MOBILITY AS A SERVICE: CHALLENGES OF IMPLEMENTATION IN SMALL CITIES

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Examiner(s): Professor, Leonid Chechurin

Junior researcher, Anna Kruzenshtern

ABSTRACT

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The continuous increase in the population of cities is creating new challenges for the mobility sector. This problem may be particularly acute in small and medium-sized cities, where many problems may already exist, including those related to funding and the state of infrastructure. Mobility as a Service can act as a possible solution to overcome the mobility problems of residents in urban environments, but as it is a young concept, more studies are needed.

The main part of the paper was conducted as a literature review. The theoretical part showed the lack of literature that relates to the implementation of MaaS in small cities, which required analyzing already existing information and an attempt to apply this knowledge in relation to the case under consideration.

Empirical data was collected by conducting a survey among the residents of small cities, which made it possible to identify the most important problems related to mobility that people are concerned about. The majority of respondents were from the city of Lappeenranta, but there were also participants from other cities in Finland.

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- Dmitrii Ustiantsev

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SYMBOLS AND ABBREVIATIONS

AI	Artificial Intelligence
MaaS	Mobility as a Service
AV	Autonomous Vehicle
UN	United Nations
EU	European Union

1 Introduction

The world's population is constantly growing, which increases the demand for various types of transportation, especially in urban infrastructure. Increased traffic has a negative impact on many aspects, from poor air quality to more incidents on the road, which is supported by many studies, including recent research that considers the latest changes in mobility (Jittrapirom et al., 2018). Consequently, there is a need to improve the situation. One possibility is to automate many processes using artificial intelligence (AI) to reduce the human factor in the transportation system. Many companies are leaning towards more use of automation already, which has a positive impact on productivity and efficiency. However, while the transportation of goods can change without major problems, it is impossible to replace everything with robots and AI when interacting with living people as easily.

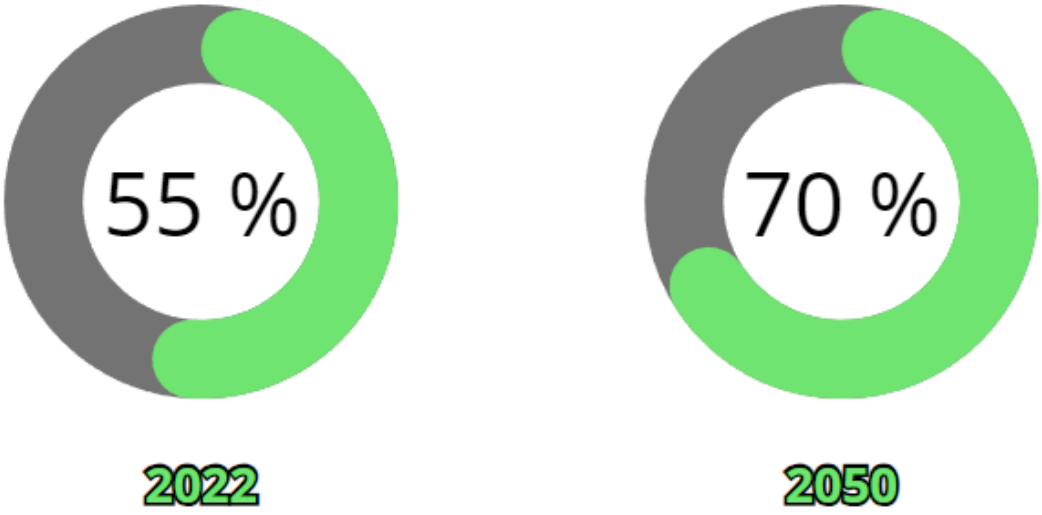

Figure 1. Percent of people living in urban areas (United Nations, 2023)

According to UN statistics shown in Figure 1, the percentage of people living in cities is constantly growing and it is expected that there will be a significant increase in the number of populations living in urban environments in future (United Nations, 2023). Mobility as a

Service (MaaS), which is the concept of providing mobility services through a single interface, offers to reduce the burden that will be placed on transportation systems with a large number of residents. However, it is worth considering how MaaS is able to achieve this and whether there are already successful cases of its implementation.

The challenges of digitalization and modernization are particularly acute in small and medium-sized cities. As a rule, all innovations are primarily focused on big cities or capitals, and the same applies to the mobility industry (Stratigea et al., 2017). This can be due to many factors, including the opportunity for more funding, larger number of potential stakeholders and other factors. However, this does not exclude the potential of small and medium-sized cities, where the development of some projects may be even easier, for instance because of fewer number of competitors. With the right approach, great results can be achieved, especially considering the mobility challenges in small towns.

Some studies show that it is possible to change the mobility habits of residents. Most people have poor understanding what options are available to them. For instance, a study from China shows that 38% of ride-hailing trips can be made by public transportation, and this number can increase to 80% for work-related rides (Qiao & Gar-On Yeh, 2023). Such large figures indicate that this topic is not widely researched, which does not allow the city's transportation resources to be used in a rational way. However, it can be assumed that in small cities the situation is even worse. In addition to infrastructure challenges, there may be problems with the lack of alternative means of transportation and providers that could offer their services.

The thesis consists of five coherent parts describing the work process and results in Chapters 2-4, as well as analysis of the data obtained and conclusion with limitations in Chapters 4-5.

1.1 Research Gap

The concept of Mobility as a Service is rather new and the first definition of MaaS was given only in 2014 (Jittrapirom et al., 2017). Accordingly, there are not many practical examples of its full realization. Despite the increasing interest among people in the concept and the increasing amount of literature, the amount of books and articles is still quite small and the topic is not well researched (Jittrapirom et al., 2017). Given the permanent innovations,

including new discoveries and modernizations of existing systems and technologies, it is safe to say that more relevant literature on the topic is needed to make the idea practically feasible.

Additionally, the focus of the existing literature is mainly directed towards the implementation of the concept in large cities, for instance Helsinki, Stockholm, and others (Smith et al., 2018). Small cities, in contrast, often lack sufficient resources (Semmanjski I, 2023), including developed infrastructure, causing many people to have to purchase a personal car to fulfill their own mobility needs.

Therefore, at the present time, it is not possible to find a detailed study of MaaS implementation within small cities in the open access among the academic literature, which creates a Research Gap. This thesis aims to raise awareness of this topic and provide additional background for further study.

1.2 Research Questions

The Research Question is: "*How can Mobility as a Service be adopted in small cities and what is the state of implementation of the concept in general?".*

Sub questions that can help evaluate aspects of the chosen topic from different angles are listed below:

1) *What are the key challenges of implementing MaaS in small cities?*
2) *What are the key benefits of implementing MaaS in small cities?*

1.3 Key Definitions

Mobility as a Service (MaaS) – It is a concept that changes the mobility paradigm with a focus on not requiring users to own a particular vehicle, but to use already available solutions (Nanaki E., 2021). Services should be accessed and paid for either on an as-needed basis or through a subscription system.

Smart City – Cities that actively use digitalization technologies, bringing benefits to residents and businesses, can be called "smart" cities (Yang & Zhen, 2024). This thesis focuses on the mobility capabilities of such cities, which are expressed in the use of autonomous vehicles, automatic traffic light regulation, and others.

Autonomous Vehicles (AV) - Vehicles that eliminate human involvement from the driving process, which can lead to improved sustainability through better transportation utilization, as well as reduced accidents on the road due to increased safety and elimination of human error (Tsigdinos et al., 2021).

2 Research Methodology

To answer the research questions correctly, it was necessary to follow a structured approach that consisted of two main parts, namely:

1) searching and analyzing relevant literature;
2) conducting a survey to obtain actual data from individuals.

Thesis work is a sequential execution of certain steps shown in Figure 2.

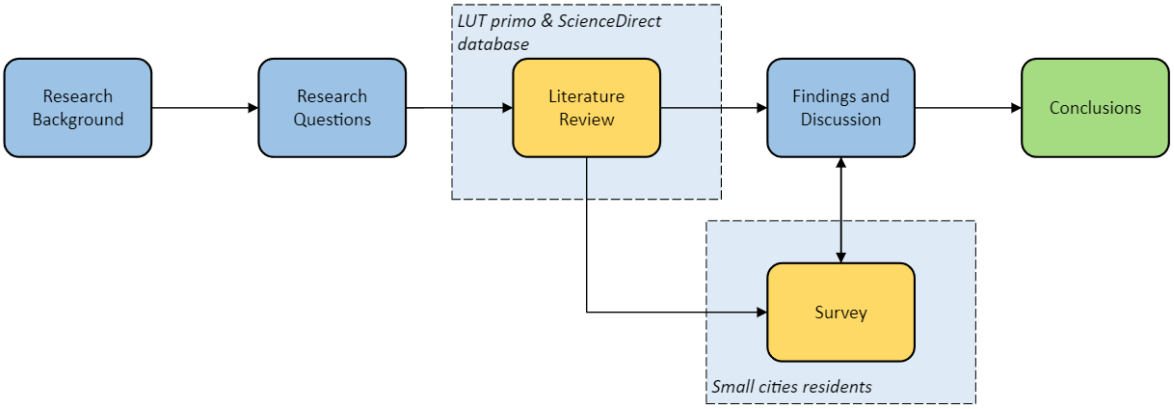

Figure 2. Research Methodology

Following this principle made it possible to find relevant literature to match the research queries, subsequently analyzing it. A specific strategy was also used for this purpose, which is described in the next subsection.

The design and implementation of the survey was done in parallel with the literature review, which made it possible to create some questions based on the statements found by different authors and to obtain more data in the available timeframe. This also made it possible to subsequently compare the results obtained from respondents with the information contained in the literature.

2.1 Literature review search strategy

There are numerous literature search strategies, but the method developed by Zhang, H. et al. (2011) was chosen. Although it was made for software engineering searches, it can still be used for other purposes. The idea is to formulate four basic questions to be answered. This determines how the literature is searched, whether automation is used in this case, what search tool is used and when. In summary, the following results were collected:

1. **Which: defined by the search method that was used.** Combined approach was followed. The highest priority was given to automatic search, but some sources were manually selected by the author.

2. **Where: specified in which databases a search is conducted.** Initially, the LUT-Primo search engine provided by LUT-university was selected. Thanks to the "advanced search" function it became possible to reduce the amount of literature that does not meet the requirements of the selected topic. However, despite the matching sources that were used for the thesis, there were still many inappropriate researches. Thus, a second search engine "Science Direct" was chosen, which also allowed to set strict search parameters for literature selection.

3. **What: expressed in terms of what exactly needs to be found.** This part includes the keywords that were searched for. The main keywords and phrases were: "MaaS", "Mobility", "Mobility as a Service", "Small city" and "Implementation". The exception word was "Economy", as many inappropriate results were related to this word. Consequently, the search string for LUT-Primo looked as follows:

   ("MaaS small cities" OR "Mobility as a Service small cities") AND ("implementation") NOT ("economy")

   Therefore, this search provides 103 results. The keywords, phrases, and exclusion word for search in the "Science Direct" search engine were the same except for the

keyword “Implementation”, which excluded relevant literature. Hence, the search string was as follows:

("MaaS" AND "Mobility as a Service") AND ("Small city") AND NOT ("Economy")

In summary, the second search provided 30 results of relevant literature that could then be used for further analysis.

4. **When: determined by the time period when the search was performed.** The concept of MaaS is relatively young, therefore it was searched several times, at the beginning of the work, in the middle and at the end. During this time, some literature was removed from public access, but new ones also appeared.

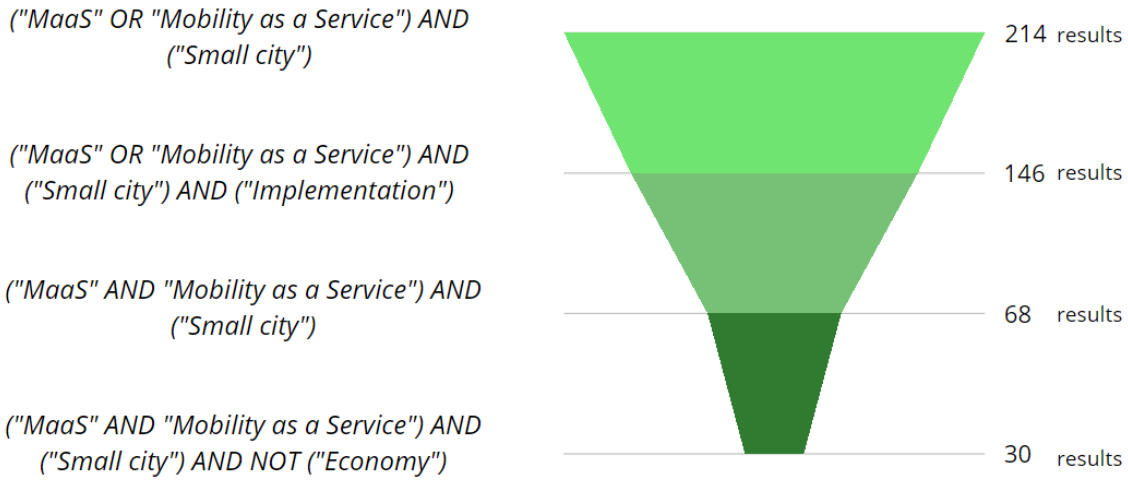

Figure 3. The process of changing the search string in Science Direct

The detailed process of changing the search string for the Science Direct database is shown in Figure 3.

2.2 Survey development

Literature cannot always reflect the real situation. Every city, especially small sizes, has its own peculiarities depending on many factors. In this regard, it was decided to conduct a survey among the residents of small cities in Finland, mainly in the city of Lappeenranta. Theoretical guidelines were used to provide more systematic approach and a better understanding of how to contact people to provide them with the opportunity to complete the survey (Walliman N., 2021).

Microsoft forms tool was used to create the survey as it is able to fulfill the necessary requirements. Since the target audience for the survey was ordinary people in Finland, it was necessary to take into account the linguistic features of this region. Therefore, for a better response, the survey was made in two languages, English and Finnish.

The purpose of the questions is to clarify exactly what problems people are facing and why. Since each city has its own features, it was worth assessing their situation, and then compare and understand whether there are no similar issues that different municipalities fail to solve.

To explain in more detail the reason for constructing the questions and what they are based on, in this part a few of the most relevant questions from the survey have been selected. The full survey can be found in Appendix 1.

First of all, based on Narayanan & Antoniou (2023) study, which claims that people between the ages of 20 and 44 are more likely to use the most mobility modes, such as bike-sharing, carsharing, and ridesharing, first question was created. The goal was not to try to confirm or deny this statement, but to use this to get more optimal results later. Thus, respondents had to start the survey by choosing from the proposed age groups:

1) *Less than 20 years old*
2) *21-30 years old*
3) *31-44 years old*
4) *45-60 years old*

5) *Over 60 years old*

Despite the useful data that the over 60 age group can provide, the focus and goal was to obtain information among 21 and 60 year olds. The reason for this is that people in this age range use transportation most often and for different purposes.

The next question, the development of which is worth paying attention to, is presented below:

Please rank the following aspects of mobility in terms of importance to you:

The most important on top and the least important on bottom

- *Safety*
- *Speed*
- *Convenience*
- *Price*
- *Eco-friendliness*

Mobility as a Service can be viewed from different angles and it is possible to see various aspects of the concept, but it is also needed to understand what people think about it. As a rule, the wealthier people are, the more attention they pay to sustainability. It relates to the fact that price and safety may play a more important role for residents with low and medium incomes. Nevertheless, it is necessary to assess how residents of small cities allocate priorities and try to understand what this is related to.

What problems do you think exist in the availability of transportation services in your city?

The question was open-ended so that people could describe what they think prevents transportation services in their city from becoming more accessible. By understanding this problem, it can help to find the direction in which to go when modernizing infrastructure

and mobility, and to understand whether the options offered by MaaS can provide a solution.

To determine interest and to obtain more detailed information on how potential users of MaaS imagine interacting with the system, it was necessary to create several questions regarding this aspect at once. Thus, the following two questions should be considered in pair, as one is directly related to another:

If you were given access to test versions of MaaS applications, would you use them to travel around the city?
**For example, pay for trips for different means of transportation and create a route for your trip in the same application.*

This question attempts to identify residents' interest in using MaaS applications by assumption. Since it is only necessary to quantify how many people might be interested, the possible answers were "yes", "no" and "I am not sure".

If you answered positively to the previous question, would you prefer a user-friendly design or more functionality but a more complex and unclear interface?

Since the interaction of the MaaS system with users should mainly take place through the mobile application, it is necessary to determine what exactly people want to see on their smartphone. The design of the application may be too confusing and unclear, and unnecessary features and visual clutter will only increase the power consumption of the device without adding much value to the user (Sochor et al., 2015). Therefore, a question was designed which asked for a ranking from 1 to 5, where 1 meant functional and complex design, and 5 was the more friendly design, but with not all possible features.

The survey, while focusing on public transportation, also tries to identify the interests of car owners as well. The next question aims to find out whether such people are willing to become part of the MaaS ecosystem. Some aspects of a concept such as carpooling require both passengers and drivers to work, hence there is a need to interest all parties. For this

purpose, it is suggested to use a bonus system for car owners, which can be utilized through the same MaaS application.

It is worth noting that the introduction of the bonus system is only theoretical and does not imply the realization of this idea in reality. It is only a suggestion of what could interest car owners to participate in the MaaS system. In any case, the introduction of bonuses may require additional costs and arrangements, which may be a challenge in the initial stages of implementing Mobility as a Service.

If you were offered a bonus for using the MaaS app, would you be willing to give other people rides in your car with little or no deviation from your main route sometimes?

**Bonuses can be, for example, a discount on parking or a discount on the purchase of a ticket for public transportation.*

Despite the possible costs this may entail in the initial stages of MaaS development, it is necessary to stimulate people to participate in the concept. If this question does not provide clear information regarding opinions of car owners, it will still help determine the interest of residents in such a service.

2.3 Data analysis

By establishing a clear structure for further work, it was possible to explore the existing literature on MaaS simultaneously with the gradual collection of survey responses. Two key aspects of this study were conducted in parallel. Given the identified research gap, finding inconsistencies between the responses received from residents and statements in the literature is to be expected. However, even if the findings match, it is possible to determine the relevance of the research in relation to small towns.

The survey contains several types of questions. To obtain qualitative data, open-ended questions were formulated to which residents could give more precise answers. This makes it possible to look at the problem from a different angle, from the perspective of a potential user. In addition, questions that aim at quantitative results were also designed. Their purpose

was to show how many people are ready or not to use different MaaS services. This data also made it possible to analyze the number of people who responded and correlate it with the open-ended questions, which gave a clearer picture of the work.

The results of the conducted work and the analysis of the obtained results are presented in the next chapter.

3 Literature review

This chapter aims to explore the possible advantages and disadvantages of implementing MaaS in small cities, as well as to assess their causes. This will allow to understand the feasibility of developing the concept in the future.

High level searching of academic databases revealed that there is a substantial amount of literature available regarding Mobility as a Service in overall. However, most of them consider the case of large and high-populated cities, both within the broad concept of smart cities and in private cases. Either way, it is still relevant to use literature that describes MaaS in general or within big cities, but it is also necessary to understand the positive and negative aspects that may arise in small towns.

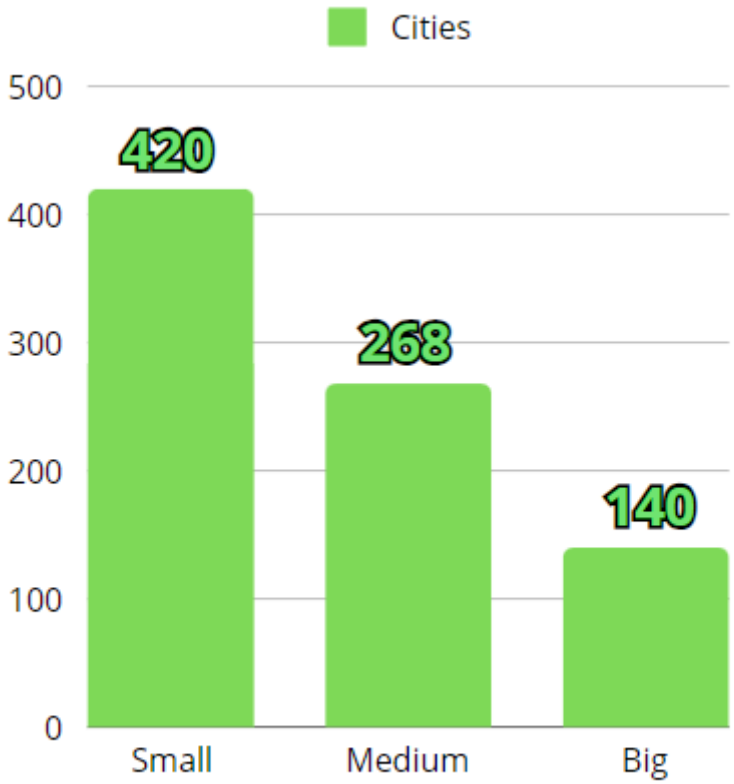

Figure 4. Number of different types of EU cities in 2012 (Stratigea et al., 2017)

First of all, it is necessary to define the concepts of small and big cities. According to the authors of the study, cities of EU with a population of 50,000 - 100,000 people are small in size, medium-sized cities are characterized by 100,000 - 250,000 inhabitants, and anything larger is a big city (Stratigea et al., 2017). Further work with the literature takes this distribution into account and the aim of the analysis is to understand the difference in the implementation of MaaS systems between big and other cities.

Furthermore, it is needed to analyze the literature and understand what Mobility as a Service is and whether it is important to separate the development of this concept within small or big cities.

3.1 Mobility as a Service in literature

Mobility as a Service does not have a single universally recognized definition, as it is a relatively recently developed idea. This paper takes MaaS as a concept of mobility that connects people and different modes of transportation (Jittrapirom et al., 2017). Generally, access to the service should be provided based on user preferences through a subscription or a Pay-as-you-go fee (Ho & Tirachini, 2024). Therefore, the user becomes the center of the concept, and around him or her are various functions and services that are offered on the basis of recommendations and preferences (Aguilera & Boutueli, 2018). The main task of MaaS is to offer the mode of transportation that a person actually needs at a given moment.

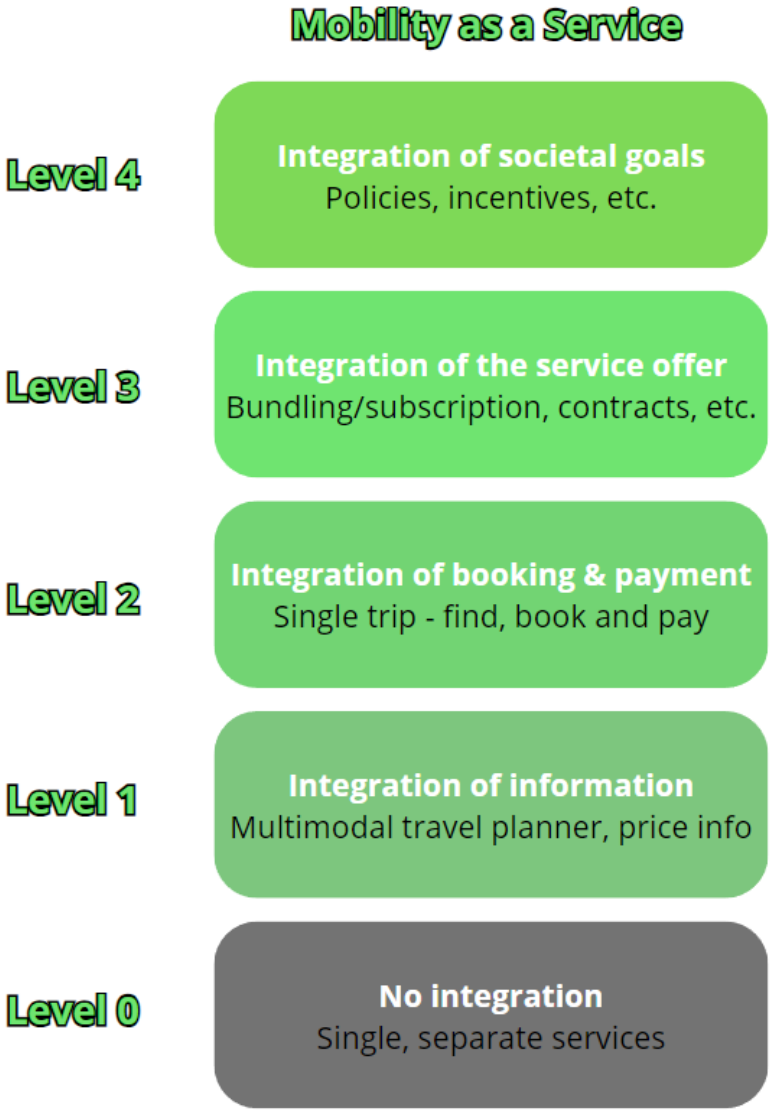

Figure 5. Levels of MaaS integration (Sochor et al., 2018)

Different sources may suggest different levels of MaaS development or integration (Sochor et al., 2018) (Lyons et al., 2019). However, it can be traced without doubt that everything starts with zero level of integration and ends with the full operation of MaaS systems. The most developed level can be associated with smart cities and high automation, as well as a high level of trust from the side of users. As shown in Figure 5, the highest level of integration also means policy changes, which will allow MaaS to spread more and with it help to change people's mindset according to the new mobility paradigm proposed by the concept.

Mobility as a Service includes many different aspects and opportunities, which can be categorized in different ways and concepts (Nanaki A., 2021). Some of the technological capabilities include autonomous vehicles and artificial intelligence. Possible mobility features can be expressed in the form of carsharing, carpooling, bikesharing and other. However, one of the key features is the ability to pay with one ticket for different modes of transportation.

It is worth realizing that the aspects that relate to MaaS are numerous, but only a few of those that are discussed further in this paper have been noted.

To attract users to MaaS, various methods can be used, including additional services and offers such as product delivery and discounts (Kriswardhana & Esztergár-Kiss, 2023). This can increase the attractiveness of a subscription system, especially if a person moves around the city very frequently. Discounts for the use of transportation options in the MaaS environment can encourage users to use the services in the long term, which can be compared to the cashback system applied by various banks. In general, this approach aims to improve the reputation among potential users, although it does not guarantee great results (Kriswardhana & Esztergár-Kiss, 2023).

According to Vij & Dühr (2022), MaaS could have certain implications in the form of additional opportunities as well as challenges. For instance, it will be possible to reduce pricing and costs for operators through adaptability and the absence of the need to perform all operations themselves, which will generally improve the reputation among potential users. However, problems can arise primarily from already existing operators who do not want to lose potential profits and see more competitors.

New technologies and methods that are inherent in digitalization may meet resistance from potential users depending on their religion, culture and more (Bünyamin A, 2017). In small and medium-sized cities, such a problem may be felt more acutely. The connection between people in such places is stronger, which may prevent MaaS from offering its services. Therefore, this also needs to be studied and taken into consideration before introducing the concept in small cities.

3.2 Benefits of the MaaS concept

In general, the benefits to big cities and small cities from MaaS are similar. Therefore, there is no need to separate these terms when identifying advantages and disadvantages. Nevertheless, this does not exclude the fact that some issues may affect small cities much more than large cities for various reasons, which will be defined below.

Since MaaS involves subscription and pay-as-you-go methods, it gives users a better understanding of exactly what they are paying for (Aguilera & Boutueli, 2018). By being able to pay for any mode of public transportation through a single application, confusion is eliminated, and people are less dependent on the schedule of a particular transportation option. Thus additionally, user fixation on a particular mode of transportation is prevented. For instance, if a person's plans change, they do not need to use the bus ticket they bought in advance, because they can use any other public transportation instead or use that ticket another time.

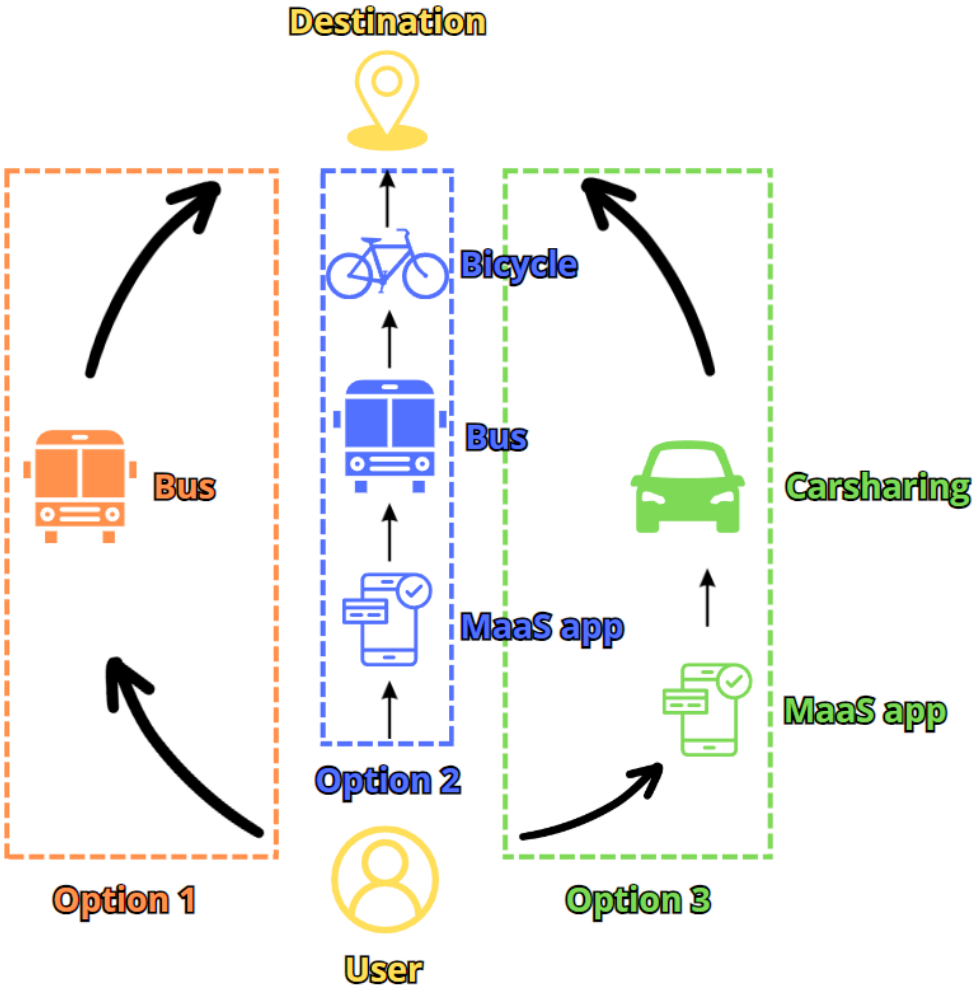

Figure 6. Travel possible options with MaaS

As will be noted in the results of the survey, buses may not always be able to satisfy peoples' needs. For example, on long routes, buses may go infrequently, and the person may not even be aware of what other options they have. MaaS will make it possible to see all the options that will allow the user to get from point A to point B. Combining bus and bike may be a faster and more convenient option that the person may not even know about. In this way, MaaS provides a choice for its users, who decide for themselves whether or not to take advantage of a particular offer. With additional use of the recommendation system and taking into account people's preferences, this can also create a certain level of trust in the concept, which can be beneficial for MaaS operators, not only for ordinary users. A variation of possible options to better understand the operation of MaaS is shown in Figure 6.

Mobility as a service includes the use of automation, including autonomous vehicles (AV), which have great inherent benefits. One of these advantages is increased safety on the road. Thanks to the absence of human factors and errors, many accidents can be prevented (Tsigdinos et al., 2021). Any possible crash with pedestrians or other vehicles will be instantly avoided due to the very fast processing of information by automated systems (Katrakazas et al., 2019).

With automation, the accessibility of public transportation will also improve. For AVs, there is no barrier to continuous operation beyond the need for timely maintenance and fuel or electricity supply. Thus, it provides an opportunity for buses, subways and other modes of transportation to operate at night.

Furthermore, in integration with smart cities, AVs will be a key aspect of the urban environment. For MaaS, this would be of great importance, as it would allow all vehicles to be linked to each other and to smart city elements, such as smart traffic lights. All of this has the potential to increase the efficiency of car distribution on the road, reducing congestion (Tsigdinos et al., 2021).

It is worth noting that the increased convenience offered by the concept may also increase the number of tourists (Leung et al., 2023). For small cities, this can be significant, as it means additional funds for the city budget with subsequent improvement of the city infrastructure. MaaS offers a simple and straightforward solution for everyone, regardless of whether one lives in the city or is only traveling. In addition to tourists, a small town can also become attractive for stakeholders, which can be a good advantage for MaaS itself. This can take the form of additional funding that can be directed towards improving the offered services and modernizing technologies. In the case of autonomous vehicles, stakeholder support is particularly important and can play a significant role in how successful the use of such a mode of transportation will be in an urban environment, especially in a small city (Shibayama et al., 2020).

Sustainability is one of the key factors that are inherent in MaaS. The concept does not aim to directly change the amount of harmful emissions into the atmosphere but can encourage users to use environmentally friendly transportation (Jittrapirom et al., 2017). Also due to more rational use of transportation, traffic congestion and the number of personal vehicles in general may decrease, which is also related to the amount of harmful substances emitted

into the atmosphere by cars. In this way, MaaS can help change people's way of thinking by drawing attention to existing problems in the environment caused by irrational or excessive use of traditional modes of transportation. Despite the fact that many people are already aware of these issues, they have little incentive or opportunity to change their behavioral patterns when traveling in urban areas. By providing similar or even better levels of comfort with more sustainable options, positive environmental impacts can be realized.

If we talk about stimulation more specifically, it is worth taking into account that this method is not universal. In some countries or cities, the transportation system may be underdeveloped, making this way of reducing emissions ineffective. In addition, price may not always be the decisive factor in which people are inclined to choose a particular mode of transportation (Ho & Tirachini, 2024). Therefore, while it is a good opportunity to offer people a green alternative, it is worth considering where to do it. If stimulated appropriately, this can have a positive result.

3.3 Disadvantages and risks of implementation MaaS

It is worth noting that many companies that offer their services in the field of transport already have their own databases and even applications, which, among other things, can generate additional income both by attracting users and through additional commercialization. Companies in the absence of any support, for example from the government, will not give up their own mobile applications and services (Siegfried P, 2022). Thus, to integrate all modes of transportation into one ecosystem, the participation of all such organizations is needed, which acts as a big barrier to achieve full integration of the MaaS concept. Although this is not a significant problem for automated systems, the inability to integrate can slow down or stop the process of further project implementation.

The idea of selling tickets in one app and cheaper looks very tempting to users, but it may not be feasible in different cities or countries. To implement such features, permission is needed from legal departments, which may refuse to provide this kind of service. There can be many reasons for this, most of which are completely impossible to influence. Some laws do not allow, for example, the sale of tickets by third parties, which MaaS must act as (Polydoropoulo et al., 2020). Consequently, there is a problem with which it is possible to

appeal to the authorities, but even in case of approval it will be necessary to spend a huge amount of time and even money.

Special mention should be made regarding the handling of data when implementing such systems as MaaS. Private companies will almost certainly not want to share their data, which may contain very important or even sensitive information (Utriainen & Pöllänen, 2018). On the other hand, there are users of those companies who will also not want their data to be shared with third parties. However, even the possibility to agree with each private company will not solve the problem, because before working with the information received, it is necessary to convert it into a single format, since MaaS is supposed to be a solution with a unified format.

In addition to the previous, companies and users may have fair questions about how the data will be stored in MaaS ecosystem, how secure it will be, and whether they can guarantee the safety of this information and what happens in the case of a leak. In summary, those responsible for implementing the concept will be challenged to answer such questions with evidence of reliability.

Nevertheless, before trying to gain the trust of the other operator companies and potential users, it is necessary to face again the legal peculiarities of the place or country where MaaS is planned to be implemented (Polydoropoulo et al., 2020). Everything that concerns the security of the people who are supposed to become users as well as their information is considered by the authorities in a very long and strict way. It is not enough to prove reliability on theory, but it is necessary to spend certain resources to demonstrate the capabilities and compliance with security standards in a particular area. Thus, before attempting to enter the market, it is important to adapt not only to the culture or preferences of future users, but also to be prepared to modify the technology and rules to meet local standards. However, it is not only companies that are associated with city mobility can hinder the development of MaaS. It is also worth considering car manufacturers, who may also face a potential threat to their own business. A loss of interest in personal transportation means fewer potential consumers. Despite the already existing trend towards a decrease in the use of the private car among the younger generation, the share of this mode of transportation is still high (Wong et al., 2020). Therefore, it can be said that there is a certain dependence of MaaS development on how actively green policy is applied by car manufacturers and how successfully they switch to the construction of electric vehicles.

It should also be considered that the government has a special role in the implementation of the MaaS concept (Wilson & Mason, 2020). Active cooperation between different operators, governmental bodies and technology developers will be required. In addition, it will be necessary to use modern digital technologies such as mobile applications, online platforms and convenient payment systems. The huge number of failures and loss of funds during testing and attempts to implement projects related to this concept cannot be excluded. This is why support from the government is very important, as private companies will not be willing or able to provide such development. It is much easier to use already existing automated systems with the introduction of functions that MaaS implies, so government intervention is necessary.

Implementing changes in the transportation sector cannot happen without high costs (Tomaino et al., 2020), which once again emphasizes the special role of the government, which is able to cover this. Nevertheless, it should be understood that the MaaS concept does not imply quick or immediate financial and time benefits. It is not possible to completely stop transportation in urban environments to implement MaaS more efficiently, and the bureaucratic process is complex and time-consuming (Nathanail et al., 2020). Consequently, stakeholders are even less likely to want to deal with the development of this concept.

With more advanced implementations of MaaS, such as partial or full automation of passenger transportation, it is worth considering the risks of failure of the technologies that underpin automated systems, from sensors and machine learning algorithms to AI. There is always a risk of system failure or malfunctions that could threaten the safe operation of automated vehicles. To prevent such a scenario, for example, it is necessary to continuously test and validate hardware and software, which means additional costs.

3.4 Mobility in small cities

The literature review confirms the lack of literature that focuses exclusively on mobility as a service in small or medium-sized cities. Many of the studies that are conducted for large cities may well be used in the context of this master’s thesis, but it is worth considering that in reality it may be different due to many of the factors that were listed earlier in the introduction part.

Durand et al. (2018) confirm that people in small towns need their own car. This is related not so much to the desire to have their own convenient means of transportation, but also to the lack of alternatives. This study also points out the reasons why people do not always use even the public transportation that is already offered. It is worth highlighting reasons such as the lack of comfortable and quiet places with a stable internet connection that could even allow the passenger to work during the trip.

Among the factors that influence people's perceptions of the multimodal transportation that MaaS offers, the social environment is crucial (Huang et al., 2024). As stated earlier, in small cities people more tend to use personal cars as it is the most convenient option that combines speed, comfort and independence. However, it is important not to ignore the country and culture that directly or indirectly influence the behavior of the inhabitants of such places (Klinger et al., 2013).

The case of a small city in Italy shows that mobility changes aimed at providing innovative services similar to the work of MaaS can indeed improve the accessibility of transport for residents and also allow a better distribution of public transport in general (Giuffrida et al., 2021). However, at the same time, vulnerable groups of people, among which are the elderly, have experienced a deterioration in the accessibility of transportation. Accordingly, the transition to MaaS should not entail drastic changes, including modifications to the price and benefit system that applied before. It is also necessary to consider the interests of residents, even if they oppose the implementation of the concept, and offer them other options.

According to the different case studies that compare urban and rural areas, it can be said that small towns adopt the criteria of both areas (Eckhardt et al., 2020). The types of communities considered in this paper have problems with the accessibility of transportation and how often it can be used. As noted earlier, the lack of an alternative mode of travel also plays a major role, which is not the case in larger cities, which generally have a great deal of choice. On the other hand, there are not as many stakeholders in rural areas that can contribute to the development of mobility as a service in the future. Small towns have more opportunities in this, despite the difficulty of attracting them.

3.5 Conclusion of the literature analysis

Based on the literature analyzed, it can be seen that the challenges and disadvantages to implementing the concept are considerable. Realization of MaaS requires large investments and time, while the benefits in many cases may not appear immediately. All of this requires a serious balanced approach. Stakeholders should have a clear understanding of what to expect from the implementation of the concept. Only by realizing all possible risks and losses it is possible to try to achieve success and even benefit from MaaS.

It is also worth noting that increased availability of public transportation, both in small towns and in general, does not necessarily mean improved sustainability. By making it faster and easier for residents to travel, the incentive for them to use transport more frequently increases (NÆss & Jensen, 2004). Consequently, a scenario can be assumed in which the situation on the roads will only become worse due to improved accessibility and mobility, because the time that people used to lose by waiting for the bus, for instance, can be spent on other activities that will also require the use of transportation.

In case of uneven implementation of MaaS or unwillingness of a part of the city residents to participate in it, as well as taking into account possible challenges, as it was stated earlier, it is possible to increase the digital divide. This may be particularly acute in small towns where many people know each other. The customs and culture of certain places, as well as the financial well-being of the city, can add additional complexity. Some cities may not be ready for full-scale implementation of MaaS, depending on the state of infrastructure, the way of thinking of the residents or other reasons. Therefore, it is necessary to properly understand not only what is being implemented, but also where and for whom.

The literature review also indicates that there is still no clear and unified view of what a potential MaaS user should look like (Durand et al., 2018). Ideally, the service should be provided to everyone regardless of gender, age, financial status, and other. However, at the same time, each of these factors may hinder the adoption of MaaS. As can be seen in the literature, place of residence also plays a significant role in whether changes in the mobility paradigm will be met positively or negatively. Therefore, it is important to conduct research about the residents and the place where MaaS systems are planned to be developed, as with equal opportunities, the ultimate effectiveness may vary depending on the city or country.

The research of Vozelj & Blaž (2018) emphasizes that MaaS should not fully replace existing transportation infrastructure and personal means of transport completely but should complement it. There is no need to invent something new if there are already in-demand mobility options. The task of implementing the concept should be framed as a means of improvement, which in turn can help to avoid unnecessary costs and the need to gain the trust of residents from scratch.

4 Survey findings and discussion

To correctly understand the answers that were received in the survey, it is necessary to analyze them and realize which reasons formed the basis of a particular answer. It is also important to try to suggest possible solutions to these problems, as the success of MaaS implementation may directly depend on this.

It is not possible to fully cover a large number of respondents within the scope of this thesis and obtain a big survey sample, but it is important to refer to existing literature that may help in understanding the responses that were received. Thus, the following presents the results of the survey with a description and discussion of the reasons for these responses, considering the literature review that was done in the last chapter.

4.1 Survey results

The survey was conducted from the beginning of April to the end of May. According to the results, **37 responses** were received from different people with diverse backgrounds. In the following, the results of the answers to some of the questions that play the most important role will be described below.

Figure 7. Question 1 - Age groups of respondents

As can be seen in Figure 7, the majority of responses were received from people between the ages of 21 and 30, who are mostly students from LUT University. The other age groups are represented by a smaller number of people. The survey did not include people over 60 years old, whose opinion is also important, hence it is impossible to say precisely how such people would react to MaaS in this case. Nevertheless, the opinion of older respondents in similar cases can be found in the reviewed literature.

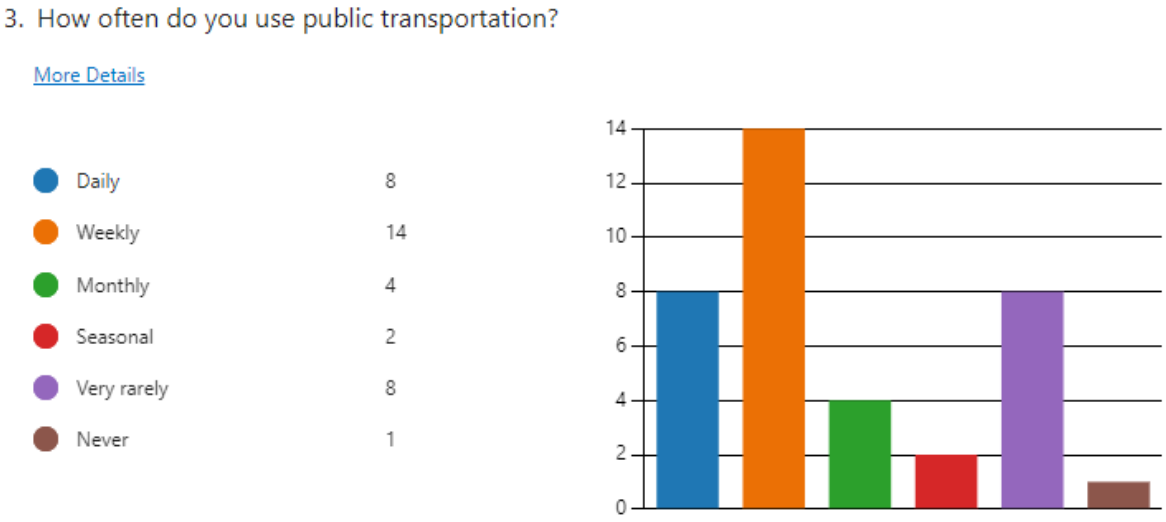

Figure 8. Question 3 – Frequency of use of public transport

The answers to question 3 show that the vast majority of people use public transportation quite often. The most selected options indicate that these respondents may have a particularly acute perception of possible existing problems, which should be inquired about in this survey. Nevertheless, also among the respondents there were those who do not use public transportation at all or very rarely. Accordingly, in this case it can be expected that people with different points of view will respond, which is very useful in evaluating new concepts as MaaS.

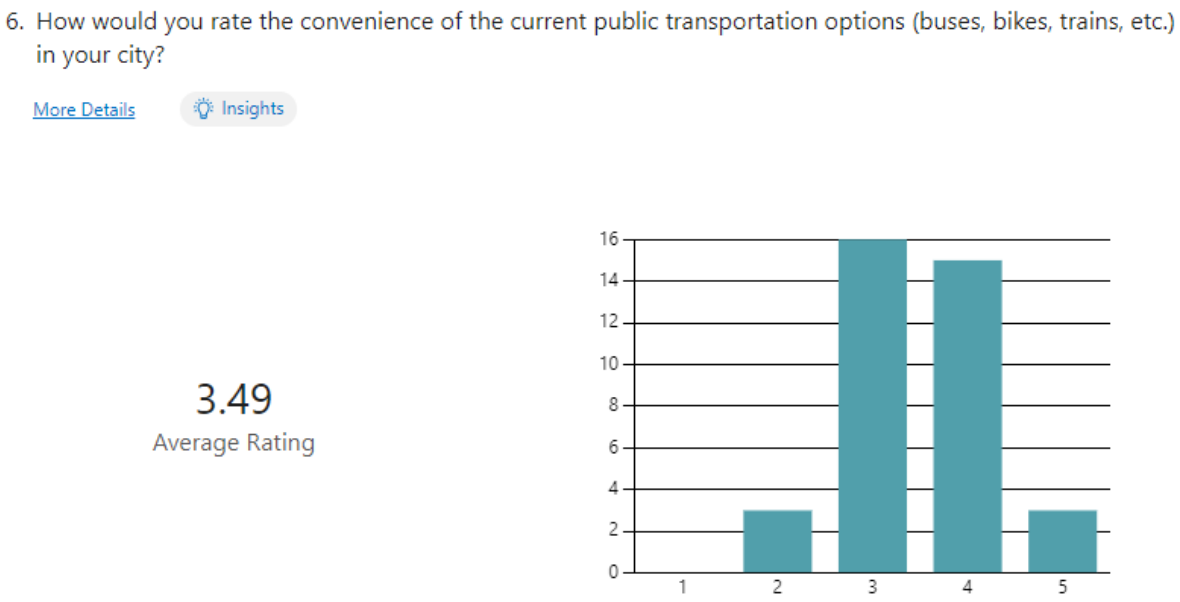

Figure 9. Question 6 – Current convenience of transportation

This question shows that the majority of respondents rate the current convenience of transportation above average. Those who gave the highest scores mention the speed with which they can get to places they need to go, which, however, can more likely be attributed to the better location of these respondents. The problems of people who gave the lowest scores will be described further under question 8 (Figure 11).

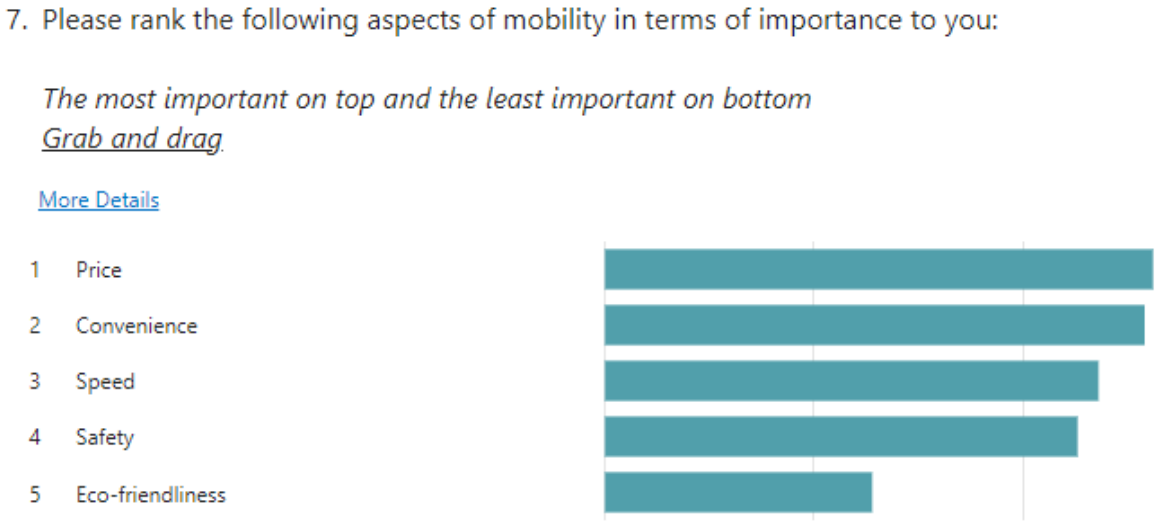

Figure 10. Question 7 – Mobility priorities

Question 7 shows the value of different aspects of mobility as a service, from the most important to the least significant. As expected for small towns, price is the main factor. In contrast to residents of big cities, people do not care as much about speed and especially environmental friendliness (Eckhardt et al., 2020). It can be assumed that it is connected to the smaller number of cars on the road, which makes emissions into the environment not a huge problem. Additionally, age groups should also be taken into account, as for young people and students the price is often a decisive issue.

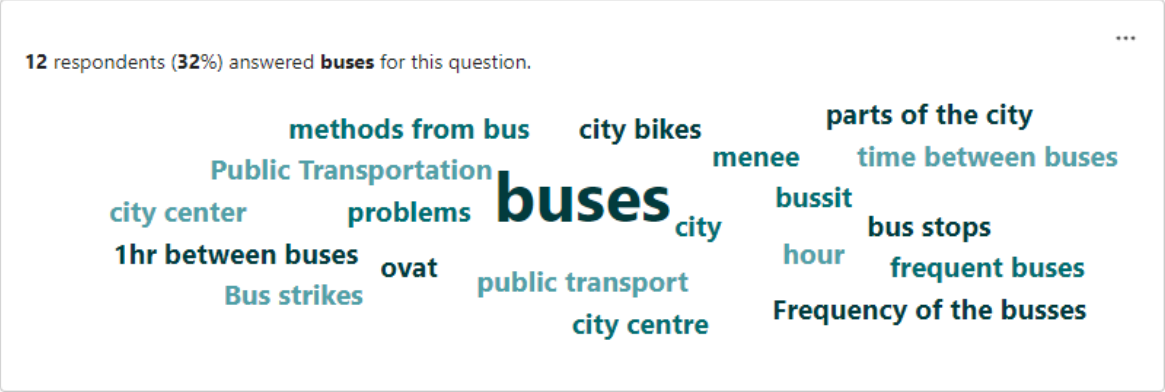

Figure 11. Question 8 – Existing challenges in mobility

According to the responses to this question, most people mention problems related to buses. Among the issues that are worth highlighting are the low frequency of buses. Some routes can take a long time and for those who work or study, this factor can play a significant role. It is also worth considering strikes and holidays, when timetables are changed, or buses stop running altogether. This created big problems for those who live far away from their desired destination, forcing people to use personal car transportation or taxi.

Also noted is the lack of information that bus stops provide, which increases reliance on smartphones and the internet, as well as the possibility of incorrect information that misrepresents reality. This can also include the mentioned problem of not being able to get information in one place, as different modes of transportation have different apps and/or websites that provide details on location, price and the possibility to purchase tickets or rent a vehicle.

Some respondents highlighted that the existing public transportation has non-optimal routes for them. This means that people have to walk for a long time to get to a place they need. Low-populated cities with long distances can have inconveniently located stops, not covering all the necessary places in the city, which causes additional problems for residents.

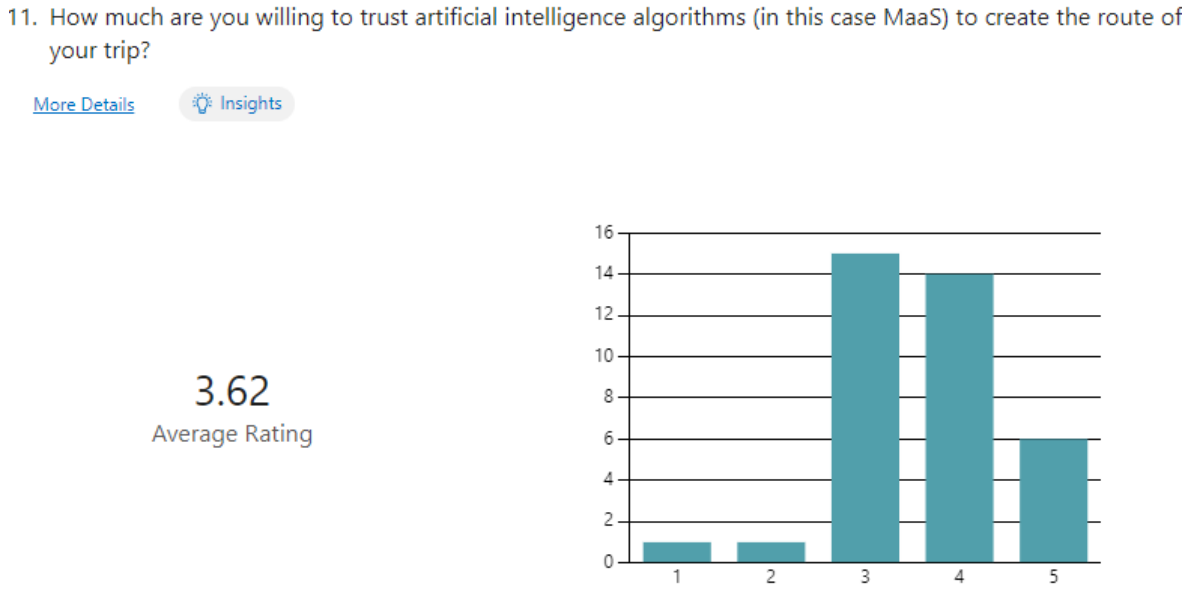

Figure 12. Question 11 – Trust in AI algorithms

The answers to this question emphasize the appropriateness of choosing such age groups in question 1. The results mainly point to the tendency of people to entrust their trips to artificial intelligence with the desire to still have some control over the process in the form of the possibility to change any details in their route or mode of transportation. Nevertheless, among the responses there are also those who have a negative attitude towards the use of such systems and prefer to manage their route completely or almost completely on their own. These answers correspond to the age group of 45-60 years old, which indicates a support of the idea promoted by the Narayanan & Antoniou, 2023.

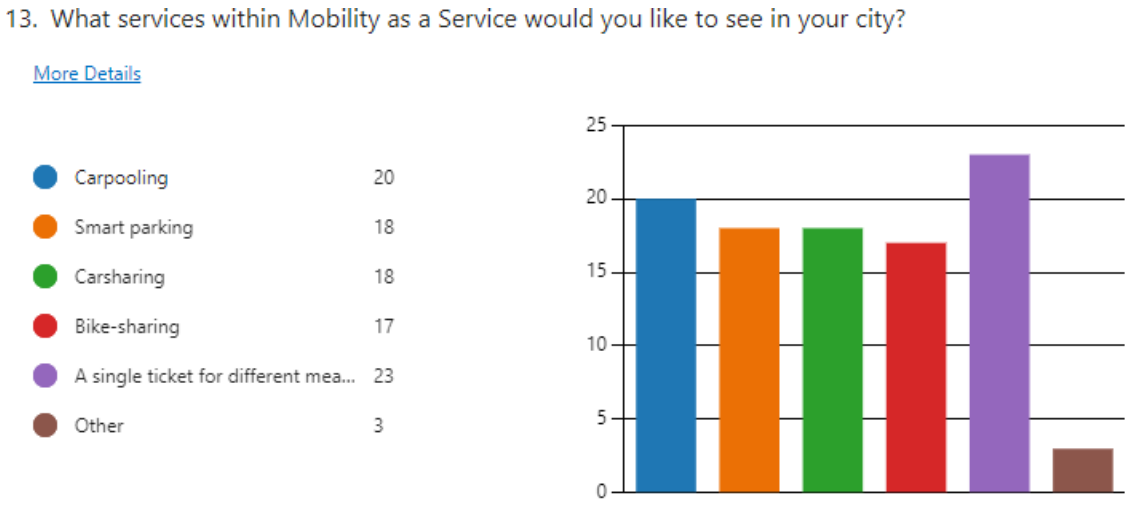

Figure 13. Question 13 – Service preferences

The answers received to question 13 show that the majority of respondents see the ability to purchase tickets for different modes of transportation in one application as the most attractive service. Among the proposed options, residents mentioned metro, despite its absence in their city. This supports the statement that residents of small cities want to see more options and alternatives for transportation within the city.

However, as mentioned in Chapter 3, the implementation of the ticketing option requires legal permission from the authorities, which is not always possible to obtain. Thus, it can be concluded that if this function cannot be implemented, it is very likely that users will lose interest in the MaaS.

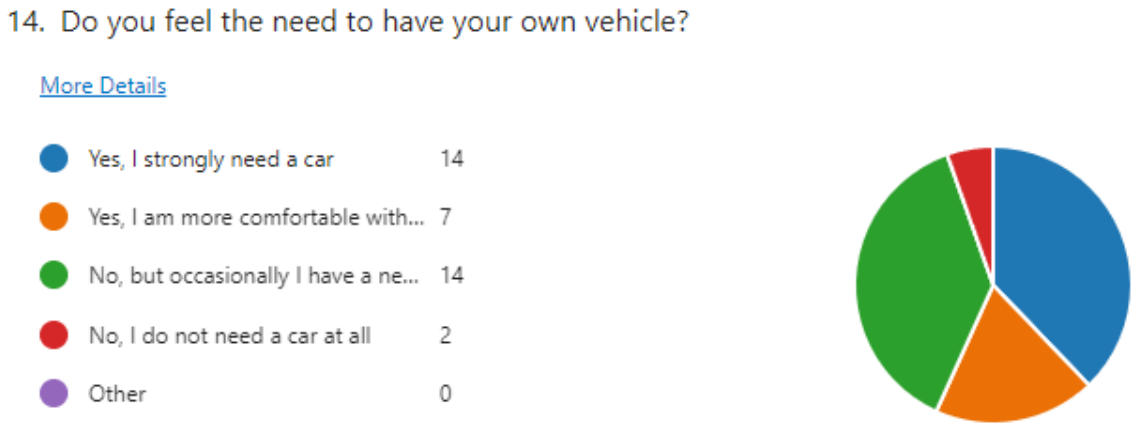

Figure 14. Question 14 – Car dependency

Question 14 aims to identify people's dependence on owning their personal vehicle. As can be seen from the literature, residents of small cities have a rather strong need to have their own car, and it can be said that the answers obtained from the survey confirm this statement.

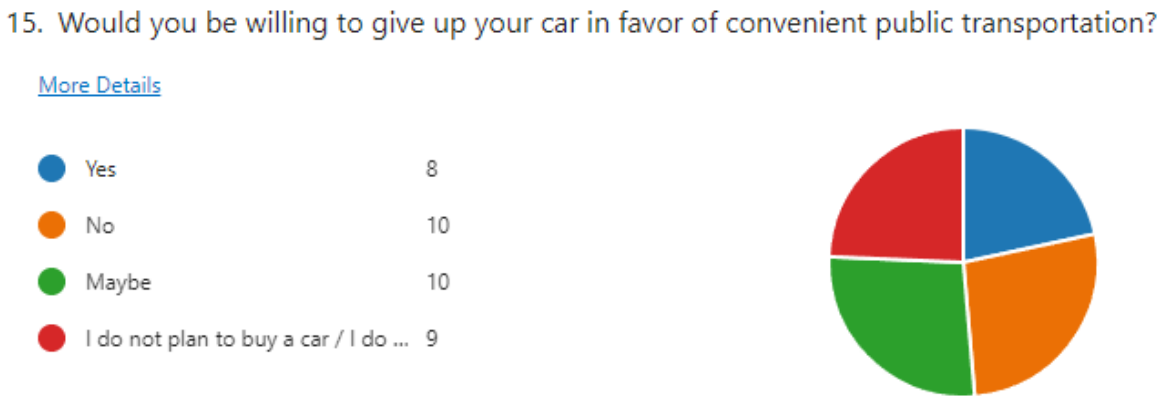

Figure 15. Question 15 – Willingness to give up a car

As the graph in Figure 15 shows, the answers to this question vary widely. There is an almost equal proportion of people who are sure of their decision, but a big number of respondents chose also "maybe". It can be concluded that those who are undecided are such because of the little information they have about MaaS. The lack of practical application of the concept in small towns also has an impact, so the respondents cannot fully imagine what their mobility experience would look like when MaaS is implemented. However, with the right approach, by offering quality services based on preferences, these people can be encouraged to choose public transport over private cars.

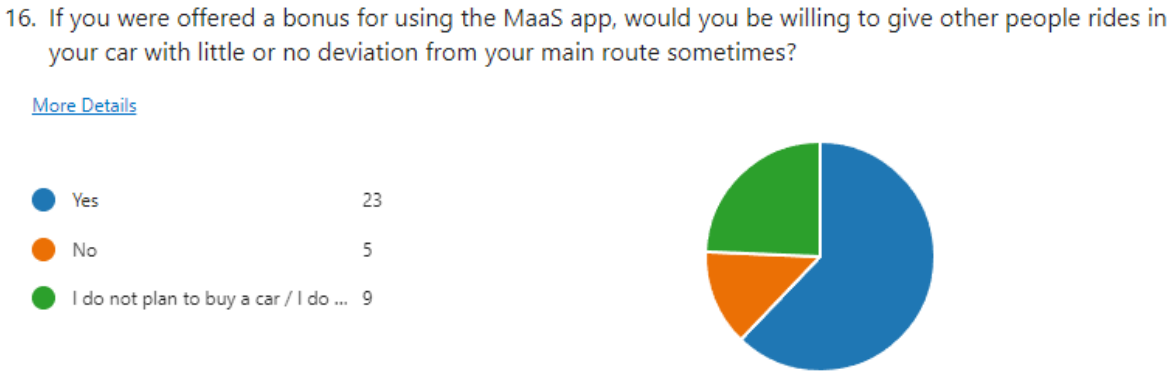

Figure 16. Question 16 – Willingness of drivers to participate

The results of the responses to this question show quite a lot of interest among car owners to participate in MaaS. More than half of the respondents answered positively, indicating additional development opportunities. Negative answers were mostly given by people in the age range from 45 to 60 years old. It can be assumed that this is related to more conservative views as well as the need to transport their family members by car. Without information on how MaaS participants are secured, people will be skeptical.

4.2 Analysis of results

Among the survey responses received were 27% of those who disagree that using personal transportation is starting to be considered as something bad. This deserves special attention because the literature review does show such a trend where people should switch to alternative modes of transportation. However, not everyone is willing to forfeit their own cars and therefore the level of comfort they provide. In the absence of motorists' willingness to use public transportation, emphasis can be placed on electric cars. One of the main goals of MaaS is to reduce emissions and improve the environmental situation, so it is possible to shift the focus to this kind of cars, leaving people with a choice and respecting their opinion, even if it differs from MaaS policy.

Thus, there is a situation in which many people do not mind giving up their personal car, 49% of respondents, but are unable to do so because of the impossibility of an alternative mode of transportation to meet all needs. Consequently, a low level of concern about the environmental friendliness of their preferred transportation can also be observed. As can be

seen from the literature review and the survey, there are too many problems in small cities mobility that make sustainability the last thing that the majority of residents think about. For instance, 65% of respondents selected this as the least important aspect. However, for people to choose eco-friendly transportation over traditional transportation, it is necessary to offer a worthy alternative, which, if it has its disadvantages, can provide significant advantages in addition to sustainability.

As noted in the analysis of question 16 (Figure 16), the reluctance of 14% of respondents to transport strangers may be directly related to safety issues. This creates a new challenge for MaaS providers who must ensure safety for all its participants. The literature review also showed the relevance of this aspect, because to operate and provide this kind of service would require permission from the authorities, and after that it is necessary to gain the trust of ordinary users, which can be even more difficult.

By complementing the already existing mobility infrastructure and considering the preferences of local residents, including the most urgent problems of the selected city, the best results can be achieved. Nevertheless, it is worth realizing that although MaaS is a versatile concept that can be adapted to the needs of residents, it does not guarantee success and greater benefits for the operators of the concept in the early stages of implementation. According to the literature, the higher the level of trust from users, the more level of MaaS implementation can be performed (Sochor et al., 2018). This is supported by the responses received to the questions, indicating the need to introduce services gradually, allowing residents to understand how the concept works and to see the benefits that may follow.

5 Conclusions

The literature review shows that there are successful cases of MaaS implementation within the urban environment and the concept can be beneficial. Considering the peculiarities of a small city, *it is very difficult to implement MaaS entirely, but it is possible to gradually introduce some aspects* that could both improve the mobility situation and pave the way for further implementation of the concept. The conducted survey also shows that *the majority of residents are ready for changes* if it would at least slightly facilitate their movement around the city and increase the availability of transportation.

Therefore, the main **benefits** that can be expected from implementing MaaS in a small city are *increased accessibility to public transport, providing alternatives for residents and potential cost savings.* Improving sustainability and switching to green transportation is also important, but not as much as in big cities, as the problem with harmful emissions into the environment is more acute there. Among the main **challenges** of implementing MaaS in a small city are *a highly possible lack of funding, a small number of stakeholders and potential resistance from the local population.*

The study emphasizes the need for further work in exploring the opportunities for implementing MaaS in low populated cities as well as determining the impacts and challenges of the concept in general.

5.1 Limitations and Future Research

One of the main limitations of the work is the small number of responses to the survey. Although it was possible to cover almost all age groups except people over 60 years old, it is worth noting that their ratio varies greatly. The majority of those who responded are between the ages of 21 and 30. However, given the analyzed literature and the responses received, it can be assumed that the results would not significantly change with an increase in the number of respondents.

As a further addition to the low number of respondents, it is difficult to say what is the key factor in answering for many questions. For instance, question 7 (Figure 10) in the survey

suggests ranking certain aspects according to importance. Preference of people may be affected by both their status as a student and as a resident of a small town. Therefore, it is not possible to state with certainty whether responses were fully relevant to the aims of the work.

The scope of the paper could also be larger, but due to the existing research gap, it is not possible to find enough relevant literature regarding the development of MaaS in small cities. This also emphasizes the relevance of the chosen topic and the need for further research.

There are still a lot of aspects that need to be studied regarding the development of MaaS in small cities and in general. Future research could be related to the problem of attracting stakeholders in the field of small town mobility, to the issue of increasing residents' interest in the concept and sustainability, and many others. Undoubtedly, the positive aspects of the MaaS should also be analyzed considering the constant innovations in the field of transport, but only a full understanding of the advantages and disadvantages will allow to implement the concept in the most efficient way.

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Appendix 1. Survey Form

Question 1. Your age:

1) *Less than 20 years old*
2) *21-30 years old*
3) *31-44 years old*
4) *45-60 years old*
5) *Over 60 years old*

Question 2. Are you familiar with the concept of Mobility as a Service?

1) *Yes, I know a lot about it*
2) *Yes, I know a little bit about it*
3) *No, but I've heard of it*
4) *No, I'm not familiar with it*

Question 3. How often do you use public transportation?

1) *Daily*
2) *Weekly*
3) *Monthly*
4) *Seasonal*
5) *Very rarely*
6) *Never*

Question 4. Does your need for public transportation depend on the season of the year? *(1 – weakly dependent, 5 – strongly dependent)*

Question 5. What modes of transportation do you prefer to use for your trips in the city?

1) *Bus*
2) *Taxi*
3) *Bicycle*
4) *Personal car*
5) *Scooter*
6) *Walking*
7) *Other….*

Question 6. How would you rate the convenience of the current public transportation options (buses, bikes, trains, etc.) in your city? *(1 – very uncomfortable, 5 – very convenient)*

Question 7. Please rank the following aspects of mobility in terms of importance to you. (The most important on top and the least important on bottom)

1) *Safety*
2) *Speed*
3) *Convenience*
4) *Price*
5) *Eco-friendliness*

Question 8. What problems do you think exist in the availability of transportation services in your city?

Question 9. If you were given access to test versions of MaaS applications, would you use them to travel around the city? *For example, pay for trips for different means of transportation and create a route for your trip in the same application.*

Question 10. If you answered positively to the previous question, would you prefer a user-friendly design or more functionality but a more complex and unclear interface? *(1 – functionality and complex design, 5 - user-friendly design, 3 = balance with limited functionality, but also with an interface that is understandable to a large number of users)*

Question 11. How much are you willing to trust artificial intelligence algorithms (in this case MaaS) to create the route of your trip? *(1 – create the route yourself, 5 – create a route without your input, 3 - create a route based on your recommendations with the possibility to change it)*

Question 12. Do you think the full implementation of the Mobility as a Service concept could improve mobility in your city?

Question 13. What services within Mobility as a Service would you like to see in your city?

1) *Carpooling*
2) *Smart parking*
3) *Carsharing*
4) *Bike-sharing*
5) *A single ticket for different means of public transportation*

Question 14. Do you feel the need to have your own vehicle?

1) *Yes, I strongly need a car*
2) *Yes, I am more comfortable with a car*
3) *No, but occasionally I have a need for it*
4) *No, I do not need a car at all*

Question 15. Would you be willing to give up your car in favor of convenient public transportation?

1) *Yes*
2) *No*
3) *I do not plan to buy a car / I do not have a car*

Question 16. If you were offered a bonus for using the MaaS app, would you be willing to give other people rides in your car with little or no deviation from your main route sometimes? **Bonuses can be, for example, a discount on parking or a discount on the purchase of a ticket for public transportation.*

1) *Yes*
2) *No*
3) *I do not plan to buy a car / I do not have a car*

Question 17. Do you have any additional comments or suggestions regarding mobility in your city?