) and the replacement of new energies such as electricity or LNG. Another critical aspect of this issue is the cultural aspect. Except for the younger generation, marginalization and the desire to live outside the city are increasing. As a result, the use of cars will increase in the future, accompanied by significant technological advances, including non-fossil fuel. The inflation-adjusted costs of public transportation are also increasing, which will further limit their competitive advantage in the future. In such a situation, the fate of many public transportation systems is uncertain.

4. Conclusion

From the perspective of future studies, the problem of efficient planning for developing urban transportation systems, considering the operational limitations, financial resources, diversity of demand, and consumption patterns, cannot be solved absolutely. Therefore, based on scenarios and the ultimate goal, i.e., creating the future ideally, it considers four phases separately, which are distinct: strategic, tactical, operational, and real-time. Scenarios for the strategic level consider network design (for all

transport systems) and users as part of a long-term planning process. At the tactical level, attention is paid to determining the operational characteristics of services, such as time schedules and frequencies. At the operational level, timing is important, and attention is paid to the utilization, productivity, and stages of updating the system. Finally, real-time, which deals with daily events and developments and also analyzes the spatial structure while referring to management strategies (such as control and monitoring).

This paper discussed different public transportation types, such as trains, buses, and taxis. The basics of the future of public transportation and its major obstacles were explained in a general and comprehensive manner. The development of railways will significantly impact the lives of citizens, reducing time and energy consumption, injuries caused by traffic accidents, and depreciation of personal vehicles. The railway is one dynamic system that contributes to sustainable development in big cities. As for the buses of the future, tech companies and startups are looking for ways to drive those using technologies like artificial intelligence and electricity that will reduce air pollution as well as the volume of urban traffic. At the same time, saving time and speed of arrival are important considerations.

In recent years, many talented designers from around the world have come up with interesting ideas about the future taxis and how they will move around the cities, some of which have stood out for their distinctive features. The taxis of the future will include flying taxis that move around in the skies of the future cities and water taxis that move through waterways.

In relation to the key findings and the issue of strategies that can be a suitable auxiliary tool for urban planners and managers without sensitivity to the goals of more sustainable transportation in the future, the following are extracted from the studies:

- Strategy 1: Development of human-centered transportation;
- Strategy 2: Development and expansion of public transportation;
- Strategy 3: Developing and increasing the use of smart transportation;
- Strategy 4: Development of information technology and electronic communication systems to establish new ways of travel.

These strategies require key factors as well as uncertainties, and undoubtedly, all of them are important considering the type and method of city development and the values of human society. Due to the criticality of some uncertainties, the development of the city depends on policy-making at high management levels according to the type of perception and attitude towards the city, and in this step, the value of human society based on the growth of individualism, attention to social welfare and the quality of urban life is a key factor that should be applied in planning for future cities and their transportation systems and be able to turn the mentioned strategies into effective and practical scenarios. In parallel with technological advances, it will be the basis for more investments in sustainable and flexible public transportation systems.

Transportation is an essential part of modern life and is changing drastically as a result of technological advances. The future of transportation includes highly automated and driverless vehicles, reducing traffic congestion, traffic accidents, and negative environmental impacts. Automatic buses equipped with advanced intelligent systems and new technologies will play an important role in reducing traffic and pollution in the future world, and policymakers, practitioners, urban planners, and managers should be aware of its impact on the citizens' economy and well-being. With the rise of transportation network companies (TNCs) such as Uber and Lyft, the taxi industry has also undergone significant changes due to digitization and automation. In order to continue operating, traditional taxis

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must change their services, and shared autonomous vehicles (SAVs) have the potential to replace traditional taxis. However, there are concerns about how automation will affect taxi drivers' working conditions and future career opportunities. Future research will look for ways to provide better and more attractive taxi services while considering the potential and probable consequences of losing taxi drivers' jobs.

Currently, three types of autonomous driving are being developed and tested: autonomous public transportation, personal autonomous vehicles, and shared autonomous vehicles. Self-driving technology, such as self-driving buses, trains, and automated shuttle buses, is expanding public transportation options. Also, SAVs are fully automatic vehicles that can be called via an application, go to the user's location, and transfer to the desired destination without the need for ownership or responsibility of driving.

Ultimately, the future of transportation will be defined by highly automated and driverless vehicles, as well as the use of new technologies and advanced intelligent systems. Due to digitization and automation, the taxi industry will undergo significant changes, and shared autonomous vehicles have the potential to replace traditional taxis. Policymakers, stakeholders, and urban planners must consider how these changes affect the economy and well-being of the citizens. These strategies require key factors and uncertainties, and all of them are undeniable according to the type and method of the city's development and the values of human society.

Considering the criticality of some uncertainties, the city's development depends on policymaking at the high management levels based on the type of perception and attitude towards the city. In this step, the value of human society is based on the growth of individualism, attention to social welfare, and the quality of urban life. This is a key factor that should be used when planning for future cities and their

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transportation systems, and it should be able to turn the mentioned routes into opportunities.

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