

Mobility-as-a-Service: An Introduction

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ABSTRACT

Mobility-as-a-service (MaaS) is a term used to describe digital transport service platforms that allow users to access, pay for, and get real-time information on a variety of public and private transportation options. It refers to a concept where users can access various transportation options through a single digital platform. MaaS delivers a one-stop shop for all transportation needs by combining various modes of transportation, such as public transport, ridesharing, peer-to-peer rentals, and e-bikes/scooters into one unified platform. It is revolutionizing transportation by offering integrated, seamless, and user-centric mobility solutions. MaaS platforms leverage technology to integrate various modes of transportation, providing users with a comprehensive and convenient mobility experience. This paper provides an overview of mobility-as-a-service (MaaS), a consumer-centric model of people transportation.

KEYWORDS: *mobility-as-a-service, transportation, transportation industry*

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INTRODUCTION

The way we commute has evolved significantly over time. As the population has grown, so has the number of cars on the roads. With each passing day, we are witnessing more traffic, more congestion, and a lot of inconveniences while commuting. According to the United Nations, 68% of the world's population is predicted to live in urban areas by 2050. This poses a major challenge to those in charge of planning the transport infrastructure in cities and we are already seeing the devastating impact this has had on the environment as well as urban life. Public transportation has been looked at as a solution to many transportation problems we see today and has the potential to enhance mobility in cities. There is an urgent need for new modes of transportation that are not only sustainable but also allow citizens of cities to move around more freely, with more choices, improved safety, accessibility, and convenience.

What does the future of transportation look like? The answer lies in the concept of Mobility-as-a-Service (MaaS). Mobility-as-a-Service holds the potential to drastically reduce the number of cars on the road and get those passengers to use more flexible and eco-

friendly modes of transport for their daily commutes [1].

Mobility is a very important part of our lives, as depicted in Figure 1 [2]. The urban mobility landscape is evolving fast, and the number of mobility services is growing rapidly; yet for the user it can be challenging being confronted by all these options when choosing the best way to travel. This is where the mobility-as-a-service (MaaS) concept comes in. MaaS is a drastic paradigm shift in the transportation that uses applications (apps) to do a variety of things. For users, getting from point A to point B becomes a more fluid, integrated experience. The core idea of MaaS is to match transport needs with options available. Although the services may differ from place to place, every MaaS project needs the minimum integration of search, book, and payment functions. Car-sharing apps and ride-hailing services have become more and more popular among consumers over time. Several start-ups are constantly entering the market, and some ride-hailing apps, like Lyft and Uber, have already seen a meteoric rise.

CONCEPT OF MOBILITY-AS-A-SERVICE

Instead of owning a vehicle, you can plan, reserve, and pay for all of your transportation needs, including both public and private modes. Mobility-as-a-service (MaaS) (also known as transportation-as-a-service (TaaS) or smart mobility) is an innovative approach to transportation that provides urban residents with a more integrated way to travel around their cities. It is a concept that seeks to provide a more integrated, convenient, and cost-effective approach to urban mobility. It aims to reduce dependency on private cars and has the potential to cut traffic congestion, reduce transportation costs, and promote the use of environmentally-friendly transportation options. MaaS symbol is shown in Figure 2 [3]. The key features of MaaS are depicted in Figure 3 [4].

At its core, mobility-as-a-service (MaaS) aims to integrate various forms of transport and transport-related services into a unified, comprehensive, and on-demand mobility service. Figure 4 shows the difference between MaaS and the current situation [1]. In our current transportation models, users typically plan, book, and pay for transport services separately, whether that is public transit, car-sharing, private taxis, etc. MaaS offers end-users the added value of accessing different mobility options through a single application and a sole payment channel. It aims to encourage a radical transformation in the way people approach mobility in cities by facilitating a change in citizens' travel behavior and habits. It shifts the focus from traditional travel methods such as private cars and providing, newer, more sustainable modes of transportation that are accessible, affordable, and adaptable to traveler's demands and individual needs. People can gain access to a range of mobility options with ease, with the possibility of personalizing their journeys. The MaaS market is divided into categories such as taxi services, ride-hailing, car sharing, and others. The ride-hailing sector of these services is anticipated to rule the MaaS market in the coming years

The three components of MaaS are services, mobility solutions, and integration [5]:

- *Services* in MaaS refer to the convenience of having various routing, transportation, and payment options available at your fingertips. They refer to the availability of routing, transportation, and payment options.
- *Mobility solutions* component refers to the breadth of dynamic transportation choices for each journey, which includes everything from buses and trams to bikes and scooters. Services refer to the availability of routing, transportation, and payment options. Mobility solutions

encompass a variety of transport choices, from public transport to micromobility.

- *Integration* refers to the seamless combination of planning, routing, and paying for transportation needs without having to switch apps. MaaS integrates various transportation services and mobility solutions into a single, user-friendly platform, allowing users to easily access the options that best meet their needs and destinations. Figure 5 shows levels of MaaS integration [1].

These components work closely together to deliver a seamless transportation experience.

The main three pillars of MaaS are accessibility, inclusivity, and sustainability. MaaS makes transportation more inclusive for underserved communities such as people with limited mobility, the elderly, as well as low-income families. This transportation method has gained popularity due to its accessibility, convenience, affordability, and flexibility when compared to traditional taxis or having to drive yourself. MaaS offers a chance for individuals to rent out their cars to other drivers (or monetize their underutilized vehicles) while allowing for a cost-effective mode of transportation that reduces the number of cars on the road. As government authorities move from regulating transport as a sector to regulating transport as a service, they will be presented with a new set of challenges regarding the careful planning, integration, and execution of MaaS.

EXAMPLES OF MAAS

MaaS platforms typically include a wide range of transportation options, such as buses, trains, ridesharing services like Uber and Lyft, peer-to-peer rental services like Turo and Getaround, and micromobility options such as electric scooters and bicycles. Three current examples of MaaS solutions are ridesharing apps, peer-to-peer rental services, and micromobility solutions [1].

- *Ridesharing Apps*: Ridesharing apps, such as Uber and Lyft, are current examples of MaaS solutions. Think of MaaS as the sun, while ride-share companies are the planets that orbit it. The "sharing" component in ridesharing refers to the sharing of a private vehicle between the driver and the passenger. Ridesharing refers to the sharing of a ride in a private vehicle, either with the driver or with other passengers, to reduce the number of cars on the road and make transportation more sustainable. Ridesharing has gained popularity due to its convenience,

affordability, and flexibility compared to traditional taxis.

- *Peer-to-Peer Rental Services*: Peer-to-peer rental services, such as Turo and Getaround, are another component of MaaS. These services allow individuals to rent out their personal cars to others, providing a more cost-effective alternative to car rental services. This form of MaaS allows individuals to monetize their underutilized vehicles, while providing a cost-effective mode of transportation, reducing the number of cars on the road, and contributing to more sustainable transportation practices.
- *Micromobility*: Micromobility refers to the use of small, light, and low-speed vehicles, such as electric scooters and bicycles, and is another component of MaaS. Micromobility typically provides users with a convenient way to complete short trips, travel to larger transport hubs, or complete the first and final legs of their journeys.

Uber is a peer-to-peer transportation provider that is branching out into short-term car rental and public transit ticket purchasing. The company has expanded to more than 800 cities and 80 nations since its inception. Lyft is in over 300 cities and servicing over one million rides per day. Turo, which has been called the “Airbnb of cars,” is a peer-to-peer rental company that enables private owners to rent out their cars to others. Mobble offers a MaaS for business solution, also including hotel, expense tracking and concierge service. Geotab also offers free aggregated data for smart cities and businesses at data.geotab.com [6].

Over the past decade, shared mobility has also become an attractive field for investors. More than 150 cities are currently working to introduce measures aimed at reducing private-vehicle use. Cities such as Pittsburgh, Singapore, and Helsinki have experimented with or implemented MaaS, and their experiences showcase both the benefits and difficulties of changing how we think about transportation in our cities. Cities such as Paris, Eindhoven, Gothenburg, Montpellier, Vienna, Hanover, Las Vegas, Los Angeles, Denver, Singapore, and Barcelona, already have pilots for MaaS platforms. A perspective of the MaaS ecosystem is the MaaS “business” ecosystem. Figure 6 shows the layers of which the business ecosystem is composed [7].

HISTORY OF MAAS

The evolution of MaaS emphasizes sustainability and shared mobility solutions. MaaS promotes shared rides, electric vehicles, bike-sharing, and walking. By

doing so, it aims to reduce congestion, emissions, and reliance on single-occupancy vehicles. The term “MaaS” first appeared in Finland in the mid-2010s. A well-executed trial was conducted in Gothenburg under the monthly subscription model. The service was well received; however, it was discontinued due to lack of support at the government level. In June 2012, Agrion, an energy storage company, sponsored a 1/2-day conference in San Francisco, CA titled “E-Mobility as a Service” at which the concept of mobility as a service was discussed. MaaS became a popular topic at the World Congress on Intelligent Transport Systems 2015 in Bordeaux, and subsequently, the Mobility-as-a-Service Alliance was formed. The MaaS Alliance has three dedicated Working Groups addressing issues related to user needs, regulatory challenges, governance and business models, technology and standardization. In September 2019, Berlin's public transport authority Berliner Verkehrsbetriebe (BVG) continued mobility-as-a-service development [8]. Technological advancements like mobile apps, IoT devices, AI algorithms, and data analytics drive the growth and scalability of MaaS platforms.

HOW TO IMPLEMENT MAAS

So how can governments and organizations get started with MaaS? A successful MaaS program is built upon the existing public transportation network which is then reinforced by private providers to fill in the gaps. One of the earliest forms of implementation of MaaS involved tolls, where different toll agencies collaborated to develop common toll collection systems across their network, mainly with the use of RFID tags. Any MaaS project requires far more than just a fancy app. A well-thought-out backend system is of fundamental importance to ensuring integration. The integration of the appropriate providers for MaaS is key to a successful project.

For example, if need to take the bus and then an electric scooter to get somewhere, instead of having to locate, book and pay for each mode of transport separately, the MaaS platforms make it possible to plan the journey door-to-door using a single mobile application. MaaS allows you to rent vehicles or buy public transport tickets from an application. MaaS can be implemented via mobile applications to bike share infrastructure placement and can incorporate many modes of transportation as well. Figure 7 shows the infrastructure needed for MaaS [1].

In its essence, MaaS creates a network of (mobility) networks by providing the interstitial connectivity needed to support a variety of mobility modes so that they are viable, easy-to-use, and frictionless. On top of that, MaaS can even be implemented as a mobility

management tool to introduce more travelers to shared mobility. Properly understood and well-executed MaaS can benefit consumers, communities, and transit agencies alike, and address many of the problems transportation is facing around the world.

APPLICATIONS OF MAAS

Mobility-as-a-service (MaaS) refers to the transition towards using on-demand services for transportation, which provides cost advantages, saves time, and enhances the overall travel experience. There are many ways in which MaaS can help to solve travel and transportation problems for individuals, organizations, and governments. MaaS is not limited to the integration of multiple mobility service modes; it launches new forms of transportation such as e-bike sharing, car-sharing, other innovative forms of demand-responsive transportation, and supplements the existing public transportation systems. Common areas of application include the following [9]:

- *Bike Sharing*: Connectivity in the first and last mile is a problem that all people who use public transportation have to deal with. A bike-sharing program enables users to short-term rent bicycles. They must pay a small fee to use the bike. The bikes can be picked up and dropped off anywhere. An example of bicycle-sharing apps is Citi Bike in New York.
- *Car Sharing (or Carpooling)*: Similar to how the bike-sharing program operates, so do the car-sharing apps. The users of this system can borrow a car for a predetermined amount of time, which can be anything from a few hours to a few days. Most car-sharing services require the user to return the vehicle to a specific location, just like bicycle-sharing applications. Some car-sharing services resemble traditional car rentals companies like Avis or Hertz. These services include those provided by companies like Car2go, Zipcar, GoGet, and Car Sharing. Figure 8 shows two elderly women sharing a shuttle ride [10].
- *Traffic Management*: MaaS platforms can provide dynamic data on travel times, speed, traffic flow, congestion, and more to transit authorities and transport operators. The system can then be used to spread demand more efficiently, e.g. by adjusting prices and/or number of vehicles, or shifting demand to another mode. Overall, MaaS enables proactive measures to be taken to ensure transport operates smoothly, reducing journey interruptions where possible.
- *Demand-responsive Transport (DRT)*: This is becoming an essential component of MaaS. It is divided into two categories: collective and

individual demand responsive systems. Individual demand responsive system refers to the ride-hailing app car services. It is comparable to a regular taxi service. Some examples of this category are Ola, Uber, Lyft, etc. Collective demand-responsive transport services insist on transportation from door-to-door or stop-to-stop. No need to flag down a taxi on the street. It is a flexible public transportation service. Frequently, this type of transportation uses minibus services. Some examples of this category are Lyft Line, UberPOOL, Citymapper Ride, ViaVan, etc.

- *Smart Cities*: Today, city inhabitants have access to almost a dozen different modes of transportation requiring different apps, payment methods, and authorizing documents which can prove to be a hassle for users and operators alike. Mobility in big cities has become both a personal and an environmental challenge. Stress, traffic jams, air pollution, and the associated premature deaths, as well as noise pollution all call for new mobility solutions. As more cities strive towards becoming “smart,” government officials, along with city planners and investors have recognized the importance of making those cities not only modern and technologically advanced but also citizen-orientated, highly accessible, efficient, and convenient. An essential part of achieving this has to do with creating good transportation systems and improving mobility in urban areas. MaaS is an innovative approach to transportation that provides urban residents with a more integrated way to travel around their cities. It is on its way to fundamentally change the way consumers travel and use different types of transportation. More and more cities from the different corners of the world are exploring mobility-as-a-service. Getting from point A to point B will become a fluid, convenient, and integrated experience that streamlines the entire travel experience for residents of cities.
- *Autonomous Vehicles*: Autonomous solutions for transportation are emerging worldwide, and one of the sectors that will benefit the most from these solutions is the public transport by shifting toward the new paradigm of MaaS. Many automobile manufacturers and technology companies have announced plans to develop autonomous vehicles, including Tesla, Mobileye, General Motors, Volkswagen, Waymo, Apple, and Local Motors. As the development of the autonomous car accelerates, the company Uber has announced that it plans to transition its app to a fully autonomous service and aims to be cheaper than

car ownership. Autonomous vehicles could have a large impact on the quality of life in urban areas and form a critical part of the future of transportation, while benefiting the traveler, the environment, and even other sectors such as healthcare. For example, Volkswagen is consistently and rapidly advancing the development and implementation of autonomous driving. Figure 9 shows a typical autonomous vehicle [11].

GLOBAL ADOPTION OF MAAS

Mobility-as-a-Service (MaaS) is the integration of various forms of transport services into a single mobility service accessible on demand. The global MaaS market is witnessing rapid growth driven by the increasing demand for convenient, efficient, and sustainable transportation solutions. For governments, transport service providers, and other organizations in the transportation industry, MAAS means a significant break from the way things were running in the past, resulting in more efficient use of assets and happier customers. Governments from all over the world are taking action to encourage digital payment. For example, the Indian government has started programs to encourage cashless commerce and the use of electronic payment systems there. Asia pacific at the top position holds the market growth and increase the revenue share to boost the market of mobility as a service. North America, Europe, Latin America, Middle East and Africa hold the highest position of mobility as a service with increasing demands due to increased population. Here we consider the adoption of MaaS in some countries [12-14].

- *China:* The development of MaaS is consistent with China's low-carbon and sustainable strategy. China has been focusing on testing and piloting MaaS projects in recent years. The Chinese government is just now starting to understand all the benefits that come about from a more unified transportation ecosystem. Despite the obvious benefits, there are still some hurdles to adopting this new infrastructure. To date, Chinese regional public transportation authorities have participated in commercial MaaS offerings. The problem with current MaaS offerings in China is the lack of an integrated payment system and the absence of door-to-door planning for multimodal journeys. Government participation in the MaaS ecosystem will be key to overcoming these limitations.
- *Europe:* The diverse and well-connected transportation systems in Europe have embraced MaaS concepts to address urban mobility challenges effectively. Europe's ride-hailing

segment is growing steadily, with Uber and Bolt expanding to multiple cities. Car-sharing has gained traction in Europe. The services align with the region's emphasis on sustainable urban mobility solutions. The success of bike-sharing in Europe has inspired the integration of these services into MaaS platforms, enabling users to access shared bicycles boost the MaaS industry growth in Europe. With a rising number of alternatives to traditional transport gaining popularity in European capitals, the conversation around implementing mobility-as-a-service (MaaS) to encourage sustainable transport and harmonize the offer from Transport Service Providers (TSP) is gaining more visibility.

- For example, Voi recently partnered with Liverpool City Council to replace its fleet of e-bikes, planning to place 500 e-bikes along with 2,000 e-scooters in the city. Billy bikes in Brussels announced they would cease services to its 25,000 subscribers. The Europe mobility as a service market size is evaluated at USD 77.42 billion in 2024 and is predicted to be worth around USD 381.57 billion by 2034, rising at a CAGR of 17.28% from 2024 to 2034.
- *Finland:* Over four years ago, the Finnish Transport Agency (FTA) was early to recognize the importance of MaaS. If you could hop on any bus, train, tram, metro, bicycle, taxi, ferry, car-share, rental car, etc., for a single monthly fee, how much would you be willing to pay? And more importantly, would you be willing to give up car ownership? That is the experiment happening right now in Helsinki, Finland, and the early results are very promising, including a 25% increase in the use of public transport. This is mobility-as-a-service. The idea of MaaS is that all transport options in a city are connected to a single service – on your mobile device – for a single monthly fee.
- *United States:* The market is driven by an increase in the use of smart connected devices. As the number of devices increases, the task of managing, monitoring, and maintaining the data generated within an organization becomes increasingly challenging. Companies are currently witnessing significant improvements in their business processes due to the adoption of IoT analytics. The close monitoring of business processes enables more efficient real-time decision-making. Ongoing efforts for the development of autonomous vehicles are the emerging trend influencing the mobility as a service market. For example, St. Louis residents

can use their Metro pass as a ticket for the rideshare service, and they can easily convert a rideshare ticket into a Metro pass when transferring to a bus or train. The electric scooter rental company Spin operates on college campuses and in cities across North America and Europe.

- *India:* As the population in India grows, so does the need for more mobility options. India is home to 1.3 billion people, making it the country with the second-largest population in the world. With rapid urbanization and a growing population, efficient mobility is a prime concern. Car ownership amongst Indian millennials is also down. Some simply cannot afford a car, many are deterred by the high insurance payments, and others are frustrated by the fluctuating fuel prices that come with car ownership. In cities, parking is not only hard to find, but often extremely expensive. As for public transportation, the metro is making travel and commutes around India quicker and more efficient. Mobility in India is depicted in Figure 10 [12]. Rapido, Ola, Quick Ride, and Bounce aim to solve mobility issues with services such as carpooling, ride-sharing, bike taxis, bike-sharing, auto-rickshaws, and hassle-free taxi services, to residents who are looking for better travel options.

FUTURE OF MAAS

Mobility-as-a-Service (MaaS) is a type of service that enables users to plan, book, and pay for multiple types of mobility services through an integrated platform. It aims to be the best value proposition for users, societies, and the environment. MaaS has attracted significant attention especially for urban areas, as it provides a one-stop access to mobility services for consumers. MaaS is not just a trend but a fundamental shift towards a more connected, sustainable, and efficient future in transportation. In order to provide safe, reliable, sustainable, and affordable mobility that is accessible to all members of a community, we need to look at today's standard model and realize its solutions lack consistency and efficiency.

By the middle of the century, the UN estimates that 66% of us will be living in urban areas, up from just 30% in 1970. With such a radical change will certainly involve MaaS.

In ten years' time, MaaS is predicted to be worth a staggering \$1.76 trillion, a quarter of the entire transportation industry, and to have completely revolutionized how we all live and work. Ride-sharing is still on the rise. By 2024, ride-sharing apps

are set to boast over 23 million members, up from less than 2 million in 2012 [6].

The use of shared mobility services will become more prevalent in transportation services in the future. MaaS is in its early stages of development. Over the next few years, the number of pilot programs is expected to rise. Within the next decade, we are going to see more and more deployments of MaaS. As MaaS continues to grow, it promises to enhance urban mobility, reduce environmental impact, and provide more efficient, user-friendly transportation options.

Mobility-as-a-service (MaaS) is a concept for the future of mobility. It attracts transportation researchers in recent times and invites businesses to test its market feasibility. An increasing number of urban dwellers are demanding more MaaS solutions to meet their mobility needs. Consequently, the MaaS market and associated profit opportunities are poised for continued growth in the upcoming year [15]. Ride-hailing (including the emergence of shared autonomous vehicles) would likely generate the biggest revenues, followed by shared micromobility, car sharing, and urban aerial mobility (UAM).

BENEFITS

(MaaS) can be described as a concept that aims to fulfil individuals' mobility needs in a sustainable way by combining different transport services. Figure 11 shows the MaaS promise [16]. The benefits of MaaS include improved accessibility, reduced congestion, and enhanced sustainability. MaaS aims to provide the best value proposition for users, societies, and the environment. It strives to provide an affordable travel alternative to using private cars by aiming to be as convenient, and more sustainable, as well as reduce congestion and obstacles regarding transport capacity. MaaS promotes higher vehicle utilization, meaning fewer cars are needed overall, saving valuable parking space. Many people are switching from car ownership to adaptable and cost-effective sharing options. Other benefits include the following [9,17]:

- *Accessibility:* Mobility-as-a-service makes travel easier for everyone, including people with mental health considerations, sight/hearing impairments, and reduced mobility. MaaS apps allow for more independent planning and travel, and make the whole experience as smooth and hassle free as possible.
- *Healthy Communities:* Active travel leads to more health and lower healthcare costs, as well as fewer emissions and less air pollution. MaaS apps make it quick and easy to incorporate active travel into users' daily lives. They can also be used to

further incentivize users and encourage them to travel more actively, more often. A range of health information, like vehicle occupancy or virus hotspot warnings, and safety features, like lighting around the destination and driver profiles, can be integrated into MaaS apps. This helps especially vulnerable individuals feel safe and confident in their travel.

- *Lifestyle Assistant:* Due to its ability to make travel seamless and hassle free, MaaS makes it easy to get together for any occasion. The ability to integrate contextual information or promotions for travelers in the MaaS app benefits organisations, transport providers, and the users. Businesses in the MaaS industry, like Lyft, Ola, and Uber, are also providing incentives to customers in the form of shopping coupons and cashback on e-wallet purchases.
- *Vehicle Optimization:* MASS apps that include booking, payment, and real-time trip planning and are customizable to the user's preferences make travelling from A to B quick and pain free. The system can also be used to reduce provider downtime, ensure optimal charging, and through flexible pricing and incentives and help optimize use.
- *Inclusive Approach:* MaaS is for everyone, regardless of ability, gender, income or age. Especially those with low incomes often rely heavily on public transport; MaaS can provide the perfect first and last mile solutions to ensure users get where they need to go.
- *Less Expensive:* Petrol, diesel, and gas prices have been steadily rising as a result of the volatile oil market. People are finding it more difficult to afford car ownership and maintenance due to the increase in inflation. As a result, a lot of people are choosing alternative forms of transportation, such as ride-hailing services.
- *Convenience:* Today's commuters face a significant hassle when searching for and paying for a parking space on their own. More consumers are turning to MaaS due to this. Additionally, it gives you the choice to forgo driving, which requires effort in and of itself in today's hectic world.
- *Environmental Impact:* People are becoming more conscious of how owning a car affects the environment. To reduce their carbon footprint, they are looking for solutions. Environmental risks are obvious, and people simply want to contribute to a greener environment.

➤ *Sustainability:* MaaS contributes to global sustainability goals by reducing emissions, pollution, and the number of vehicles on the road. From a sustainability perspective, MaaS plays an important role in the lowering of the levels of CO₂ emissions in cities, providing valuable insight and transparency into the value of each transport option. MaaS makes it possible to reduce emissions in large cities. Using gamification or incentives can further support the tendency towards active travel that MaaS apps provide. This leads to a reduction in congestion and CO₂ emissions. Figure 12 shows CO₂ emissions for different modes of transportation [1].

➤ *Good Transport Alternative:* Businesses have the chance to offer their staff members better transportation options thanks to MaaS. These workers can sign up for various online travel planning services. Depending on their criteria, they can choose from a wide range of options. There are several choices, including renting electric bikes, using public transportation, and using a shared vehicle.

CHALLENGES

As with any market trend, mobility-as-a-service brings both opportunities and challenges. Partnering with technology companies, software developers, mobility service providers, and other stakeholders is essential for delivering MaaS solutions. Navigating regulatory requirements, data privacy laws, and cybersecurity risks is essential. There is often a misconception about MaaS subscription-based services that they have to be based on an "all you can travel" fee for all mobilities. Other challenges include [18-20]:

➤ *Government Support:* To reap the greatest benefits of MaaS, city governments must quickly equip themselves to: (1) understand the challenges and opportunities of multimodal integration in an increasingly data- and technology-driven mobility market, and (2) create a governance and regulatory framework that provides clear signals for how the transport system should evolve to support broader social, environmental, and economic goals. This will require the public sector to act as a facilitator and will rely on the development of analytical capacity, flexibility to try new models, and willingness to reform the regulatory environment. Without government leadership, MaaS's reliance on technology could exacerbate mobility and digital equity issues. Government intervention will be crucial in shaping MaaS to achieve

sustainable urban development goals such as access, social inclusion, and climate action.

- *Public Policy:* For MaaS to be an accelerator of social cohesion at the local level, communities must ensure that it continues to support public policy, not only in terms of its purpose and performance indicators, but in terms of the monetization and security of the data collected by the system put in place. A strong case can be made that important developments in the mobility sector have the potential to be mutually reinforcing, and lead to profound changes in our mobility systems. The uncertainty concerning the net impacts of shared mobility solutions and of automated vehicles implies that the correct pricing of transport will become more important in the future rather than less important. Moreover, the pricing of distance travelled will need to be coordinated with the pricing of other services, such as parking and vehicle-to-grid services.
- *Regulatory Barriers:* In several nations, the transport sector is heavily regulated, which constitutes a safeguard for public values, but might hamper innovation. Navigating regulatory compliance, obtaining permits, and ensuring legal clarity can be complex and fragmented. Regulators tend to treat mobility services and private transport as similar entities, while in reality, mobility services are a hybrid between private and public transport, ignoring the potential value these services offer society. For MaaS to develop, national policy needs to support MaaS and implement facilitative legislation.
- *Infrastructure Limitations:* Every modality is only as efficient as its relevant infrastructure allows it to be. The need for high initial investments in infrastructure is a major challenge that may impede mobility as a service market growth. The absence or inadequacy of infrastructure in certain areas hinders MaaS systems' efficiency. Although MaaS offers a lot of benefits, it needs the right infrastructure and support system for the model to be successful. A robust and interconnected transportation infrastructure is essential for MaaS, including public transit systems, charging stations, and designated pick-up/drop-off zones. Providing end-to-end mobility for customers requires the involvement of infrastructure providers, all levels of government, and businesses.
- *Vehicle Safety:* The future of transport will be safer than it is now. Governments, city planners, vehicle manufacturers, and fleet operators already face a big challenge when it comes to reducing accidents for passengers and pedestrians and improving vehicle safety. Autonomous vehicles operating in a MaaS model can help reduce road traffic accidents and fatalities because the vehicles have advanced sensor and control features that detect potential collisions and rapidly activate avoidance measures reducing accidents caused by human error. As with all forms of transport, people will only want to use autonomous vehicles operating in a MaaS model if the solution addresses their needs.
- *Data Privacy and Security:* Ensuring data privacy, implementing strong cybersecurity measures, and complying with data protection regulations are significant challenges.
- *Technological Complexity:* Developing and integrating the required technology stack for MaaS can be complex and resource-intensive.
- *Customer Behavior Change:* Encouraging consumers to shift from traditional car ownership to shared mobility services requires targeted marketing, education, and incentives.
- *Customization:* MaaS offerings are often too generic rather than being tailored to specific user groups. Tailored MaaS offerings should consider specific mobility needs and patterns within a given city or region. For example, rural dwellers who require regular travel to city centers for work have very different needs compared to young families with children and no car living in city centers.
- *Lack of Economic Viability:* The financial business case of MaaS remains questionable if it is considered solely from a private point of view. Consumer-facing MaaS offerings are failing to achieve enough scale to become economically viable on their own. Commission-based models especially need substantial scale before they can provide meaningful returns. For example, an urban e-scooter service that sells 20,000 trips per week in a small city might seem to be doing reasonably well. But at a typical average trip price of €5, a commission of 5% yields only €260k/year. This raises the question of the viability of the commission-based model altogether.

CONCLUSION

Mobility is changing due to new, emerging technologies, and part of the population is opting for pay-per-use shared vehicles, eliminating fixed maintenance costs. Mobility-as-a-service (MaaS) integrates various forms of transport and transport-related services into a single, comprehensive, and on-demand mobility service. It offers a cost-effective,

reliable, and convenient alternative to traditional transportation methods. It is being adopted by governments and cities as well as commercial and not-for-profit organizations. The rapid growth in MaaS adoption hints at consumers' continued interest in different modes of transportation like carpooling, bike sharing, and other cutting-edge forms of on-demand transportation. The MaaS market will continue to expand as a result of this shift, which will have significant effects on both businesses and individuals. Organizations can benefit from MaaS in a variety of ways. Companies can reduce the need for company cars and related costs, such as maintenance, insurance, and fuel.

Mobility-as-a-Service (MaaS) represents the future of transportation because it is a convenient, cost-effective, and environmentally-friendly alternative to popular modes of transportation like car ownership. It has the potential to significantly improve urban mobility, reduce traffic congestion, and promote sustainability, making it a key solution for cities and organizations alike. More information about mobility-as-a-service can be found in the books in [21-26] and the following related journals:

- *Transportation Research Part A: Policy and Practice*.
- *European Transport Research Review*
- *World Electric Vehicle Journal*

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Figure 1 Urban mobility [2].



Figure 2 MaaS symbol [3].

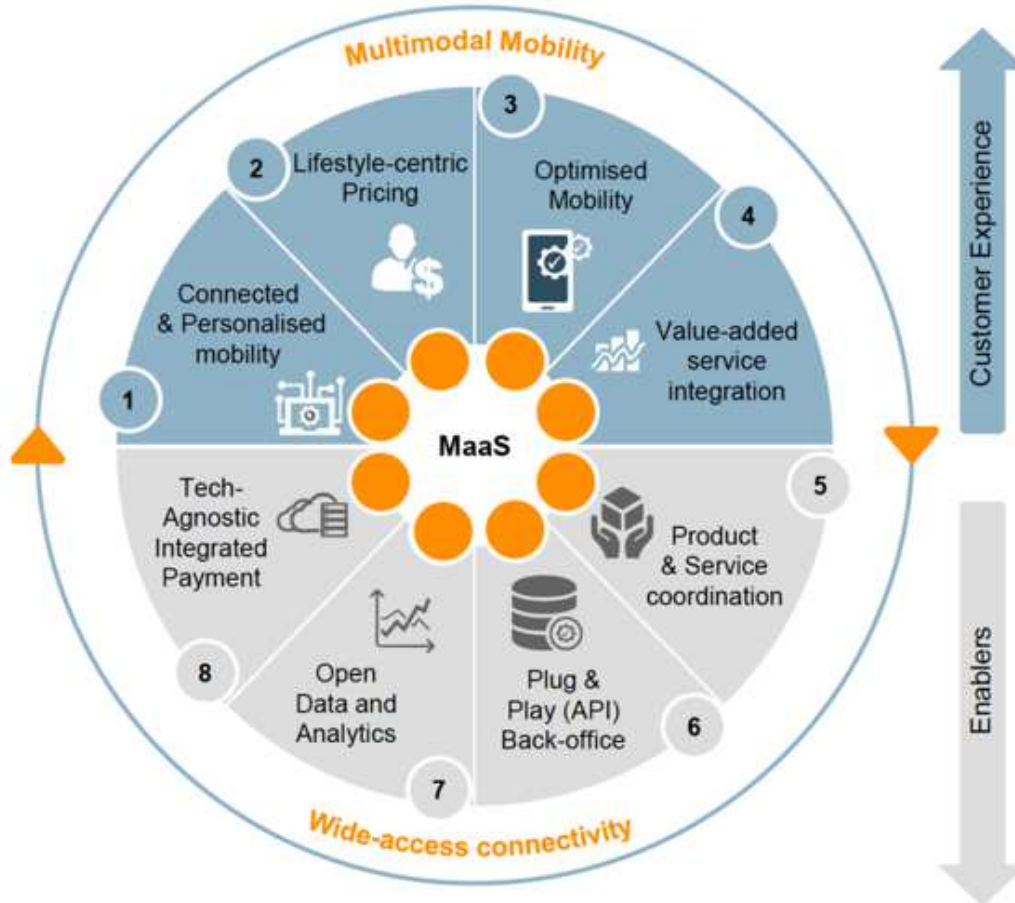


Figure 3 The key features of MaaS [4].

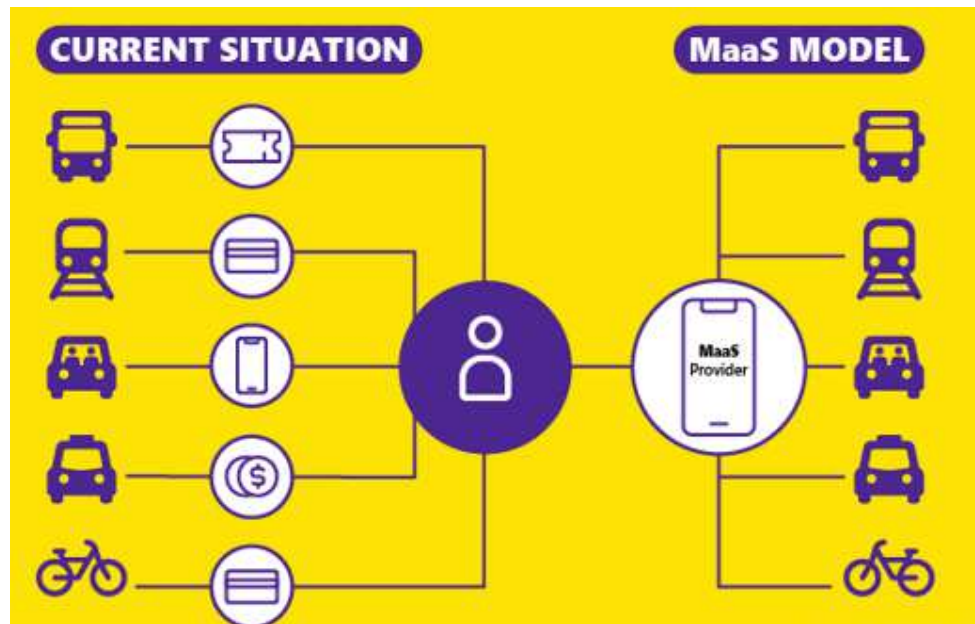


Figure 4 The difference between MaaS and the current transportation models [1].

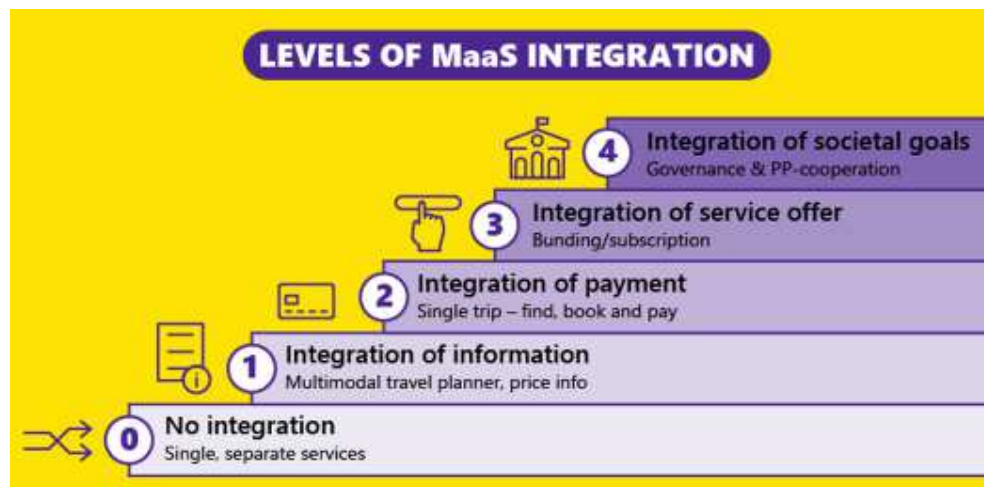


Figure 5 Levels of MaaS integration [1].

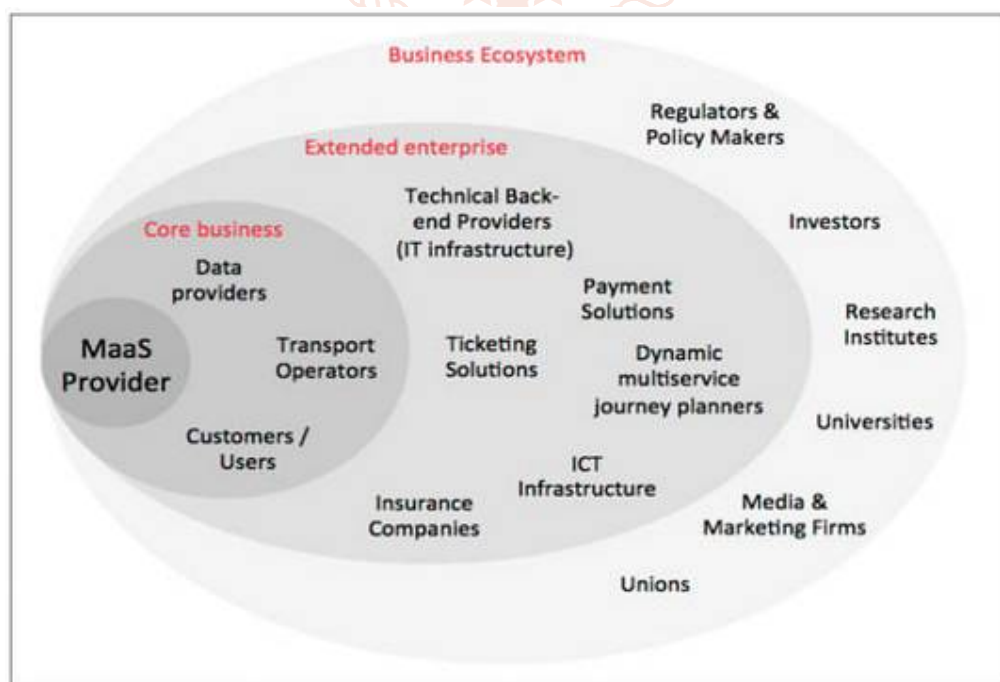


Figure 6 The layers of which the business ecosystem is composed [7].

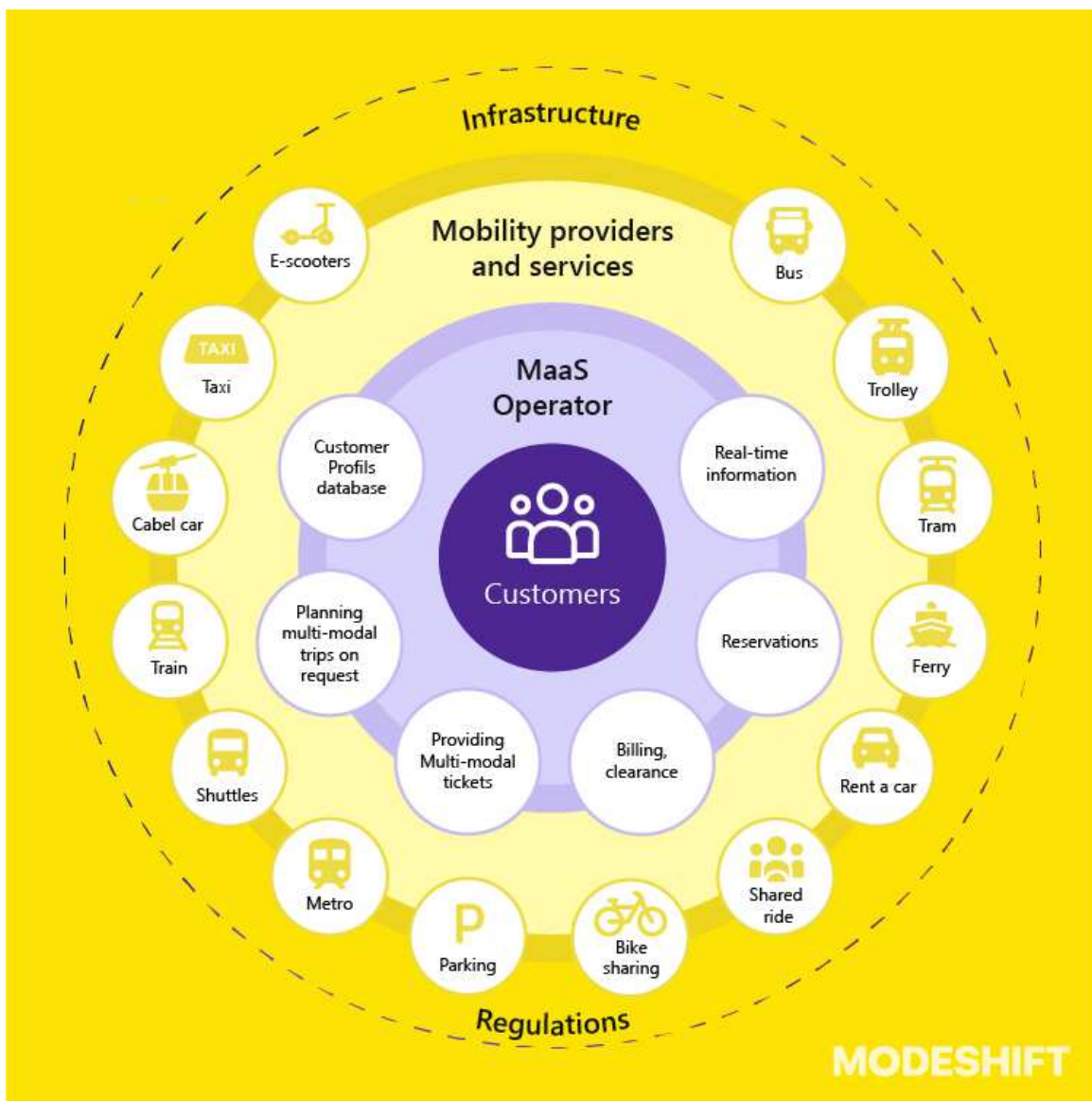


Figure 7 The infrastructure needed for MaaS [1].



Figure 8 Two elderly women sharing a shuttle ride [10].



Figure 9 A typical autonomous vehicle [11].



Figure 10 Mobility in India [12].



Figure 11 The MaaS promise [16].

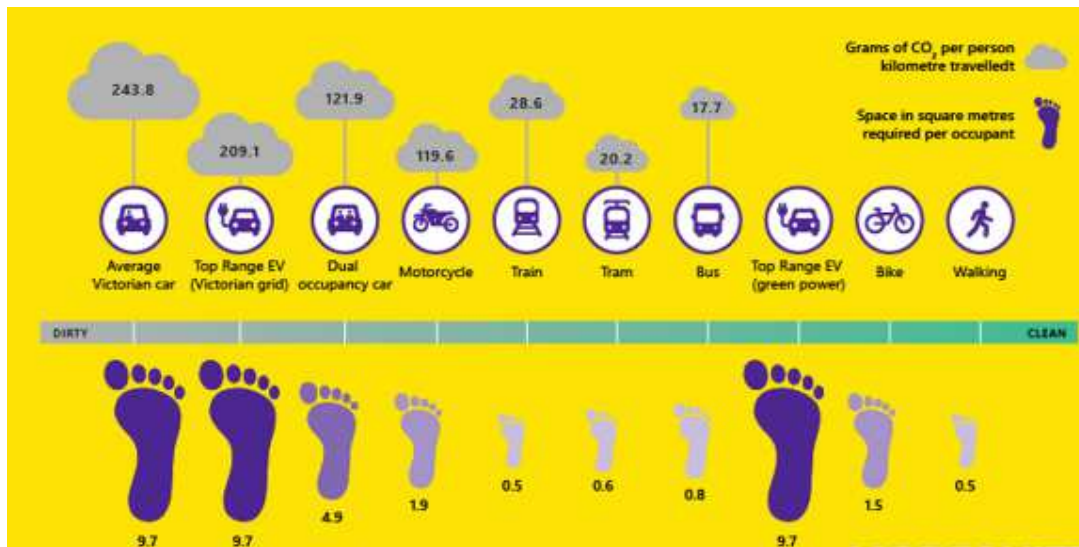


Figure 12 CO₂ emissions for different modes of transportation [1].

