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Future implementation of Mobility as a Service (MaaS): Results of an international Delphi study

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For more information on the SCRIPTS project, visit <https://goo.gl/e6Nr2j>

Summary

The prospects of MaaS as a potential solution for urban mobility has inspired a high level of interest from various transport sectors. Nevertheless, the concept is still in its early stage of development with limited evidence to support its anticipated benefits. Moreover, there is a high-level of uncertainty surrounding MaaS that may restrict or delay its implementation on a large scale, such as the formation of collaboration between actors, appropriate business models and the travellers' acceptance of MaaS.

The objective of the study was to **explore future prospects of MaaS**. Although some MaaS applications are currently available on a small scale, this study focuses on opportunities for large-scale implementation, as this could contribute significantly to public policy goals. To be more particular, the study aimed at clarifying initial MaaS markets, today's barriers which obstruct introduction and/or further developments, and measures which should be taken to overcome these barriers. The results of this study contribute to the general understanding of MaaS development by addressing the planning of its implementation in a systematic manner.

In this study, the results of a Delphi study on the future implementation of MaaS, which engaged a panel of international MaaS experts are presented. The survey was carried out between September 2017 and April 2018. The main findings of this study are summarised below.

The expectations on Early Market

- Fully-integrated MaaS is expected to be in operation in urban areas before 2020
- Younger generations (Gen-Z and the Millennials) will lead the adoption of MaaS.
- Regular public transport users and flexible travellers, who combine different modes of transport to make their trips, are thought to be the early adopters of the concept.
- Experts also see MaaS being used for commuting and business trips in its early stage.
- Transport operators are seen as the most important actors and the experts prefer them as the MaaS service integrator.
- Investors and shareholders are also seen as the most important stakeholders.

Planning of MaaS implementation

- Top objectives to implement MaaS from public organisations' perspective (i.e. local authority or the central government) are to reduce car dependency and its usage and to provide public accessibility.
- The implementation of a pilot project to experiment and to enable learning is the most preferred policy.
- The pilot will require a close collaboration between key actors and stakeholders as the most important condition to ensure its success.
- The key constraints that may prevent the stated objectives to be reached are the perception of users that MaaS service is of limited value, the existing forms of public transport contracts, and the current inadequate ICT condition.
- The most important vulnerability or an event that can cause the preferred policy to fail is the lack of collaboration between the crucial actors. The experts similarly agreed that the reverse is also true; they see an active collaboration between actors crucial for the success of the preferred policy.

This Delphi study confirms a number of earlier reported surveys and studies on MaaS and makes additional contributions to the knowledge. This study is unique in its focuses on the planning aspects of MaaS, which have not been researched in this way before. Moreover, the objectiveness and the overarching nature of this study implies its outcomes may be used as reference points for practitioners and researchers in the field of MaaS planning. Further work will be required to validate the findings reported here. A possibility is by contextualising them in a planning process of a specific MaaS pilot or an operational MaaS service.

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Provincie Noord-Brabant	Gelderland Provincie	MuConsult

This study would not have been possible without the cooperation of 89 experts in the field of Transportation and Mobility as a Service. The survey team would like to thank 24 respondents below and additional 65 anonymous respondents, who kindly dedicate their precious time in making an invaluable contribution toward this survey. The following 24 experts indicated that their name could be mentioned in this report:

Title	Name	Surname	Affiliation
Mr	Hans	Arby	Ubigo Innovation
Dr	Saroch	Boonsiripant	Kasetsart University
Prof	Eric	Bruun	Kyyti Group
Mr	Lewis	Chen	-
Mr	James	Datson	Principal Technologist - MaaS
Mr	Keith	Firth	Director - NRP Traffic & Transportation
Mr	Mads	Gaml	City of Copenhagen
Mr	Richard	Harris	Director Europe, Ohmio Automotion
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	Greg	Lindsay	Senior Fellow, NewCities
Mr	Niels Tvilling	Larsen	CPO, Demandtrans
Mr	Jukka	Lintusaari	University of Tampere
-	Karel	Martens	Technion - Israel Institute of Technology
Mr	Brian	Masson	Director
Director	Jeffrey	Matthijs	Autodelen.net
Mr	Angelo	Meuleman	Taxistop
Prof Emerita	Corinne	Mulley	University of Sydney
Mr	Sébastien	Mure	GoSwift
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-	Andrew	Nash	crowdsourced-transport.com
Mr	David	Pickeral	-
Mr	Eetu	Pilli-Sihvola	Finnish Transport Safety Agency
Mr	Jaakko	Rintamäki	Senior Adviser, Sitowise Ltd
-	Steffen	Schaefer	New Zealand Transport Agency
Mr	Daan	Stevens	Transdev
Drs	Patrick	van Norden	-
Mr	Eric	Verhulst	KURT.mobi
-	Susan	Zielinski	Independent Consultant

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1 Introduction

Major changes influence the structure and dynamics of the mobility sector. This transformation is driven by multiple trends, such as urbanisation, demographic and societal changes, and an increased awareness of environmental ethics (Hoppe, et al., 2014). Additionally, advancements in technology, especially in telecommunication and computation, has enhanced global interconnectivity and facilitate the emergence of another trend: digitalisation (WEF, 2016).

The digitalisation of the mobility sector is expected to deliver many benefits, such as an improved efficiency in traffic and transport management and an improved choice of transport services (EC, 2015). In fact, it has already enabled new transport services to emerge in many cities. For example, travellers in Vienna and Amsterdam can nowadays plan, book, and pay for their trips across available transport modes through their smartphones using Apps, such as NS Extra and Wiener Linien. Commuters can use their smartphones as a digital key to access various transport services, including bicycles and car rentals, such as Citybike and Car2Go. Online peer-to-peer car sharing platforms, such as SnappCar, can offer services that rival cumbersome car rental firms.

The transformation of the mobility sector is ongoing and will bring significant opportunities and challenges (UITP, 2017). A significant development in this context concerns Mobility-as-a-Service (MaaS). MaaS is a transport concept that combines services from different transport modes to provide a user with a transport solution via a single interface. MaaS can be offered to users based on a monthly payment package or based on a pay-as-you-go fee, similar to mobile phone services (Hietanen, 2014). The underlying concept of MaaS is a user-centric mobility solution, i.e. tailored to suit individual's needs (MaaS Alliance, 2017).

MaaS has the potential to cause a paradigm shift in the transport system as it offers a change from the current ownership-based transport system towards a consumption based one (Holmberg et al., 2015) In other words, MaaS liberates the users from any potential mode-specified sunk costs, such as car ownership or annual public transport subscription fees, that potentially 'lock' users to specific modes. Instead, by using MaaS, users can flexibly combine the available modes to fit their changing needs best, through a digital platform, a virtual marketplace that mediates mobility supply and demand (Meurs & Timmermans, 2016). This potential change can have significant implications for the organisation, the dynamics and the impacts of the transport system.

Although the provision of integrated transport services is not new, MaaS is different to the other transport concepts, such as integrated transport or multimodal mobility, in several ways. Finger et al. (2015) highlight three elements of MaaS that distinguish it from other concepts, namely 1) its emphasis on personalisation, 2) its dependence on digitalisation, and 3) the 'business dimension' or potential to connect transport services with services from other sectors, such as tourism and entertainment or social services such as health or education.

MaaS has inspired a high level of anticipations from various actors within the transport sectors. For instance, an independent think tank CIVITAS (2016) highlights several potential benefits of MaaS for the user (e.g. high service quality and competitive pricing), the public sector (e.g. improvement of system effectiveness), and for businesses (e.g. new profitable market). Recent funding of over 10 Million Euro raised by MaaS Global, a developer of the concept and the forecasted revenue of MaaS to exceed 1 trillion US dollar underpins the potential prospect of the concept value by the industry (MaaS Global, 2017).

This potential contribution of MaaS to the development of improved transport has been recognized by the Netherlands Organisation for Scientific Research (NWO). NWO has initiated a research project called the Smart Cities' Responsive Intelligent Public Transport Systems (SCRIPTS). The SCRIPTS project was initiated in 2016 under the SURF (Smart Urban Regions of the Future) programme. The SCRIPTS project aims to deliver (a) a novel model to predict the demand for hybrid public transport systems involving new demand responsive transport services that are flexible in routing and scheduling and that are organized through smart city mobile ICT platforms, (b) a set of models for the optimal design of such hybrid systems and the simulation of their performance and (c) an evaluation and planning framework addressing institutional aspects of a Maas innovation.

In addition, the Dutch government has the ambition to be a leader in the field of transport innovation and technology. It has taken a pro-active approach in piloting cutting-edge technology and mobility, such as self-

driving cars, the Hyperloop, and MaaS. In particular, the Dutch government has initiated various initiatives to investigate and accelerate the realisation of MaaS. Many of their initiatives also include the implementation of projects, such as SCRIPTS (2016) and the organisation of a market consultation on MaaS (Minienm, 2017). The latter will probably be followed by a tendering process for pilot projects in seven Dutch regions in 2018.

In addition to these public initiatives, there are activities related to MaaS from other stakeholders. For example, a multi-stakeholder task force, named MaaSifest¹, was established in 2016. The task force aims to create an action plan to speed up the adoption of MaaS in the Netherlands. It sees MaaS as a stepping stone toward delivering a more sustainable and smarter city, which is strongly driven by potential efficiency gained for transport system operations and prospective future business opportunities. The task force seeks to combine expertise and experiences from various types of institutions and organisations, such as local authorities, private companies, public transport providers, technology developers, and academic institutes. Moreover, there are several MaaS pilot projects established over the recent years, such as S!im Nijmegen, the Palieskwartier in Den Bosch, and Whim in Amsterdam.

This report presents an initial outcome of the SCRIPTS project in developing a planning framework for the implementation of MaaS. Experts around the world were interrogated in a systematic way (using the Delphi method) on various matters related to MaaS implementation, such as expected implementation period, early markets, barriers and opportunities, and policies to handle these. Before going into detail on the set-up of the research, first, some thoughts will be presented with regard to the complexity of public policy making and the related uncertainties for decision making.

1.1 Public policymaking on MaaS

The potential prospects of MaaS in improving efficiency and accessibility of transport system have drawn interests from various organisations related to public policymaking in Europe (Polis, 2017), including the Netherlands. Cities are worldwide the focus for economic activity and social development. The combined influence of population growth, demographic change and changing urban form leads to increasing demand for travel in city centres, suburbs and between the two. Demand for improved intercity mobility is also growing, to create faster and more direct connectivity between them. Increasing demand also raises concerns about global greenhouse gas emissions, congestion, noise and poor air quality in cities. The inability to provide an adequate supply of physical transport capacity resulting in crowding, congestion, and an unpleasant experience of the city. These problems are partly attributed to spatial constraints - which inhibit the additional growth of transport networks, but also on budgetary limitations on physical infrastructure maintenance and renewal.

Given these trends, MaaS is seen as a promising alternative alongside investment in transport infrastructure and public transportation in alleviating urban transport problems. Potentially, MaaS can enable the realisation of a more responsive, more efficient and more robust transport system for the traveller. From a policy point of view, MaaS may contribute to:

- A better product offering (to the travellers): MaaS must be able to offer a platform for all modes of transport, including less familiar and new ones, such as car sharing and bike sharing. This would give the consumer more freedom of choice and the transport provider the option of improving the services, retaining customers and instilling loyalty in new customers, all based on this interchangeability;
- Social inclusion: MaaS would potentially be able to combat the problem of impoverished transport, on the one hand in certain areas and, on the other, for certain vulnerable groups. In more concrete terms: offering transport in situations where it is either not present or has a diminishing presence and contributing to lowering the threshold for using forms of transport (better use).
- Congestion reduction: If MaaS ultimately contributes to the better use of the available capacity, this will lead to reduced peak-time use and, thus, to the reduction of congestion. MaaS should make it easier for travellers to switch spontaneously from, say, congested forms of transport to systems with available capacity and no traffic congestion.
- Accessibility: MaaS can focus specifically on an area's accessibility and brings together all the information and services that are relevant for the users of those areas, including information

- issuing from the national government or the area authority (public and/or private).
- Sustainability: The initial results of foreign initiatives seem to indicate that MaaS causes people to more often use forms of transport other than their own cars, which ultimately is the most effective measure when it comes to the transition to sustainability.

It is expected that the lively discussions and initiatives around MaaS will continue in the coming years. In particular in the light of the European policy on transport. The European Commission has declared 2018 a year of Multimodality with an aim to raise awareness on the importance of multimodality for EU transport system (EC, 2018). Three of the key thematic areas apply to MaaS, namely digitalisation, support to multimodal (physical and digital) infrastructure and innovation, and legislative framework to protect passenger rights in multimodal journeys. In particular, the Commission aims to provide support to multimodal infrastructure through its funding mechanisms, namely Connecting Europe Facility, Horizon 2020 and the preparation of the next Multiannual Financial Framework (MFF) and the new Framework Programme for research and innovation (FP9).

1.2 Uncertainty surrounding MaaS implementation

Given the positive expectations of MaaS, there is still limited, real-world evidence on its anticipated benefits. Some MaaS schemes have been implemented around the world. Among those, are pilot projects that operated within a limited time period such as Ubigo (Sweden) and the SMILE project (Austria). Others are ongoing operational schemes, such as Tuup and Whim (Finland), Hannover Mobility Shop (Germany), and MyCicero (Italy). These pilot and schemes provide some first indications of necessary conditions for implementing MaaS on a large scale as well as quantification of the potential MaaS impacts on transport system performance. However, these indications are still too limited in number and often case-specific to allow for generalization. Due to this, there are still several uncertainties that may restrict or delay MaaS implementation on a large scale. These include i.e. the preferences of public transport operators regarding the nature of collaboration with other stakeholders, the travellers' acceptance and valuation of MaaS services, various concerns about privacy and security (related to the crucial role of digitalisation), and the overall contribution of MaaS to the performance of the transport system as a whole (Jittrapirom et al., 2017).

The level of uncertainty surrounding an implementation of MaaS is high for several reasons. Firstly, there is still limited knowledge about this novel transport concept. Several of the underlying ambiguities have been mentioned already, such as the ongoing debate on the precise definition and demarcation from other innovations, or the overall effect on the urban transport system, or the uncertainty about user and stakeholders' acceptance. It may be possible to speculate on these concerns based on lessons learnt in other sectors, such as hospitality in Airbnb or within the transport sector itself from Uber. However, such speculation is likely to have a limited level of accuracy and can trigger polarised opinions from stakeholders and researchers in the academic community (Jittrapirom et al., 2017). The second dimension concerns the complexity of the system of MaaS. Urban transport is known to be a highly complexed system, mainly due to the interconnectivity and interoperability between the included entities (Kölbl et al., 2008; May, 2003). The exact dynamics in case of intervention are not always predictable (Pojani & Stead, 2015). Moreover, certain transport policy measures can bring about unintended effects that worsen the overall performance of the system (ADB, 2009; IET, 2010; Jittrapirom et al. 2017). Thirdly, uncertainty might arise due to differences in the valuation of the outcome of interventions by decision makers. These outcomes may be forecasted with some certainty but the inherent subjectivity in valuation can also be influenced by other factors that have a high level of uncertainty, such as public mood at the time of valuation. Finally, uncertainty associated with external forces play a significant role. Certain forces, such as demographic development can be forecasted using past data with some accuracy, whereas other forces, such as national economic development, are more difficult to predict accurately.

The preceding brief exploration indicates that there exists a clear need for a better understanding of future MaaS developments. This study intends to contribute to this need. It uses the Delphi method for identifying and evaluating (a) future markets for MaaS, (b) barriers to further developments and (c) policy measures to overcome these barriers. This section introduces the report and its context. The remainder of this report is structured as follows. Section 2 briefly deals with the research approach, it also details the Delphi method in general and the setup of this Delphi in particular. In Section 3, we describe the respondents of this Delphi and their profiles. The findings of the survey are discussed in the three subsequent sections: Early market expectations (Section 4), planning for future implementation (Section 5), and possible events that can cause

the policy to implement MaaS to fail or succeed (Section 6). We examine the levels of stability and consensus of the survey in Section 7. Finally, the discussions and conclusions of this study are drawn in Section 8.

2 Research Approach

2.1 The Delphi method

The Delphi method was developed by Norman Dalkey, Olaf Holmer, and others at the RAND Cooperation for a military application in the early 1950s. The method was devised to obtain the most reliable opinion from a group of experts by means of multiple rounds of anonymous interviews or questionnaires, combined with controlled feedbacks of information (Dalkey & Helmer, 1963). Over the years, the Delphi has become a popular method to develop collaborative judgements on specific issues and for structuring a group communication process (Linstone & Turoff, 2002).

Basic characteristics of the Delphi method (Box 2-1) are anonymity, iteration, controlled feedback and statistical group response (Linstone & Turoff, 2002; Rowe et al., 1991):

Box 2-1 Basic characteristics of the Delphi method

- **Anonymity:** participants of a Delphi survey can express their views anonymously. The anonymity removes any potential influences participants can have on each other as they express their views to the group. In other words, the technique eliminates any halo effects that frequently influence communication within a group. Thus, the anonymity ensures participants to judge the subject of interest on its merit without the possible dominance of some experts or without being influenced by group conflicts. This should provide more accurate judgements than those produced by techniques which involve direct interactions between individuals.
- **Iteration:** the Delphi method consists of a number of repeated rounds. After each round, participants are allowed to adjust their previous replies. This process is repeated until a certain condition, usually, a predetermined degree of consensus or a number of rounds is fulfilled.
- **Controlled feedback:** after each round, participants receive feedback on the collective opinion on various aspects alongside their own individual opinions. Participants can evaluate their earlier responses in the light of the group's view. The intermediate group responses are often represented by various descriptive statistics (i.e. frequencies, median, mean, variance, etc.). Inclusions of arguments underlying individuals' opinions are also possible.
- **Statistical group response:** in each round the level of concordance is calculated to ensure the group opinion is represented by an adequate measure of the central tendency of opinions. The dispersion of opinion is often also given, as this indicates the degree of consensus among the experts.

The Delphi method has been applied to various fields for various purpose, such as a tool for technology forecasting by American business and industry (Porter et al. 1990), a method to analyse the future path of ICT in foresight (Keller & von der Gracht, 2014), a tool to assess policy of driver support system implementation (Marchau & van der Heijden, 1998), and a long-range planning tool for a sustainable transport system (Shiftan, Kaplan, & Hakkert, 2003). Moreover, a number of variations in the method have been reported, such as Policy Delphi (Turoff & Linstone, 2002) and Real-time Delphi (Gordon & Pease, 2006; Zimmermann et al., 2012).

The Delphi method has shown to yield more valuable and robust information than other methods based on individual or group interviews (Rowe et al., 1991). It also proved to be a useful method in dealing with future decision making on complex societal problems with no or limited historical data (Gupta & Clarke, 1996; Linstone & Turoff, 2002). Additionally, the simple process of expert interaction yields higher confidence among forecast users than "black-box" models. Moreover, it enables remote interaction, which allows participants to deeply consider the subjects at hand, reducing the associated cost and effort, and the potential halo-effect by certain members of the panel (Hasson et al., 2000; Linstone & Turoff, 2002; Pawlowski et al., 2004; Tersine & Riggs, 1976).

However, the Delphi method has also received criticisms for its lack of methodological robustness in sampling control, reliability and validity of results, and potential influence from the researcher (Beretta, 1996). Sackman (1975) evaluated the technique and recommended that the Delphi should not be considered a 'serious professional practice'. Similarly, Woudenberg (1991) found no evidence from previous Delphi studies that support its' superiority in relation to other judgement methods. He also suggests that the consensus reached in a Delphi study is a result of strong pressure to conform to group opinion. However, these critiques may yield to Delphi studies which aim to seek consensus, whereas Linstone & Turoff (2011) strongly purports against such an aim. They emphasise that the technique should not be used to derive a consensus but to help to structure a group communication process. For further details on the Delphi method see (Linstone & Turoff, 2002; Marchau & Van de Linde, 2016).

2.2 Set up of the present Delphi study

In this study, the Delphi method is applied to examine the diverging opinions on the future of MaaS and its development, rather than to achieve a consensus on the subject. In addition, the method is applied to identify the uncertainties associated with MaaS implementation and to explore different possibilities to cope with the uncertainties. Our approach here build on the Assumption-Based Planning (ABP), a planning approach develop by Dewar (2002) to identify and deal with uncertainties, thus ensuring a success of a given plan.

The survey took place between September 2018 and March 2019. The media format of the survey is entirely online. The respondents were invited by email, which included the link to the survey website. The survey was hosted on an online survey platform, which assisted the administration and the processing of the questionnaire. The survey is presented in Appendix B and consisted of 3 rounds. The types of questions included in each round are a mix of pre-specified answer options and open-ended ones and the topic in each round is shown in Table 2-1 below.

Table 2-1 Types of questions in each round

Round 1 & 2	Round 3
(a) Initial market prospects (b) Business ecosystem of MaaS (c) Initial planning elements <ul style="list-style-type: none"> • possible objectives, • preferred public policies, • constraints, • conditions for success 	(d) Potential opportunities and vulnerabilities arising from implementing the preferred policy and their plausibility (e) Possible actions to handle with stated opportunities and vulnerabilities (f) potential up-scaling and social issues.

The topics of the questionnaire were changed in the third round because, after the second round, we found that the levels of stability (i.e. non-changes) for most items at the group level were sufficiently high after the first two rounds. (See Section 6). However, there are several topics that arose from the first two rounds that we would like to explore further. Therefore, in the third (final) round, we used a list of explorative questions asking the experts to identify elements related to the topics listed above.

MaaS concepts

In this study, two types of mobility integration were considered that were assumed to be more or less representative for the full range of the existing mobility concepts. The simplified typology focused on a difference in the level of service and information integration from a user's perspective. The two types are Semi-integration (Type-A) and Full integration or MaaS (Type-B). In the context of semi-integration (Type-A), users need different apps to access information for each mode of transport. For example, in the case of the Netherlands, a user will need a public transport app to check the bus and train timetables (9292 App) and a car-sharing app (Car2Go App) to reserve and locate a car-sharing service. If users need to make a trip that requires the use of different modes (e.g. train and car sharing), they will have to integrate these modes manually.

In contrast, users of a fully integrated or MaaS service (Type-B) will be able to inquire information on different modes, making reservations and obtaining their tickets through a single app. The app combines different modes to offer the most convenient transportation service. Examples of this type of integration are Whim

(Finland) and Ubigo (Sweden). The icons used to depict these two levels of integration in the survey are shown in Figure 2-1.



*Figure 2-1 Icons depicted two level of mobility integration
Semi-integration (Type-A - left) and Full-integration or MaaS (Type-B - right)*

The experts

The selection of experts is an essential element to ensure the quality and completeness of a Delphi study. In general, the selection of experts logically breaks down into two parts (Helmer, 1988): the determination of the types of expertise needed for the problem under attention and the identification of the experts for each type of expertise. The experts for this Delphi study were selected based on the following procedure:

- The areas which needed expertise were listed, both within the fields of MaaS and broader fields of transportation (e.g. smart mobility, connected and self-driving vehicles, transport planning, and transport policy analysis). The search included a wide range of candidates from different sectors from academic to transport providers.
- We scanned recent literature on MaaS to identify researchers and scholars with recent publications in this field. We also identified a number of conferences, congresses, and exhibitions focused on MaaS and related topics. We reviewed the presenters and exhibitors who took part in these conferences and exhibitions and drew up a shortlist of their names.
- We also reviewed the recent MaaS and smart mobility projects and extracted the names of their participants to select experts with practical experience.
- It was apparent at this stage that the shortlist was strongly dominated by European experts. An effort was made to ensure a better representation from other continents (North America, Asian Pacific, Africa, and the Middle East). As MaaS had a strong presence in Europe and North America, it appeared a real challenge to identify experts from the other parts of the world.
- We contacted each expert via email or social network service for professionals before we sent the invitation to participate in the first round. We also asked each expert to provide names of experts he or she knew in the field. These recommended contacts were also included in the panel. In total, we identified 352 experts and sent them invitations to participate in the first round.
- In addition to the above, we also asked each expert to provide information on his/her expertise in the field of mobility in general and in MaaS in particular. We present the profile of our expert panel in Section 3.

Analysis

For ordinal questions (e.g. expected period of occurrence), we use the median value to represent the panel's preferred choices and the associated interquartile range (IQR) to represent the level of consensus on the question. The higher the IQR value the higher level of disagreement in the group.

For questions asking for a ranking of items, we calculated the weighted mean ranking to represent the group preference. The processing of these indicators was made using SPSS. We present in this report only the top-five in each category. We also mention the percentage of our panel that included each option in their choices. The level of agreement between experts on the selection and ranking is assessed using Kendall's coefficient of concordance or w (See Sheskin, 2004), a non-parametric statistic which ranges from 0 (no agreement) to 1 (complete agreement). It is suggested in the literature that an effect size of 0.5 indicates a large or high level of agreement, 0.3 equates to a medium level and 0.1 indicates a low level of agreement. The validity of the coefficient also depends on its associated p-value, which should be less than 0.005 (i.e. $p < 0.005$), signifying a chance less than 0.5% for disagreement among the experts on the subject.

To process the qualitative data, we use the qualitative analysis program Atlas.ti (Friese, 2014) to assist the coding, organisation and analysis of the data.

Limitations

Although our study has provided a number of interesting outcomes, there are several shortfalls. Firstly, the somewhat complex questionnaire of this Delphi study may have induced respondent fatigue (Lavrakas, 2008). Another potential setback is the research team's decision to conclude the repeating questionnaire in the 2nd round. Additional rounds of the questionnaire may increase the level of agreement between experts and the level of stability. However, since for our research purpose the level of stability was sufficient, we decided to dedicate the 3rd round to exploring related topics more in-depth, thus slightly expanding the scope of the survey. Thirdly, despite our initial effort to include experts from different regions, the diversity of the expert panel is still limited. An inclusion of experts outside of Europe may further increase the generalizability of the findings. However, it is evident that, as MaaS will continue to evolve and develop, certain findings and insights reported here should be periodically monitored and updated to ensure their validity. Alternatively, further work in contextualising the findings reported here in a planning process of a specific MaaS pilot or an operational MaaS service can also contribute to enhancing them.

3 Survey response and experts profile

In the first round, a total of 352 experts were invited to participate in the survey via email. The selection of these experts was based on their recent academic and practical activities in the fields of MaaS and smart mobility (See Section 2). Additionally, a handful of experts were recommended by some respondents.

Out of the 352 experts, 312 were reachable by the given emails, and 89 participants completed the first round, which represents a response rate of 29%. In the second round, 46 out of 89 completed the questionnaire (a 52% response rate). In the third and final round, 35 out of 89 completed the survey (a 39% response rate). These response rates are highly comparable to other Delphi studies, such as Schuckmann, et al. (2012) with a response rate of 31% and higher than Keller & von der Gracht (2014) with the 19% response rate. Consequently, the response rate can be considered adequate given the considerable amount of information required from the respondents in completing the questionnaires. Moreover, the number of respondents still allows for basic statistical analyses.

The participants were encouraged to take part in the survey through a motivation letter with an early-access offer to the survey report guaranteed to those who complete the survey. They were given approximately 4 weeks to complete each round of the survey with a period of the interval between the rounds. Reminder emails were sent three times in each round to encourage respondents to complete the survey and minimise the drop-out rate of participants during each round.

Certain participants sent a reply to the invitation emails to express the lack of time to participate in the survey and requested to be omitted from the mailing list. Three experts proposed replacement colleagues to take part in the survey instead of themselves, citing a lack of time or expertise to respond to the questionnaire. Additionally, three individuals proposed inclusions of their peers in the panel.

In Table 3-1 and 3-2, the respondents over the different rounds are segmented into their geographic background and professional background or sector.

Table 3-1 Respondents by geographical background

Region	Questionnaires successfully sent	1 st round	2 nd round	3 rd round
Africa	2	1	1	0
Asia-Pacific	22	6	5	4
Europe	227	73	34	26
Latin America	2	1	0	1
Middle East	4	1	1	1
North America	55	7	5	3
Total	312	89	46	35

Table 3-2 Respondents by sector

Sector	Questionnaires successfully sent	1 st round	2 nd round	3 rd round
Academic and Research Institution	58	19	8	7
Government and public authority	50	11	5	4
Transport provider	28	12	7	3
Business and industry	46	11	4	5
Technology developer	33	10	5	6
Consultant	32	12	8	6
Interest group and association related to transport	32	6	4	1
Interregional and International organisation	33	5	3	2
Other	n/a	3	2*	1
Total	312	89/312 (29%)	46/89 (52%)	35/89 (39%)**

* figure in parenthesis is the response rate ** We sent invitations to the third round to 89 participants.

The distribution of the respondents by their geographical background shows an apparent strong representation of experts from Europe and, to a much lesser degree, North America. These two continents are the forerunning continents in MaaS development, especially in Europe. Unfortunately, the response rate of experts from North America is significantly below the group average (13% in the first round, as compared to the group's rate of 29%). Consequentially, this led to a relatively strong representation of European respondents in the subsequent rounds. The segmentation regarding professional background is far less dominated by a specific sector. Participants working in international organisations and interest groups related to transport have somewhat lower response rates in comparison to other groups. In contrast, respondents working for transport providers appeared relatively most enthusiastic in completing the survey. This might be due to their possibly stronger direct interest in the survey topic than other professionals, who may have a lesser stake in any related changes.

The distribution across different professional sectors shows a significant proportion of respondents to have a practical background, ranging from consultancy, technology developing, providing transport services, and being involved in public policy development. Respondents from academic and research backgrounds represent around 17-21% of the total respondents in each round, the most significant single proportion within the sectoral category.

As mentioned in Section 2.2, the third round of the questionnaire differs from the first and the second round and for this reason, the 46 respondents of the second round are considered the final panel in our study.

Table 3-3 shows the field of expertise for this selected group of respondents as well as their source of knowledge. A high proportion of experts worked in the fields of intelligent mobility (10) and transport planning (12). Other respondents were involved in transport engineering, mobility behaviour studies, shared mobility services, and MaaS. Within the selected group, 7 respondents worked in technology and ICT development, including the development of Apps; 4 worked on connected and self-driving vehicles; 2 in local public transportation; 2 in logistic operation and management, and 1 in transport economics. A total of 17 experts obtained their knowledge from their practical experience, whereas 11 gained their insights from applied research and policymaking. Finally, 8 have received knowledge of MaaS from some form of formal education, 2 with self-study, 2 with academic research and 1 with self-study.

Table 3-3 Respondents' field of expertise and source of knowledge

Field of expertise	Number of respondents	Source of knowledge	Number of respondents
Connected and Autonomous Vehicles	4 (9%)	Academic research	3 (7%)
Intelligent Mobility	10 (22%)	Applied research and policymaking	11 (24%)
Transport technology, ICT, and App development	7 (15%)	Formal learning and education (e.g. high-level education)	8 (17%)
Mobility business, such as car sharing	6 (13%)	Practical work, learning by doing	18 (39%)
Local public transport	2 (4%)	Self-study	3 (7%)
Logistics operation and management	2 (4%)	Specialised training course	1 (2%)
Transport economics, policy, and planning	12 (26%)	Other, please specify	2 (4%)
Other area, please specify	3* (7%)	Total	46
Total	46		

*One to policy and two to tech-transport

Table 3-4 summarises the respondents' degree of expertise in their professional work and in MaaS. The ratings were obtained by questions using an expertise self-rating scale of 1 to 5. The results show that over 91% of the experts believe they have a level 4-5 of insights in their fields, with a mean value of 4.4. 61% of them also believe to have a level 4-5 of expertise in MaaS, with a mean group value of 3.8.

Table 3-4 Level of Expertise of the panel

Level of expert	1	2	3	4	5	Group Mean (n=46)
Expertise						
Own field	0%	0%	9%	41%	50%	4.4
MaaS	4%	4%	30%	28%	33%	3.8

Based on the information in the previous tables we can conclude that the average profile of the Delphi panel is European experts in the transportation field, who gained their knowledge from practical work experience and learning by doing or through their applied research and policymaking. They are likely to work in academic and research Institution or work as consultant or transport provider. They have a high expertise in their professional work and on the concept of Mobility-as-a-Service. Overall, the expertise of the panel is considered adequate to draw conclusions from the data collected in this Delphi study.

4 Expectations on early market

This section presents the panel's opinion on the expected MaaS early market penetration and its ecosystem. We asked the panel on the initial market characteristics of MaaS through expressing their thoughts regarding the expected MaaS application area, the period of introduction, the profile of the MaaS Early Adopters² in terms of their age, their current dominant mode of transport, and their trip purpose. Moreover, we asked the experts to identify and rank important actors, stakeholders, and their preferred MaaS operator.

4.1 Expected application area and period

The results of the experts' opinions on the expected application area and period are presented in Table 4-1. A large proportion of respondents (72%) indicate that Semi level of integration (Type-A) is already available in their urban areas, nearly one-third already observe Type-A in their rural (28%) and national (26%). 39% expect their rural areas to be served by Type-A in the next two years, and 31% in their national areas. All of the experts expect Type-A to be available in their countries at all levels.

For the full level of integration or MaaS (Type-B), a marginal proportion of experts (7%) already have it in their urban areas and none have it in their rural or national areas. Most of the experts (59%) expect it to arrive in their urban areas within the next two years; before 2020 and somewhere between 2020-2030 for their rural (63%) and national (59%) areas. However, not all experts are optimistic with MaaS; 2% of the panel does not believe MaaS will be available in their urban or rural areas at all and a slightly higher proportion (6%) does not foresee its implementation at the national level.

Table 4-1 Expected period of market introduction

Level of integration / application area	Semi / Urban	Semi / Rural	Semi / National	Full / Urban	Full / Rural	Full / National
Period:						
(1) already available	72%	28%	26%	7%	0%	0%
(2) before 2020	17%	39%	31%	59%	26%	24%
(3) 2020-2030	11%	33%	39%	30%	63%	59%
(4) after 2030	0%	0%	4%	2%	9%	11%
(5) never	0%	0%	0%	2%	2%	6%
Median* (IQR**) n = 46	1 (1)	2 (2)	2 (2)	2 (1)	3 (1)	3 (0)

* group opinion by a median; ** degree of group consensus by interquartile range (IQR), i.e. the interval containing the middle 50% of responses.

Experts indicated that they based these expectations on the past and ongoing works, and their experience. They expect MaaS to first become available in an urban area, where the transport infrastructure and organisation are better developed, before expanding into the more challenging rural and national areas. They consider the necessary technology for MaaS to be already available but certain conditions need to be fulfilled better to enable a successful implementation, such as the availability of e-payment.

Our findings that experts expect MaaS to first become operational in an urban area is similar to that of König et al. (2016). Also, the scores for the 'already available' category suggests barriers to implementing MaaS at the rural and national level even though there is a demand for integration platforms offering multimodal mobility services. A respondent commented that "it is challenging to coordinate this integration on regional/national level[s]". Other experts also express similar concerns on coordination challenges. However, the other side of the coin is that the process of implementation could go fast once an agreement among the main stakeholders has been reached as the required technology is already available.

² An early adopter is a term coined by Roger (1962) that represents an early customer within the first 15% segment of a given technology, such as MaaS.

The level of consensus between the experts' expectations on this topic is medium. They fully agree on the combination Full-National and have a high level of agreement on the combinations Semi-Urban, Full-Urban, and Full-rural. However, their opinion is less consistent on the expected period regarding the combinations Semi-rural and Semi-National.

4.2 Expected Early Adopter and users

The panel's expectations on the potential MaaS adoption by categories of travellers are given in Table 4-2. Only the Full integration or MaaS (Type-B) is considered here. A large proportion of experts (80%) considers Generation Z as an Early Adopter of MaaS. Nearly all of the experts (98%) think the Millennials will lead the usage of MaaS. In contrast, the majority of the experts (65%) sees Generation X as a Follower. Similarly, a high majority of the panel (81%) sees the Baby Boomer as a Follower. Finally, more than half of the experts (54%) foresee the Silent generation as non-user of MaaS, the largest category of non-users. Nevertheless, 44% see them as a Follower.

Table 4-2 Expected MaaS user by generation

Generation (Age)	Gen-Z (Under 20)	Millennials (21-34)	Gen-X (35-49)	Baby Boomer (50-64)	Silent Gen (65+)
Adopter:					
(1) Early Adopter	80%	98%	33%	4%	2%
(2) Follower	18%	2%	65%	81%	44%
(3) Non-user	2%	0%	2%	15%	54%
Median* (IQR**) n = 46	1 (0)	1 (0)	2 (1)	2 (0)	3 (1)

* group opinion by a median; ** degree of group consensus by interquartile range (IQR), i.e. the interval containing the middle 50% of responses.

The level of consensus between experts' expectations in this topic is relatively high. There is almost full agreement on their expectations regarding Generation Z, Millennials, and Baby Boomers and a high level of agreement in the other categories.

The result above illustrates the panel's dominant expectation is that the younger generations will lead MaaS adoption. However, individual experts expressed a less positive opinion on this expectation. For example, Generation Z may not be an early adopter of MaaS, because their mobility pattern is less complicated and they have a limited purchasing power.

Table 4-3 presents the panel's expectations on the potential MaaS user categorized in terms of their current modes of transport. Only a marginal group of experts (2%) see regular car users as an Early Adopter of MaaS. Instead, most of them (63%) believe the automotive users to be a Follower or even a non-user (35%). In contrast, two-thirds of the panel (65%) see public transport users making a switch to MaaS as an Early Adopter, whereas the other 33% believe the same group will switch to MaaS at a later stage. Only 2% expect current public transport users not to become a user of MaaS. Flexible travellers or those who combine different modes available to reach their destination is seen by most experts (83%) as an early adopter of MaaS; 13% think they will adopt MaaS at a later stage and 4% do not expect them to use MaaS at all.

Around 1 in 5 (22%) of experts foresee cyclists as an Early Adopter of the novel transport concept, while the majority (67%) expects cyclists to switch to MaaS at a later stage, or not even using it at all (11%). Similarly, the panel does not expect the Special need group to be an Early Adopter (15%) but a Follower (63%). However, more than 1 in 5 experts (22%) think the disabled and elderly travellers will not use MaaS to provide their required mobility services at all.

Table 4-3 Expected MaaS user by current mode of transport

Mode Adopter:	Regular Car users	Regular public transport user	Flexible travellers	Regular cyclists	Special needs (e.g. disable and elderly)	Other
(1) Early Adopter	2%	65%	83%	22%	15%	82%
(2) Follower	63%	33%	13%	67%	63%	9%
(3) Non-user	35%	2%	4%	11%	22%	9%
Median* (IQR**) n = 46	2 (1)	1 (1)	1 (0)	2 (0)	2 (0)	1 (0)

* group opinion by a median; ** degree of group consensus by interquartile range (IQR), i.e. the interval containing the middle 50% of responses.

The level of consensus in this topic is relatively high, particularly on roles of the flexible travellers, cyclists, and special needs groups. There are medium levels of consensus regarding the roles of regular car users and public transport travellers in the early market of MaaS.

Some experts believe that switching from car to MaaS will not be 'easy', whereas switching from public transport to MaaS has fewer barriers due to familiarity (on average) with some kind of a multimodal app. Moreover, one expert feels the special-need group may play a prominent role if MaaS is developed and operated by a public authority with a special focus on this group. An example of such project is a MaaS pilot in Tampere.

Table 4-4 presents the panel's expectations on the potential MaaS users categorized by their trip purpose. Considering this categorisation, 63% of the panel foresees commuters switching to MaaS at an early stage. The business trip also has a similar expectation pattern with 65% expecting an early adoption. The panel's opinion is more evenly split on the educational trip, where 42% of the experts considering this category of travellers to be an early adoption of MaaS, whereas more than half (53%) of the panel believe educational trips will be made by MaaS at a later stage. The panel's opinion is more homogenous for the shopping trip, while only 13% think these travellers will switch to MaaS at an early stage, a majority (80%) assumes a switch to MaaS at a later stage. A similar expectation pattern applies to Leisure and social trips: 24% anticipate an early adoption of MaaS for such trips and 74% assume a later adoption. With regard to other trip purposes, experts mention tourism and special events as potential MaaS trips.

Table 4-4 Expected MaaS user by trip purpose

Trip purpose Adopter:	Commuting	Business	Education	Shopping	Leisure & social	Other
(1) Early Adopter	63%	65%	42%	13%	24%	33%
(2) Follower	30%	33%	53%	80%	74%	50%
(3) Non-user	7%	2%	4%	7%	2%	17%
Median* (IQR**) n = 46	1 (1)	1 (1)	2 (1)	2 (0)	2 (0)	2 (1)

* group opinion by a median; ** degree of group consensus by interquartile range (IQR), i.e. the interval containing the middle 50% of responses.

The level of consensus on this topic is relatively high. The experts fully agree on that shopping trips and leisure and social trips will adapt to MaaS at a later stage.

4.3 Actors, service integrator, and stakeholders

In general, a transport system consists of a multitude of parties, each of them playing a unique role. Some parties may have direct involvement in transport service operations, such as a bus company, a mass transit operator, or a company driving taxis. Others may indirectly influence the organisation of a transport system through their policies or regulations, such as a local authority or a transport regulation body. This multitude of parties relevant to the structure and performance of the transport system interacts dynamically, giving rise to the complexity and related uncertain development of the system (May et al., 2003).

Gaining an insight into the complex interactions of MaaS is a prerequisite action to design a plan for implementing such a system successfully. In this section, we take a first step in comprehending actors'

interactions within a MaaS ecosystem by identifying actors³, service integrators⁴ and stakeholders⁵. We only considered Type-B: Full integration or MaaS here and requested the panel to select their three most important options in each category.

Table 4-5 presents the top-five critical actors ranked by the panel. A majority of the panel (74%) include public transport providers in their selection, reflecting the perceived importance of public transport in MaaS by the group. An expert's comment can exemplify this view: "Public transport is the backbone of MaaS". Over half (57%) of the experts select the Local authority, and nearly half (46%) the ICT developers as their choices of critical actors. Also, 39% of the experts believe a 3rd party mobility service provider has a role to play in MaaS, as well as the central government (35%). The expectations on the important actors reflect experts' perceived significance of public transport in MaaS, a similar finding to König et al. (2016).

Table 4-5 Important Actor

Rank	Important Actors	Selected by % of respondent n = 46
1	a) Transport and logistics service providers or operators	74%
2	b) Local authority	57%
3	g) ICT and technology developers	46%
4	e) 3rd Party mobility service provider	39%
5	c) National government / national public agencies	35%
w = 0.27 P = 0.000		

The Kendall's coefficient shows that there is an agreement among the experts with an effect size of medium. In addition to the choices available, the panel suggests additional Important actors, namely National integrator, car manufacturers, and large mobile operating system provider.

Table 4-6 presents the top-five parties ranked by the panel as the most preferred service integrator. The role of Service integrator is unique to the novel transport concept in MaaS and essential for the success of this concept. 67% of experts include a transport provider in their choices, which is coherence with their preference shown the previous question. A slightly lower proportion (63%) opt for a 3rd party mobility provider and 52% preferred their local authority to operate a MaaS platform. However, the central government, another public agency, is less preferred (26%). 20% of the experts also proposed a user-operated system, such as a P2P transport service provider.

Table 4-6 Preferred service integrator

Rank	Preferred service integrator	Selected by % of respondent n = 46
1	a) Transport and logistics service providers or operators	67%
2	e) 3rd Party mobility service provider	63%
3	b) Local authority	52%
4	c) National government / national public agencies	26%
5	f) User ranks (e.g. P2P transport service)	20%
w = 0.26 P = 0.000		

The Kendall's coefficient shows that there is an agreement among the experts with an effect size of medium.

There are sharp delineations in the experts' preferences on this subject. Certain respondents clearly prefer a public organisation to take the role of service integrator, as this organisation has the public interest in mind, is unbiased, and can ensure societal benefits (sustainability, good level of services, security, and equal opportunity). Others believe the transport operators should take the lead as public transport is perceived as the 'backbone' of MaaS and these operators can ensure a reasonable level of service. A suitable contract

³ An actor has a direct involvement in the service provision

⁴ A Service integrator is responsible for providing, maintaining, and regulating a communal platform, which enables transport providers and related services to interact with users.

⁵ Stakeholders are parties with no direct involvement with the business but with influence on MaaS' implementation and operation (e.g. taxi union and community group)

arrangement is also mentioned as a measure for a public authority to indirectly reign the operator. Experts that prefer the private sector (a technology developer or a third party) mention their commercial drive, technological advance, and ability to invest locally as their strengths, a similar observation was reported by Holmberg et al. (2016). In addition, the expert expects a 3rd party company to adorn with impartiality and customer focus. Alternatively, public sectors can take enabling or regulatory roles by providing a regulatory framework or collaborate with parties from the private sectors in a Public-Private-Partnership.

Table 4-7 presents the least preferred service integrator ranked by the panel. Providers of Mobile phones and internet received the highest negative vote, chosen by nearly half (48%) of the experts. Non-public investors are the next unfavourable, selected by 41% of the respondents. The national government and non-transport actors are not favourable options for 37% of the panel and 26% of respondents preferred not to have an infrastructure operator as their MaaS provider.

Table 4-7 Least preferred service integrator

Rank	Least preferred service integrator	Selected by % of respondent n = 46
1	j) Mobile phone network and internet provider	48%
2	i) Investors (semi-public and private)	41%
3	c) National government / national public agencies	37%
4	k) Actors from non-transport sector (e.g. tourism)	35%
5	h) Transport infrastructure operator	26%
w = 0.10 P = 0.000		

The Kendall's coefficient shows that there is an agreement among the experts with an effect size of small.

The experts' selection on the least preferred integrator seems to strongly oppose their ideas on the preferred integrators. They argued that the parties mentioned in the Table are not a suitable party for this role for they have major doubts regarding their quality as an integrator, notably because of a lack of transparency, non-partiality, and, in the case of the national government, the non-commercial attitude.

As mentioned, actors directly involved in offering the services, are distinct from stakeholders who have no direct involvement but have some indirect influence. Table 4-8 shows the most important stakeholders in MaaS selected by the panel. Most of the panel (72%) foresee Investors to play a very important role in MaaS. Media firms (39%) and tourism business (34%) are also seen as imperative stakeholders, perhaps for their potential roles in raising awareness about the service and expanding its market reach. More than one-third (34%) of the experts also see research institutions playing significant roles in MaaS implementation and operation, whereas slightly less than one-third (28%) of the experts believe that services from other sectors will have an important influence on MaaS.

Table 4-8 Important stakeholders

Rank	Important Stakeholder	Selected by % of respondent n = 46
1	a) Investor and shareholders	72%
2	c) Media and Marketing Firms	39%
3=	d) Tourism business	34%
3=	b) Research institutions	34%
5	f) Other service sectors	28%
w = 0.20 P = 0.000		

The Kendall's coefficient shows that there is an agreement among the experts with an effect size of small-medium.

Several experts expressed the need to expand the circle of stakeholders beyond transportation and to include other sectors, such as tourism, real estate development, large private companies, and specific educational

concentration areas (e.g. universities). Systematically linking MaaS to services, such as home delivery and children pickup services, can reduce the need for a private car and adds value and importance to MaaS.

5 Planning for future implementation

In this section, we evaluate the panel's opinion on potential public policies to implement MaaS from a public authority's point of view (i.e. national government and local authority).

5.1 Public authority's view on the planning of MaaS

In formulating a transport policy, there are often contrasting views on the question which level of public authority should be involved. Recognising this, we examine in this study the potentially different perspectives on the planning of MaaS between the central government and local and regional authorities. We asked the panel if they think the national government and local authorities within a country have the same (i.e. mutually consistent) or largely different views on planning public objective, constraints, and policies associated with MaaS. We summarized the panel's opinion in Figure 5-1.

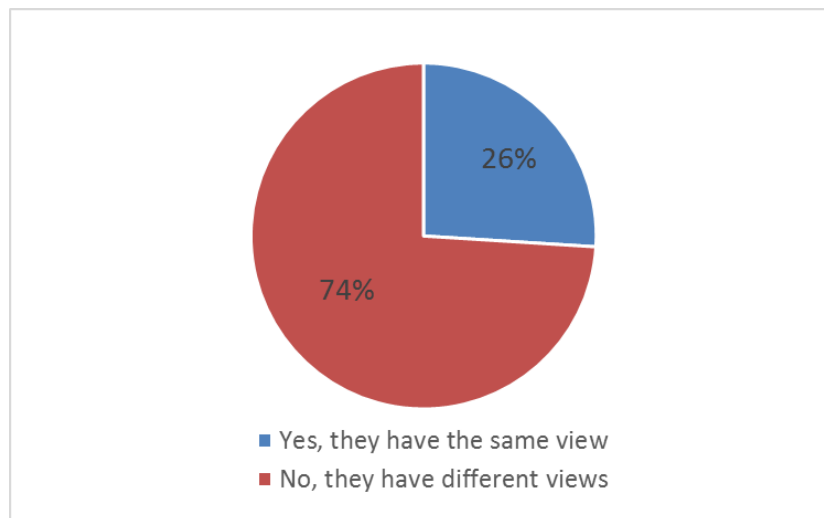


Figure 5-1 Do national government and local authorities have similar views on the planning of MaaS?
(n = 46)

Hence, nearly 3 in 4 experts believe significant differences exist between the two levels of public authority regarding the planning of MaaS, whereas 26% foresee no differences in their views. We then asked the experts that see potential disparities (n = 34) to provide two separate sets of planning elements to implement MaaS; one for a central government and another for a local authority. The experts that expect consistent views (n = 12) were asked to provide one set of planning elements for both public authorities. The following sub-sections report the panel's opinion on these matters.

5.2 Objectives of implementing MaaS

Table 5-1 highlights five objectives that are selected by the two groups (i.e. experts who believe government and local authority have the same view on planning MaaS and those who do not). The results illustrate the top-five most selected objectives to implement MaaS across the three categories (government & local, government, and local) are the same, but are given different weights. For instance, a) providing public accessibility is ranked third for central government & local authority (50%), third for central government (59%), and first for a local authority (76%).

Table 5-1 Objectives to implement MaaS.

Central gov. & local authority (n=12)	%	Central government (n = 34)	%	Local authority (n = 34)	%
b) Reducing car dependency and usage	83%	b)	62%*	a)	76%
f) Improve cost-effectiveness of transport	50%	c)	62%	e)	68%
a) Provide public accessibility to key destinations and services to ensure social and economic inclusion	50%	a)	59%	b)	56%
c) Promote cleaner transport modes	42%	e)	41%*	f)	32%
e) Reduce level of congestion	25%	f)	44%	c)	29%
w = 0.30 P = 0.001		w = 0.23 P = 0.000		w = 0.27 P = 0.000	

Note: % - percentage of respondents included the option in their selections

*Certain options may be selected by an equal or a lower proportion of experts but are placed in a higher rank, resulting in a higher mean-ranking.

The high level of consistency suggests that experts believe the two levels of public bodies to have a similar outlook on what transport issues MaaS is able to resolve. However, the different weights placed on items, reflecting their given priority, may result from the experts' differences in the perceived responsibility of the two organisations. For instance, they believe local authority will implement MaaS to solve public accessibility to key destinations and (urban) congestion problems, which are localised transport issues. Whereas, according to the panel, the central government tends to operate MaaS primarily to reduce car dependency and to promote cleaner transport, which are transport issues with a broader boundary.

In addition to the pre-defined choice options, the panel suggested the following objectives for MaaS implementation: reduce emission; provide mobility that supports national/global social, environmental, and economic goals, a similar finding to Sochor et al. (2016); show action before the next election; and create a new service industry. Also, several experts expect MaaS to reduce the public spending on transport by replacing costly local initiatives.

The Kendall's coefficients show that there exists a high degree of agreement among the experts within all three categories, with medium effect sizes.

5.3 Constraints for implementing MaaS

Next, the panel provided a ranking of constraints that may prevent their selected objectives to be reached. The results are displayed in Table 5-2. A possible constraint which may prevent experts' selected objectives to be reached that is indicated by all three groups are a) limited public budgets, b) perception of a too limited value proposition, e) limitation due to formal regulation, and f) existing contract arrangements. This pattern represents a high consistency (four out of five) in the experts' selection, although their weightings may be different. In the first group, b) and e) are selected as the most prominent (50%) constraints. For the central government, f) the existing public transport contract is mentioned as the foremost constraint (71%). For local authorities, the required ICT-condition is the most vital constraint (62%).

In addition to the predefined choices, the panel suggests the following constraints to implementing MaaS: Existing public administration culture or organizational inertia; lack of expertise, knowledge and effective political strategy/vision; lack of standardization & Insufficient transportation modes to include in the service; lack of coordination between different players; fear for losing control as current stakeholders, such as public transport companies might try to hold on to their current operational models because they might be afraid of losing control/influence and are uncertain of their new role; existing tax incentives e.g. for leasing company cars to employees; lack of interest from the public (citizens and voters); and the monopoly positions of public transport operators.

The Kendall's coefficients for the three categories show that there is no agreement among the experts in one category (Central government & local authority). In two other categories, their level of agreements among the experts is much higher with different levels of the effect sizes: medium in the central government and low in the local authority category.

Table 5-2 Possible constraints to selected objectives

Central gov. & local authority (n=12)	%	Central government (n = 34)	%	Local authority (n = 34)	%
b) Perception of limited value proposition of MaaS service	50%	f)	71%	g) ICT-condition (i.e. available infrastructure and data, safety and privacy)	62%
e) Limitations in formal regulation regarding finance and operation	50%	e)	65%	a)	56%
h) other	42%	b)	59%	e)	50%
f) Existing public transport contract	33%*	a)	32%	f)	41%
a) Limited public budgets	33%	c) Insufficient physical transport infrastructure	29%	b)	35%
w = 0.04 P = 0.872		w = 0.22 P = 0.000		w = 0.15 P = 0.000	

Note: % - percentage of respondents included the option in their selections

*Certain options may be selected by an equal or a lower proportion of experts but are placed in a higher rank, resulting in a higher mean-ranking.

5.4 Alternative policies to implement MaaS

The experts' ranking on alternative policy measures to implement MaaS is presented in Table 5-3. The policies that appear in all three categories are a) implement pilot projects, b) give priority to MaaS in high-level policy formulation, and e) improve the physical transport infrastructure. Interestingly, policy a) is ranked as the foremost policy for all three categories. In the first category of experts (central & local authorities have the same opinion), policy e) is the next most prominent (50%) policy measure. The second category of experts rank policy d) (specify clearer roles within the MaaS eco-system) for both the central government and the local authority, as the second most important policy.

Table 5-3 Most important MaaS policies

Central gov. & local authority (n=12)	%	Central government (n = 34)	%	Local authority (n = 34)	%
a) Implement pilot projects to experiment and enable learning	92%	a)	65%	a)	85%
e) Improve physical transport infrastructure; PT network, car-sharing, and bike-sharing facilities	67%	d) Specify clearer roles and responsibilities within the MaaS eco-system	53%	d)	56%
f) Improve the digital infrastructure and data collection and handling conditions	42%	b)	44%	e)	35%*
g) Develop an open market for services innovation	33%	g)	41%	b)	35%
b) Give priority to MaaS in high-level planning and policy documents	25%	e)	32%	f)	26%
w = 0.35 P = 0.000		w = 0.12 P = 0.000		w = 0.25 P = 0.000	

Note: % - percentage of respondents included the option in their selections

A possible policy to implement MaaS that all three groups mentioned as the most important policy is to implement pilot projects. Pilot projects enable 'learning by doing', which is an effective approach to increase knowledge on the variety of aspects (e.g. the feasibility of alternative business models) and reduce the general level of uncertainty. Related to this is the need to carefully monitor and evaluate the impacts of the MaaS pilots. In addition, the panel suggested an improvement to the institutional context by creating supportive legislation and by taking away tax incentives for leasing company cars.

In addition to the provided list of alternative choices, the panel suggests the following policies to implement MaaS: Creating supportive legislation; remove the existing tax incentives for leasing company cars, or at least expand incentive to include mobility packages; carry out Impact analysis studies, and evaluations of pilots to gather evidence to develop MaaS in a socially sustainable direction.

The Kendall's coefficients for the three categories show that agreement exists among the experts within each category. However, the effect sizes are different, ranging from Medium (first and third categories) to low (second category).

5.5 Necessary conditions for implementing MaaS

The expert opinion on necessary conditions for the success of their selected policy is presented in Table 5-4. The conditions that are mentioned by all three expert categories are a) a close collaboration between key actors and stakeholders, b) the availability and standardisation of mobility data, h) an attractive business opportunity/model, and l) a successful operationalisation/performance of pilots. This represents a high level of consistency (four out of five) in experts' selection.

Table 5-4 Necessary conditions for the success of the selected policy

Central gov. & local authority (n=12)	%	Central government (n = 34)	%	Local authority (n = 34)	%
a) Close collaboration between key actors and stakeholders	67%	a)	59%	a)	74%
l) Successful operationalisation of pilot schemes	50%	b)	50%	h)	41%*
h) Attractive business opportunity for actors and stakeholders	50%	l)	44%	l)	41%
b) Availability and standardisation of mobility data	33%	h)	32%	b)	35%
i) Provision of appropriate physical infrastructure	17%	e) Suitable regulation regarding data security and privacy	26%	i)	26%
w = 0.28 P = 0.000		w = 0.23 P = 0.000		w = 0.27 P = 0.000	

Note: % - percentage of respondents included the option in their selections

*Certain options may be selected by an equal or a lower proportion of experts but are placed in a higher rank, resulting in their higher mean-ranking.

In addition to the predefined choices, the panel suggests the following conditions for the success of implementation of MaaS: a clear and proven effect of MaaS in improving transport condition and the creation of a national transport access point or platform that enable mobility service providers to offer their services to users.

The Kendall's coefficients show that there are agreements among the experts within each category. The level of agreement or the effect sizes for all of them are medium.

6 Vulnerabilities, opportunities, and responding actions

In the third and final round of the Delphi, we presented to the panel the group's preferred policy and asked them to select a set of vulnerabilities (an event or development that can affect the policy negatively), opportunities (an event or development that can affect the policy positively), and responding actions to cope with them. We also ask the experts how important they think their selected vulnerabilities and opportunities are and how certain they are to occur. The aim of this round is to discern likely events that can affect the selected policy and what can be done either to mitigate against or to enhance such events. The results can be useful in prioritising resources in reducing or enhancing the impacts and likelihoods of these possible events. To memorize: in total 35 experts respondent in this final round of the Delphi.

First, we presented the panel with the groups' most preferred policy: **Implementing MaaS pilot projects to experiment and enable learning** and a hypothetical pilot project to operationalise the policy. The pilot project is constructed using outputs from the previous rounds of our survey (See Box 6-1 for information on the hypothetical pilot project). The time period of the pilot is set to two-year.

Box 6-1 Details of the hypothetical pilot project

<p>Duration of pilot project: two years</p> <p>Service integrator*: Public transport provider</p> <p>Objectives of a MaaS pilot project:</p> <ul style="list-style-type: none"> • To stimulate learning on MaaS related aspects, such as governance, operation, and user behaviour. • To test the technology underlying the MaaS concept • To examine the feasibility of scaling up or adjusting MaaS after the pilot <p>Conditions for the success of a MaaS pilot project:</p> <ul style="list-style-type: none"> • Strong financial and political support • Close collaboration between key actors and stakeholders • Attractive business opportunities for actors and stakeholders • Availability and standardisation of mobility data • Provision of appropriate physical infrastructure • User acceptance <p>Note: *A service integrator is responsible for providing, maintaining, and regulating a common platform, which enables transport providers and related services to interact with users.</p>
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The respondents were then asked if they would agree with the objectives and the conditions of success of the pilot. If not, they could suggest modifications. A majority of experts agreed with the proposed objectives (68%) and conditions for the success (79%), see Figure 6-1.

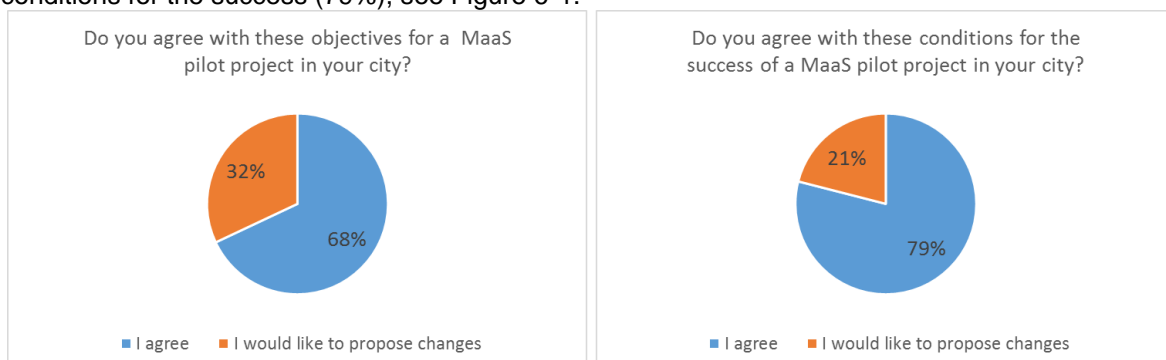


Figure 6-1 Agreement on the proposed MaaS pilot's planning
(n=35)

The experts also suggested inclusions of assessments on potential outcomes of MaaS, such as effects on road congestion, user behaviour, quality of mobility, and its impacts on the accessibility of vulnerable group.

Additionally, these experts believe the pilot project should be used to better understand user's preference and acceptance, explore possible cross-border operation issues, learn about the feasibility of an attractive business model, and analyse how MaaS fit with different user groups. One expert emphasized the importance of having a strong business component in the pilot, with a complete and high-quality evaluation of user experience. Another expert also expressed a lack of support to start such a pilot in his locality in the first place, thus governance and feasibility issues should be included in the objective.

Regarding the conditions for success, some experts believe certain conditions should be excluded, notably the provision of appropriate physical infrastructure, a strong financial support, and a strong political support. Instead, a MaaS pilot should be able to start, driven solely by the market. Other experts believe standardisation of the payment method, a sufficient and reliable mobility service level, and the involvement of a city champion should be included.

Next, the respondents were asked to explore possible events or developments that can make the MaaS pilot project fail or be a success (i.e. in relation to the stated condition of success) and to identify associated actions to handle these events.

6.1 Vulnerabilities

The panel was asked to select and rank three most significant events or developments that can negatively affect the pilot project to a point where the pilot is no longer successful. The mean ranking of these vulnerabilities is shown in Table 6-1.

Table 6-1 Vulnerabilities of the pilot project

Rank	Most significant vulnerability	Selected by respondents (%) n = 35
1	b) Crucial actors are unwilling to collaborate	31 (89%)
2	c) Lack of an appropriate and attractive business model	20 (57%)
3	f) Travellers do not recognise the added value of MaaS	15 (43%)
4	a) A weakening ..of financial and political support	13 (37%)
5	e) Insufficient physical infrastructure	13 (37%)*
w = 0.23 P = .000		

The Kendall's coefficient shows that there is an agreement among the experts with an effect size of medium. In addition to the available choices, the experts added that there may not be political support in the first place or unavailability of a suitable pricing model for a subsidy. Moreover, the design of the pilot project may not be acceptable to travellers and related organisations as it might (implicitly) exclude certain segments of the population. The experts also provide the rationales behind their selections, summarised in Box 6-2

Box 6-2 Summary of Experts rationales on selected vulnerability

Collaboration:

Multi-stakeholder cooperation is essential but also a challenge to achieve; Public transport providers are the key stakeholders but they may not be willing to participate in MaaS; Data sharing is necessary but can be difficult to realise.

Service and business model:

The nature of a (successful) business model for MaaS is still unknown; A significant initial investment may be required from public transport authority to support access to non-public transport modes. This may be a requirement working counter-productive toward the transport system level objectives; The current pricing model prevents the integration between subsidised and profit-making services for a MaaS provider; Protectiveness of existing business models limits the possibility for Public Transport operators to create value-added services; The service needs to be comprehensive with excellent marketing and customer support.

User:

It is expected that users will hesitate to change their behaviour due to a car-centric attitude and aversion against PT in certain population segments; User's expectation on MaaS will be high but must be fulfilled to ensure widening adoptions; Customer focus is essential for a successful project, the customers must perceive added value in the service to be willing to pay more.

Infrastructure:

Availability of physical infrastructure is important to ensure visibility, proximity, and feasibility of MaaS; Unreliable and insufficient infrastructure will discourage service adoption; A real-time data flow is essential to deliver MaaS.

Other comments:

Keep the MaaS concept simple, and focus on the service integration point of view; Ensure benefits for players in and outside the value chain but a MaaS service will never be stronger than its weakest link. Media coverage increasingly becomes critical on (digital platforms, such as) Facebook and Uber; There is a lack of support and push from the national government to regional and local authorities to support MaaS; Additional political and financial support is always good.

We also asked the experts to provide their opinion on the importance and certainty of selected vulnerabilities (Figure 6-2 below). The figure can be interpreted as follow. With respect to the label "crucial actors are unwilling to collaborate" 31 experts indicate that they believe that the actors' unwillingness to collaborate is an important vulnerability. Next, 52% of them think it is certain that this problem will occur in the pilot during the two-year period. Another example: half of the experts who think that a lack of an appropriate business model is an important vulnerability and certain that this applies to the pilot; 35% think it is an important issue but uncertain to occur; 5% think it is not important but will occur, and 10% think it is unimportant and uncertain to occur.

The results below illustrate that more than 70% of experts believe the vulnerabilities they selected are important to the pilot. The vulnerabilities with a complete consensus on their importance are, according to all experts, b) unwillingness to collaborate, f) lack of recognition of the added value of MaaS, and a) weakening of support. Other selected issues are c) lack of an appropriate business model (according to 85% of the experts) and e) insufficient physical infrastructure (indicated by 70% of the experts). The high percentages suggest a high level of agreement among experts on these matters.

On the level of certainty, also a high share of experts believe that the following vulnerabilities will manifest themselves during the pilot project with certainty: b) crucial actors are unwilling to collaborate (52%) and c) a lack of an appropriate business model (50%). It is interesting to observe that the percentage of experts who believe a vulnerability will happen decreases in case it concerns vulnerabilities with a lower mean ranking, which suggests a correlation between their ranking and their perceived certainty by the experts.

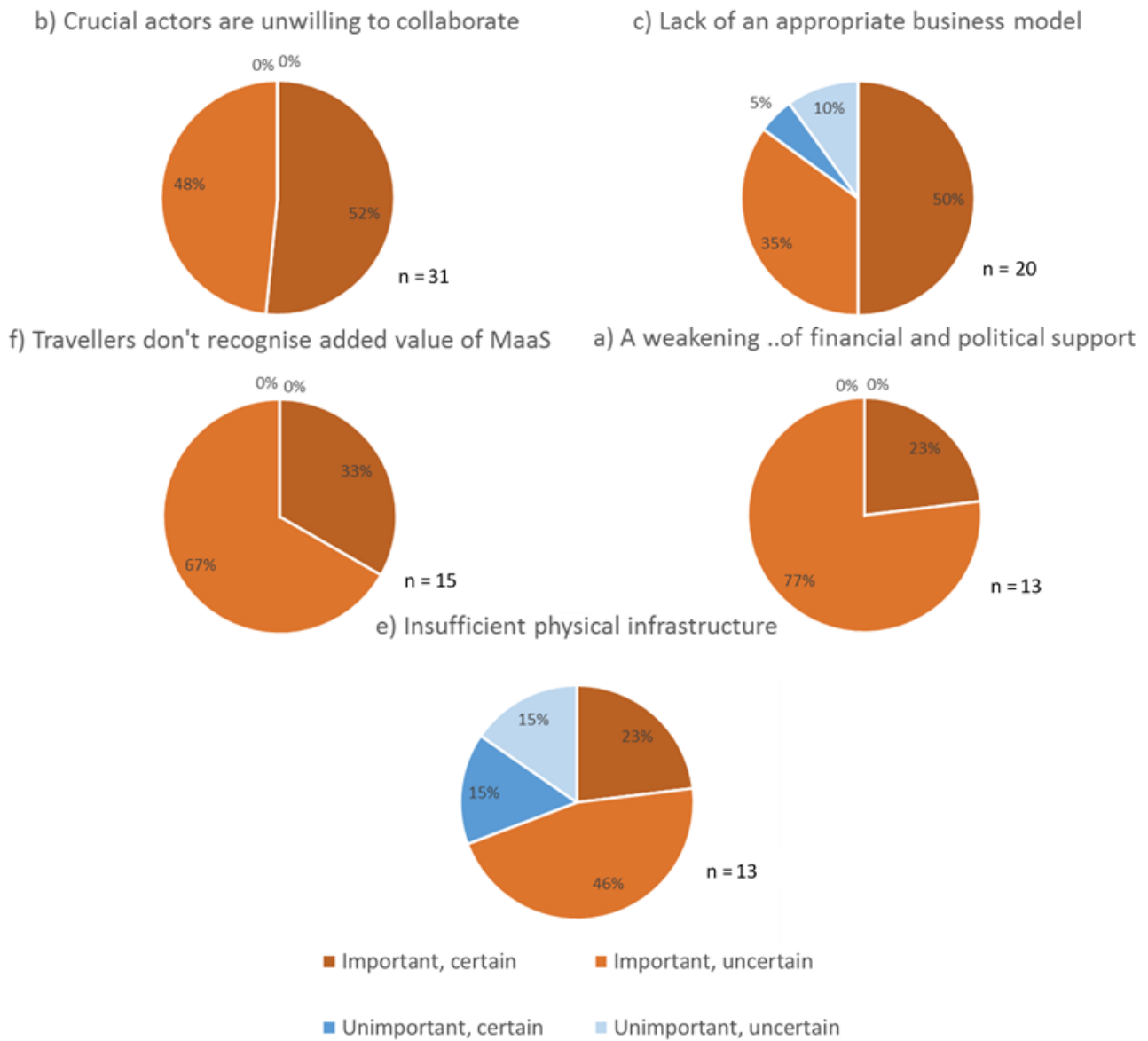


Figure 6-2 Importance and certainty of selected vulnerabilities

Additionally, the expert opinion on the certainty of these vulnerabilities is highly discordant, or in other words, the disagreement on the certainty of the selected vulnerabilities is high. The vulnerabilities with a high level of discordance are those with an evenly split percentage, i.e. b) 52% certain versus 48% uncertain and c) 55% certain versus 45% uncertain. Others have a relatively lower level of discordance.

Next, we asked the experts to suggest responding actions to the vulnerable events they selected. We categorised these in relation to each vulnerability and summarised them in Table 6-2. The suggested actions can be used to prepare mitigation (against certain vulnerabilities) and hedging (against uncertain vulnerabilities) actions for the pilot project.

Table 6-2 Summary of responding actions to vulnerabilities

Rank	Most significant vulnerability	Responding action to selected vulnerable events
1	b) Crucial actors are unwilling to collaborate in the pilot due to various reasons (e.g. lack of trust, potential loss of control, unforeseen benefits)	<p>Planning: Formulate contingency and exit plans in advance; enlist alternative actors into the pilot; minimise or limit potential financial loss due to the potential failure of the pilot for the actors; organised collaboration in the pilot with a detailed plan and clear roles; ensure governance-related aspects of the pilot are clear to all parties.</p> <p>Trust and transparency: A high level of transparency and a clear demonstration of the pilot's benefits; appoint a trusted third-party as a mediator for any potential conflicts; obtain governmental supports and leadership from relevant authorities to ensure success and sustainability and prevent conflict of interest or profiteering; employ co-creation and lean methods to build trust among the actors.</p> <p>Other: Lock-in actors' commitment through PPP or trust fund; formulate a legal framework and regulations to support the pilot; involve actors as partners from the planning stage of the pilot.</p>
2	c) Lack of an appropriate and attractive business model for actors and stakeholders in the pilot project	<p>Collaboration and leadership: Ensure a strong leadership from the national government and open discussions to align all actors; a strong involvement and collaboration between stakeholders; a clear expectation and commitments from each actor in the pilot.</p> <p>Planning: Ensure the pilot can adapt to any change in its operating conditions with a possibility to include additional actors.</p> <p>Transparency: Apply due-diligence examination or other methods to ensure transparency of the business model.</p> <p>Risk and incentive: Minimise actors' risk to enable testing of business models in the pilot; ensure attractive sales commission and transaction fee for smaller service providers; underwrite or limited possible financial losses of actors.</p>
3	f) Travellers do not recognise the added value of MaaS due to various reasons (e.g. unattractive service design, unattractive pricing, and inadequate support functions)	<p>Products and support: Ensure the MaaS service is of high-quality with a focus on user experience; provide a strong customer support; continue to adjust the service's design until the added value is apparent to the users.</p> <p>Incentive: Provision of rewards and incentives to motivate the users to shift their behaviour; deploy adoption campaigns to promote the pilot.</p> <p>Marketing: Emphasis on community outreach with a clear marketing strategy; employ advanced market analysis method to identify potential users and early-adopters.</p> <p>Communication and monitoring: Employ the co-creation process to implement MaaS; demonstrate MaaS service at local events to raise awareness; establish a strong communication channel with users; monitoring users' satisfaction using various means to understand and mitigate any arising issues.</p>
4	a) A weakening or disruption of financial and political support to the pilot project	<p>Planning: Plan the pilot project to coincide with the local election cycle; monitor political support closely before initiate a pilot project; setting clear objectives and aims of the pilot project; secure the funding for the pilot project in advance; raise public opinion on the pilot prior to starting it; ensure a transparent approach in the pilot.</p> <p>Collaboration: Ensure a strong partnership with media outlets to gain public support toward the pilot; establish a good channel of communication with elected officials; gain political support from the early stage of the pilot; seek financial support for the pilot from the private sector and other sectors.</p>
5	e) Insufficient physical infrastructure (such as for car-sharing, bike-sharing, and public transport) to operate the MaaS pilot	<p>Planning: Planned required infrastructure and services in advance; selects a pilot area where required infrastructures are already available; ensure the local authority are willing to approve and complete required infrastructures on time; delays the pilot until required infrastructures are in place.</p> <p>Action: Use pre-pilot research to understand potential physical infrastructure requirements; inform the service users of infrastructure constraints; ensure a strong political will, policy and actions by the government to support the operators; promote mobility hub concept; adopt co-creation and lean methods to identify required infrastructure.</p>

6.2 Opportunities

We asked the panel to select and rank the three most significant events or developments that can accelerate the success of the MaaS pilot. The mean ranking of the opportunities is shown in Table 6-3 below.

Table 6-3 Most significant opportunity to the pilot project

rank	Most significant Opportunity	Selected by respondents (%) n = 35
1	b) Active collaboration between actors and stakeholders	23 (66%)
2	a) A strengthening of political and financial support.	18 (51%)
3	f) Travellers' satisfaction is above expectation	21 (60%*)
4	c) The emergence of new business models	17 (49%)
5	d) A significantly improved digital infrastructure	13 (37%)
w = 0.17 P = .000		

Note: *Certain options may be selected by an equal or a lower proportion of experts but are placed by them in a higher rank, resulting in a higher mean-ranking.

The Kendall's coefficient shows that there is an agreement among the experts with a low-medium effect size. The experts did not suggest an addition to the offered possible choices but provided the rationales behind their selection as summarised in Box 6-3

Box 6-3 Summary of Experts rationales on selected opportunities

Collaboration:

Multi-stakeholder cooperation is essential and is what currently lacks. A pilot project can be used to address this challenge (of forming a collaboration), as collaboration can help to address other problems as well.

Political support:

Additional political and financial support is always welcome, as MaaS cannot cover the operational cost and forming of a collaboration may require governmental support; political support, improved digital infrastructure, and user experience are the main drivers of MaaS deployment.

User:

Satisfied users will spread the word, thus customer-focused quality is important, especially at the beginning. It is also a key factor to determine the feasibility of a MaaS project; learning from users' experience will help to further increase the number of users and improve the service quality; Users' satisfaction gives rise to the development of new transport services. This process may start with political support and forms a reinforcing loop to enable improvement and further spreading of services.

Service and business model:

Multimodal services will require new business models, which rely on a reliable data flow; a demand responsive transport (DRT) service is an essential part of MaaS to fill the gap between private car and bus; emergence of new business model determines the feasibility of scaling up; self-driving vehicles are not required for MaaS to be successful; inclusion of new mobility services will attract customers to MaaS.

Next, we asked the experts to provide their opinion on the importance and certainty of selected opportunities (see Figure 6-3). The figure shows that 76% to 100% of the experts believe the opportunities they selected are important to the pilot. The only opportunity with a complete consensus on its importance concerns is b) active collaboration between stakeholders. The other selected opportunities generate a somewhat lower (but still high) level of support: namely a) a strengthening of supports, (89%), f) travellers' satisfaction (85%), c) the emergence of new business model (76%) and d) a significant improved digital infrastructure (85%). These high percentages indicate rather high levels of agreement on the importance of these matters.

The expert opinion on the certainty of these opportunities is more discordant: the percentage of experts that assume their selected choice to occur during the running of the pilot range between 28% and 65%. The opportunities that generate the highest percentage concerns active collaboration (65%) and the emergence of new business models (65%), followed by a significantly improved digital infrastructure (62%). The experts are

significantly more pessimistic on the certainty of a strengthening of political and financial support (28%) and whether traveller's satisfaction will be above expectation (43%).

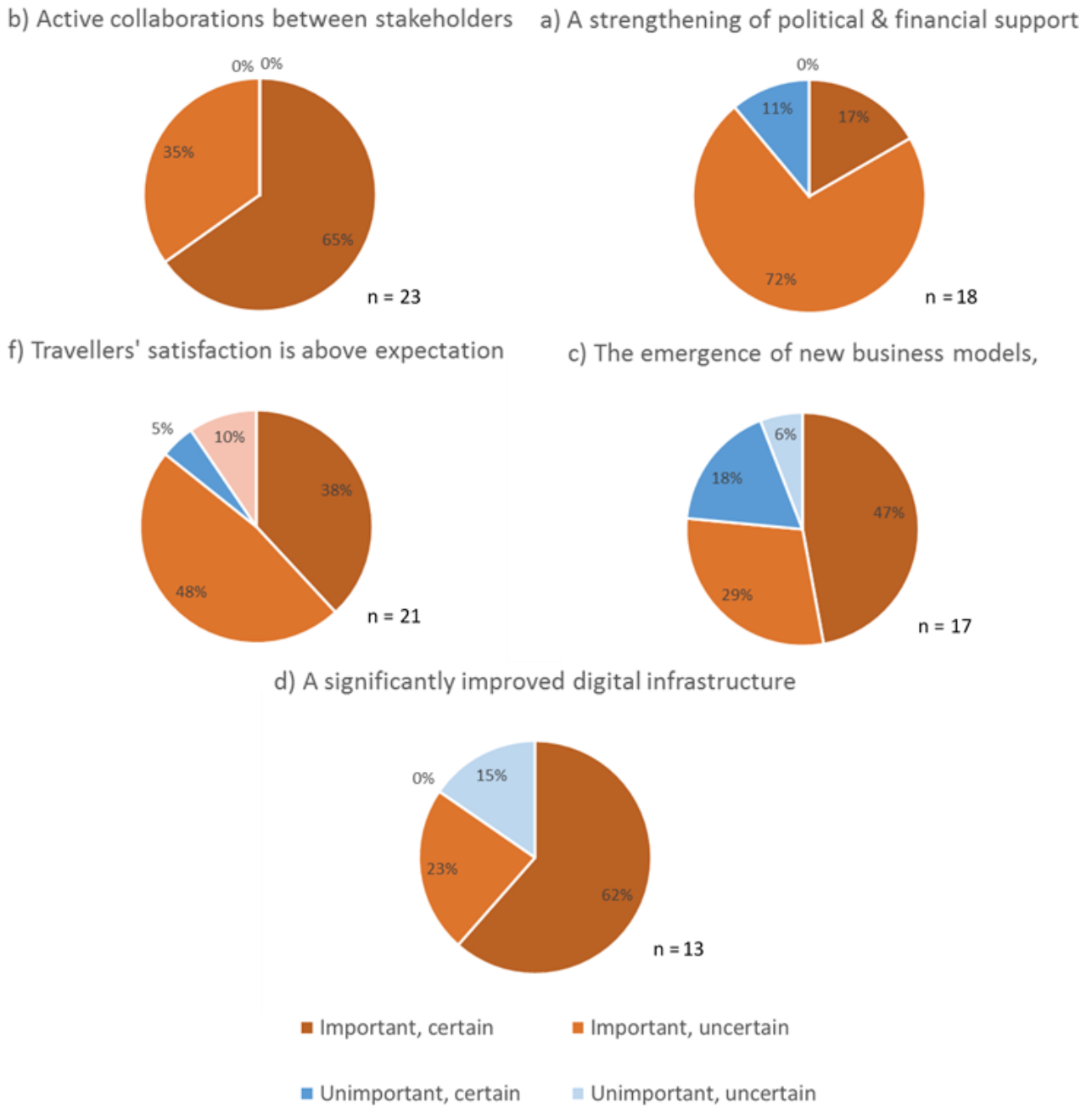


Figure 6-3 Importance and certainty of selected opportunities

Next, we asked the experts to suggest responding actions to the opportunistic events they selected. We categorised their suggestions in relation to each opportunity and summarised them in Table 6-4 below. These suggestions can be used to prepare seizing (for certain opportunities) and exploiting (against uncertain opportunities) actions for the pilot project.

Table 6-4 Summary of responding actions to opportunities

rank	Most significant opportunity	Responding action to selected opportunity
1	b) Active collaboration between actors and stakeholders involved in the pilot project	<p>Enhancement and development: Create a platform to support the collaboration between actors; ensure the strong collaboration achieved, is reflected in the mobility service options offered; further organise and continue to improve the collaboration with clear goals and rules</p> <p>Reporting: Provide a clear monitoring process e.g. via dashboard metrics for a regular period; record and transfer lessons learnt to future partners and political leaders; demonstrate that a win-win solution is possible within the collaboration; establish a regular personal briefing to all decision makers involved.</p>
2	a) A strengthening of political and financial support for the pilot project	<p>Enhancement and development: Develop strategies within local, regional, and national transport policies to further support MaaS; use experience gained from the pilot to enhance understanding of the social and political benefits from MaaS.</p> <p>Reporting: Provide a regular briefing for all decision makers; raising awareness on MaaS through political action groups; use success stories to create support; collect lessons learnt for subsequent projects</p> <p>Other: Elect more progressive politicians who support the concept.</p>
3	f) Travellers' satisfaction with the pilot project is above expectation, leading to high demand for the service	<p>Planning: Prepare for possible expansion of capacity to cope with the high demand before the pilot commenced; undertake capacity planning for the services and the platform.</p> <p>Enhancement and development: Continue to focus on customer satisfaction, while broadening the applicability of the MaaS service.</p> <p>Reporting: Carry out a survey to capture user opinions; communicate intensively with a selected group of users to learn from them; communicate ongoing progress of the pilot and its benefits to all travellers; use social media to communicate with the public effectively.</p> <p>Other: Construct a discrete choice model to capture willingness to pay for variable prices and joint fares.</p>
4	c) The emergence of new business models, transport services, and other value-added services that can be applied to the pilot project	<p>Enhancement and development: Develop a cooperative framework to share risks and rewards; strengthen trust among actors and stakeholders; open up additional MaaS services; avoid 'closure' of the MaaS concept by involve new operators and expand and enhance the pilot; keep an open mind for new opportunities; nurture an organisational culture that brings success due to openness to external initiatives; encourage further success; use success to trigger further investment and commitment; use implemented infrastructure as an accelerator for new initiatives</p> <p>Reporting: Further promote MaaS and its benefits to users; enhance and adapt monitoring and measuring processes; clarify risks and benefits for businesses joining the pilot;</p>
5	d) A significantly improved digital infrastructure, including digital data management, security, and standardisation practices to facilitate the pilot project	<p>Enhancement and development: Use improved infrastructure as a basis for further development and scaling up of MaaS; facilitate standardisation at an international scale; formulate standards for data and open APIs but avoid over-designing; deploy an e-ticketing system if it does not exist yet; work with the national government to develop a technology roadmap and data standards.</p>

6.3 Potential up-scaling and social issues

In the last part of the final survey, we asked the experts to provide their final thoughts on the matters related to MaaS in three aspects in an open-ended format. Namely, the potential issues in scaling up the pilot, the potential social issues and any other matters.

First, the experts were asked to imagine the issues that should be considered by the local authority to upscale the pilot into a full-scale operation after the two-year pilot period, with an assumption that the pilot shows to be a success. The outputs from the panel are summarised in Box 6-4.

Box 6-4 Possible issues in up-scaling MaaS pilot project

Financial and infrastructure: Ensuring a continue financial and policy support beyond the pilot can be a challenge; the provision of physical infrastructure in an extended area beyond the pilot will be required to ensure a complete range of mobility solution.

Business model: A sustainable and viable business model with a clear case for a public subsidy will be essential. The evolution of these digital business models will take time, but once a feasible business model is established the pilot can be scaled up straightaway. There can be some potential provider related issues, such as vendor lock-in or exclusion of certain modes or operators.

Operation: Cross-border operation, such as the role of PTA in managing service in areas outside the existing coverage, can be an issue. Additionally, integrating additional services into an existing platform can entail multiple levels of complexity (interoperability, management, and security) and can lower commercial incentives and slow down the adoption rate of the service. The reliability of the service's connectivity will need to be checked, with backup plans putting in place; the smooth operation and stability of the supply side and IT infrastructure to support the up-scaling are also crucial.

Planning and governance: National and international standardisation are key for successful upscaling; measures need to be in place to avoid 'undesired' transport options gaining popularity or unfair and cost-focused competition; it can be unclear which actors have the main responsibility in up-scaling and in finding technical partner with relevant capability and know-how; the planning process will need to consider who to involve in the process, taking into account the existing relationship between transport operator and private sector partners.

Suggestion and other topics: Results and lessons learnt from the pilot must be fully understood and utilise in the up-scaling; regular briefing to stakeholders and media during pilot period will be required to prepare for upscaling. As user acceptance is the key that drives political support and funding; it will be important to ensure adequate public service of accessibility to vulnerable groups and low-density area.

In the next section, the experts were asked to consider potential social issues in connection with a MaaS service in the case that MaaS implementation becomes mainstream. We provided a number of possible issues, such as travellers need to have a smartphone, internet connection, and a certain level of technology literacy to access MaaS services. These requirements may exclude certain groups of the population, such as households with lower income and the elderly. The output from the panel is summarised in Box 6-5 below.

The three dominant themes that are pervasive in the potential social issues are 1) the security and safety of MaaS, particularly of data privacy, 2) how it will affect the fairness and equity in the transport system, and 3) its implications on the level of transport service from users' perspective.

Lastly, we provided an opportunity for the experts to express their final thoughts and/or reflection on MaaS. Their outputs are summarised in Box 6-6.

Box 6-5 Possible social issues wider implementation of MaaS

Security and privacy

Data privacy and security is a concern, in particular in the light of the recent breach of data privacy by Facebook. There is also perceived safety issues on MaaS services itself, such as privacy and safety in sharing a smaller public transport vehicle (i.e. shared taxi) with strangers and the utilisation of services offered by multiple operators. The additional social issue can arise from incorporating new technology, such as the self-driving vehicle, into MaaS. These new technologies can deter some users from the MaaS service.

Exclusion, fairness, and equity

MaaS can leave out segments of the population, such as those without a permanent address, a bank account, or a credit card; it is unclear how MaaS will affect accessibility for the elderly, the disabled, and those with limited mobility living outside an urban area. MaaS is currently being marketed as a high-cost high-quality service with an affluence image associated with it. This image can alienate some potential user groups from using it; it is uncertain if MaaS is an applicable concessionary scheme. However, there may be an equity issue should MaaS become a solely commercial driven activity, instead of a subsidised service. As a fully privatised MaaS is likely to focus more on the most profitable group of users and use cases.

Operation and level of service

Replacing a scheduled service with MaaS may bring efficiency in certain cases, but it may not be able to replace the real freedom of a high frequency fixed route service can provide (which does not require smartphone, app, pre-booking and pre-planning); MaaS can encourage a greater demand for travel and may lead to an increase in congestion level if it is managed ineffectively; MaaS can also reduce the usage of public transport as taxi and other demand-responsive transit services are offered in a package. Transparency in the service operation (e.g. which mode to offer to users) will be an important factor.

Other topics

A better use of technology can provide solutions to bridge the digital divide among the population. An increase in the smartphone adoption may help to solve potential social issues in MaaS, as well as, a provision of landline access; By its definition, MaaS should meet the need of each individual, thus provides rooms for different operators that may have a different focus (e.g. group of customers). Some of these operators may be applicable for concession; Inclusion of self-driving vehicle and other automation may cause jobs loss.

Box 6-6 Final thoughts on MaaS

Design

A non-digital ticketing alternative should always be provided as part of MaaS; MaaS should be kept simple in its design and approach, using technology as a tool to link the customer with supply chain; MaaS is more than a multimodal transport service and a marketplace approached is preferred over a packaged mobility approach.

Technology

The self-driving vehicle will not be coming in the near future and additional questions should be included to ascertain opinion on SV and if it is an important choice for MaaS users;

Planning and governance

Commitment to open a selection procurement or PPP, instead of a traditional request for proposal (RFP) or tender based procurements will be an essential element to MaaS [implementation]; MaaS may require a standardisation at the national or EU levels to be effective without overlooking the local context; Currently, the role of government is unclear; The local authority's involvement in the governance layer is needed to ensure community-wide benefits of MaaS.

Possible effects of MaaS

There is still uncertainty on the outcomes of MaaS, such as more or fewer car km. However, the opportunities for improving the efficiency of moving commuters during peak periods, or providing a wider choice for personalised transport needs at other times of the day, are potentially immense, yet MaaS could simply increase the number of travellers. This is counter to policies and strategies developed previously to reduce the need to travel. If MaaS can result in the need for fewer vehicles on our streets, then there are significant opportunities for improving our streetscapes and radically improving conditions for pedestrians and cyclists.

7 Levels of stability and consensus

In this section, we examine the levels of stability and consensus of the panel's responses by comparing the results of round 1 and round 2. The level of stability was used in this survey as a stopping criterion (Linstone & Turoff 2002).

We examine the changes both at the group and individual level. At the group level, we compare the group results and their associated level of concordance between the first and the second rounds. We then present the changes at an individual level, which illustrate how each expert changes their selections in response to the group result. These changes are presented in relation to the group opinion. In addition to the stopping criteria, the stability at an individual level can also represent how 'certain' the experts are on their response, assuming that those who are convinced that their view is right, tend to stick to their earlier answers. In the other words, individual stability may be used as an indicator of the perceived level of certainty by the experts on each subject.

7.1 Expectations on the early market

Table 7-1 shows the level of stability and concordance on the early market expectation of MaaS. At the group level, the comparison between the two rounds shows the feedback of the group results has a minor effect to the group's preferences (median), only one out of 21 items changed in the second round. In other words, the stability of the group results in this category is high. On the level of concordance, the experts have medium to high levels of agreement; most items have low IQR values, with a variation between 0 and 1. Only two items have a low level of concordance, with the IQR values of two. The comparison between the IQR values of the two round shows that the group feedback increases the level of agreement in five items (i.e. decreased their IQR values).

At the individual level, the exposure to the group results triggered around 0-20% of experts to change their selections in the second round. The highest percentages can be observed in Semi-National (20%) and Semi-Urban (17%), which indicate that the experts are swayed by the group's result, i.e. they are uncertain about the matters. Four different types of alterations of experts' selections in the second round can be observed; a) more optimistic, converge toward the median, b) more optimistic diverge away from the median, c) less optimistic, converge toward the median and d) less optimistic diverge away from the median. However, these changes do not affect the preferences at the aggregate level (i.e. the Median and IQR remained unchanged).

In most cases of the expected period and area of implementation, excepts in Full-rural, the majority of the experts who changed their selections become more optimistic in the second round. Additionally, in most cases experts converged their selections in the second round toward the group's results, however, in some cases, a large proportion of experts further diverged their selections from the group's preference, exacerbated their positions as outliers. Some of these outliers are more 'optimistic' in their expectation than their peers, such as in the two cases of the semi-integrated at the national level and MaaS in urban. In the other cases, they are less optimistic than their peers, such as in the case of semi-urban.

A number of remarks can be made on the phenomenon observed. Firstly, these experts may have strong personal convictions on the subjects; one expert reported his motivation behind retaining his selection that the group's answers are too optimistic and that his choice is more realistic, while another stated her rationale that her context is unique and does not match that of the majority's. Secondly, in addition to the group's results, these experts could have received external information on the developments of MaaS during the interval between the first and second round. Although it is difficult to distinguish the effects the group results and external information may have on their adjustments, it appears that in most cases the combined effects made the experts to be more optimistic in their expectations.

In the expectations on users, most experts who adjusted their selections were converged toward the group selections. Only in a few cases, such as flexible traveller, that a majority diverge away from the group's results. It is possible that the experts are more in agreement on these expectations.

Table 7-1 Levels of stability and consensus on early market expectations

(n=46)

Level of integration area	Semi Urban	Semi Rural	Semi National	Full Urban	Full Rural	Full National
Group level Median* (IQR**) Rd 1 / Rd 2	1 (1) / 1 (1)	2 (2) / 2 (2)	3 (2) / 2 (2)	2 (1) / 2 (1)	3 (1) / 3 (1)	3 (0) / 3 (0)
Individual level						
% experts changed view in 2 nd round	17%	15%	20%	11%	11%	9%
More optimistic, toward median	11%	4%	0%	2%	2%	0%
More optimistic, away from median	0%	4%	11%	4%	0%	4%
Less optimistic, toward median	0%	7%	7%	2%	9%	4%
Less optimistic, away from median	7%	0%	2%	2%	0%	0%
Generation (age)	Gen-Z (under 20)	Millennials (21-34)	Gen-X (35-49)	Baby Boomer (50-64)	Silent Gen (65+)	n/a
Group level Median* (IQR**) Rd 1 / Rd 2	1 (0) / 1 (0)	1 (0) / 1 (0)	2 (1) / 2 (1)	2 (0) / 2 (0)	3 (1) / 3 (1)	n/a
Individual level						n/a
% experts changed view in 2 nd round	2%	0%	0%	9%	4%	
More optimistic, toward median	2%	0%	0%	9%	0%	
More optimistic, away from median	0%	0%	0%	0%	0%	
Less optimistic, toward median	0%	0%	0%	0%	4%	
Less optimistic, away from median	0%	0%	0%	0%	0%	
Existing mode of transport	Regular Car users	Regular PT user	Flexible travellers	Regular cyclists	Special needs	Other
Group level Median* (IQR**) Rd 1 / Rd 2	2 (1) / 2 (1)	1 (1) / 1 (1)	1 (0) / 1 (0)	2 (1) / 2 (0)	2 (1) / 2 (0)	1 (1) / 1 (0)
Individual level						
% experts changed view in 2 nd round	13%	9%	7%	7%	11%	0%
More optimistic, toward median	9%	9%	2%	0%	4%	0%
More optimistic, away from median	0%	0%	0%	2%	2%	0%
Less optimistic, toward median	4%	0%	0%	4%	4%	0%
Less optimistic, away from median	0%	0%	4%	0%	0%	0%
Trip purpose	Commuting	Business	Education	Shopping	Leisure and social	Other
Group level Median* (IQR**) Rd 1 / Rd 2	1 (1) / 1 (1)	1 (1) / 1 (1)	2 (1) / 2 (1)	2 (0) / 2 (0)	2 (1) / 2 (0)	2 (2) / 2 (1)
Individual level						
% experts changed view in 2 nd round	13%	11%	9%	7%	15%	0%
More optimistic, toward median	11%	11%	4%	0%	0%	0%
More optimistic, away from median	0%	0%	2%	2%	2%	0%
Less optimistic, toward median	0%	0%	2%	4%	13%	0%
Less optimistic, away from median	2%	0%	0%	0%	0%	0%

7.2 Important actors, service integrators, and stakeholders

The level of stability and consensus on MaaS Ecosystem is shown in Table 7-2. At the aggregate level, the differences in ranking between the two rounds varied between no changes (Important actors) and some changes in the ranking (Service integrators and Stakeholders). However, the differences were minor and did not affect the top two ranked items in any categories. Moreover, the items included in the top-five did not change in any categories in the second round, indicating a high level of stability in the experts' preferences.

The comparison between the Kendall w values of the first and second round shows an increase of the level of concordance by 5-10%, indicating that the feedback of the group's results increased the level of agreement among the experts in this topic. At the individual level, the feedback caused 13%-26% of experts to change their selections in some ways. The highest percentage of change is observed in the important actor, on the other hand, the lowest percentage is observed in the important stakeholder. The relative difference between these percentage may indicate how certain the experts were on their selections. Assuming that those who are more certain with their preference will not change their selection.

Additionally, the results also point toward the need in examine changes in experts' selection at the individual level as well as the group level. For instance, the important actor category has the highest percentage of experts who changed their views in the second round, yet its group ranking was totally unchanged in the second round.

Table 7-2 Change of experts' selections on Important Actors
(n=46).

rank	Round 1	Round 2
Important actor		
1	a) Transport and logistic service providers or operators	a) [=]
2	b) Local authority	b) [=]
3	g) ICT and technology developers	g) [=]
4	e) 3rd Party mobility service provider	e) [=]
5	c) National government / national public agencies	c) [=]
w Rd 1 / Rd 2 (% change) = 0.24 / 0.27 (10%)		
Individual level: 26% experts changed his/her view in the 2nd round		
Important stakeholder		
1	a) Transport and logistic service providers or	a) [=]
2	operators	e) [=]
3	b) Local authority	b) [▼]
4	e) 3rd Party mobility service provider	c) [=]
5	c) National government / national public agencies	f) User ranks (e.g. P2P
	g) ICT and technology developers	transport service)
w Rd 1 / Rd 2 (% change) = 0.23 / 0.26 (8%)		
Individual level: 13% experts changed his/her view in the 2nd round		
Most preferred service integrator		
1	j) Mobile phone network and internet provider	j) [=]
2	i) Investors (semi-public and private)	i) [=]
3	k) Actors from non-transport sector (e.g. tourism)	c) [▲]
4	c) National government / national public agencies	k) [▼]
5	h) Transport infrastructure operator	h) [=]
w Rd 1 / Rd 2 (% change) = 0.10 / 0.10 (5%)		
Individual level: 17% experts changed his/her view in the 2nd round		
Least preferred service integrator		
1	a) Investor and shareholders	a) [=]
2	c) Media and Marketing firms	c) [=]
3	b) Research institutions	d) [▲]
4	d) Tourism business	b) [▼]
5	f) Other service sectors	f) [=]
w Rd 1 / Rd 2 (% change) = 0.19 / 0.20 (9%)		
Individual level: 22% experts changed his/her view in the 2nd round		

* the symbols in the parathesis denote a change in the ranking in relation to round 1

7.3 Planning for future implementation

Table 7-3 reports the level of stability and consensus for the planning elements of MaaS. At the aggregate level, a higher level of differences in ranking between the two rounds can be observed. These changes include the alteration to the top-ranked items in two categories (i.e. objectives to implement MaaS and constraints). In several categories, the level of concordance significantly increased (between 11%-105%). However, reductions in the level of concordance between -3% and -9% were also observed in two cases. At the individual level, the comparison between round 1 and 2 shows that 17%-56% of experts (between 2 out of 12 experts and 19 out of 34 experts) changed their selections in some ways.

Table 7-3 Changed of experts' selections on Objectives to implement MaaS

Objectives to implement MaaS						
Level	Central gov. & local authority		Central government		Local authority	
	Rd 1 (n=16)	Rd 2 (n=12)	Rd 1 (n = 30)	Rd 2 (n = 34)	Rd 1 (n = 30)	Rd 2 (n = 34)
Group level	a) Provide public accessibility to key destinations...	b) [▲]	a)	b) [▲]	a)	a) [=]
	b) Reducing car dependency and usage	f) [▲]	c)	c) [=]	e)	e) [=]
	c) Promote cleaner transport modes	a) [▼]	b)	a) [▼]	b)	b) [=]
	f) Improve cost-effectiveness of transport	c) [▼]	f)	e) [▲]	c)	f) [▲]
	e) Reduce level of congestion	e) [=]	e)	f) [▼]	f)	c) [▼]
	w Rd 1 / Rd 2 (% change) = 0.32 / 0.30 (-9%)		w Rd1 / Rd2 = 0.20 / 0.23 (17%)		w = 0.25 / 0.27 (11%)	
Individual level	No. of experts changed view in 2 nd round (%): 2 (17%)		12 (35%)		13 (38%)	
Possible constraints.						
Level	Central gov. & local authority		Central government		Local authority	
	Rd 1 (n=16)	Rd 2 (n=12)	Rd 1 (n = 30)	Rd 2 (n = 34)	Rd 1 (n = 30)	Rd 2 (n = 34)
Group level	e) Limitations in formal regulation regarding finance and operation	b) [▲]	f) Existing public transport contract	f) [=]	g)	g) [=]
	b) Perception of limited value proposition of MaaS service	e) [▼]	e)	e) [=]	a)	a) [=]
	g) ICT-condition (i.e. available infrastructure and data, safety and privacy)	h) other	b)	b) [=]	b)	e) [▲]
	a) Limited public budgets	f) Existing public transport contract	a)	a) [=]	f)	f) [=]
	c) Insufficient physical transport infrastructure	a) [▼]	c)	c) [=]	e)	b) [▼]
	w Rd 1 / Rd 2 (% change) = n/a (not significant)		w = 0.16 / 0.22 (33%)		w = 0.12 / 0.15 (12%)	
Individual level	No. of experts changed view in 2 nd round (%): 3 (25%)		11 (32%)		19 (56%)	

Note: % - percentage of respondents included the option in their selections

*Certain options may be selected by an equal or a lower proportion of experts but are placed in a higher rank, resulting in their higher mean-ranking. The symbols in the parenthesis denote a change in the ranking in relation to round 1

Table 7-3 (continued): Changed of experts' selections on available MaaS policies.

Available MaaS policies						
Level	Central gov. & local authority		Central government		Local authority	
	Rd 1 (n=16)	Rd 2 (n=12)	Rd 1 (n = 30)	Rd 2 (n = 34)	Rd 1 (n = 30)	Rd 2 (n = 34)
Group level	a) Implement pilot projects ..	a) [=]	a)	a) [=]	a)	a) [=]
	e) Improve physical transport infrastructure...;	e) [=]	d) Specify clearer roles and responsibilities ...	d) [=]	d)	d) [=]
	f) Improve the digital infrastructure ..	f) [=]	b)	b) [=]	e)	e) [=]
	c) Create a statutory body to guide MaaS development ..	g) [▲]	g)	g) [=]	c)	b)
	g) Develop an open market for services innovation	b) Give priority to MaaS in high-level planning..	e)	e) [=]	f)	f) [=]
	w Rd 1 / Rd 2 (% change) = 0.17 / 0.35 (105%)		w = 0.09 / 0.12 (42%)		w = 0.26 / 0.25 (-3%)	
Individual level	No. of experts changed view in 2nd round (%): 4 (33%)		10 (29%)		11 (32%)	
Necessary conditions for the success of the policy selected						
Level	Central gov. & local authority		Central government		Local authority	
	Rd 1 (n=16)	Rd 2 (n=12)	Rd 1 (n = 30)	Rd 2 (n=34)	Rd 1 (n=30)	Rd 2 (n = 34)
Group level	a) Close collaboration between key actors and stakeholders	a) [=]	a)	a) [=]	a)	a) [=]
	b) Availability and standardisation of mobility data	l) [▲]	b)	b) [=]	h)	h) [=]
	h) Attractive business opportunity for actors and stakeholders	h) [=]	h)	l) [▲]	l)	l) [=]
	l) Successful operationalisation of pilot schemes	b) [▼]	e) Suitable regulation regarding data security and privacy	h) [▼]	b)	b) [=]
	f) Reformed system of PT regulation and tax system	i) Provision of appropriate physical infrastructure	l)	e) [▼]	i)	i) [=]
	w Rd 1 / Rd 2 (% change) = 0.24 / 0.28 (19%)		w = 0.18 / 0.23 (32%)		w = 0.19 / 0.27 (45%)	
Individual level	No. of experts changed view in 2nd round (%): 3 (25%)		13 (38%)		13 (38%)	

Note: % - percentage of respondents included the option in their selections

*Certain options may be selected by an equal or a lower proportion of experts but are placed in a higher rank, resulting in their higher mean-ranking. The symbols in the parathesis denote a change in the ranking in relation to round 1

There are a number of possible reasons for the high differences and variations in the level of concordance observed. Firstly, four experts shifted their selections on whether they believe the central government and local authority have the same view on planning or not in the second round(See Section 5.1) to join the group majority. The shift appeared to affect the ranking and level of concordance of all other questions in this section because the structure of the questionnaire, which recorded the experts' opinion on the planning elements in a separate manner, depending on what view they believe the public authority has on the planning. This change affected the values of the Central gov. & local authority in particular because it already had a lower number of respondents.

Secondly, the research team decided to end the survey in after the second round even though the second round was the first opportunity the experts can adjust their selections in the light of the group's results. Additionally, the higher levels of variations suggest a need for an additional round of Delphi to ensure a higher stability of the outcomes. However, the survey team decided to accept the outcomes as it is. The rationale behind the decision was that the Delphi survey is part of a larger planning exercise that will require contextualisation to our case study (i.e. the Netherlands), thus an increase in stability will bring limited benefits to the exercise. Instead, as discussed before, we decided to dedicate the third and final round of the Delphi to address possible vulnerabilities, opportunities, and explore possible social issues and in scaling up of a pilot project (See Section 6).

8 Discussion and conclusions

Our Delphi study confirms a number of earlier reported surveys and studies on MaaS and makes additional contributions to the knowledge. The need for this Delphi was argued in the first section; it focuses on the planning aspects of MaaS, which have not been researched in this way before. Moreover, the objectiveness and the overarching nature of this study implies its outcomes may be used as reference points for practitioners and researchers in the field of MaaS planning

Our findings highlight experts' expectations on the early market of MaaS. The experts expect MaaS to start operating in their urban area within the next two years. They also expect the younger generations (Gen-Z and the Millennials), public transport users, and flexible travellers to be the early adopter of MaaS, whereas the regular car driver may adopt it at a later stage. The panel believes MaaS will be first use for commuting and business trips. The findings also stress the crucial role of the public transport providers in MaaS as an actor and also as the most preferred MaaS operator. Additionally, investors and shareholders are also seen as the most important stakeholders.

The experts believe the objectives to implement MaaS are reducing car dependency and usage; improve cost-effectiveness of transport, provide public accessibility, promote cleaner transport, and reduce the level of congestion. The order of importance for these objectives are different, depending on whether the experts took the perspective of the central government or the local authority. These objectives may be prevented to realise by the following constraints: perception of limited value in MaaS, existing public transport contract, and poor ICT-condition. The panel believes the most important MaaS policy is to implement a pilot project to experiment and enable learning. The findings also underline the importance of a strong collaboration between actors in MaaS as the experts see it as the most important event that can cause the policy to fail (vulnerability) or to succeed (opportunity)

The findings suggest a number of planning and policy implications. Five of them will be highlighted here. Firstly, the panels' expectations about the period of market implementation suggest a logical evolution of the transport system from semi-integrated to fully integrated services into urban and rural areas. However, the experts believe that the two levels of integration may occur in the same period for services at a national level, thus implying that there is a possible overlap or even a leap directly to the full level of integration. This possibility reveals that there may be a potential advantage to directly implementing MaaS for this type of services, instead of following an evolutionary approach.

Secondly, the expectation that the younger generation will be the first to adopt MaaS is in line with the general observed trend that youths are more receptive towards the 'shared economy' (Newlands et al., 2017). However, the perceived lower purchasing power of this group by experts, suggests a need to consider the position of MaaS in terms of pricing against the quality of its service (i.e. affordability). A repositioning of MaaS as a high-end high-priced product can reduce the value prospect of MaaS. Additionally, the phasing of MaaS adoption as seen by the majority of our panel, also suggests that the MaaS business model may need to anticipate a possible delay in its income stream as the users with higher purchasing power (i.e. the Gen-X and the Baby Boomer) are mainly seen as the follower. Alternatively, a MaaS operator might consider implementing additional strategies to accelerate the adoption of MaaS or even to stimulate the potential followers to become an early adopter.

Thirdly, experts have suggested that the regular car users will adopt MaaS at a later stage, thus playing down the prospect of MaaS as an alternative to the personal private vehicle. This finding is in line with the stakeholders' expectation reported by König et al. (2016). This expectation is in conflict with the experts' selection that one of the objectives to implement MaaS is to reducing the level of congestion (Section 5.2), suggesting a possible incoherency in the experts' thinking on this matter. However, it is possible that in the longer term car drivers who use MaaS may be more attracted to public transport via its participation in MaaS (Kamargianni et al., 2017). This seems to imply a trigger for PT providers to participate in MaaS. The expectation that the regular PT user will be the first to adopt MaaS may, on the other hand, weaken the attractiveness for public transport providers to associate themselves with MaaS. This is because the potential increase in users, switching from car to MaaS, would be marginal and MaaS might even become a potential competitor to the regular public transport services. In any case, unless the transport operators can be convinced that MaaS will not pose a threat to the existing businesses and the advantages MaaS can offer,

such as the optimisation of supply capacity, are apparent to the providers (Kamargianni et al., 2017; Kamargianni, Matyas, Li, & Schäfer, 2015), it will be difficult to ensure the collaborations from and between the operators.

Fourthly, this Delphi explicitly focused on investigating the panel's opinions on various aspects of planning for MaaS implementation, which includes the experts' judgements on the importance and certainty of the policy elements. These judgements can be useful in designing policy and plan for MaaS implementation as they represent an effort to prioritise resources allocation to reduce or enhance the impacts and likelihoods of possible events that may affect the implementation and increase its likelihood to succeed. In particular, the results emphasise that a strong collaboration between actors is a highly critical factor that can enhance the success of a given MaaS service, thus more effort and resource should be allocated to address this issue.

Finally, this study reveals a number of interesting effects of using the Delphi method by reporting the group results to the expert panel. We find that the exposure of group results increased the level of agreement among the experts in the subsequent survey round. Additionally, the exposure can induce changes of preference at the individual level that may not be apparent at the group level, emphasising the importance to make an observation of preference changes at the individual level. Also, the percentage of individual experts who changed their preferences may be used as a relative indicator to illustrate how certain or confident the experts are on their initial selections. Assuming that those who do not change their preference are more certain or confident about their initial selections. The study also finds the experts appeared to be more optimistic with their expectations in most cases of the subsequent round, in light of the group results and any external information they might receive during the interval between the first and second round. However, in certain cases, there may be 'outliers' who have preferences that are diverged from the group's. These individuals appeared to hold strong personal opinion on their selections.

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Appendix

Questionnaire round 1/2

Dear $\{m://FirstName\}$ $\{m://LastName\}$, Welcome to the Future of Mobility-as-a-Service (MaaS) survey.

The survey progress is shown via a coloured bar on top of the screen.

Click Next to proceed forward and Previous to return to the previous page.

Part 1: MaaS types considered in this survey

Mobility as a Service (MaaS) is an emerging concept that seeks to provide individualised multimodal mobility service through an integration of different transport modes. It shifts the transport system from vehicle-ownership to transport use-based. The user can plan, reserve, pay, and obtain his/her ticket for a full trip by a single interface on a smartphone. We consider two different types of MaaS in this survey:

Type A: Semi-integration

Various apps are available to assist users in integrating public transport services, such as OV9292 (Netherlands) and CityMapper(London, Berlin). These Type-A apps help users to plan their trips and in some cases, can purchase tickets for their full trip chain. However, users still need to consult a number of apps to access all services available.

Type B: Full integration

One app integrates all modes of transport. Users can plan and obtain the ticket for their multimodal trip through the app. Some service (Whim, Finland) may offer options of monthly packages, while others provide only a Pay-as-you-go basis (Tuup, Finland).

Part 2: Personal Information

Q2.1 Country

In which country do you currently reside?

▼ Afghanistan (1) ... Zimbabwe (1357)

Q2.2 Sector

In which sector are you mainly working in?

- Academic or research institution (1)
- Inter-regional and international organisations (2)
- Interest group and association related to transport (3)
- Private company and business (4)
- Consultant (5)
- Central government (6)
- Local and regional public authority (7)
- Transport operator (8)
- Technology developer (9)
- Other (10) _____

Q2.3 Area and level of expertise

Q2.3a Specify your main area of expertise.

- Local public transport (1)
- Connected and Autonomous Vehicles (2)
- Intelligent Mobility (3)
- Transport Economics (4)
- Transport technology, ICT, and App development (5)
- Transport policy and planning (6)
- Logistics operation and management (7)
- Other area, please specify (8) _____

Q2.3b Specify the level of the selected expertise.

Level of expertise (1) 1-5

Q2.3c Specify your main source of knowledge in the selected field

- Formal learning and education (e.g. high-level education) (1)
- Specialised training course (2)
- Practical work - learning by doing (3)
- Academic research (4)
- Applied research and policy making (5)
- Self-study (6)
- Other, please specify (7) _____

Q2.4 Expertise in MaaS

Specify the level of your expertise in MaaS prior to this survey.

Level of my expertise in MaaS 1 -5

Part 3: Early Market

3.1 Expected application area and period

Q3.1a Indicate the period you expect to see a large scale operation and use of MaaS Type A: Semi-integration in these environments in your country/region.

	Already available (1)	Before 2020 (2)	2020-2030	After 2030	Never
Urban (City and Metropolitan area)					
Regional (Urban and Rural)					
National					

Q3.1b Indicate the period you expect to see a large scale operation and use of MaaS Type B: Full-integration in these environments in your country/region.

	Already available (1)	Before 2020 (2)	2020-2030	After 2030	Never
Urban (City and Metropolitan area)					
Regional (Urban and Rural)					
National					

Q3.1c If possible, please provide your motivation for your expectations

Q3.2a Early users - Mobility preference segmentation

Specify the user groups you expect to be an Early Adopter (i.e. first 15% of MaaS users), a Follower (a potential user but not an early adopter), or a Non-user of MaaS with Full integration in your country/region.

	Early Adopter	Follower	Non-user
Regular car users			
Regular public transport user			
Flexible travelers*			
Regular cyclists			
Special needs (e.g. disable and elderly)			
Other, Please specify			

*Flexible travelers - those who combine different modes of transport to form most convenient trips

Q3.2b Early users - Age group segmentation

Specify the user groups you expect to be an Early Adopter (i.e. first 15% of MaaS users), a Follower (a potential user but not an early adopter), or a None user of MaaS with full integration in your country/region.

	Early Adopter	Follower	Non-user
Generation Z (under 20)			
Millennials (21-34)			
Generation X (35-49)			
Baby Boomer (50-64)			
Silent Generation (65+)			

Q3.2c Early users - Trip purpose

Specify the user groups you expect to be an Early Adopter (i.e. first 15% of MaaS user), a Follow (i.e. a potential user, but not an early adopter), or a None user of MaaS with full integration in your country/region.

	Early Adopter	Follower (3)	Non-user
Commuting			
Business			
Education			
Shopping			
Leisure & social (visiting family, etc.)			
Other, please specify			

Part 4: Business ecosystem of MaaS with full integration

Q4.1 Identify critical actors* in the early phase

Select three critical actors that will be directly involved in the early phase of implementing and operating MaaS with full integration (Type B) by dragging and placing the actors in the box in order of their importance.

Tip: 1 - most important actor

*An actor has a direct involvement in service provision

Select 3 Critical actors

- _____ l) Other, please specify (8)
- _____ a) Transport and logistic service providers or operators (x1)
- _____ b) Local authority (x2)
- _____ c) National government / national public agencies (x3)
- _____ d) Data providers (x5)
- _____ e) 3rd Party mobility service provider (x6)
- _____ f) User groups (e.g. P2P transport service) (x10)
- _____ g) ICT and technology developers (x11)
- _____ h) Transport infrastructure operator (x12)
- _____ i) Investors (semi-public and private) (x13)
- _____ j) Mobile phone network and internet provider (x15)
- _____ k) Actors from non-transport sector (e.g. tourism, public services) (x16)

Q4.2a MaaS operator

Identify the three most preferred / least preferred and the three least preferred actors to play the role of service integrator* of MaaS from a societal point of view by drag and place item in the box in order of their importance

Tip: preferred 1 = the most preferred; unfavourable 1 = the most unfavourable

*Service integrator responsible for providing, maintaining, and regulating a communal platform, which transport providers and related services interact with users.

- _____ l) Other, please specify (x8)
- _____ a) Transport and logistic service providers or operators (xx1)
- _____ b) Local authority (xx2)
- _____ c) National government / national public agencies (xx3)
- _____ d) Data providers (xx5)
- _____ e) 3rd Party mobility service provider (xx6)
- _____ f) User groups (e.g. P2P transport service) (xx10)
- _____ g) ICT and technology developers (xx11)
- _____ h) Transport infrastructure operator (xx12)
- _____ i) Investors (semi-public and private) (xx13)
- _____ j) Mobile phone network and internet provider (xx15)
- _____ k) Actors from non-transport sector (e.g. tourism, public services) (xx16)

Q4.2b If possible, please provide rationale of your selection in 4.2a

Q4.3 Potential stakeholders*

In addition to the main actors, identify at least one potential contextual stakeholders: those with no direct involvement with the business but with influence on MaaS' implementation and operation (e.g. taxi union and community group).

Tip: 1 - most important actor / Select 3 most important stakeholders

- _____ h) Other, please specify (7)
- _____ a) Investor and shareholders (x1)
- _____ b) Research institutions (x3)
- _____ c) Media and Marketing firms (x2)
- _____ d) Tourism business (x4)
- _____ e) Academic institutions (x5)
- _____ f) Other service sectors (x6)
- _____ g) Labour unions (x8)

Part 5: Identify objectives, possible constraints, and available policies

Do you think a national government and local authorities within the country have the same (i.e. consistent) view on planning public objectives, constraints, and policies associated with MaaS?

- Yes, they have the same view (same objectives, same policy choices, etc.) (1)
- No, they have different views (2)

Q5.1a Government and local authority / Government / Local 's objectives

Select 3 objectives to implement a MaaS Type B from the perspective of your national government and local authority by drag and place them in the box in order of their importance.

Tip: 1 - Most important objective / Select 3 Objectives

- _____ h. Other, Please specify (9)
- _____ a. Provide public accessibility to key destinations and services to ensure social and economic inclusion (x1)
- _____ b. Reducing car dependency and usage (x2)
- _____ c. Promote cleaner transport modes (x3)
- _____ d. Improve safety of transport (x5)
- _____ e. Reduce level of congestion (x6)
- _____ f. Improve cost-effectiveness of transport (x7)
- _____ g. Reduce parking space demand (x10)
- _____ Yes, they have the same view (same objectives, same policy choices, etc.) (xx1)
- _____ No, they have different views (xx2)

Q5.2a Possible constraints at Government and local authority / Government / Local levels

Select three possible constraints that may prevent the objectives you selected to be reached by drag and place items in the box in order of their importance. (1 - constraint that is more critical).

Tip: 1 - Most critical constraint Reminder: The objective you selected are - [\\${Q5.1agl/ChoiceGroup/SelectedChoices}](#) / Select 3 Constraints

- h) Other, Please specify (8)
- a) Limited public budgets (x1)
- b) Perception of limited value proposition of MaaS service (x2)
- c) Insufficient physical transport infrastructure (x10)
- d) Lack of appropriate business model (x4)
- e) Limitations in formal regulation regarding finance and operation (x5)
- f) Existing public transport contract (x7)
- g) ICT-condition (i.e. available infrastructure and data, safety and privacy) (x9)

Q5.3a Available MaaS policies and their priority - Governmental and local authority / Government / Local levels

Select 3 most important policies for your national government and local authority to ensure a successful implementation of MaaS Type B by drag and place them in the box in order of their importance.

Tip: 1 - most critical policy Reminder: The objectives you selected are - [\\${Q5.1agl/ChoiceGroup/SelectedChoices}](#) / Select 3 Available policies

- h. Other, Please specify (14)
- a. Implement pilot projects to experiment and enable learning (x1)
- b. Give priority to MaaS in high-level planning and policy documents (x2)
- c. Create a statutory body to guide MaaS development and implementation (x3)
- d. Specify clearer roles and responsibilities within the MaaS eco-system (x4)
- e. Improve physical transport infrastructure; PT network, car-sharing, and bike-sharing facilities (x5)
- f. Improve the digital infrastructure and data collection and handling conditions (x6)
- g. Develop an open market for services innovation (x7)

Part 6: Identify condition of success

Q6.1a Conditions of success - Governmental and local authority / Government / Local levels

Identify three necessary conditions for the success of the most critical policy selected by placing them in the box in order of their importance. Tip: 1 - most important condition *Conditions for the success is what will be required to ensure accomplishment of the selected policy. Reminder: The policies you selected are - [\\${Q5.3agl/ChoiceGroup/SelectedChoices}](#)

Select 3 Conditions of success

- p) Other, please specify (14)
- a) Close collaboration between key actors and stakeholders (x1)
- b) Availability and standardisation of mobility data (x2)
- c) Societal access to and general use of ICT (x3)
- d) Strong financial support (x4)
- e) Suitable regulation regarding data security and privacy (x5)
- f) Reformed system of PT regulation and tax system (x6)
- g) An innovative contractual framework to enable MaaS. (x15)
- h) Attractive business opportunity for actors and stakeholders (x7)
- i) Provision of appropriate physical infrastructure (x9)
- j) Related ICT infrastructure and applications (x11)
- k) General recognition among customers of added value of MaaS e.g. personalised service, easy access, easy payment, etc. (x12)
- l) Successful operationalisation of pilot schemes (x13)
- m) Support from interest groups (actors and stakeholders) (x22)
- n) Increasing variability in travel needs/preferences (x24)
- o) Increasing number of elderly (x25)

Part 7: Suggestion and other points

Q7.1 MaaS typology

In addition to the three types of MaaS proposed in this survey, are there other types of MaaS you believe should be included in the next round of survey?

Q7.2 Other suggestions

Please state any comment and suggestions, including other of information should be included in the next stage of the questionnaire.

Questionnaire round 3

Dear *\$(m://FirstName) \$(m://LastName)*,

Welcome to the final round of Future of Mobility-as-a-Service (MaaS) survey. This round consists of 3 parts (you will need approximately 15 minutes to complete the survey)

Please check if your name matches the respondent tag on top of the screen. If the name is not correct, please contact the survey manager p.jittrapirom@fm.ru.nl.

All your inputs are handled anonymously.

Click Next to proceed forward and Previous to return to the previous page.

You may return to this survey at any time.

We thank you for your time and interest.

Best regards.

Peraphan Jittrapirom

Survey manager

Please specify if you would like us to include your name in the acknowledgement list of this Delphi report. The report will be made available to the public.

Yes, please include my name (1)

No, I want to remain anonymous (2)

If you click, Yes. Please provide here the information as you would like it to appear on the list.

Title (1) _____

First name (2) _____

Last name (3) _____

Affiliation (4) _____

Part 1: Types of MaaS considered in this survey

Mobility as a Service (MaaS) is an emerging concept that provides individualised multimodal mobility service through integration of different transport modes. In fully integrated MaaS, the user can plan, reserve, pay, and obtain his/her ticket for a trip by a single interface on a smartphone.

We consider two different types of MaaS in this survey:

Type A: Semi-integration

Various apps are available to assist users in integrating public transport services, such as OV9292 (Netherlands) and CityMapper (London, Berlin). These Type-A apps help users to plan their trips, and in some cases, users can purchase tickets for their full trip chain. However, users still need to consult a number of apps to explore all available transport services.

Type B: Full integration

One app integrates all modes of transport. Users can plan and obtain a ticket for their multimodal trip through one app. Some services (Whim, Finland) offer a monthly subscription (e.g. unlimited travel on public transport in addition to a fixed number of taxi kilometres), while others provide services on a Pay-as-you-go basis (Tuup, Finland).

Part 2: Identify vulnerabilities and opportunities of implementing the selected MaaS policy

From the previous rounds, the most favourable starting policy is:

Implement MaaS pilot projects to experiment and enable learning

Please imagine that the responsible public authority in your city/region decides to implement this starting policy for its urban area.

The duration of the pilot project is two-year.

Service integrator*: Public transport provider

Click Next to proceed.

(You can return to this page by click Previous.)

Note: *A service integrator is responsible for providing, maintaining, and regulating a common platform, which enables transport providers and related services to interact with users.

We derived the following set of objectives for the pilot project from the group's opinion over the past rounds:

Objectives of a MaaS pilot project:

- To stimulate learning on MaaS related aspects, such as governance, operation, and user behaviour.
- To test the technology underlying the MaaS concept
- To examine the feasibility of scaling up or adjusting MaaS after the pilot

Do you agree with these objectives for a MaaS pilot in your city?

If not, please suggest changes.

I agree with the stated objectives (1)

I would like to suggest changes/additions, please specify (2) _____

We derived the following set of conditions for success for the pilot project from the group's response:

Conditions for the success of a MaaS pilot project:

- Strong financial and political support
- Close collaboration between key actors and stakeholders
- Attractive business opportunities for actors and stakeholders
- Availability and standardisation of mobility data
- Provision of appropriate physical infrastructure
- User acceptance

Do you agree with these conditions for success for the MaaS pilot in your city?

If not, please suggest changes.

I agree with the stated conditions (1)

I would like to suggest changes/additions, please specify (2) _____

2.1 Vulnerabilities

Next, we explore the possible events or developments that can make the MaaS pilot project in your region fail in terms of conditions for success (see the previous question) that might not be met.

Q2.1a Identify three most significant events or developments that can negatively affect the pilot project to a point where the pilot is no longer successful: Three most significant events/developments

Please drag and place them in the box in order of their significance (1 - most significance)

_____ a) A weakening or disruption of financial and political support to the pilot project (21)

_____ b) Crucial actors are unwilling to collaborate in the pilot due to various reasons (e.g. lack of trust, potential loss of control, unforeseen benefits) (4)

_____ c) Lack of an appropriate and attractive business model for actors and stakeholders in the pilot project (10)

_____ d) Unavailability of relevant digital data or inappropriate format of the data (8)

_____ e) Insufficient physical infrastructure (such as for car-sharing, bike-sharing, and public transport) to operate the MaaS pilot (1)

_____ f) Travellers do not recognise the added value of MaaS due to various reasons (e.g. unattractive service design, unattractive pricing, and inadequate support functions) (15)

_____ g) Other, please specify (14)

Please indicate the rationale behind your selection

Q12 2.1b Identify the level of plausibility for each selected event within the period of the pilot project (two-year). Also, identify the event's importance in achieving the objective of the pilot.

	Level of plausibility of the event within the MaaS pilot period		Importance of the event in achieving the objectives of the pilot	
	Uncertain (1)	Certain (2)	Unimportant (1)	Important (2)
a) A weakening or disruption of financial and political support to the pilot project (Q12_xa)				
b) Crucial actors are unwilling to collaborate in the pilot due to various reasons (e.g. lack of trust, potential loss of control, unforeseen benefits) (Q12_xb)				
c) Lack of an appropriate and attractive business model for actors and stakeholders in the pilot project (Q12_xc)				
d) Unavailability of relevant digital data or inappropriate format of the data (Q12_xd)				
e) Insufficient physical infrastructure (such as for car-sharing, bike-sharing, and public transport) to operate the MaaS pilot (Q12_xe)				
f) Travellers do not recognise the added value of MaaS due to various reasons (e.g. unattractive service design, unattractive pricing, and inadequate support functions) (Q12_xf)				
g) Other, please specify (Q12_xg)				

2.1c Please suggest possible anticipatory actions for each selected vulnerable event/development that may be taken by your public authority.

Such an anticipatory action may aim to reduce the adverse impacts of the vulnerable event or reduce its risk. For example, a possible action to anticipate the unavailability of relevant digital data may be an agreement to share data between different parties, specifically for the use of the pilot project.

	Responding action to selected vulnerable events
a) A weakening or disruption of financial and political support to the pilot project (2.2c_xa)	
b) Crucial actors are unwilling to collaborate in the pilot due to various reasons (e.g. lack of trust, potential loss of control, unforeseen benefits) (2.2c_xb)	
c) Lack of an appropriate and attractive business model for actors and stakeholders in the pilot project (2.2c_xc)	
d) Unavailability of relevant digital data or inappropriate format of the data (2.2c_xd)	
e) Insufficient physical infrastructure (such as for car-sharing, bike-sharing, and public transport) to operate the MaaS pilot (2.2c_xe)	
f) Travellers do not recognise the added value of MaaS due to various reasons (e.g. unattractive service design, unattractive pricing, and inadequate support functions) (2.2c_xf)	
g) Other, please specify (2.2c_xg)	

Please indicate the rationale behind your proposed actions

2.2 Opportunities

In this section, we explore the different events or developments that can accelerate the success of the MaaS pilot project in your region.

2.2a Identify three most significant events or developments that can enhance or accelerate the pilot project's success:

Three most significant opportunities

Please drag and place them in the box in order of their significance (1 - most significance)

- _____ a) A strengthening of political and financial support for the pilot project (10)
- _____ b) Active collaborations between actors and stakeholders involved in the pilot project (11)
- _____ c) The emergence of new business models, transport services, and other value-added services that can be applied within the pilot project (3)
- _____ d) A significantly improved digital infrastructure, including digital data management, security, and standardisation practices to facilitate the pilot project (5)
- _____ e) A rise of smart transport infrastructure and service, such as shared self-driving vehicles that contributes to enhancing the attractiveness of MaaS pilot project (1)
- _____ f) Travellers' satisfaction with the pilot project is above expectation, leading to high demand for the service (4)
- _____ g) Other, please specify (9)

Please indicate the rationale behind your selection

2.2b Identify the level of plausibility for each selected event within the period of the pilot project (two-year). Also, identify the event's importance in achieving the objectives of the pilot.

	Level of plausibility within the MaaS pilot period		Importance to achieving the objectives of the pilot	
	Uncertain (1)	Certain (2)	Unimportant (1)	Important (2)
a) A strengthening of political and financial support for the pilot project				
b) Active collaborations between actors and stakeholders involved in the pilot project				
c) The emergence of new business models, transport services, and other value-added services that can be applied within the pilot project				
d) A significantly improved digital infrastructure, including digital data management, security, and standardisation practices to facilitate the pilot project				
e) A rise of smart transport infrastructure and service, such as shared self-driving vehicles that contributes to enhancing the attractiveness of MaaS pilot project				
f) Travellers' satisfaction with the pilot project is above expectation, leading to high demand for the service				
g) Other, please specify				

2.2c Please suggest possible responding actions for each selected opportunistic event or developments that may be taken by your public authority.

An action to respond to an opportunity aims to take advantage of the opportunity. For example, an action to prepare for higher demand for MaaS than expected is to prepare for expanding the MaaS operation.

	Responding actions to selected opportunity
a) A strengthening of political and financial support for the pilot project (2.3c_xa)	
b) Active collaborations between actors and stakeholders involved in the pilot project (2.3c_xb)	
c) The emergence of new business models, transport services, and other value-added services that can be applied within the pilot project (2.3c_xc)	
d) A significantly improved digital infrastructure, including digital data management, security, and standardisation practices to facilitate the pilot project (2.3c_xd)	
e) A rise of smart transport infrastructure and service, such as shared self-driving vehicles that contributes to enhancing the attractiveness of MaaS pilot project (2.3c_xe)	
f) Travellers' satisfaction with the pilot project is above expectation, leading to high demand for the service (2.3c_xf)	
g) Other, please specify (2.3c_xg)	

Please indicate the rationale behind your proposed actions

Part 3: Final thoughts

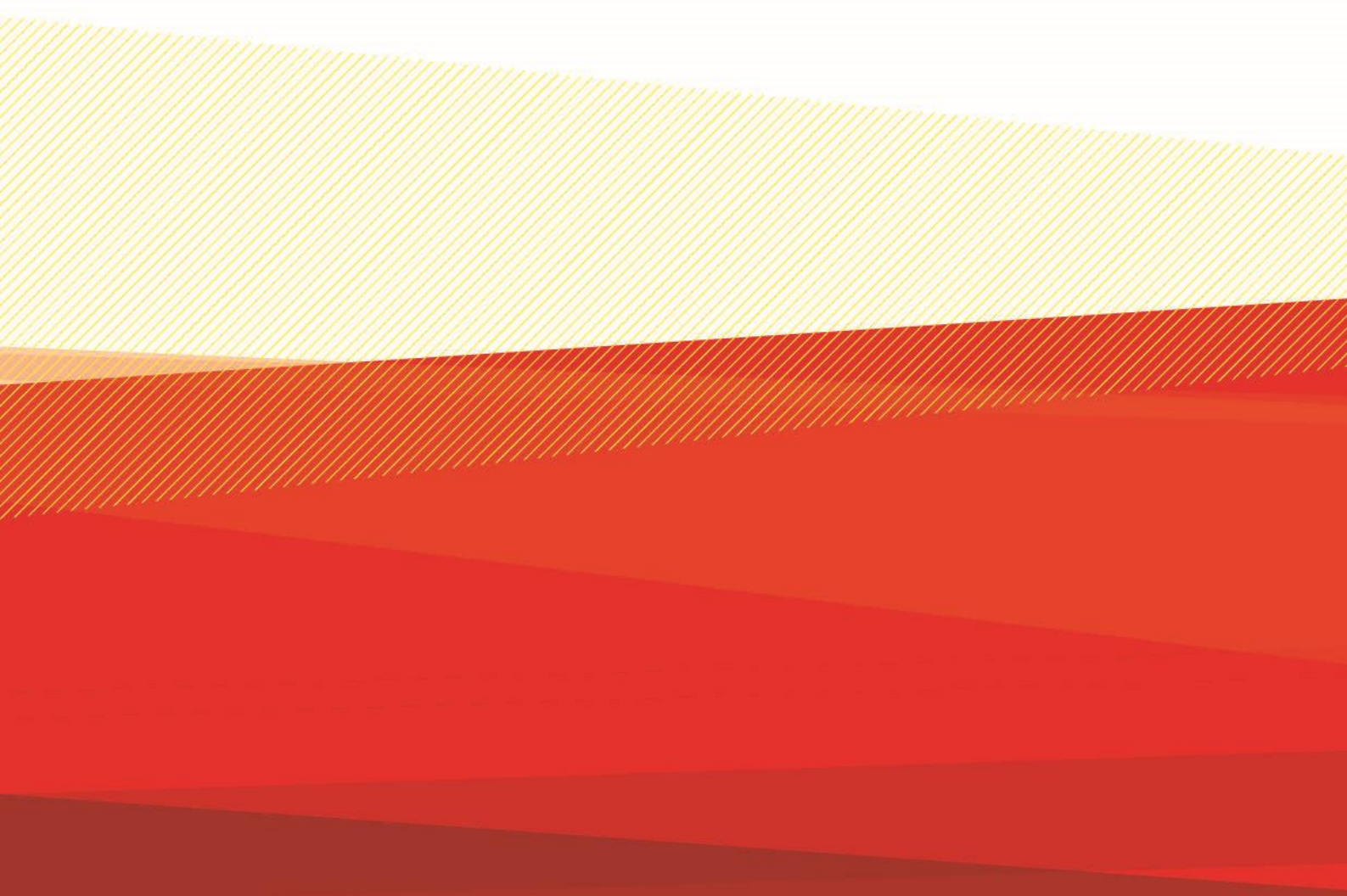
3.1 Potential issues in scaling up the pilot Assume that after the two-year period, the implementation of the pilot shows to be a success. Your local authority decides to scale up the MaaS pilot into full-scale operations. What are the issues that should be considered in that process of upscaling?

3.2 Potential social issues in relation to MaaS

Should MaaS implementation become mainstream, there may be potential social issues in connection with the service. For example, travellers need to have a smartphone, internet connection, and a certain level of technology literacy to access MaaS services. These requirements may exclude certain groups of the population, such as households with lower income and the elderly. What are other potential social issues in connection with MaaS that you are aware of?

3.3 Any other matters

Please express any other thought or reflection on MaaS as a concept and its implementation below.



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