Linking User Requirements to Government Goals in Mobility-as-a-Service Concepts

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Preface

The main aspect that drew me to the subject of personal transportation is its ubiquity. How we travel is inextricably linked to how we live. In fairness, the strange times we live in as I am writing this preface have demonstrated how much we can get done while travelling as little as possible. Nonetheless, it is inevitable that sooner or later, we have to get somewhere. And when we do, we need mobility offerings. And if MaaS is to be the new transport paradigm in the future, as some would claim, then it will become an immensely important part of our human life. If I am honest, it is that which made me want to work on this project. Making sure that the user perspective is taken into account when designing MaaS (or anything for that matter) is for me not just about making it usable and popular. It is also about doing right by the users. It is about doing right.

The road to writing this thesis was longer than we had initially planned, and there were the occasional stumbling blocks. But in the end, I am proud of what I have created, and I sincerely hope it will go a ways to not only ensuring properly human-centred MaaS is designed, but that the same can also be done for other mobility solutions. Along the road, there were people who helped me reach this destination. To these 'transport providers' I owe my thanks.

First and foremost, I would like to thank my supervisors, Arie Paul van den Beukel and Rick Schotman. I have learned a lot from their advice, guidance, and feedback, and they helped me focus this thesis on what is truly important. Our interactions and meetings were admittedly rough at times, but I came out of nearly all of them with new ideas for what I wanted to do next. For that, I am grateful.

My thanks moreover go out to the interview participants from the cities of Enschede, Almere, Groningen, and Utrecht. They provided me with very valuable input, not only on the plans and visions of municipal governments, but also on how policymakers really think.

I would also like to thank my colleagues for these last few months, at Keypoint Consultancy. They made me feel welcome and inspired. Special thanks first of all go out to the participants in the evaluation workshops, for the great criticism (but also compliments) they gave me for my conceptual tool. Secondly, I would like to give special mention to the top (and best) floor of Keypoint's Enschede office, for providing me daily company and distraction when I needed it. I think I missed them the most during these last weeks of having to work from home.

At this time, I also want to mention my family, for supporting me not only throughout the writing of this thesis but of course also throughout my entire studies. They kept me going, and taught me to take pride in my work. Werner, Monika, Robert, and Laura, you once again have my deepest thanks.

On that note, I want to express my gratitude to my friends. Whether it is finding out who truly is just my type, or acquiring time consultants, I needed our little outings in between all of the craziness. So to Eefje, Maarten, Roald, Robert, and Samir, I say: you are truly the best party a guy can ask for.

Summary

This thesis describes a study of the relations between government goals and user requirements for the theme of Mobility-as-a-Service (MaaS). MaaS broadly encompasses the concept of a centralised system that provides users access to transportation on their demand. The transportation methods included are explicitly meant to be owned and offered by an external provider, rather than being owned by the users themselves. Local governments are interested in implementing some form of MaaS in their regions as a means of achieving their visions for future mobility.

The study addresses the problem that governments are often unaware of the user requirements and wishes that would need to be met to reach a sufficient user base amongst their residents. As a result, their current MaaS systems often do not manage to satisfy their goals. The aim is firstly to study the governmental goals and user requirements that play a role for the implementation of MaaS. This is done in chapter 2 through 5. Secondly, in chapters 6 through 8, this study includes the design of a MaaS tool, that aids municipal policymakers in understanding and defining a MaaS product that aligns both with their own goals and with the requirements of users. Through this tool, the policymakers are aided in foreseeing challenges and opportunities of implementing MaaS in their region, and can plan accordingly.

In chapter 2, a comprehensive definition of MaaS is built, that is based around the integration of multiple non-owned modalities and mobility features into a single platform that provides a door-to-door journey for users. According to reviewed literature, MaaS integrates many travel options, influences travel behaviour, and makes travel easier and accessible. For travellers to be interested in use, a new service will have to integrate successfully with their habits, such as car use. It needs to furthermore have a distinct added value. This literature review thereby defines what MaaS is, and gives first input for what MaaS needs to do for it to be effective at achieving governmental goals and inviting for travellers to use.

In chapter 3, a review of governmental documents shows that municipalities have various mobility visions and goals that MaaS can play a part in. Goals include increased liveability, accessibility, and sustainability, or changing travel behaviour in some other way. To supplement the review of documents, interviews were conducted with representatives from four municipal governments. Their goals, understanding of MaaS, and plans of approach are thereby studied. This part of the study thereby gives input for a list of government goals that municipalities would like to achieve through MaaS. This list of goals is integrated into the designed tool.

In chapter 4, practical tests are used to assess existing mobility services. These tests are meant to further deepen the understanding of the user perspective beyond the literature. The tests consist of two journeys that were undertaken using the services for travel. Based on the results of these tests, current capabilities and shortcomings of MaaS were researched. It was found that availability of vehicles is an important factor for the usability of a service, and that current services do not always manage to provide them when and where needed. This research provides the input for determining the user requirements of MaaS. These requirements contributed to the list that was integrated into the designed tool.

In chapter 5, to reflect on the societal impact of MaaS, reflections are done through the lens of philosophy of technology. The Product Impact Tool is applied to explore the general impact of MaaS and its technologies. This shows uncertainties regarding whether MaaS is unequivocally

be able to achieve goals set by government like increased sustainability or reduced congestion. A reflection through ethical frameworks shows that there is potential for people and society to be benefited by what MaaS offers. However, there are also potential harms that could occur if it is not implemented with proper foresight. Moreover, there is a risk that the institutions in charge of the services can abuse their power, to the detriment of vulnerable users. The importance of availability and inclusiveness of MaaS is demonstrated. These reflections contribute to the study by reframing and assessing the possible approaches to MaaS implementation, the goals of particular municipal governments, and the needs and requirements of users and society as a whole. They also thereby offer additional input for the list of user requirements that is integrated into the designed tool.

In chapter 6, the insight garnered from the previous chapters is used to design a conceptual MaaS tool. In a matrix, governmental goals and user requirements are individually compared to each other, and assessed on whether they offer opportunities, risks, or direct conflicts. The tool is designed to fulfil a set of requirements for perceived usability and usefulness. Policymakers using the tool select the goals that are relevant for them, and thus get the specific information they need for specifying MaaS in their municipality. Through creative thinking, they can better foresee potential challenges ahead of time.

In chapter 7, the tool is evaluated in workshop sessions with mobility policy advisors. The goal is to determine whether the tool meets its requirements and is effective at aiding the process of policymakers. The results show that participants are able to use the tool for creative thinking about the challenges of MaaS and possible solutions. However, in regards to the content of the tool, the way that goals, requirements, and relations are presented needs to be fine-tuned. An additional result is that it appears that there remains scepticism whether governments should be concerned with user needs.

In chapter 8, insights from the evaluations are finally used to further improve upon the initial tool concept. The contents are adjusted to be more clear and uniform. The presentation of the tool is also improved, with a mock-up of a potential digital graphical interface. This results in a more usable tool, that helps policymakers in the process of determining the requirements of a MaaS system that fits their goals, while also being user oriented.

Samenvatting

Deze thesis onderzoekt de relaties tussen overheidsdoelen en gebruikswensen op het gebied van Mobility-as-a-Service (MaaS). In MaaS is er een gecentraliseerd systeem dat gebruikers toegang biedt tot vervoer wanneer zij het nodig hebben. De vervoersmethodes die deel uitmaken van dit systeem zijn bezit van en worden aangeboden door externe aanbieders, in plaats van bezit te zijn van de gebruikers zelf. Lokale overheden zijn geïnteresseerd in het implementeren van MaaS in hun regio om hun visies voor toekomstige mobiliteit te behalen.

Het probleem is dat deze overheden veelal niet bekend zijn met de gebruikseisen en -wensen die moeten worden voldaan om de nodige hoeveelheid gebruikers vanuit hun inwoners te krijgen. Het gevolg hiervan is dat hun huidige MaaS systemen vaak niet in staat blijken om de overheidsdoelen te behalen. Het doel van deze thesis is ten eerste om de overheidsdoelen en gebruikseisen voor het implementeren van MaaS te onderzoeken. Dit wordt gedaan in hoofdstukken 2 tot en met 5. Ten tweede is, in hoofdstuk 6 tot 8, het doel om een MaaS tool te ontwerpen, dat gemeentelijke beleidsmakers helpt in het begrijpen en definiëren van een MaaS product dat past bij zowel hun eigen doelen als de eisen van gebruikers. De tool helpt de beleidsmakers om uitdagingen en kansen te voorzien voor het implementeren van MaaS in hun regio, en daarmee kunnen zij hun plannen hierop aansluiten.

In hoofdstuk 2 wordt een uitgebreide definitie van MaaS opgebouwd, die zich focust op integratie van meerdere mobiliteitsfuncties en modaliteiten die geen eigendom zijn van de gebruiker, in een centraal platform dat deur-tot-deur reizen biedt. Op basis van onderzochte literatuur integreert MaaS reis opties, reisgedrag wordt beïnvloed, en reizen wordt makkelijker en toegankelijker. Ook zal een nieuwe service geïntegreerd moeten worden met gebruiksgewoontes, zoals autogebruik, om het interessant te maken voor reizigers. De service moet een toegevoegde waarde bieden. Dit literatuur onderzoek definieert daarmee wat MaaS is, en geeft de eerste input voor wat MaaS moet doen om effectief te zijn in het behalen van overheidsdoelen en het uitnodigen van gebruik.

In hoofdstuk 3 laat onderzoek in gemeentestukken zien dat gemeentes verschillende mobiliteitsvisies hebben waarin MaaS een rol kan spelen. Voorbeelden zijn het verbeteren van leefbaarheid, toegankelijkheid, en duurzaamheid, of het veranderen van reisgedrag. Het onderzoek wordt ondersteund door interviews met mobiliteits-medewerkers van vier gemeentelijke overheden. Hun doelen, begrip van MaaS, en plannen van aanpak worden bestudeerd. Dit deel van de studie geeft daarmee input voor een lijst van overheidsdoelen die gemeentes willen behalen door middel van MaaS. Deze lijst is geïntegreerd in de ontworpen tool.

In hoofdstuk 4 worden praktijktests uitgevoerd van bestaande mobiliteitsservices, om het gebruiksperspectief beter te begrijpen. Deze tests bestaan uit twee reizen die zijn uitgevoerd door middel van de services. Op basis van de resultaten van deze tests worden de huidige mogelijkheden en tekortkomingen van MaaS onderzocht. De tests laten zien dat beschikbaarheid van voertuigen een belangrijke rol speelt voor de bruikbaarheid van MaaS, en dat huidige services niet altijd in staat zijn deze te bieden waar en wanneer dat nodig is. Dit geeft verdere input voor het opstellen van een lijst van gebruikseisen voor MaaS. Deze lijst is geïntegreerd in de ontworpen tool.

In hoofdstuk 5 wordt gereflecteerd op MaaS vanuit de lens van techniekfilosofie. De Product Impact Tool is toegepast om de algemene impact van MaaS en gerelateerde technologieën te

verkennen. Deze analyse toont onzekerheden over of MaaS door overheid gezette doelen zal behalen, zoals verbeterde duurzaamheid en verminderde congestie. Een ethische reflectie laat zien dat er potentieel is voor mens en maatschappij om te profiteren van MaaS. Echter, er zijn ook potentiële gevaren als het niet geïmplementeerd wordt met de nodige voorzorg. Verder zijn er risico's dat de organisaties die over de services gaan misbruik maken van hun macht, ten nadele van kwetsbare gebruikers. Het belang van beschikbaarheid en inclusiviteit van MaaS wordt aangetoond. Deze reflecties dragen bij aan het onderzoek door de gevaren te laten zien van het volgen van sommige benaderingen voor het implementeren van MaaS, van het focussen op bepaalde overheidsdoelen, en van het negeren van zekere gebruikseisen. Verder bieden zij daarmee ook extra input voor de lijst van gebruikseisen die is geïntegreerd in de ontworpen tool.

In hoofdstuk 6 worden de inzichten uit de voorgaande hoofdstukken gebruikt om een concept MaaS tool te ontwerpen. Overheidsdoelen en gebruikseisen worden individueel vergeleken in een matrix, en beoordeeld op of zij kansen, risico's, of directe conflicten bieden. Beleidsmakers kunnen in de tool de doelen kiezen die relevant zijn voor hen, en daarmee specifiek informatie krijgen die zij nodig hebben om MaaS te specificeren in hun gemeente. Door middel van creatief denken kunnen zij daarmee beter uitdagingen vooraf al zien.

In hoofdstuk 7 wordt de concept tool geëvalueerd in workshop sessies met beleidsadviseurs. Het doel is om vast te stellen of de tool voldoet aan gestelde eisen, en effectief is in het ondersteunen van het proces van beleidsmakers. De resultaten geven aan dat hoewel deelnemers de tool kunnen gebruiken voor creatief denken over de uitdagingen van MaaS en mogelijke oplossingen, er alsnog ook twijfel is over of overheid zich moet bezighouden met het gebruikers perspectief.

In hoofdstuk 8 worden de inzichten uit de evaluaties gebruikt om de tool verder te verbeteren. De inhoud is aangepast om duidelijker en meer uniform te zijn. De visuele presentatie van de tool is verbeterd, met een mock-up van een digitale grafische interface. Dit leidt tot een meer bruikbare tool, die beleidsmakers helpt in het proces om de eisen te bepalen van een MaaS systeem dat zowel past bij hun doelen alsook gebruiksvriendelijk is.

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1. Introduction

The way we travel, the way we transport ourselves from one place to another, is an indispensable component of how we live our daily lives. As a result, it is imperative that developments in the mobility sector are designed and implemented in a socially responsible and user friendly manner. One of the primary emergent developments in the sector is Mobility-as-a-Service, commonly abbreviated as MaaS. MaaS broadly encompasses the concept of a centralised system that provides users access to transportation on their demand. The transportation methods included are explicitly meant to be owned and offered by an external provider, rather than being owned by the users themselves. Governmental institutions see MaaS as a means to achieve their visions and goals for mobility in the future. On a municipal level, governments hope MaaS will help them overcome challenges like congestion, accessibility, and sustainability. However, for it to be implemented both responsibly and effectively, the user perspective needs to be taken into account as well. The scope of this research is therefore how a proper MaaS system should be implemented on a municipal level while including the government and user perspectives. Moreover, the focus is on the context of the Netherlands. The study is conducted on behalf of Dutch mobility consultancy firm Keypoint Consultancy.

From here on, unless otherwise specified, the term 'government' will refer in this thesis to the municipal level of government in the Netherlands. Furthermore, 'user requirements' refers not only to the immediate hard needs of the users of MaaS, but also to more personal wishes, desires, and preferences they might have. Moreover, these requirements are not all uniform across all users, as some will have different priorities, preferences, and wishes than others.

The main research question for this study is:

'How can user requirements be incorporated into the goals of municipal governments in regards to Mobility-as-a-Service?'

To answer this main question, the following sub-questions are answered, divided into two parts that comprise this thesis:

part 1	1.	*What is MaaS?*
	2.	*What are the current capabilities of MaaS?*
	3.	*What are the current shortcomings of MaaS?*
	4.	*What goals would municipal governments like to achieve through MaaS?*
	5.	*What are the requirements of users for MaaS?*
part 2	6.	*Which government goals and user requirements of MaaS complement each other?*
	7.	*Which government goals and user requirements of MaaS conflict with each other?*
	8.	*Which government goals and user requirements of MaaS are undetermined in their relation to each other?*
	9.	*How can policymakers use the relations to incorporate user requirements into their goals for MaaS?*

Below, for each chapter of this report, the contents are described, as well as naming the sub-questions that they contribute to answering. Chapters 2 through 5 form **Part 1** of the thesis, wherein the goals and requirements for MaaS are studied and analysed. Chapters 6 through 8 form **Part 2**, wherein the determined goals and requirements are used to design a MaaS tool for use by policymakers to incorporate the user perspective into their MaaS plans.

In chapter 2 of this thesis, a review of the preceding academic literature is done to study the state of art of MaaS and its user requirements. This literature review defines what MaaS is, and what the capabilities are of current services, and gives first input for the governmental goals and user requirements for MaaS *(questions 1,2,3)*.

In chapter 3, the perspective of municipal governments is explored through a review of mobility policy documents, and through a series of interviews with representatives from local governments. This part of the study gives input for a list of government goals that municipalities would like to achieve through MaaS *(4)*.

Chapter 4 describes a series of practical tests that are used to assess the capabilities of current MaaS-related products and services, and to gain insight into the user-product interaction that occurs. This provides further input for determining the user requirements of MaaS *(5)*.

Chapter 5 provides a reflection on MaaS, governmental goals, and user requirements, through the lens of theoretical frameworks from philosophy of technology. These reflections contribute to the study by reframing and assessing the results from the preceding research, and the way that government and user relate to each other *(4,5)*.

In chapter 6, a conceptual tool is designed for studying and illustrating the relations between specific governmental goals and user requirements for MaaS. This conceptual tool offers a way for municipal policymakers to better understand the challenges of implementing MaaS, and to act accordingly *(6,7,8,9)*.

In chapter 7 this conceptual tool is evaluated through workshops with mobility policy advisors. These evaluations contribute to improving the usability and added value of the tool *(9)*.

Finally in chapter 8, the contents of the tool proposal are improved based on the results of the preceding chapter's evaluations. This results in a more clear and understandable tool, that helps policymakers in the process of determining the requirements of a MaaS system that fits their goals, while also being user oriented *(6,7,8,9)*.

Part 1

Goals and Requirements for MaaS

2. State of art of MaaS

While MaaS as a concept is still undergoing a significant amount of development, there exists a body of literature already studying it. A review of this literature is conducted to investigate the state of art of MaaS. The results thereof are presented in this chapter. They provide initial input for what governments want to achieve through MaaS, and what the requirements and wishes of its users are.

Three research sub-questions are addressed:

1. *What is MaaS?*
2. *What are the current capabilities of MaaS?*
3. *What are the current shortcomings of MaaS?*

The review is focused on five subjects, which are used to address the three research questions. First, the fundamental characteristics that are ascribed to MaaS are studied, and used to build a definition for the still rather ambiguous concept. Second, as MaaS is still in fairly early development stages, there exist various expectations within the literature for how implementation will work, and what its effects will be. Third, a short review is given of current developments and projects that are ongoing, both in the Netherlands and globally. Fourth, the evolving user wishes and requirements are studied, as MaaS needs to fit with these to be successful. Finally, in order to replace the regime of owned mobility, MaaS needs to overcome or fit into current user habits, and so these habits too are explored in the literature.

The literature reviewed is selected as being the most relevant for the chosen subjects. A selection of primary sources was made based on their prevalence in the fields of MaaS, mobility studies, and design studies. Citations found within these primary sources, and literature building further upon them, were used to expand the review. Remaining queries and details after this process were finally covered by searching specific literature that addresses these topics. In addition, where possible it is sought to also incorporate literature that addresses specifically the context of the Netherlands. The reviewed literature was assessed to have come from credible and relevant sources and authors.

2.1. Core characteristics of MaaS

Generally, MaaS is a system wherein travellers can receive transportation upon demand from one or more central providers, who own and supply the needed transport modalities. This is contrasted by the conventional system of travellers owning their own transportation methods, like for example a car or a bicycle. This conception of MaaS is considerably rough, ambiguous, and open. Differing detailed perspectives exist on what else it is and needs to be. To be able to design a suitable service, it is necessary to gain an understanding of the fundamental features and characteristics. Previous academic and governmental publications studied the subject of MaaS, and accordingly give core characteristics. In the following, the characteristics ascribed to MaaS in the literature are discussed. Based on this study, a provisional definition is created, that is used throughout the rest of this thesis.

2.1.1. Characteristics of MaaS in literature

Jittrapirom et al. (2017) give nine inherent characteristics of MaaS, based on their own literature review:

- Integration of multiple transport modalities;
- A method of payment for transportation;
- One central (digital) platform for accessing the services;
- Multiple actors and stakeholders that contribute to the system and interact;
- Multiple technologies being used, such as mobile internet, GPS, and e-payment;
- Demand-oriented and user-centric;
- Need for end-user to register in the central system;
- Providing of a service personalised for the individual end-user;
- Customisability for end-user to fit to their preferences.

Durand, Harms, Hoogendoorn-Lanser, and Zijlstra (2018) take these characteristics as a basis for their own understanding of MaaS. They define it as being specifically about integration, of multiple functionalities that are related to mobility into a central platform. Functionalities include journey planning, payment, ticketing, and travel information.

Building further upon the theme of integration, Sochor, Arby, Karlsson, and Sarasini (2018) built a topology of five levels for MaaS (fig. 1). The levels are based on the amount and type of features that the central system offers. Levels range from only providing information on a single modality at level 0, to integrating societal goals and policies into the system itself at level 4. Examples are given for each level that the authors believe has already been achieved. In their taxonomy, no system has thus far achieved the highest level of integration.

The MaaS Alliance is a coalition of various stakeholders involved in the development and implementation of MaaS, including governmental agencies and the automotive sector. They have a definition of MaaS, which is as follows:

Figure 1 Levels of MaaS, with examples (Sochor et al., 2018)

"Mobility as a Service (MaaS) is the integration of various forms of transport services into a single mobility service accessible on demand. To meet a customer's request, a MaaS operator facilitates a diverse menu of transport options, be they public transport, ride-, car- or bike-sharing, taxi or car rental/lease, or a combination thereof. For the user, MaaS can offer added value through use of a single application to provide access to mobility, with a single payment channel instead of multiple ticketing and payment operations. For its users, MaaS should be the best value proposition, by helping them meet their mobility needs and solve the inconvenient parts of individual journeys as well as the entire system of mobility services.

A successful MaaS service also brings new business models and ways to organise and operate the various transport options, with advantages for transport operators including access to improved user and demand information and new opportunities to serve unmet demand. The aim of MaaS is to provide an alternative to the use of the private car that may be as convenient, more sustainable, help to reduce congestion and constraints in transport capacity, and can be even cheaper." (MaaS Alliance, 2018)

Here the main focus is on centralising a large variety of travel modalities. The existence of a single platform is meant to make mobility easier for users. It furthermore is of interest to the private transport providers, as they can more easily reach users and determine what they need. A clear stated goal is given for MaaS to replace the private car, and thereby have a positive societal impact.

The focus on centralising a range of modalities is also apparent in the characteristics given by Utriainen and Pöllänen (2018). MaaS combines public and private transport, and provides the traveller with options and alternatives. Through MaaS, users no longer need a private car, or the separate tickets and cards used by other transport providers. A multimodal journey is booked and paid for through a single mobile application. MaaS will not only combine but also improve upon the current transportation options. Shared cars are considered a key component of what MaaS should offer, together with public transport. Bicycles on the other hand get less attention.

Heikkilä (2014) considers MaaS as a system wherein a wide range of mobility services is offered to consumers by mobility operators. Mobility operators are defined as companies that buy mobility services from service producers. These operators then combine these services into the packages that are offered to consumers.

According to Lyons, Hammond, and Mackay (2019), the ideal of MaaS is to offer door-to-door transport. That is to say, the system should take care of the user's entire journey, from their exact departure location to their exact destination. MaaS is furthermore a shift from mobility ownership to mobility access. A similar shift is suggested by Pakusch, Bossauer, Shakoor, and Stevens (2016), who see it as a shift from mobility ownership to mobility usership.

2.1.2. Combined definition for MaaS

Based on the discussed core characteristics, fundamental aspects of MaaS become clear. It consists of an integration of multiple mobility features into a single digital platform. These features include route planning, ticket information, booking, and ticket payment. The services need to offer multiple modalities. The options are maintained, owned, and offered by the operator of the system or by external partner organisations. The service is driven by demand rather than supply, which should result in a user-centred system. Furthermore, the services need to offer multiple options for the user to choose from based on their personal needs and wishes.

These fundamental aspects are summarized into the following definition, which will be used throughout the remainder of this thesis: *A MaaS system integrates into a single platform the multiple features and multiple modalities required to make a door-to-door journey, offering multiple options in a demand-oriented service, with the mobility used not being owned by the users but maintained and offered by an external organisation.*

Furthermore, the following steps are distinguished as making up a traveller's journey, and as being points where MaaS can offer support: *(1) Preparation; (2) Planning; (3) Booking; (4) Reserving; (5) Payment; (6) Execution; (7) Additional Support; (8) Ending Journey*

2.2. Expectations of MaaS in literature

Within the literature about MaaS, different expectations exist for what it will look like and what its effects in the world will be. These expectations offer suggestions for how MaaS could develop in the future. They also indicate potential challenges that will need to be overcome, and needs and wishes that need to be met. The following section explores these expectations within the literature, and their implications for the design of a MaaS system.

Utriainen and Pöllänen (2018) have themselves conducted a literature review, focussing on the expected role of various modalities and services, and the results of various pilots. Shared cars will become a fundamental part of the services. These could be offered as a free-floating system, allowing travellers to pick up and park them anywhere. The use of shared cars is expected to change the meaning of car ownership. Public transport is also likely to play an important role if it can manage to become efficient enough. Bicycles on the other hand are less prominently discussed. Although features like shared bikes are possible, the focus is generally on car mobility. That said, for short distances bicycles could be a viable solution. Based on the results from pilots, there is an expectation that MaaS can successfully change travel behaviour. However, the novelty of MaaS also raises doubts and scepticism from travellers. As a result, proper planning is needed.

Karlsson et al. (2019) studied the expected challenges and enabling factors for implementing MaaS from a socio-political perspective. There is a need for political will to push development, and to enable and support implementation. The transport sector is subject to regulations that protect societal values, but these can also constrain innovation. As such, a proper balance needs to be found. Governments need to give space to new schemes such as shared mobility, to allow them to become part of MaaS. The understanding of public transport needs to be redefined, so that it can evolve to be a part of the service offerings, rather than being threatened by MaaS. Private actors will also need to get involved, by investing and adding their own services to the system. Both public and private modalities are needed for MaaS to be a success.

Jittrapirom, Marchau, van der Heijden, and Meurs (2018) investigated the uncertainties of MaaS, that can make implementation challenging. It is for example not clear to what degree MaaS is in fact able to reduce car use and ownership. Similarly, the safety- and privacy-concerns from the data exchanges need to be addressed. It is also needs to be determined whether MaaS operators will be offering their services mainly to user groups that would most benefit from them, or only to users that are most profitable. Economic developments and the acceptance of shared vehicle systems are difficult to predict. Predictions about the future of MaaS and its effects can only to a limited extent be based on other sectors, due to dissimilarities. To deal with all these uncertainties, it is suggested that governments working on MaaS develop a dynamic policy plan. That is to say, a plan that can flexibly adapt to changes and challenges that show

themselves along the way.

Eckhardt, Nykänen, Aapaoja, and Niemi (2018) have studied the expected role of MaaS for rural areas. The coverage of public transport in rural areas is comparatively low, and so MaaS should not purely rely on it in those regions. Because of efficiency, it might be necessary to combine different transport functions with each other. For example, vehicles could be implemented that move both goods and people. It should be noted that the study focussed on Finland, and as such the meaning of 'rural area' can be expected to be different from the Netherlands.

Lyons et al. (2019) expect that MaaS will lead to a reduced cognitive workload for users. They assess the advancement of a MaaS system to be based on how much it can lower the user's cognitive effort (see fig. 2). This expectation for easing the user experience is similar to that of Giesecke, Surakka, and Hakonen (2016). Based on a study of potential future users, they conclude there are two directions that can be taken for MaaS to be successful. It needs to offer either a reduced cost while keeping convenience the same as before, or offer increased convenience while keeping costs the same.

Through development of scenarios, Smith, Sochor, and Karlsson (2018) give their expectations for what MaaS will mean for society. Accessibility of mobility will improve, as modalities that were previously limited will become available for everyone. The scope of public transport will grow, as it will offer more modalities and more services. Moreover, there will be less strict boundaries between individual modalities, and between public and private transport services. This may be accompanied with the public transport sector losing a degree of control over the frontend interaction with users, if the platforms are operated by private companies. Similarly, if the public sector has no active influence over the services of private providers, they will be unable to guarantee quality of service. Through change of travel behaviour, users will make less trips with their private car. That said, for this latter effect to happen, the incumbent regime of the automotive industry would need to be overcome, which has proven challenging in the past.

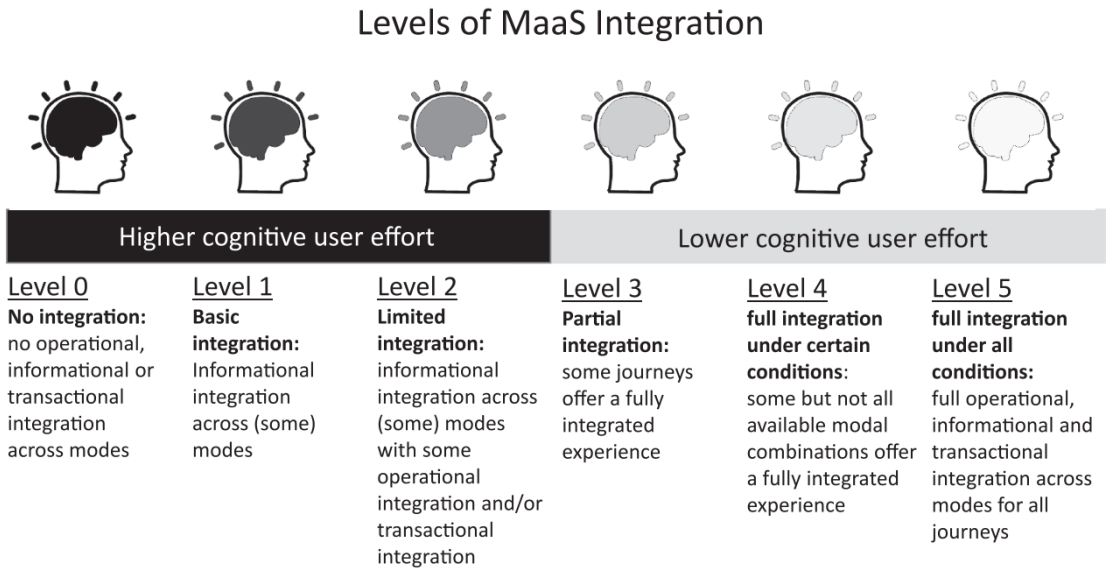


Figure 2 Levels of MaaS Integration (Lyons et al., 2019)

Zijlstra, Durand, Hoogendoorn-Lanser, and Harms (2019) explore what societal groups are expected to be most interested in MaaS. They distinguish four personal traits that influence a user's interest in MaaS:

- A person who likes new technologies and their application will be more willing to use a digital platform for mobility;

- People who make use of sharing and rental systems are similarly expected to have a raised potential;

- Multimodal travellers are already used to switching vehicle partway through a journey, which may be necessary for MaaS to function;

- Certain people desire centralised and up-to-date travel information, and so would likely be responsive to MaaS.

These four traits are influenced by personal variables. Important variables include age, frequency of public transport use, and frequency of personal air travel use.

2.3. Current developments of MaaS

Thus far there have been initiatives around the world to implement some form of MaaS system. These mainly consist of pilot projects, and are generally implemented on a local or regional scale. A significant amount of such pilots has also at this point been discontinued. The literature on the current and past developments can be used to assess how far MaaS has advanced, and how it could develop in the future. It thereby becomes clear what MaaS is currently capable of, and what aspects it currently falls short on. Moreover, by studying the projects that municipalities are working on, some of the mobility goals that they would want to achieve through MaaS are determined.

Studies by Durand et al. (2018) and by Jittrapirom et al. (2017) discuss existent MaaS schemes. The tables in which the authors summarise the studied services are shown in Appendix A. The schemes differ in what modalities and mobility features have been integrated. The majority comprises pilots. The current operational status of the schemes differs, with some presently still being in use, and others discontinued. The systems studied are nearly all based in Europe, with the two exceptions of the short-lived start-up project SHIFT in the United States, and the TransitApp that was implemented in the United States, the United Kingdom, Canada, Europe, and Australia. Regarding features, the majority of schemes have only integrated travel information, booking, and (partial) ticket payment. Three have also integrated subscriptions and bundled mobility packages. Notably, only one of those three (Whim) is still in operation today. The systems were created and operated by varying types of actors, such as commercial companies and local traffic authorities.

In 2018, the Dutch government launched MaaS pilots in seven regions in the Netherlands (Ministerie van Infrastructuur en Waterstaat, 2018). The pilots distinguish themselves by focussing on different areas, themes, or target groups.

- Rotterdam's pilot will improve the accessibility of the nearby airport, for both air travellers and local workers;

- MaaS is planned to be used in Amsterdam to better connect individual modalities, and to reduce car use amongst workers;

- The city of Eindhoven plans its pilot on sustainability, and will use MaaS to achieve

emission-free mobility by offering environmentally friendly options;

- The province Limburg plans to achieve 'borderless mobility' through MaaS, connecting modalities seamlessly to each other in a highly convenient and flexible system;

- The province Groningen and Drenthe are working together on their pilot to build a platform where transport providers can 'bid' on how efficiently they can fulfil an individual user's transport request;

- The pilot for the area Twente is focussed on raising mobility access for groups like the elderly and people with disabilities;

- The pilot in the Utrecht neighbourhood Leidsche Rijn has the goal of reducing local traffic and congestion through MaaS.

2.4. User wishes and developments for MaaS

For MaaS to fulfil its ambitions and be effectively implemented, it needs to meet the wishes and requirements of its users. The users have needs and expectations for what a service should offer them. The needs of users are also evolving over time. MaaS can also offer them additional features and value, thereby further convincing travellers to use the system. With this in mind, the following section reviews literature on the current and changing user requirements, and the added value of MaaS.

For a basic overview of the factors that influence whether a user will accept and intend to use a particular technology, the Technology Acceptance Model can be used (Davis, Bagozzi, & Warshaw, 1989). According to this model, a user's behavioural intention for using a technology is a result of their attitude towards its use and their perceived usefulness of the technology. Their attitude is in turn also influenced by the perceived usefulness as well as by how easy to use they perceive the technology to be. Both perceived usefulness and perceived ease of use are influenced by external factors, which includes both the technology's own characteristics like its interface, and user characteristics such as their expectations. Venkatesh, Thong, and Xu (2012) have extended upon this basic model to develop the Unified Theory of Acceptance and Use of Technology. Their model identifies factors that impact a user's behavioural intentions and use behaviour. For example, one factor is how much effort the user expects is involved in using the technology, implying that a newly designed technology, such as MaaS, should aim for (perceived) convenience. Similarly, both intent and behaviour are influenced by facilitating conditions, that is the availability of support and information for the user. These conditions are moderated by user characteristics like age, gender, and experience. A technology should moreover aim to align with habits, or build up new habits, as this will also impact both the behavioural intention and use behaviour of the user.

More specific to MaaS, Harms, Durand, Hoogendoorn-Lanser, and Zijlstra (2018) conducted discussions with focus groups to determine their travel behaviour and stance towards MaaS. The chosen focus groups were differentiated based on geographical circumstances. Participants came either from a high-urban, mid-urban, or rural area. The groups from the urban environments made significantly more use of cycling and public transport than the participants from rural areas. The latter was more inclined to use their personal car. All three groups were satisfied with their current travel behaviour, and therefore saw no reason to change something. Most were also familiar with travel information systems, and shared mobility concepts. Based on subscription pricing suggested by the researchers (50-500 euros per month), participants largely thought that MaaS would be too expensive. This is ascribed to travellers not realising how high

their current mobility costs are, and that MaaS would replace these. For MaaS to be interesting to consumers, it will need to not only be user friendly and technically available. It also needs to offer added value for the user. Possible aspects to that end are flexibility, independence, and autonomy, or providing vehicles that fit with a user's personal image (Pakusch et al., 2016).

Bachand-Marleau, Lee, and El-Geneidy (2012) investigated the determining factors for travellers making use of shared bicycle services. The biggest influence is whether there is a hub nearby for the user to pick up a bike. As such, there need to be enough such hubs built. Shared vehicles can also offer an aspect of risk avoidance, as users need to be less afraid of their bike or car being stolen. It is recommended that a shared bike system is designed to fit in with the habits of current and future users. The bicycles should finally have a pleasant design, and a desirable status, which mainly relies on activities like advertising.

The Dutch organisation Raad voor Verkeer en Waterstaat (2010) has conducted a study of how societal lifestyle groups will evolve in regards to mobility. The lifestyle groups are based on factors like needs, motivations and attitudes, rather than demographic traits (Hengstz, 2019). Social climbers and the convenience oriented will grow in the coming years. Groups like traditionals on the other hand will decline. As a result, values will change. Focussing on one's own life and gaining new experiences become more important. Values like obedience, solidarity, reflection, and social engagement will conversely become less important. The growing groups have a strong emotional connection to the car, seeing it as an important status symbol. They also prefer to travel alone. For the diminishing groups, the car is purely a functional object. As such, the car will not diminish in importance for people, but rather its meaning will change. It is advised that for behaviour change to occur, the desired behaviour should be given a high status. Emotion, experience, and convenience should be emphasised.

2.5. Current habits of travellers

Within the current mobility regime, based on vehicle ownership and supply-oriented transport, travellers have certain habits for how they carry out journeys. They are used to driving their own car even over short distances, and having their own bike at home. Based on the factors researched by Venkatesh et al. (2012), as discussed earlier, one user requirement for MaaS to become the main method of travelling is that it will need to fit with or change these habits. As such it is important to understand what habits there are in regards to mobility, and more importantly what the motivations behind them are. Therefore, the following section discusses the literature on the travelling habits of consumers, and their underlying reasons. This gives initial input for the user requirements that MaaS will need to satisfy.

Mackett (2003) studied why people use their private car for short distance mobility, through a survey. There is a fairly high frequency of cars being used for journeys where alternatives should be viable. Though the study bases itself on findings in the United Kingdom, earlier research has indicated similar results in other countries, including the Netherlands (Mackett, 2000). The main reasons respondents gave for their short distance car use are wanting to transport heavy goods, needing to give someone a lift, or being short on time. 22% of respondents said they were unable to think of alternative options for specific trips where they used a car. Those that do give alternative mostly name either walking or taking the bus, followed by cycling and calling a taxi.

Steg (2003) compared the perception of car use to that of public transport, based around various aspects. Dutch participants were asked to rate both the private car and public transport on traits like convenience, reliability, and comfort (fig. 3). The comparison between the results

shows that the car is seen as more attractive than public transport in nearly all aspects. The only exception is traffic safety, indicating that respondents think buses and trains are comparatively the safest way to travel. This perception of the car as the most pleasant mode of travel likely poses a challenge for MaaS, particularly considering the key role that public transport will likely have. It should be noted that perceptions of the modalities are likely to have changed since the publication of Steg's study. However, the traits given could still serve a useful role as focus points for the design of new mobility systems, such as MaaS.

Hiscock, Macintyre, Kearns, and Ellaway (2002) discuss the psycho-social advantages of car ownership and use on mental health. Their study shows that there are positive effects on feeling protected, autonomy, and prestige. Participants felt that a car protects them from other people and weather conditions, and is more comfortable than public transport. A portion of them also felt more safe if they were driving themselves, than if they were a bus passenger. The autonomy of the car is ascribed to convenience and freedom of choice. Some respondents do admit it can at times limit freedom of choice, by prohibiting consuming alcohol or needing to find a parking spot. It does offer high reliability. Car ownership is finally seen as a source of prestige, and a symbol of status and property. It gives its owner feelings of excitement and freedom. Users of public transport can comparatively feel inferior. Those users can however appeal to sustainability. It is likely that the value and status of being sustainable has become even more important in the years since the study.

Hagman (2003) reports on interviews held about the advantages and disadvantages of car use. One advantage is that ownership and use offers freedom and independence. Independence therein refers to being not reliant on either other travel modalities nor other people. Aspects like convenience, flexibility, and comfort are also seen as positive features of car mobility. The car can moreover offer door-to-door mobility. The main stated disadvantage are the financial costs, including fuel, taxes, and maintenance. Car use can furthermore lead to laziness and dependence on the vehicle. Travellers moreover often experience trouble finding a parking spot. There are also risks of accidents, which are strengthened by the high activity on the roads.

Heinen (2011) studied the use of bikes, focussed on daily work-related travel. The main question is why travellers do or do not choose to travel by bicycle to their work. It appears that cycling

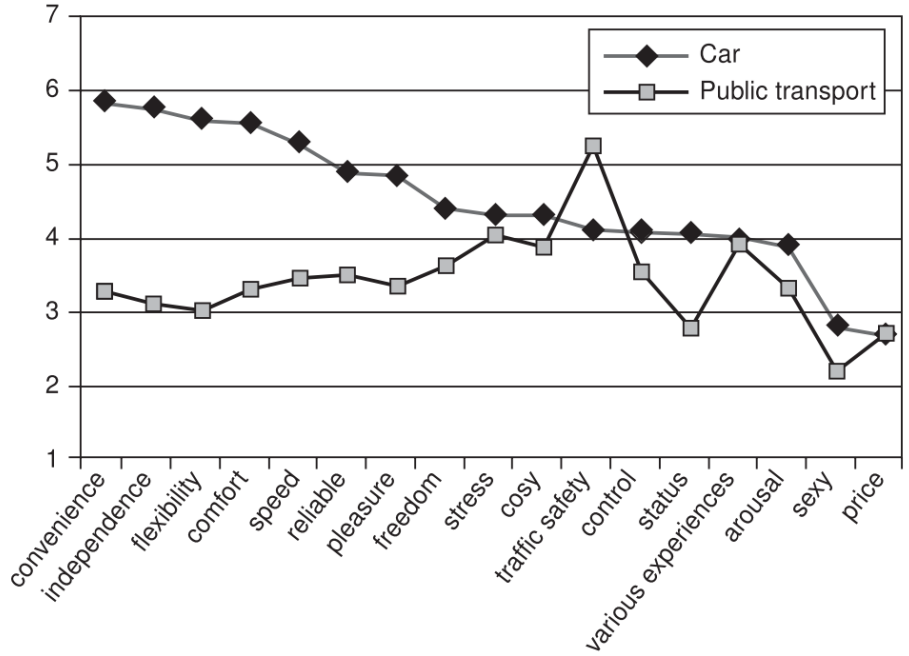


Figure 3 Ratings of car use versus public transport (Steg, 2003)

is more subject to mode alternation for daily commute than other modalities. That is to say, bicycle users will more often change to a different option on a particular day. One explanation is that cycling is subject to circumstances like weather and physical health. Work circumstances can also play a role. Employees might be obligated to wear a suit or visit clients with a company car, thereby limiting a bicycle's viability. The attitude of the traveller, and the norms of people in their social and work environment also matter for their willingness to commute by bike.

Pucher and Buehler (2008) investigated important geographical and governmental factors that influence bicycle use. To this end, they compared circumstances in the United Kingdom and United States, to those in the Netherlands, Germany, and Denmark. Bicycle use in the former two countries is very low, whereas it is comparatively high in the latter three. Cycling needs to be made safe, and governments need to invest in infrastructure and research. Eight strategies are given for how governments can make cycling attractive:

- There should direct and connected cycling paths, supported by route planning systems;
- Car traffic should be slowed down and made less efficient, strengthening the flexibility and safety of cycling;
- Road crossings should be changed to improve the safety of cyclists, for example with special traffic lights and crossing paths;
- There should be ample safe parking space for bicycles;
- Cycling facilities like parking should be integrated into train stations and bus stops, and the option of allowing travellers to take their bicycle into the train or bus should be considered;
- Cycling should be stimulated through training and education, particularly amongst children, and behaviour towards cyclists should be a part of car driving lessons;
- Regulation should be applied to stimulate both car users and cyclists to drive safely;
- Special events should be organised to stimulate residents of cities to try cycling.

Most of these strategies have already been applied in the Netherlands. That said, they could also be used for the purposes of stimulating Maas.

2.6. Conclusions

The literature review in this chapter has been used to study five subjects. The core characteristics of MaaS have been explored to build a definition of what MaaS is. This definition focusses on the integration of multiple non-owned modalities and mobility features into a single platform that provides a door-to-door journey for users.

MaaS is expected to incorporate various types of travel options, and to influence travel behaviour. Challenges like developing appropriate policy and unintended effects need to be overcome for MaaS to be successful. MaaS is furthermore expected to make travel easier and more accessible for all users. These results indicate what MaaS is expected to be capable of.

At present, there have been multiple (pilot) projects to implements some form of MaaS system. A considerable part of these have been discontinued, and none appear to have moved past integrating subscriptions and bundled packages. More local to the Netherlands, seven pilot projects are currently being conducted in various regions, aimed at differing goals. These pilots show some of the goals that these regions would like to achieve through MaaS, such as improved sustainability, efficiency, and accessibility.

Finally, the literature offered a first exploration of the user requirements of MaaS. One requirement is that it will need to fit with or change the current habits of travellers. Habits include using the car for short distance trips, due to practical concerns and its attractive traits compared to public transport. The car furthermore provides feelings of safety, prestige, and freedom. The use of bicycles on the other hand is subject to factors like weather, work environment, and most importantly personal attitudes. Policy and infrastructure also play a role. A further requirement for users to become interested in MaaS, is that it will need to offer them an added value such as cheaper travel or enhanced flexibility. Physical infrastructure needs to be such that the services are always available when the user needs them. Due to evolving lifestyles, the literature furthermore advises that MaaS brands itself as high status. The factors investigated by Steg (2003) could offer a fruitful avenue for further improving the branding of MaaS. MaaS could similarly emphasise the advantages it gives to personal choice. Examples of this include getting drink alcohol when one does not have to drive a car and instead uses the public transport or shared bicycle offerings of MaaS. Travellers also have the convenience of not having to find a parking spot.

Answers to research questions:

1. What is MaaS?

MaaS has been defined in this chapter as: *A MaaS system integrates into a single platform the multiple features and multiple modalities required to make a door-to-door journey, offering multiple options in a demand-oriented service, with the mobility used not being owned by the users but maintained and offered by an external organisation.*

The following steps are distinguished as making up a traveller's journey, and as being points where MaaS can offer support: *(1) Preparation; (2) Planning; (3) Booking; (4) Reserving; (5) Payment; (6) Execution; (7) Additional Support; (8) Ending Journey*

2. What are the current capabilities of MaaS?

Current MaaS systems mainly offer travel information, ticket booking, and (partial) ticket payment. A small section of services also offers subscriptions to mobility offerings, and bundled transport packages.

3. What are the current shortcomings of MaaS?

Current MaaS systems do not yet integrate societal goals and mobility policies. Only a limited amount of services offers bundled subscriptions and transport packages, and many services have already been discontinued. Due to its connection with public transport, MaaS has to firstly overcome the comparatively unattractive image of public transport in the eyes of travellers. Secondly, it has to integrate itself with current travelling habits, which it has not yet succesfully achieved.

3. Plans and visions of local governments

The reviews in chapter 2 of this thesis of the expectations from governments and the current MaaS pilots in the Netherlands provide initial insights on the perspective of local governments. These insight are expanded upon through further study of this governmental perspective. Regional and local governments are expected to take an important role in the development and implementation of Maas, as they become not only initiators of projects but also representative stakeholders of public and societal interests. By way of mobility policies and projects, including those related to MaaS, these governments aim to fulfil their desired future visions for mobility in their regions. It is these governments that set the goals that MaaS will need to help in fulfilling. As such, in this chapter the perspective of local governments is studied in depth, to answer the questions of what goals municipal governments would like to achieve through implementing MaaS, and how MaaS could do this.

One research sub-question is addressed:

4. *What would municipal governments like to achieve through MaaS?*

To explore the governmental perspective on MaaS, two research methods are applied. Firstly, a review is conducted of governmental policy literature from various municipalities, which define their current activities and their visions on mobility in the future. Secondly, interviews are held with representatives from four municipal governments, to get a more hands-on perspective on how MaaS is developing in a particular city, and to deepen the findings from the policy review. The results of these studies are used to condense a list of governmental goals for MaaS, that will be used for the design of the MaaS tool in chapter 6 of this thesis.

3.1. Review of municipal policy publications

To garner initial insight into the governmental perspective on MaaS, a review is conducted of governmental policy publications on a municipal level. These publications have been studied to determine what MaaS-related projects governments currently work on, and what the overarching vision and desires for mobility are on the governmental level. The selection of studied municipalities is based on their apparent interest in MaaS, and the availability of recent mobility visions or similar documents. The publications are studied and documented separately for the larger municipalities. For the smaller municipalities and those that do not have extensive MaaS and mobility plans, general conclusions are drawn. In the following, there is first a look at general literature on the municipal perspective on MaaS, and the options available to governments in regards to the role they take up in the system. Next, the significant findings for the studied municipalities are presented.

3.1.1. General municipal perspective

For a general perspective for how municipal governments see MaaS and what is being worked on, one can look at the report on the role of municipalities for MaaS by the Gemeentelijk Netwerk voor Mobiliteit en Infrastructuur (GNMI) (2018). The GNMI is an alliance of more than fifty Dutch municipalities that are working together and communicating on various mobility

and infrastructure related themes. In their report on MaaS, they describe their expectations for its societal effects. The perceived benefits of MaaS include improved accessibility of remote regions, reducing mobility poverty, raising social cohesion, improving efficiency, and reducing the environmental impact of transportation. It is seen as the responsibility of municipalities to provide the infrastructure and spatial policy for all modalities, including regional public transport. They acknowledge that there is a challenge in balancing user needs, company interests, and societal goals. A commercial operator could for example prioritise a profitable business case, which might come at the cost of sustainability or reduced congestion. Governments also need to decide to what degree they wish to influence the market, and whether they will merely act as facilitators or take an active role in execution.

According to Smith, Sochor, and Karlsson (2018), there are three scenarios for the role that the public sector, including municipal government, could take in MaaS. The public sector only taking care of public transport would allow commercial parties operating MaaS to innovate better and faster, though it would also sacrifice a great amount of the public sector's influence over the system. Alternatively, the public sector could act as both integrator and operator of the MaaS system, taking responsibility for financing, organisation, and implementation. This would allow them to focus the services specifically on societal mobility goals rather than financial gain.
A midway scenario between these two options is that the public sector takes only the role of integrator, and the operator role being taken up by one or more private actors. This could allow the public sector to act as a sort of buffer, preventing the private operators from becoming too dominant or deviating from the goals set by municipal governments.

3.1.2. Enschede

The mobility vision that has been defined by the city of Enschede (Smuling et al., 2019) indicates that the municipality wishes to invest in new mobility innovations, naming MaaS explicitly as a part of innovation in the field of service creation. There is also a specific focus on stimulating bicycle use. The main goals that are set are

- accessibility;
- attractiveness of the city for work, studying, living, and shopping;
- safety;
- and sustainability.

This translates into a diagram of four themes and three conditions that would need to be met, shown in figure 4.

Internal versus external travel

According to the mobility vision, the majority of movements in Enschede take place within city boundaries (around 66%). This implies that a potential MaaS system should pay particular attention to internal transportation, in order to fit with the city's circumstances. Nonetheless, Enschede wishes to invest in external transport, that is into and out of Enschede, to improve the city's 'catchment area'. A large percentage of traffic (50-60% for internal, 80% for external) in Enschede takes place by car.

Mobility hubs

For public transport, the mobility vision introduces so-called Mobipunten. These hubs provide mobility solutions for the first- and last-mile. Travellers can use such points to change between modalities, specifically modalities that exist as services or shared systems. This concept could be

considered a MaaS system. The vision also mentions the vehicles offered at the suggested points should be electric. This system is meant not only for visitors to the city, but also specifically for residents. Distinctions could be made between different types of Mobipunten, based on the specific requirements of a particular location. This could ensure more flexibility for implementing the system.

3.1.3. Utrecht

Sytsma and Stulen (2018) discuss the implementation of MaaS in Utrecht, based around the city's regional pilot (cf. Ministerie van Infrastructuur en Waterstaat, 2018). The stated goal of this pilot is to improve accessibility, mainly by offering alternative modalities to cars and stimulating their use. They understand MaaS as a system that enables travellers to plan, book, execute, and pay for an entire multimodal trip in one app. On top of that, the system should allow for a personalised service and advice for the traveller.

Expected effects

The municipality expects that MaaS will improve the accessibility of cities and the countryside. Moreover, it will lead to better liveability by reducing the need for parking space and the amount of traffic congestion. It will make society more sustainable by decreasing car usage and

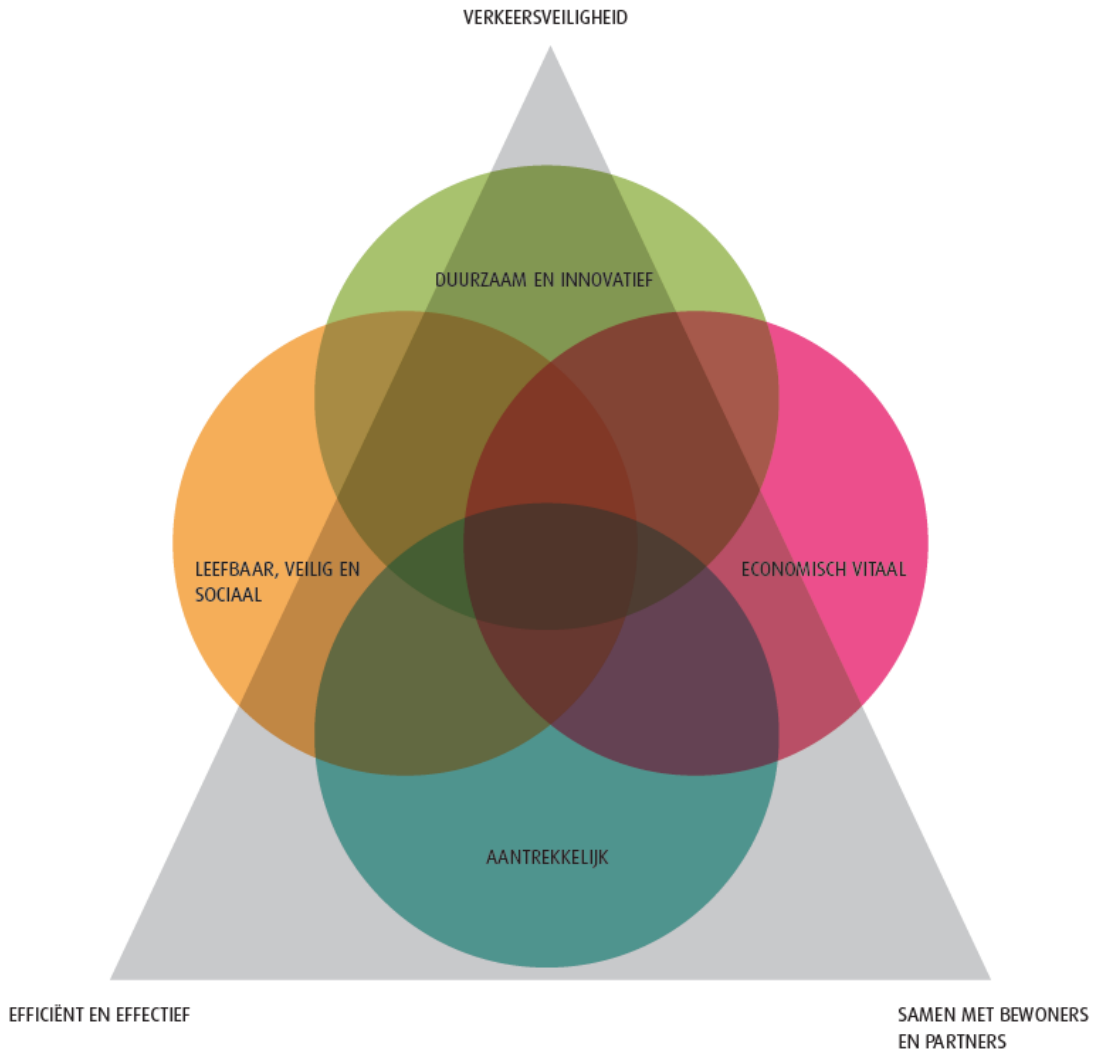


Figure 4 Diagram mobility vision Enschede (Smuling et al., 2019)

increasing that of public transport. The transport system will become more resilient, as trips are made faster and more flexible. Social inclusion will be raised, as public transport and shared vehicle modalities become more common.

User profile

A profile is given of characteristics that are hypothesised make a user most interested in making use of MaaS. First amongst these is young age. The city believes people who recently moved house will be more receptive for changing their travel habits, including making use of MaaS. Second, people living in locations where there is less parking space, or where parking space needs to be paid for, may similarly be receptive as MaaS could save them expenses. Third, households that do not own a car could become interested in MaaS as a primary means of transportation. Fourth, due to the reliance of MaaS on public transport services, there is also a need for these services to be sufficient for the user to consider changing their habits. Finally, people who consider sustainability important will be more interested in what MaaS could offer them. This is in contrast to people who value status and success, as these will prove more difficult to persuade to not make use of a personal car.

Facilitating role

According to the vision, the municipal government of Utrecht explicitly only wishes to take on a facilitating role in the pilot. The offering of transportation, as well as the improvement thereof, would mostly be left to the market to take care of. As such, Utrecht's vision can be considered a fairly hands-off approach.

3.1.4. Rotterdam

The mobility vision of the municipality of Rotterdam (2017) frames mobility and accessibility as a means to an economically strong and healthy city. Starting points are the growth of the city, economic revitalisation and energy transitions, and a transition from car to bicycle and public transport. The government plans to invest in smart mobility, and to use the city to experiment with innovative solutions. MaaS gets raised as a means to offer small scale transportation in areas where there is a large walking distance between public transport stops and urban facilities.

Mobility poverty

The challenge of reducing mobility poverty is given specific attention in the vision of Rotterdam. Due to various circumstances, such as economic poverty, disability, or age, certain travellers have reduced access to transportation. Careless changes to the transport network in a region can exacerbate these issues. With this in mind, Rotterdam wishes to ensure all residents have equal access to mobility to participate in society. To achieve this, the city will be offering transport solutions for special target groups, diversify the mobility offerings in the region, and explore how mobility can lead to more social inclusion. They see MaaS as part of the solution as well.

MaaS pilot

The regional MaaS pilot in Rotterdam (Ministerie van Infrastructuur en Waterstaat, 2018) focuses on the accessibility of Rotterdam-The Hague Airport. Most people currently use cars to reach this airport, which the pilot aims to change. To this end, the pilot targets not only travellers, but also employees of the airport and nearby companies, whom they wish to offer a smooth and seamless door-to-door trip. The provider that is chosen to fulfil these goals through MaaS will be expected to create transparency in the demand for mobility, thereby also enabling the

development of new services and the making of adjustments in the services. The municipal government of Rotterdam is generally interested in MaaS for its perceived potential to solve societal goals of

- traffic-efficiency
- space-efficiency
- environmental-efficiency
- social-efficiency

Target group of pilot

Organisers of the pilot are keeping in mind that the two target groups that have been mentioned, that is travellers and employees, both have characteristics that need to be kept in mind during developments of a service. Namely that travellers will often be carrying heavy luggage, which makes certain modalities like cycling less viable for them. Meanwhile, some of the employees of the airport and surrounding companies have to travel at times when public transport is not available.

Market response

Based on its wishes with the pilot, the city of Rotterdam conducted a market consultation to gather feedback and ideas from the market and from potential service providers (Verboon, 2019). This consultation appears to show a degree of dissonance in the requirements and desires of the municipality and those of the companies in the market. There is firstly a lack of interest amongst potential providers for the airport, and they would much prefer developing a system for the entire region. They moreover would like the municipality to take a larger role in MaaS than had been planned, namely by taking care of the collection and communication of data. The market parties also wish to have more options when it comes to making changes to public transport prizes, cooperating with additional transport providers, and creating new transport products.

3.1.5. Zwolle

The mobility plan of the municipality of Zwolle (Gemeente Zwolle, 2018) firstly indicates there is a general interest in innovations in the field of (smart) mobility. They will invest in the sharing economy, which they see as part of MaaS. Applying shared vehicle concepts can not only alleviate the need for people to own a personal car. It can make it possible to always offer users an appropriate vehicle based on their specific and present requirements and wishes. A further idea is to provide businesses with a fleet of shared cars, ideally a fleet that is shared by multiple companies in a larger business park.

Travel modalities

Zwolle wishes to also invest in bicycle traffic. The city appears to not necessarily want to discourage car usage and encourage bike usage. Rather, they wish to facilitate both types of travel as well as possible, making both viable. Since public transport is unable to provide door-to-door transport for everyone, (owned) bicycles and cars are expected to continue playing an important role in Zwolle.

Mobility hubs

Zwolle plans to make use of mobility hubs. They note the challenge of the first- and last-mile for this. Transportation needs to be offered to move travellers to and from the hubs. Only then does

it become a viable system for Zwolle's residents to use.

Behaviour change

There is an interest in using smart mobility to influence travel behaviour. Ideally the city would want to influence which modalities are used, at which time, and which route is chosen by the traveller. In doing so, they would like to for example improve efficiency, throughput, and sustainability.

3.1.6. Other municipalities

Not all municipalities have defined an extensive vision and strategy for their future mobility, and specifically for MaaS. Especially smaller municipalities generally plan to await further developments before making decisions, or to see what other, larger municipalities will be doing with MaaS. Nonetheless, the smaller-scale visions of these municipalities can still substantiate the goals and visions for MaaS from a governmental perspective. With this in mind, the following will provide a summarised review of findings from policy documents of areas that have comparatively less detailed, if any plans for MaaS. The municipalities are discussed along themes that appear within their documentation.

Liveability

Municipalities try to improve the quality of living for residents within their area. For mobility, this can involve aspects like safety and speed of travel, as for the municipality Dinkelland (Beekman, 2019). They also plan to tackle public health by making cycling more desirable. Borne also mentions liveability in its mobility vision (Wissink, 2012). They prioritise the quality of living spaces, and MaaS could contribute to this. Hof van Twente (2016) plans to improve liveability by reducing the use of cars, and encourage residents to cycle more. Oss (2011) similarly wants to change travel behaviour with the end goal of making the municipality more liveable. They would like residents to use the bicycle and public transport more, and to achieve this they are aiming for facilitating an interconnected chain mobility network.

Accessibility

Mobility should be accessible for all types of residents living in a municipality. Dinkelland is working on providing customised transport for special user groups, such as elderly, people with disabilities, and school students (Beekman, 2019). Borne similarly sets itself the primary ambition to make mobility accessible for everyone (Wissink, 2012). They mainly focus their efforts in this regard on people in wheelchairs, making it easier for them to access bus stops and train stations. In the mobility plan of Almelo (2016), the municipality considers accessibility of mobility to also be related to participation and self-sustainability. They want residents to take an active part in making decisions and coming up with solutions. To this end there would be customized mobility solutions, that can provide for the specific situations of an individual traveller, who may otherwise have reduced mobility access.

Sustainability

Changes in transport systems can be used to make mobility in municipalities more sustainable. The municipalities Dinkelland and Hof van Twente make it part of their vision to be more sustainable (Beekman, 2019; Gemeente Dinkelland, 2019; Gemeente Hof van Twente, 2016). To achieve this, they plan to innovate with chain mobility, electric vehicles, and smart mobility. Through MaaS, the amount of (non-sustainable) transport taking place could be reduced, thereby being better for the environment. The municipal coalition agreement of Hengelo (2018)

also shows an ambition for sustainability in the city. They will encourage sustainable mobility. The bicycle is seen as an attractive alternative for the car.

Chain mobility

As mentioned above, the municipality Dinkelland plans to make use of chain mobility to achieve its goals for sustainability (Beekman, 2019). In their policy plans, Deventer (2013), Kampen (2018), and Oss (2011) similarly state their intents to invest in and facilitate chain mobility, consisting of multi-modal trips through bicycle, bus, and train. There need to be effective connections between modalities, to ensure travellers can easily switch during their journeys. For chain mobility, mobility hubs could be implemented at suitable transport nodes. For Borne (2012), one envisioned location for such a hub is the local train station. Travellers can easily change there between train, bicycle, and bus.

Cycling

As an alternative to travel by car, municipalities can try to encourage the use of bicycles. Deventer says in their mobility policy plan (2013) that they consider themselves a straggler on the theme of bicycle traffic, and they want to change this. To this end they are adding bicycle parking facilities at important locations, and improving the cycling road network. They furthermore plan to use marketing and education to convince residents to cycle more. Hengelo (2018), Hardenberg (2018), Kampen (2018), and Oss (2011) similarly want to make cycling more attractive. This means that cycling roads need to connect effectively to each other, so that the infrastructure itself invites them to travel by bike. Hof van Twente (2016) sees the challenge of making cycling more viable to be mainly about making it safer.

Public transport

Like the bicycle, municipalities are also investing in public transport as an alternative modality. In Deventer (2013) the bus lines do not connect effectively, reducing its viability for travellers. The municipality wishes to change this. In part their plan is to use chain mobility. In Hardenberg (2018), the municipality is trying to provide public transport specifically in smaller neighbourhoods, to ensure they are also accessible and have access to other destinations. Almelo (2016) similarly plans to invest in new public transport solutions in order to provide mobility in remote areas where the current system is not feasible. This would mean a shift from supply-oriented to demand-oriented public transport. Kampen (2018) would prefer for travellers to use public transport, together with cycling, for their daily commute.

3.2. Interviews with municipal representatives

The preceding review of policy and plans in municipal publications gives a somewhat general view on the governmental perspective, requirements, and visions for MaaS and future mobility. To deepen these insights, and to gain a more hands-on view on developments and desires when it comes to MaaS, interviews were organised and conducted with representatives from four municipal governments. These interviews were documented and analysed to answer a series of main questions.

3.2.1. Interview approach

The interviews were set up to proceed as open conversations, based on a structure of general main questions that could be elaborated on using deeper sub-questions. Participants for the interviews were contacted and chosen as a group of municipalities that were expected to differ

on key characteristics like size and vision, while also each having a potential interest in MaaS. It was also sought to gain different perspectives by finding participants with varying positions and task descriptions in regards to local mobility. This resulted in interviews being set up with representatives from the cities Enschede, Utrecht, Almere, and Groningen. This selection of municipalities deviates from those studied in section 3.1., because the availability of potential interview participants within the set timeframe was more limited. Out of respect for privacy, the names and function descriptions of interviewed representatives are not listed with their respective municipality in this thesis. The functions of each participant are instead given here in alphabetical order:

(1) commissioner mobility;

(2) junior mobility policy advisor;

(3) manager smart mobility;

(4) public transport concession monitor.

The interviews were conducted separately for each of the participants, and the audio was recorded to be documented afterwards.

The main questions that served as the initial structure for the interviews, as well as their accompanying pre-set sub questions are given below. Besides these questions that were prepared ahead of the interviews, further questions were also asked during each interview based on themes and aspects that came up.

1. What are the ambitions for mobility and transport in the region?
    a. What is the desired (travel) behaviour?
    b. What is already being done to achieve this?
2. What do they consider to be MaaS?
    a. What is already being done in regards to MaaS?
    b. What are the challenges that appear, or are expected to appear?

The findings from the interviews are summarised below, based around the above two main questions. Extended documentation can be found in Appendix B.

3.2.2. Enschede

Ambitions

Enschede's accessibility is challenged by growth. They aim for a bottom-up approach for implementing innovations. The vision is to experiment and innovate, and seeing what happens and what challenges appear. Technologies are however not to be developed in themselves, but with the user in mind. They wish to use their available resources as efficiently as possible.

They would like to see more cycling occur. They furthermore want only truly necessary traffic to be entering the city. Good alternatives need to be offered for people to consider changing their travel behaviour.

Cycling is stimulated by making every location in the city accessible by bike. The city is working on the implementation of mobility hubs. They consider chain mobility for overcoming the first- and last-mile.

MaaS

MaaS is defined as being user-focussed, and as providing one central platform for planning, booking, and payment for transport, as well as making the reserving of vehicles possible. The vision is that at some point in the future, everyone will have some kind of MaaS app on their phone, that is worthwhile for the user and dependable. They are convinced there will be some form of MaaS in the future, and are preparing for it to happen.

The mobility hubs are seen as one form of MaaS. There is also the regional MaaS pilot in Twente (cf. Ministerie van Infrastructuur en Waterstaat, 2018). The pilot is still in early development, and will focus on WMO-transport. Stad-up is a project that is currently only usable by employees of the municipality, that offers electric vehicles and cars, and public transport tickets (Stad-up, 2019). Enschede is experimenting with apps like GoAbout to offer shared vehicles to the public, though it did not meet expectations in regards to accessibility and availability.

A large challenge is connecting all the components of mobility and of MaaS to each other. There is also a need for information to be spread better, particularly about how certain modalities like buses, shared cars, and electric vehicles are to be used. A concept or product needs to be found that users truly want and are willing to use. Not everyone is able to use an app on a phone, or is willing to do so. As such there need to be alternatives for people to use the service.

Other results

There are both opportunities and threats for MaaS. Electric scooters could be offered as a shared modality, but the expectation is that they will be used at locations and for trips where the municipal government would rather prefer that people were to travel on foot or by bike. It is such a threat that keeps the municipality from trying this out.

3.2.3. Utrecht

Ambitions

Utrecht is growing fast, putting a strain on mobility. They would like to set up mobility to be as spatially efficient as possible. Cars are relatively inefficient, and so less desirable. Efficiency will lead to a more open and attractive environment.

The main desired travel behaviour is to partially move people away from car usage, except for journeys where a car is absolutely necessary. Utrecht would like people to be making conscious and thought-out decisions about their travel choices. Different modalities are desirable for different areas of the city, and often multimodal journeys are preferred.

Utrecht is cooperating with shared vehicle providers, and stimulating residents to make use of those vehicles. Currently, each of the shared bikes in Utrecht gets used once per day on average, and shared cars are seeing increasing use as well. Alternative modalities are also encouraged by actively facilitating those modalities.

MaaS

In Utrecht, MaaS is mostly seen as a 'magic word' and there is only a general vision for what to do with it. They define MaaS as a change from ownership to usership, and unburdening people by offering a central system for planning, booking, and payment. The system moreover needs to support them through the trip. Shared mobility is seen as a significant component of MaaS, and is given more active attention in the municipality. Utrecht sees MaaS' main potential in mobile apps, as these can integrate all the necessary aspects.

One current project is the pilot in Leidsche-Rijn, which aims at behaviour change to make residents use their car less. The product will eventually be usable by everyone in the Netherlands. The target group are people with high income, and who own a personal car. The pilot uses the app Trips, which is considered a potential digital component for MaaS. A second project is the implementation of mobility hubs, particularly in a new densely built area of the city. The actual contents of these hubs are still being worked out.

The primary challenge faced by Utrecht for MaaS is the integration of all the component and the different mobility providers with all the necessary features. Users should preferably not have to switch between multiple apps to access different modalities. Trust between transport providers and the service provider is a key part of this. A question that still needs answering is which modalities are to be included in MaaS, and what the scale for any project or experiment should be. People moreover need to be convinced to actually use the services.

Other results

The response from the population to MaaS is described as mixed. The current test users are very enthusiastic, but they are not representative of the whole population. Responses from other people in the city have not been gathered yet. Utrecht envisions mostly a facilitating role for itself in MaaS. They steer by prescribing modalities that need to be included, and the programming standards.

3.2.4. Almere

Ambitions

The city of Almere was built with the principle of separating the different modalities that are used. In the past, chain mobility did not use to be much of a concern, and so there was less attention for it. Sustainability, health, infrastructure and through-flow, cycling safety, and social inclusion are important themes for Almere.

The city has no intention to change the existent division between car use and bicycle use. They would prefer it if people would more often consider alternative travel methods to the car.

Bus connections and similar public transport facilities are nowadays only set up based on explicit demand from residents. Attention is however still paid that newly built living spaces are accessible by public transport and by bike. The government discusses with employers at new and existing business parks and with public transport providers to ensure connectivity for employees. A large amount of responsibility over the system is given over to the public transport provider.

MaaS

The term and concept MaaS is given very little attention in Almere, as it is not seen as an important subject. It is broadly defined as the movement of a user from point A to point B whenever they want. It is thought to be part of the general shift towards smart mobility. MaaS is considered quite 'vague', and the city wants to wait and see how it develops and what other regions are doing. Since Almere is not yet interested in MaaS and hesitant, no concrete project appears to have been set up thus far that can be ascribed to it.

3.2.5. Groningen

Ambitions

Groningen is becoming more densely built and populated, and with the building of new housing the city is growing as a whole. The ambition is to promote car usage taking place around the city, rather than within the city. This will make more space available on the street, improving quality of life. There is a wish to promote 'healthier' forms of mobility, like walking and cycling. Travel behaviour desires are largely dependent on each particular section of the city.

To change people's traveling behaviour, the city tries to look at why a certain vehicle is used in a particular location or area. Only with such understanding can behaviour be adjusted. Placement of parking locations is also used to purposefully keep cars out of the city centre.
they are considering building underground parking for bikes, so that the streets and sidewalks are not blocked.

MaaS

Groningen considers MaaS as being when a provider has created a platform that can be used by users to access services that are provided by others, but are combined and offered as a package by the central platform operator. There is a place therein for the government. They see themselves somewhat like users, but could also serve as providers of shared vehicles. They want MaaS to actually add something to the city if it is to be implemented, and to solve an actual problem.

The city is considering to use MaaS to focus on movements out of the city, rather than into or within. Locating mobility hubs outside the inner city encourages people to first travel there by bus, and then change over to a shared car. These hubs are partially implemented in the region, and can be further extended upon with additional services. Groningen furthermore plans to service new parts of the city with shared vehicle systems rather than parking space, giving residents a subscription. There is also a pilot ongoing that is focussed on WMO-transport, as this is currently not used efficiently.

When it comes to behaviour change, the city finds it challenging to translate ideas for desired behaviour into practice. The main challenge regarding MaaS is internal, as it can be difficult to convince people to look at non-infrastructure solutions to problems they come across. A lack of user knowledge about MaaS and its modalities also needs to be overcome. This lack of knowledge leads to hesitation, and to services not being used.

Other results

The municipality would ideally wish to involve potential users in mobility developments, but they admit this does not happen as often as would be desirable.

3.3. Conclusions

Through the reviews of governmental policy documents and the conducted interviews, the perspective of local governments is studied. The main goal of this is to determine what the goals are that governments would want to achieve through MaaS. As such, based on the results, a list is created of governmental goals. This list is used in part 2 of this thesis to design the MaaS tool for municipal policymakers. Below, the government goals resulting from this section of the study are listed. For the sake of structure, the goals are categorized into a set of higher order themes.

3.3.1. Travel behaviour

Most governmental mobility visions and plans include some form of intended behaviour change amongst travellers. A common goal is to reduce car use by residents. Nearly all studied municipalities mention this goal in some form, with Zwolle being a noteworthy exception for explicitly not aiming towards this end result. As an alternative for the car, further goals are to increase bicycle use and increase public transport use. A few municipalities, including Rotterdam and Groningen, also mention increased walking as a viable alternative modality that they would like to stimulate. To achieve these types of goals, MaaS would need to be designed such that behaviour like cycling or using public transport becomes more interesting and viable than behaviour like car travel.

3.3.2. Spatial efficiency

The results from Utrecht explicitly call out a goal for improved spatial efficiency in the region, as do Rotterdam, Zwolle, and the general vision of the GNMI. One means of optimizing the efficiency of the region's mobility is to stimulate chain mobility, as mentioned in the interviews with Enschede and Almere. Options provided by MaaS would likely often include a multi-modal chain-mobile trip. Utrecht moreover specifically raised a goal to reduce vehicle ownership, envisioning a shift to vehicle usership. If MaaS becomes a viable alternative, then users may no longer see a need to own their vehicles. One of the main goals of Groningen is to keep cars out of the inner city, in order to improve throughput and efficiency in that section of the city. MaaS could offer alternative methods of travelling to and in the inner city, thereby reducing the presence of cars.

3.3.3. Types of vehicles

Municipal governments might want to stimulate the use of a particular kind of vehicle. A major example of this is how Enschede wishes to use MaaS to experiment with electric vehicles. If the modalities offered by MaaS are (mainly) electric, then that could encourage more travellers to use such modalities. The interviews in Enschede and Groningen moreover raised the idea of using currently available resources, such as vehicles, efficiently. The main example of this are WMO-modalities. When vehicles are not in use for transporting their main target group, they could instead be integrated into the offerings of a MaaS system.

3.3.4. Accessibility

Improving the accessibility to the transport system is a recurring theme in the visions of governments. It refers to the desire to ensure that all residents of a particular municipality are able to get the transport that they need. To achieve this, plans include a goal of enabling mobility where public transport is unfeasible. This means that remote sections of a municipality, or sections with a relatively low population, where there are not enough users to make a regular public transport connection feasible, need to be offered some viable alternative. MaaS could provide such alternatives, as part of its offerings. Another goal is making mobility affordable, to ensure that for example low-income residents can still get transport. Similarly, there is a general goal to make mobility accessible for all segments. That is to say, certain municipalities want to ensure that all types of travellers, regardless of age, income-level, or physical ability have access to mobility. This goal largely works towards the ideal of reducing mobility poverty, an ideal that

gets explicitly called out in the vision of Rotterdam. To achieve this, a MaaS system needs to offer sufficient options, at least one of which fits the needs and circumstances of any particular users.

3.3.5. Sustainability

A large number of municipal mobility visions and plans include some form of ambition towards improving the sustainability of local transport. Earlier mentioned goals, such as reduced car use and electric vehicles, could be conceived to also fit into this category. Generally, municipalities want MaaS to change their transport system to ensure a more clean environment. MaaS could do so by limiting the environmental impact of the modalities it offers, in regards to for example pollutions as well as use of materials.

3.3.6. Individual circumstances and desired image

A municipality's particular circumstances in regards to how travel mainly happens will have an impact on what type of MaaS system is most suitable. The mobility vision of Enschede offers a viable division between focussing on internal travel and focussing on external travel. It should be noted that these are not mutually exclusive, and policymakers can deem both to be important enough to explicitly mention and work on, as Enschede itself envisions. In this category are also goals that are meant to achieve a particular sort of image for the municipality. They might be want MaaS to be designed to offer an interesting project for commercial companies. This could also be to improve the municipality's economic circumstances, by attracting such companies to the region. Cities like Enschede have set themselves the goal to be seen as innovative, by implementing new and interesting technologies. For MaaS to aid in this, it would need to actively show off the innovative capabilities and traits of its offerings. To be seen as dependable and trustworthy is another such image goal, that for example was mentioned in the Enschede interview. To do this, MaaS' offerings need to always be available at a moment's notice when the user needs them.

3.3.7. Role of government

An additional result from the research described, that has more bearing on the context of MaaS rather than on explicit goals, is the role that local governments envision for themselves in the system. Municipalities appear to largely consider themselves merely as clients and facilitators for developments like MaaS. Publications and interviews, particularly with regards to Rotterdam and Utrecht, indicate that detailed planning and execution of the related projects is to be left to commercial institutions to take care of. Notably, the market consultation by Rotterdam showed that market parties would actually prefer municipal government to involve itself more actively. Based on the interview, Enschede appears to be somewhat more critical of the market's capacity for developing a sufficient system. Overall though, it appears that the prevalent vision of the municipal governments is to follow the first of the scenarios of Smith et al. (2018), with private actors taking on the role of integrator and operator of the MaaS system.

Answers to research questions:

4. What would municipal governments like to achieve through MaaS?

The research in this chapter has resulted in the following list of government goals for MaaS:

- Reduce car use
- Increase bicycle use
- Increase public transport use
- Increase walking
- Chain mobility
- Reduce vehicle ownership
- Keep cars out of inner city
- Electric vehicles
- Use available resources (e.g. vehicles) efficiently
- Enable mobility where public transport is unfeasible
- Make mobility affordable
- Make mobility accessible for all segments
- Clean environment
- Be seen as innovative
- Focus on internal travel
- Focus on external travel
- Interesting project for commercial companies
- Be seen as dependable and trustworthy

4. Practical tests of existing MaaS products

In chapter 2 of this thesis, the user perspective of MaaS underwent an initial exploration through the use of literature. This account mainly focussed on the capabilities and success rate of current systems, the current habits of travellers, and the way that travellers' mobility needs and wishes are expected to evolve in the future. In the following chapter, this user perspective is further studied and expanded upon. To do so a set of practical tests is been conducted of existing services and product that can be considered (parts of) a full MaaS experience. Two journeys in Dutch cities were planned, and executed using these services. Through this study, the current capabilities and shortcomings of MaaS are further assessed. Moreover, a set of user requirements is determined, that a MaaS system will have to fulfil to be more user-friendly, and thus have a higher success rate at getting used.

One research sub-question is addressed:

5. *What are the requirements of users for MaaS?*

In this chapter, the methodology behind the tests, as well as their results are discussed. The studied MaaS products are first described. Next, the test plans are detailed, indicating the steps that were taken throughout the pre-planned journeys to experience the studied services, and the test questions that were used to assess the services. The results of the tests are illustrated. Finally, the results are added to those of the literature reviews, and used to compile a list of user requirements for MaaS, that will be used for the design of the MaaS tool in chapter 6 of this thesis.

4.1. Studied MaaS products

Ahead of the planned test, a selection is made of apps and services that are suitable and of interest. This selection is based on a market study of existing and available systems, according to which the most prominent and 'mainstream' services are chosen. The chosen services are described and discussed below. For each it is also described what steps of a user's journey the product is meant to aid with, using the journey steps defined in section 2.1.2. of this thesis.

- *TURNN*: TURNN mainly functions as a multi-modal trip planner, which offers and compares different options based on sustainability, price, and speed. The service is downloaded as an app onto the user's phone (TURNN, 2019). It offers support during *preparation*, *planning*, and *additional support*.

- *OV-Chipcard*: The OV-Chipcard is a nationally implemented payment and ticketing system for public transport in the Netherlands. It consists of a physical card that either holds a prepaid balance or is connected to the user's bank account, and provides access to trains, buses, trams, metros, and certain shared car and bicycle initiatives (Trans Link Systems B.V., 2019). It offers support during *preparation*, *booking*, *payment*, *execution*, *additional support*, and *ending journey*.

- *GoAbout*: GoAbout is a mobile app that offers both trip planning and access to particular modalities. Users can buy train tickets, which are registered in the app itself, as well as rent and unlock shared bicycles and cars in certain regions of the Netherlands (GoAbout, 2019). It

offers support during *preparation*, *planning*, *booking*, *reserving*, *payment*, *execution*, *additional support*, and *ending journey*.

-*Whim*: Whim is a service created by MaaS Global that aims to offer a full MaaS system, currently implemented by way of smaller scale pilots in various countries. While there are no full pilots taking place in the Netherlands, Whim does offer route planning with certain modalities, as well as ticket booking with certain transport providers in the Netherlands (MaaS Global, 2019). It offers support during *preparation*, *planning*, *booking*, *payment*, *execution*, *additional support*, and *ending journey*. As a credit card is the only possible payment option for this app, and this was not available during the tests, Whim was only tested for its route planning features.

-*Tranzer*: Tranzer allows for the planning of trips using multiple modalities, and to book tickets for those trips, which are stored in the service's mobile app. The service has agreements with a large amount of public transport providers, as well as giving access to shared vehicles, and allowing for the calling of taxis (Tranzer, 2019). It offers support during *preparation*, *planning*, *booking*, *payment*, and *execution*.

-*FlickBike*: FlickBike offers shared bicycles in a free-floating system in select regions of cities throughout the Netherlands. Available bikes are located in a mobile app, and can be scanned with the user's phone to be unlocked (FlickBike, 2019). It offers support during *preparation*, *booking*, *reserving*, *payment*, *execution*, *additional support*, and *ending journey*.

4.2. Test plans

The goal of the practical tests is to gain insight into the user experience of MaaS. The tests show what aspects and features are of importance to create a suitable and satisfying service. To do so, the selected services are assessed on their capacity of providing and fulfilling the different steps of a full MaaS service, by way of two pre-set test cases. The first describes a cultural trip to The Hague, with a more open travel plan when it comes to modalities. The second is a business meeting taking place in Utrecht, where the used modalities are more strictly pre-determined. For both cases, suitable destination locations are chosen, and hypothetical complications are inserted, that make the cases and journeys more complex as well as requiring use of multiple modalities. Ahead of the tests, the necessary apps are downloaded onto a suitable mobile phone, and a personal OV-Chipcard has its balance connected to a bank account. The planned journeys, and the planned steps to complete them, are schematically described in Appendix C.

The practical tests are used to answer a series of questions about their capabilities, features, and user experience. The test questions that are used are as follows:

-What is/are the service(s) capable of?

-How was/were the service(s) experienced?

-What aspects of the service(s) worked well?

-What aspects of the service(s) did not work well?

-What are the implications for the design of a user-friendly MaaS system?

These questions help to determine what the requirements of MaaS are, through the experience of the studied service. Secondly, by assessing how the services fulfil the requirements, it is shown how MaaS overall can fulfil the requirements of users.

4.2.1 Test scenarios

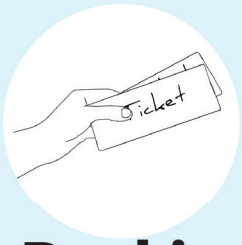
To illustrate in more detail the planned testing cases, and the possible results, scenarios are written. These show the individual steps that would be taken to successfully complete the case journeys. They moreover provide insight into potential obstacles that could occur during the tests themselves. They aid in developing initial hypotheses for advantages and disadvantages of the studied services. Finally, they provide a comparison to the practical experiences, indicating how a trip ought to proceed if everything functions broadly as intended, and therefore contrast with issues that occur during the actual trips. Two of these scenarios are created, one for each of the test cases in The Hague and Utrecht. The scenarios are summarised into expectations, ordered along the journey steps of MaaS defined in section 2.1.2.. The expectations contrast the practical results of the tests. The full scenarios are found in Appendix D.

4.3. Results of tests

Based on the test plans described, the practical tests are executed, and findings on the user experience are documented. These results are ordered and assessed based on their place in the process of eight journey steps that MaaS can insert itself into, as defined in section 2.1.2. of this thesis. The results are summarized and illustrated in the diagrams on the following pages. The eight journey steps are shown on the horizontal axis. On the vertical axis, the expectations of the particular step are first given, as based on the written test scenarios. Below that, each of the five test questions is addressed for each step.

Journey Step	1  Preparation	2  Planning
Expectations	Museum Beelden aan Zee will be selected as destination, and preparations be made to detour by the market. TURNN and GoAbout are downloaded onto phone, and a personal OV-Chipcard will be taken. The necessary accounts are made.	The trip to Beelden aan Zee is planned with GoAbout. As this app does not account for buses, a switch is made to TURNN. Later, GoAbout will be used to plan the trip to the Gemeentemuseum, and home to Utrecht.
Which systems were used for what?	TURNN, GoAbout, and Whim were downloaded onto phone. An account was made with GoAbout, and connected to bank account. Attempt was made to make account for Whim, but this required a credit card, which was not available. Personal OV-Chipcard had already been bought, and connected to bank account.	TURNN was used to plan the initial trip to The Hague's museum Beelden aan Zee, choosing 'sustainability' as the factor that options should ordered by. At one point, the trip was terminated, and GoAbout used to plot a new trip to the Gemeentemuseum in The Hague, and from there back to Utrecht. Throughout the whole journey, Whim was also checked for route suggestions.
How was it experienced?	Preparing OV-Chipcard was easy, because most of it had already been taken care of. GoAbout set-up was slower, since a large amount of information had to be provided to allow a pre-authorized debit. TURNN required no information, which made it easy in this step. Whim's demand for a credit card was disappointing and frustrating.	It was interesting to see the various options that TURNN gave, and how a selection could be made for what values are considered most important. It also provided clear information about departure times. GoAbout provided considerably less options, indicating the only viable travel means (using the app) to be walking. Whim's planning capabilities were alright, though its filtering options are more hidden than those of TURNN.
What worked well?	It was nice that TURNN only required a simple download to access all its features. Set-up and preparation for GoAbout and the OV-Chipcard is fairly involved, but it is good that it appears to only be necessary once.	All the apps that were tested had up-to-date information at time of checking, including the fact that travel to and from The Hague would be redirected. There was also good information on when trains, buses, and trams would depart, and where they would depart from. TURNN provided good options for preferences, including walking speed or the user being in a wheelchair.
What did not work well?	Whim's requirement for a credit card is frustrating, especially considering a large section of people in the Netherlands do not own one (Kosse, 2009). The fact that the OV-Chipcard requires setting up far in advance, and then waiting for the physical card to be produced and mailed makes for a quite long-winded process that needs to be undertaken far ahead of time.	The information in the Whim and TURNN apps does not update automatically, and so did not indicate a bus being delayed. Moreover, both Whim and TURNN did indicate which number bus or tram was to be taken, and which stop to get off, but not which direction they are to be taken. As such, a user has to find out for themselves which side of the street they have to be on.
Implications	It appears most suitable that a MaaS service provides multiple options for payment methods to be connected to accounts. Though it creates a barrier to entry, the services demanding a large amount of information from users during initial set-up can be accepted, as long as from thereon the system is able to function quicker and easier based on it already having all the information and permissions it requires.	Information given in MaaS needs to be up-to-date, and correspond with real world circumstances, like bus and tram directions given on the vehicles. The user should have options made available for how they wish to travel, and what their personal circumstances are, including physical ability like speed or a wheelchair, and preferences for what values they deem most important.

3



Booking

GoAbout will be used to book a bicycle trip in The Hague, opening the lock with the app. Later it will also be used to buy a train ticket to Utrecht.

GoAbout was used to buy a train ticket from The Hague to Utrecht. An attempt was also made to use GoAbout to book a trip with a shared bicycle in The Hague.

When trying to use the GoAbout app to find and access a shared bike in The Hague, it became clear that not only was there no bicycle hub nearby the tram station, but also that the two hubs that did exist in The Hague both had no bicycles available at the time. This was disappointing. The buying of the ticket did succeed quite easily. This did raise questions on whether it might be too easy, thereby allowing fast mistakes.

The interface for checking the location and availability of bicycles is quite informative and clear. The ticket buying works fast and intuitively, and results in a ticket that can open gates at train stations, and be scanned by a conductor.

An issue that occured was that GoAbout firstly did not have a bicycle hub nearby when looked for, and that moreover the two that did exist in The Hague (both near the train station) had no bikes available. The system for buying train tickets works fairly quick, and with direct debit payments are easily made even when unintended. The system is therefore somewhat accident-prone.

Coverage-rate is of great importance for a shared vehicle service to be usable and trustworthy. Users need to be able to find a hub nearby where they can get a vehicle, and for that hub to contain enough vehicles. Otherwise, they will stop trusting the system, and stop using it. While a fast ticketing system is easy for the user, it can make the system more accident-prone, and so additional confirmation steps may need implementing.

4

Reserving

GoAbout will be used to reserve a bicycle while in The Hague.

It was tried to use GoAbout to reserve a bicycle to be used for a trip in The Hague.

Since there were no bicycles available in The Hague, it was impossible to reserve one. This was experienced as disappointing. Moreover, even if bicycles were available, it is not possible to reserve one ahead of time.

The service did not work well in this step.

GoAbout had no bicycles available, and it would only be able to reserve a bike when the user is already at the location and connecting to it.

Reserving vehicles requires that there are vehicles available to be reserved. That said, if these vehicles are scarce, then it can become all the more necessary to have a system in place by which users can ensure they can get one ahead of time, through reservation. GoAbout does not offer this feature.

Journey Step	5  Payment	6  Execution
Expectations	Bus, train, and tram tickets will be paid automatically through the OV-Chipcard. One train ticket will be paid using GoAbout. The bicycle trip will also be paid through GoAbout.	The OV-Chipcard will be used to fulfil the public transport parts of the trip. A GoAbout bike will be used to execute the bicycle trip between the museums.
Which systems were used for what?	The OV-Chipcard was used to pay for the trips by bus and tram, and for the initial trip by train from Utrecht to The Hague. GoAbout was used to pay for a train ticket from The Hague to Utrecht.	The OV-Chipcard was used for the execution of the majority of the trip, by way of public transport modalities. An attempt was made to use GoAbout for a bicycle trip.
How was it experienced?	The payment through the OV-Chipcard occurred completely behind the scenes, automatically upon touching the card to the scanner in the bus or tram, or at the gates at the train station. This made it quite easy. Paying for the ticket in the GoAbout app took a little longer, but was also easily done by pressing the correct options.	No GoAbout bike was available. The execution of the public transport trip felt fairly comfortable and effortless. It was mostly a matter of simply getting on the bus, tram, or train, and finding a seat. The services added fairly little in this step of the process.
What worked well?	The OV-Chipcard demanded no real effort in use for payment, since connection to bank account for direct debit had already been taken care of far in advance. GoAbout similarly only requires pressing a button in the app for payment to take place. Both of these services are easy and effortless. The OV-Chipcard also has the advantage that payment occurs after the trip has been completed.	The OV-Chipcard made execution of the trip easier, by only having to touch the card to a scanner, and from there getting to sit down and enjoy the trip, until arriving at the destination where the card is again used to finish.
What did not work well?	Payment for tickets in the GoAbout app occurs before a trip takes place, and it is not easily, if at all, possible to reverse the payment. Considering the ease with which payment is done, unintentional payments can take place. The 'invisibility' of payment by the OV-Chipcard, and to a lesser extent GoAbout, also makes it difficult for the user to gain insight into how much they are spending.	Since there was no GoAbout bike available, it was not possible to use its services to execute the trip.
Implications	The payment in MaaS should occur quickly and easily, and it would be quite convenient if it could be done almost automatically through direct debit. Information should be given however on how much money a user is paying for their transportation. Furthermore, payments should be reversible if they are not intended, especially if the system makes it easy for such accidents to happen.	MaaS ought to probably not insert itself too intrusively into the execution aspect of the user's trip, as it is not needed there. This aspect will be mostly taken care of by the actual modality providers.

7

Additional Support

TURNN and GoAbout will provide updated travel information on how to travel, such as departure times and locations. GoAbout will provide information on where to find a bicycle, and where to return it.

TURNN and Whim were consulted throughout the journey to gain advice for how to travel. GoAbout was also used as a route map in The Hague to get from one museum to another.

The use of TURNN and Whim for advice throughout the trip is somewhat cumbersome, as advice in the app does not update automatically based on location, unless the advice is 'recalculated'. The advice that is given is nice and informative. While it was useful that GoAbout kept track of the current location relative to the proposed route on the map, it was annoying that the route was not recalculated based on that location.

Information in TURNN and Whim was quite clear and useful, indicating departure times and bus and tram numbers. GoAbout was helpful in keeping track of the current location on the map, while still showing the calculated walking route between the two museums.

TURNN and Whim did not update their advices based on time and location of the user, and it was not possible to indicate to the apps the completion of a particular step. GoAbout also did not update its route advice during the walking section. Both TURNN and Whim also did not say which direction a tram or bus was to be taken. Whim's maps also do not enable zooming.

It would be nice if the services could update their advice and steps based on current time and location, and the steps that the user has already completed. This would however put a larger burden on their data and internet connection. For trips that the user has to navigate themselves (such as walking and cycling), it is useful if the MaaS system has features that track their location, and advices them on exact navigation.

8

Ending Journey

With the OV-Chipcard, the public transport parts of the trip will be 'checked out' from. The GoAbout bike will be handed in at an allowed return station.

Upon ending (sections of) the journey with public transport, the OV-Chipcard was used to 'check out', and the GoAbout app's train ticket was used to open gates to exit the train station.

Finishing the journey's different sections was quite easy and quick, which gave a pleasant experience. GoAbout was a little annoying when it came to opening the train station gates, as the app's QR-code repeatedly turned around when trying to scan it.

The OV-Chipcard easily allowed checking out of trams and buses, and succesfully opened the gates at the train stations. Only upon doing so was the price for the trip calculated and paid from the connected bank account. GoAbout similarly managed to open the gates. Upon checking the app the next day the ticket had been removed as it was no longer valid.

The OV-Chipcard, upon checking out, is not quite insightful about how much the trip cost, as this information is only quickly show on the scanner's screen, and in an unclear format. When selecting the GoAbout ticket's QR-code to zoom in for scanning at the gates, turning the phone appeared to accidentally rotate the image so it was no longer fully shown, making scanning difficult.

Ideally, upon finishing a journey, or a part thereof, it might be nice to see how much the trip cost. This would likely be less relevant if the journey is fully booked and paid for in advance, as the user will have received the information at that point then. Small usability details like the rotation of QR-codes should also be kept in mind when designing a MaaS system, as such annoyances can grate on the user.

Journey Step	1  Preparation	2  Planning
Expectations	The business park Papendorp, and the Science Park are chosen as destinations. Tranzer, Flickbike, and GoAbout are downloaded, and prepared. The plan is to use public transport to the business park, and rent a bicycle. Then, public transport is taken to Science Park, and a new bike is rented.	Tranzer will be consulted to plan the journeys to Papendorp, and to the Science Park. It will show which buses need to be taken and when they will depart.
Which systems were used for what?	Tranzer, Flickbike, and GoAbout were downloaded onto phone. Account with GoAbout had already been set up for previous test. New accounts were made with Tranzer and Flickbike.	Tranzer was used to plan the initial trip to Papendorp, and from Papendorp to Science Park Utrecht.
How was it experienced?	Tranzer's set up was quick and easy, as preparation involved barely any steps beyond downloading, and demanded not all that much information. Set up of FlickBike took somewhat longer, in order to allow for a direct debit from bank account.	The information that Tranzer gave was clear and comprehensive, indicating where and when a particular bus would be departing.
What worked well?	The set up and preparation for both Tranzer and Flickbike was quick and easy enough, and clear steps were given for what to enter. GoAbout only requires set up once, and from thereon the user does not need to indicate further information.	Tranzer's information was up-to-date at time of planning. It was informative on where and when a bus would be departing, and gave a walking route to the correct bus stop. It also indicated which direction the bus is to be taken, so that the user knows to get to the right side of the street.
What did not work well?	Everything worked to satisfaction.	Tranzer's travel information did not indicate which section of Utrecht Centraal the second bus to Papendorp and the second bus to Sciencepark would be departing from. As such, it was necessary to check the digital screens at the stations to know where to go.
Implications	The preparation and set up of the systems for this test, compared to those used in The Hague, required little time and effort. This makes it viable for them to be downloaded and used at short notice, in the moment itself when the user requires access to transportation. In such a scenario, systems like these would be able to function well.	Travel information given by MaaS apps should include all the information that the traveler requires to make the journey, ideally such that they no longer need to check other sources like digital screens at bus stops and train stations. This should include departure time, specific departure location, and direction that a public transport modality will be going.

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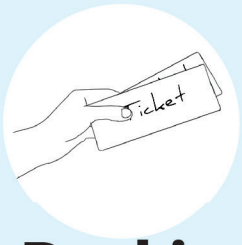

Booking

Public transport tickets will be booked through Tranzer, which will download the tickets into the app. FlickBike will book a bicycle to use in Papendorp, and GoAbout will book one at Science Park.

Tranzer was used to book tickets from De Bilt to Papendorp. FlickBike was attempted to be used to access a bicycle in Papendorp. GoAbout was used at Sciencepark to book a bicycle trip.

Booking the bus trip with Tranzer felt cumbersome, as it was necessary to log into a bank account with iDEAL, which took relatively long. Accessing a bicycle with FlickBike was unsuccessful, as the bicycles could not be found at the location designated in the app. Using GoAbout to book the bicycle trip was a lot easier, and there were enough to be found nearby which could be accessed.

FlickBike's interface for booking a bicycle is in principle quite intuitive and easy. GoAbout similarly offers a good interaction, that clearly shows where to get a bike and how many are available. Tranzer is quite clear in its booking process, indicating well what the user needs to do and how to proceed.

Since Tranzer is not connected to a bank account for direct debit, whenever a ticket is bought the user has to log into their bank account to pay. This takes a long time for a fairly simple and often cheap transaction. It became clear that Tranzer does not have a working agreement with all bus providers in Utrecht. FlickBike was not usable to access a bike, as designated locations had no bike.

The booking process should ideally be faster than the way Tranzer offers, particularly for low-cost transactions. It is also advisable that a proper MaaS system ensures that it has agreements with a wide range of transport providers. Considering FlickBike, it became clear that for a shared vehicle system it is imperative that the user is able to find vehicles, be it by using hubs or through very accurate GPS, as the service was currently unusable.

4

Reserving

FlickBike will be used to reserve for a time a bicycle in Papendorp. GoAbout will similarly reserve a bicycle at Science Park. In so doing, it will be ensured that there will be a bicycle available when needed.

FlickBike was used to reserve a series of (supposedly) available bicycles in Papendorp. GoAbout was used to use a bicycle at Sciencepark Utrecht.

The reserving process with FlickBike worked quite well, and it is reassuring to know that a bike will be kept ready for you, albeit only for 15 minutes. However, this did make the later disappointment larger when it became clear that the bicycles could not be found at their locations. GoAbout's 'reservation' aspect allows at least to keep a bike while it is being used, but it disappointingly does not allow reservation to occur ahead of time.

It is good that some time ahead you can be assured of a particular bike being kept ready for you, as can be done with FlickBike. Conversely, it is good when a bike is kept reserved you while you are still using it, even if you lock it in the interim, as is done by GoAbout.

GoAbout is unable to reserve a bicycle ahead of time at all, and so the user has to hope that there is still a bike available when they are on location. FlickBike's reservation is only for 15 minutes, and so suffers from the same kind of problem. FlickBike also appears to make a bicycle accessible again once it is locked, and so the user here too has to hope it is still there when they need it.

In theory it would be good for users if they could reserve a vehicle ahead of time, ensuring they can have it when they need it. This would come with the risk that vehicles might get reserved even though they will not be used, be it as a joke, by accident, or changed travel plans. As such, a suitable mechanism would need to be found to counteract this. It does seem right though that a vehicle is continuously reserved while in use.

Journey Step	5  Payment	6  Execution
Expectations	Tranzer will allow tickets to be paid for through the app. Payment for FlickBike's and GoAbout's bicycles will be calculated after returning the bike, and automatically paid for through bank account.	The bus section of the journey will completed using Tranzer's tickets. FlickBike's bicycle will be used to execute the rest of the trip in Papendorp, and GoAbout will do the same at Science Park.
Which systems were used for what?	Tranzer was used to pay for tickets for bus travel. FlickBike and GoAbout were used to pay for rental of bicycles.	Tranzer was used to execute the bus trip from De Bilt to Papendorp. An attempt was made to use FlickBike to make a trip in Papendorp by bike. GoAbout was used to make a bicycle trip from Sciencepark Utrecht to De Bilt.
How was it experienced?	Payment in Tranzer took quite long due to going through iDEAL, which was annoying. FlickBike's payment could not be tested since no bike was found to be used, but appears to go automatically through direct debit. The rental through GoAbout was automatically paid through direct debit, with the price calculated at the end of the trip when returning the bicycle.	The Tranzer app did not get recognized by two bus drivers, which forced use of the OV-Chipcard to pay for the bus trip. At the locations designated by FlickBike, no bicycles could be found. GoAbout did work satisfyingly, giving easy access to the bike, which could after use be returned to any nearby hub location.
What worked well?	Payment for GoAbout occurs automatically, after it has been connected during set up to a bank account. This makes it effortless for the user. It appears that FlickBike would function similarly. Tranzer is very clear and informative about how much a trip will cost, and what part make up that price.	The usage of GoAbout to get a bike worked very well, and it was convenient and satisfying that it was not even necessary to bring it back to its original pick-up point. The app worked well to unlock, and intemittently lock, the bicycle, using a Bluetooth connection. FlickBike would hypothetically function similarly, though using a QR-code scanned with the phone, instead of Bluetooth.
What did not work well?	The pricing of GoAbout and FlickBike is not very visible, making it difficult to discern how much a particular trip costs, until the moment the payment is withdrawn from the bank account. The slower payment through iDEAL for Tranzer is cumbersome, and makes it far less viable to be used at short notice when a ticket is needed. Tranzer also demands a not insignficant 'service fee'.	FlickBike failed to function, as no bike could be found at the indicated locations, or the locations were inaccessible, possibly due to the bikes being stored in company's garages. Tranzer also failed to function here, as there was an incongruence with the real world with drivers not recognizing the app and what to do with it.
Implications	Payment in MaaS should occur quicker than it does through Tranzer, so that users can get a ticket at short notice when they need it immediately. There should also be clear information presented to the user on how much they are spending on their trip. Automatic payment, such as direct debit, would appear acceptable as long as it is done after the trip has been completed, as it is otherwise increasingly prone to accidents.	The test with GoAbout shows that such a service can work well as long as coverage and availability is good. Conversely, FlickBike shows the risks of 'free-floating' systems, namely that the bikes may be taken to inaccessible locations. The issues with Tranzer indicate there is a strong need for not just technical background conditions to be met for MaaS to function, but also that human stakeholders like drivers need to know how to deal with it.

7

Additional Support

FlickBike and GoAbout will provide information necessary to find the bicycles, on how to unlock them, and how and where to return them. They will also give directions on how to reach the destinations. Tranzer will provide information on bus departure times and locations.

While looking for the bicycles in Papendorp, FlickBike was continuously checked for walking route advice. GoAbout was similarly used to locate a bike at Sciencepark, and during the cycling trip to find a suitable destination and a nearby hub to return the bike when finished with it.

Though FlickBike was fairly helpful at indicating how to get to a specific bike's location in the map, although upon arriving at such locations it became clear that the app was unable to provide enough detailed information on where exactly a bike was meant to be. GoAbout offered a specific name and address for its bicycles, and also gave an informative walking route to follow, which lead to the clearly signposted hubs.

FlickBike worked well in indicating where broadly to go to supposedly find a bicycle, continuously showing the location on the screen, and moreover giving the walking distance. GoAbout was informative and clear in where to find a bicycle hub, and the app clearly explained how to intermittently lock and unlock the bike, and how and where the trip could be ended by returning the bike.

FlickBike's location system was not detailed enough to perfectly indicate where a bike was currently located, and whether it was even accessible from outside.

For a shared vehicle feature, as part of a larger MaaS system, it is important to offer good support for the user to find a desired vehicle. This can be particularly challenging for free-floating systems, as GPS would need to be immensely accurate to be able to give a perfectly detailed location. During the trip itself, it is also good if the service offers convenient features like intermittent locking, and information on how to end the trip.

8

Ending Journey

After finishing their trips, the bicycles borrowed through FlickBike and GoAbout will be returned to suitable nearby locations, where the rental can be ended. Tranzer will store any needed information after the bus trips have been completed.

After finishing with GoAbout's bicycle, its app was used to return it to a nearby hub and end the trip. After use, Tranzer's tickets are stored in the app for a while, until they are removed once they are no longer valid.

Since Tranzer's tickets were not recognized by the bus drivers, they saw no use until they were eventually removed from the app. GoAbout was satisfactory and easy for ending the journey. It was especially convenient that the bike did not have to be returned to its original location, but could also be handed in at a different hub, which was more nearby the final destination.

GoAbout was clear in its interaction for how and where the bike could be returned when finishing the trip. It provided multiple locations of hubs, each of which could be used. It also did not matter that the bicycle was not placed exactly into the hub (which was full), but into a bike rack next to it.

GoAbout is not quite clear in informing how much a trip has cost at the end. Bike rental costs are calculated together once per month, and automatically withdrawn from a bank account at that point. As such, it is difficult to find out how expensive a particular trip was, unless calculated by hand based on pricing information in the app.

Ideally, a shared vehicle feature in MaaS should allow users to return their vehicles to locations different from those they got the vehicle at, in order to better facilitate first- and last-mile transport. These multiple locations should be clearly designated, both in the digital component of MaaS as well as the physical world. It would also be good for MaaS to provide users with clear insight into the costs of their shared vehicle trips.

4.3.3. Important features of MaaS

The results of the practical tests indicate a first set of themes and aspects that are important for the design of an effective, usable, and user friendly MaaS system. These aspects can be ordered based in their position in the journey process.

-*Preparation*: The service should allow multiple payment method options, to ensure that a larger audience of people can reliably make use of it. If the envisioned usage of the service is for users to be able to immediately access and set up the service at short notice, just before the moment they require transport, then it is imperative that said set up is quick and effortless. If the envisioned case is more to provide an overarching mobility service that users set up once and from there takes care of their everyday mobility needs, it is acceptable if set up takes longer and requires more information.

-*Planning*: It is essential that when planning a trip with the service, the information that it gives is up to date, including awareness of possible disruptions in the transport systems. The service should also provide all the information necessary to complete the journey, such as bus and tram numbers as well as their direction. Multiple options should be given for how to travel, and these should take into account the user's personal circumstances, like physical ability.

-*Booking*: Booking in MaaS should be fast and easy. It generally involves fairly low-cost transactions. That said, it should not be so fast and easy that it becomes accident-prone. A proper balance is therefore needed, requiring confirmation steps that at the same time do not slow down the process too much. For an effective service, it is important that agreements are in place with a wide range of transport providers. For a shared vehicle feature in MaaS, it is essential that users can actually find and access the vehicles, which can pose a challenge for specifically free-floating systems. Related to this is that shared vehicles need a high coverage rate, to ensure there is always a vehicle nearby and available whenever a user needs one.

-*Reserving*: For vehicle reservation to be possible, there need to be vehicles available, which reinforces the above-mentioned requirement for a high coverage rate. Few services offer a long-term reservation system, which is understandable to alleviate the risk of improper use or vehicles being reserved but not used. However, if vehicles are scarce, a reservation system might be necessary. To ensure a better and more reliable user experience it would be best if vehicles remain reserved while they are in use, even if they are intermittently locked.

-*Payment*: Payment for mobility services should be quick and easy, for the purpose of which it might be convenient if it could be done automatically. The user must be kept informed on how much they are spending. A system needs to be in place to refund accidental payments. One way to ensure this could be to have payment occur after the trip is finished.

-*Execution*: When it comes to public transport like buses and trains, it is likely best if a MaaS provider does not involve itself too much in the execution of the journey, as that aspect will be largely handled by the public transport providers themselves. It is however important that the transport providers know about the MaaS product and how to handle it. For shared vehicles, it may be necessary for the MaaS provider to get more involved, especially to ensure that coverage and availability of vehicles is sufficient. A free-floating system of vehicles may make that challenging, since vehicles could be taken to locations that are not accessible by everyone.

-*Additional Support*: A MaaS system should support the user in finding a shared vehicle when they need it. For a free-floating vehicle system this requires accurate GPS locating, that can lead users to the exact location the vehicle can be found. The service should also provide additional convenience features throughout the trip, such as intermittent locking and information on how and where to end the trip. During the trip, the service can make the journey easier

by updating its advice and steps according to what the user has already done, and what their current situation is. MaaS should also provide advice on exact navigation for journey sections that require users to follow a route themselves.

-*Finishing Journey*: For shared vehicles, it would increase convenience and usefulness for the user if vehicles can be returned to locations different from those they were picked up at. This could theoretically involve a reasonably priced additional charge. At the end of a trip, MaaS should provide the user with information on the price of their trip. This information could be also be displayed when finishing intermittent sections of the journey.

4.4. Conclusions

Based on the results of the practical tests, and the findings of the literature review in chapter 2, the user perspective of MaaS is studied. The goal of this is to determine what the requirements are that MaaS will have to meet. Using these findings, a list is compiled of user requirements. This list is used in part 2 of this thesis to design the MaaS tool for municipal policymakers. Below, the user requirements resulting from this section of the study are listed. For the sake of structure, the requirements are categorized into a set of higher order themes.

4.4.1. Added value

The literature review in chapter 2 indicated that for MaaS to be interesting for travellers, it needs to offer them some form of added value compared to currently available alternatives of owned mobility. One direction for this is if MaaS could lead to faster travel, allowing travellers to get to their destinations quicker than they can currently. To make travel faster, MaaS could try to ensure reduced congestion, thereby raising the efficiency of travel. To be an alternative to current vehicles, a further added value from MaaS could be providing comfortable vehicles, both in regards to shared vehicles and public transport modalities. Another example that was found in the literature is for MaaS to make travel cheaper than the current alternatives. MaaS could provide users with new and up to date information, accessible more easily and at a glance than current services. Based on the practical tests, this should include clear information on how much is spent after every trip the user takes.

4.4.2. Availability of shared vehicles

For MaaS to be optimally usable and viable for travellers to use regularly, it needs to be ensured that there is a mobility option available whenever one is needed. This is also an important part of making the service reliable. The practical tests show that to achieve such availability, it is important that shared vehicles have a sufficiently high coverage rate. That is to say, there need to be a sufficient number of vehicles, that are spread over a sufficiently high number of locations in a region. To improve the availability of shared vehicles further, there could be an early reservation system, that allows travellers to reserve a vehicle ahead of time, guaranteeing that it will be there when the need it. Similarly, vehicles should remain reserved while they are in use, so that even if a user parks the vehicle to take care of a short errand, they can be sure it will still be there when they return. When designing the system in such a way, a counter-measure might be needed for travellers reserving vehicles and then not using those vehicle. Such behaviour can occur due to perfectly reasonable circumstances, such as a changed travel destination, but it would unnecessarily reduce the vehicles' availability for other users.

4.4.3. Convenience

To make MaaS more interesting for users, the bar to entry for use should be as low as possible. To do so, the practical tests indicate that there needs to be quick and effortless set-up of the basic service interaction, such as a digital mobile app. It should not take too long for the user to make accounts, and to make the service ready for use in the future. Similarly, the booking process should be fast and easy, so that travellers can immediately get the mobility they need when they need it. Payment needs to be fast and easy, possibly automatic, to further make the travel process easy on the user. To make the booking and payment processes as fast as possible, one possibility shown in the tests is payment occurring after the trip is finished. This will likely be when the user has more time available, and moreover ensures they only pay for the trips and modalities that were actually completed. This reduces the risk of accidental payments. In case these do occur, there needs to be a system for refunding accidental payments, that is also easy for the traveller to make use of. For shared vehicles, the tests show it is preferable for the system to support the user in finding a shared vehicle, showing where to go and what to do to access one. In general the digital component must have easy to use interactions.

4.4.4. Health

According to the studied literature, certain user types deem physical health as an important determining factor for their mobility decisions. They could become more interested in MaaS if it were able to encourage healthier modality choices. MaaS could therefore encourage walking and encourage cycling from travellers. As the environment is also a key aspect of health, MaaS would for certain user groups also be more interesting if it could lead to more sustainable travel and reduce noise disturbance, thus leading to a cleaner and healthier living environment.

4.4.5. Variety of options

To be able to offer MaaS for a wide range of people, a variety of options should be given for the traveller to choose the one that fits them. This includes providing many travel options, in regards to routes and modality-combinations that can be chosen from, based on criteria like speed, prize, and sustainability. To do so, it will likely also be necessary to involve a wide range of transport providers, including multiple different modalities and brands. This also increases the chance of the user always being able to use MaaS for the trip they want to be making, rather than needing an additional product for one type of modality, as was at times the case during the practical tests. The practical test with GoAbout show that it is preferable if the system allows users to return shared vehicles to locations that are different from pick-up, as this for example makes the service more viable for one-way journeys. Providing this range of options also makes sure there are options to fit with the personal style and image of the user, as the literature review shows that a significant amount of travellers considers their vehicle to be an important status symbol. The issues encountered in the tests with services like Whim, namely the low acceptance of credit cards in the Netherlands, also indicates that MaaS needs to offer multiple payment options. Allowing for a variety of options also allows MaaS to better take into account personal circumstances of an individual traveller, such as whether someone is in a wheelchair, as was encountered in the practical test of TURNN.

4.4.6. Habits

To be inviting for users to make use of MaaS, it needs to be designed in such a way as to either fit with or change the current habits of travellers. Based on the literature, there is firstly a habit of single modality travel. Travellers are currently used to only use one modality for most trips, generally a car or a bicycle. Since MaaS can be expected to often involve a multimodal journey, a way would need to be found to convince travellers with single-modality habits to try the service. A related current habit concerns the convenience of modalities being close to home. Currently, users often have either a car or a bicycle parked near or in their house. These are vehicles they own themselves. Since MaaS is about vehicles no longer being owned by the travellers themselves, and transport being provided centralised for a wider public, there is an expected incongruity with this habit. Even with the sufficient coverage rate mentioned earlier, it is highly unlikely that a MaaS system will be able to offer modalities, for example in the form of (shared) vehicles or public transport stops, that are physically as close to the user's home as an owned vehicle would be.

Answers to research questions:

5. What are the requirements of users for MaaS?

The research in this chapter has resulted in the following list of user requirements for MaaS:

- High coverage rate of shared vehicles
- Early reservation system
- Vehicles remain reserved while in use
- Quick and effortless set-up
- Payment occurs after finishing trip
- Refunding of accidental payments
- Faster travel
- Up to date information
- Information on how much is spent
- Fast and easy booking
- Fast and easy payment, possibly automatic
- Support user finding shared vehicle
- Comfortable vehicles
- Sustainable travel
- Reduced congestion
- Reduced noise disturbance
- Encourage walking
- Encourage cycling
- Many travel options
- Wide range of transport providers
- Options to fit with personal style and image
- Multiple payment options
- Return shared vehicles to locations different from pick-up
- Habit of single modality travel
- Habit of modalities being close to home
- Take into account personal circumstances
- Cheaper travel
- Available in remote regions
- Available in low income regions
- Easy to use interactions in digital component

5. MaaS from a philosophy of technology perspective

It is expected that the development and wide implementation of MaaS will have an impact on both individual users and society as a whole. This is because it is meant to largely replace the regime of owned mobility, which is deeply ingrained in society. Such a paradigm shift will inevitably have consequences. While some consequences may be intentional and desirable from the perspective of both operators and users, other more undesirable effects can also be expected to exist. This is particularly true for a development like MaaS, being an intervention in personal transportation, which is an integral aspect of people's everyday lives. As such, it is important to explore and understand these effects and influences, and to discuss their desirability for individuals and society. These reflections and insights are essential if MaaS is to be developed and implemented in a morally acceptable manner. In the following chapter, MaaS will be evaluated through the lens of philosophy of technology. The approaches to MaaS implementation, the goals of municipal governments, and the needs and requirements of users and society as a whole are reframed and assessed. In doing so, it becomes clear whether all goals and requirements are equally important and desirable for the public good. Moreover, these reflections result in new additions to the compiled list of user requirements of MaaS. Finally, they offer a first exploration of how governmental goals and user requirements for MaaS interact and relate to each other, in both positive and negative ways.

Two research sub-questions are addressed:

4. *What goals would municipal governments like to achieve through MaaS?*
5. *What are the requirements of users for MaaS?*

There is first a reflection upon the concept of MaaS as a whole using a prospective thinking methodology based on the Product Impact Tool. This provides insights into the impact of MaaS and its services upon the individual and society. These insights are in addition to those found and discussed in the preceding chapters 3 and 4 of this thesis. Following this, there is a more in-depth reflection upon the findings from the previous research, through the lens of ethical frameworks. These are structured around the answering of questions about the responsibility and morality of mobility interventions. Based on the results, the implications for the development and implementation of a MaaS system are discussed, and used to refine and add to the input for the design of the MaaS tool in part 2 of this thesis.

5.1. Reflection through Product Impact Tool

As a means of exploring and analysing the impact of MaaS and its technologies, the Product Impact Tool is used (Dorrestijn, 2012) (fig. 5). This tool presents twelve effects, ordered into four 'quadrants', that represent how products and technologies impact users and society. The effects are based in philosophy of technology and design for usability. Through an analytical methodology, the tool can be used to assess the impact of future technologies and services (Raub, 2017; Raub, Dorrestijn, & Eggink, 2018). This methodology is based on framing the studied technology through the twelve 'lenses' of the tool's effects. The results are therefore largely determined and argued from the assessor's perspective and viewpoint. The method does not include a value judgement regarding the desirability and acceptability of the impacts, as these would be de-

pendent on societal norms and values at the time.

The consequences that can be expected from MaaS have in this study not been extensively explored beyond the literature in chapter 2. Analysis with the Product Impact Tool can therefore provide new insights. In the following, the tool's analysis methodology is used to study the interactions between users and MaaS, and MaaS' and its technologies' impact on users and society, based around the twelve effects. Each quadrant and its effects will be discussed in turn.

5.1.1. Before-the-eye

The before-the-eye quadrant describes products' influence on users' cognition, affecting them through their senses. Through this path, the decision making process of the user is manipulated. Included in this quadrant are aspects like usage cues, persuasive elements, and a product or brand's image and its viability for reinforcing the user's image.

Guidance

The guidance in MaaS primarily occurs through the system's digital platform, where the user can see their route and what modalities are available. The user has a need for clear and useful information, which can become a great challenge due to the complex and confusing nature of mobility networks, and the varied options that are available. Cues need to be available for how the digital platform is used to plan and book the user's trip. Outside of the platform, the service needs to make sure that there are also sufficient cues implemented for the modalities that are

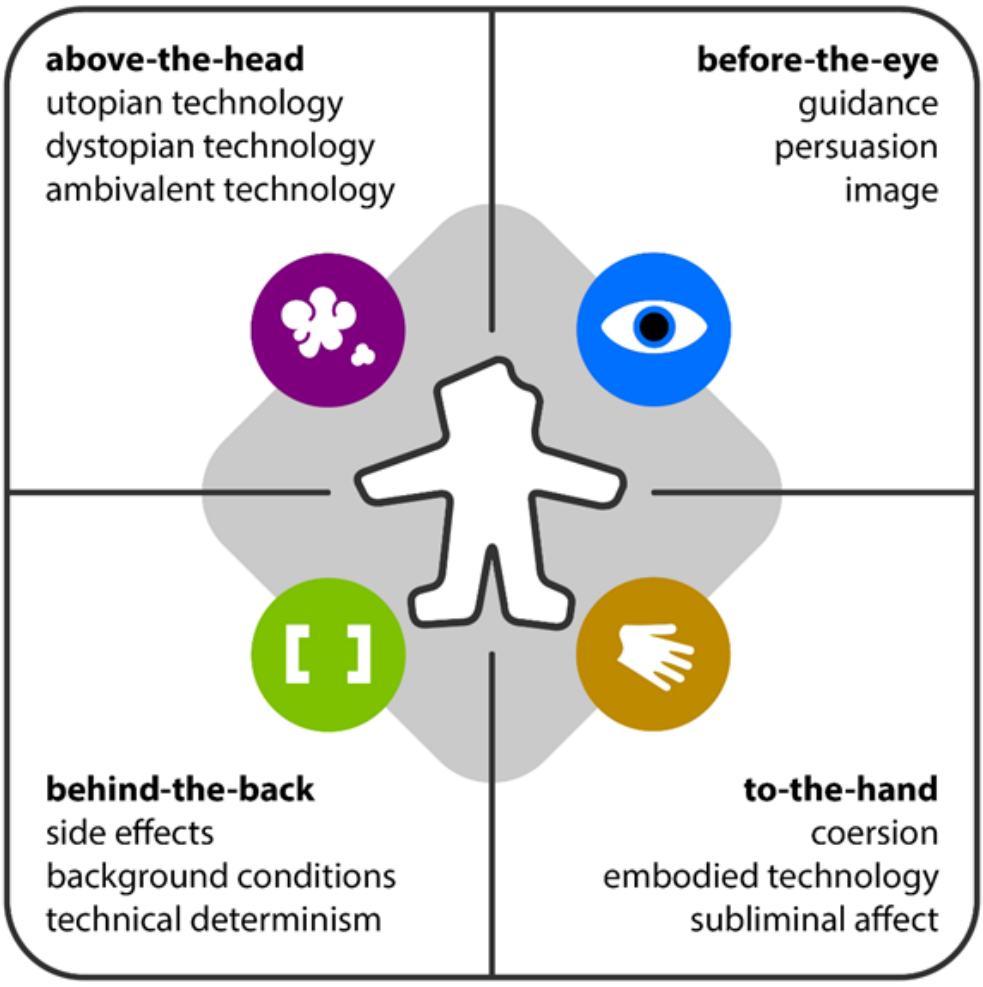

Figure 5 Product Impact Tool (Dorrestijn, 2012)

involved, and how they are to be used. Users need for example information on how to open the lock for a shared bike or car, how to recharge the battery of a rented e-vehicle, and how to scan their purchased ticket to enter a bus or train station.

Persuasion

Governmental bodies that plan on having MaaS implemented in their region will likely have larger social goals they will wish to meet, for which persuasion will play an important role to achieve the needed and desired travel behaviour. They might for example favour specific modalities, or want journeys to take place as sustainably or as efficiently as possible. Private commercial parties involved in the system will likely be oriented by financial gains, and therefore want modalities and journeys that are profitable for them. Either way, there are persuasive elements in MaaS that operators can use to have a desired effect on user behaviour. By ranking travel options, the system can suggest to the user which one is 'best' for them. There is also the potential of giving financial incentives, by making certain modalities and options cheaper compared to others, thereby encouraging users to pick those. There are some elements that operators have less control over but can still have a persuasive effect on the user, such as the speed of a particular trip option, or its sustainability, both of which can be reasons for one option to be chosen over another. Operators could still have a comparatively minor influence here, through the way the information is presented, such as how prominently it is shown that a certain trip is faster or more sustainable than another.

Image

The general intended image of a MaaS system would be one of convenience for the user. Operators will want to position their product as making personal transport easier and more effective for the end user. Hypothetically, a service could try to leverage a 'green' image, by emphasising elements of sustainability, such as theoretical reductions in car usage and congestion. The users themselves can use the services to make themselves look more progressive and innovative, by eschewing classical systems of ownership and instead relying on shared service-systems. They could moreover use MaaS to gain access to mobility options that correspond to their personal image or the image they want to exude, for example by driving a particular type of car, riding a bike, or moving from place to place on an e-scooter.

5.1.2. To-the-hand

The to-the-hand quadrant comprises effects by which the user's behaviour is directly influenced, circumventing their (conscious) decision making. These effects change or restrict users' routines and practices. They enforce a particular kind of usage, insert themselves into daily routines, and try to change behaviour subconsciously.

Coercion

The options for mobility available to the user is going to be limited by which mobility providers the operator has agreements with, thereby restricting the choices that can be made. To achieve certain societal goals like sustainability, a MaaS operator could theoretically actively leave out or restrict certain types of travel and modalities, forcing users to make use of those the operator wants them to use. In the case of the modality providers, such as companies offering shared vehicles, they can coerce users to make use of the app if they wish to access the mobility offerings, if there is no other way for the services to be used.

Embodied technology

The idea behind MaaS is that it will be seamlessly embedded into the daily travel behaviour of its users. It aims make it a part of people's routines that whenever they need to go from one place to another, they check the MaaS product for how to do it, and then continue using the product to fulfil the planned trip. To achieve this, the services need to be top-of-mind in regards to user awareness, and the services need to be usable quickly and effortlessly. This is achievable, but will require good interconnectivity between the service components, and a seamless interaction between product and user.

Subliminal affect

The operators of MaaS systems could subliminally affect travellers to ensure they will make use of the services, and even use them in a specific way. Generally speaking, this will involve making people subconsciously associate the usage of MaaS with positive feelings. To do so, the planning and ticketing aspect of the service should be quick, easy, and moreover enjoyable. Even more important is that the vehicles that are offered need to be nice and comfortable to travel with. For example, buses need to be comfortable and enjoyable to sit in, rentable cars should be fun for the user to drive, and shared bikes should have proper seats that are easily adjustable. For further effectiveness, these modalities should moreover be equipped with features such as good brakes, air conditioning, and the option to listen to music. In order for a particular user behaviour to be subliminally stimulated, the services' platforms could use techniques like priming, by for example listing particular types of travel options as the default or as the first in a list. The options listed above for subliminally stimulating general use of the services can also be applied to illicit desirable travel behaviour, by making certain options more comfortable and enjoyable than others.

5.1.3. Behind-the-back

The effects of the behind-the-back quadrant are comparatively more indirect, as they have a more general and societal impact, as well as describing the effect that society and the environment have on technology. Included are the societal side effects of MaaS, the background conditions that will need to be met for it to function effectively, and its relation to the concept of technical determinism.

Side effects

As a result of the introduction of MaaS, larger societal consequences will occur, some of which may be intentional and others unintentional. The GNMI (2018) lists a few examples of effects. Included amongst these is the improvement of accessibility of outlying areas, an increase in social cohesion because of shared vehicles and traveling together, and a higher efficiency of vehicles and infrastructure. Related to this last point is also the potential decrease in emissions, and therefore higher sustainability. This can however be contrasted with the assertions made by Pangbourne, Stead, Mladenović, and Milakis (2018), who suggest there may be a 'rebound effect'. Users could feel inclined to make more use of mobility such as shared cars and taxis, in order to get all the perceived value from their monetary investment in a service. As such, MaaS could increase, rather than decrease, the amount of traffic taking place. Similarly, something the GNMI report does not list is that an improved accessibility to mobility, for a wider group of people, could also lead to an increase of vehicle usage. Again, this would have a negative effect on sustainability and the environment. Moreover, the services could have a cultural impact, by making mobility easier and more accessible, and thereby enabling people to make more (relatively local) trips, which could in turn encourage them to visit more cultural institutions. Simi-

larly, lowering the bar for transportation could encourage users to visit their friends and family on a more regular basis, which plays further into the earlier mentioned social cohesion. A larger side effect that many municipal MaaS initiators hope for is a decrease in owned vehicles, such as personal cars and bicycles, which would hypothetically put less pressure on infrastructure, demand less parking space, and reduce the environmental impact of production. Lastly, a side effect could be that users will be enabled to more proactively and consciously choose how they wish to travel and why. If the platform allows for it, MaaS can show them different options for a journey, each with their own advantages and disadvantages, such as speed, sustainability, and effort. Users can, based on this information, more easily choose what values they deem most important, and act on those values.

Background conditions

For MaaS systems to be successfully implemented, there are a series of background conditions that will need to be met. First, the platforms will rely on quick and effective data collection and communication, which will in turn demand sufficient data-infrastructure. The systems will need to be able to 'know' when public transport modalities will arrive at and depart from their stops, and whether shared vehicles like cars and bikes are available and where. Further, these data streams will need to interconnect, so that the systems can integrate and compare them. Second, since a large amount of potential MaaS concepts rely on apps on phones to serve as their interface with users, these systems will not only require their user to own a suitable phone, but also for that phone to always be connected to the overarching system, likely through the internet and mobile data. Relatedly, this may mean that MaaS' usability and viability will decrease in places with low phone signals, such as remote or underground areas. Third, there will need to be a shift in consumer mentality. They need to become willing to give up a degree of control over their mobility, by coming to rely on the transportation that MaaS can give them. User will need to trust that when they require for example a bicycle that the system can provide them with one. On the part of the MaaS operators, they will in turn need to earn this trust from users. A fourth condition to be met is organisational. For MaaS to adequately function, agreements will need to be set up between operators and multiple different mobility providers. This will require a strong organisational framework for all connections to be maintained, and each party needs to be accountable for fulfilling their duties.

Technical determinism

Concerning the subject of the steering role of technology in society, MaaS can be considered to prescribe how humans are meant to move from point A to point B. Users can become reliant upon the systems to tell them how they should travel to their destination, and moreover need the platforms to complete the suggested journeys. As such, MaaS can come to be an integral part of society and of traveling. A second deterministic aspect of MaaS is the role it plays in a larger shift from an owning economy to a sharing economy. The introduction of MaaS is a change amongst others that aims for a societal transformation from ownership to usership, wherein most products that people use are shared with others rather than owned as one's personal possessions. When it comes to societal values, the notion of independent travel would be somewhat changed by MaaS, as it becomes less about a person themselves choosing how they wish to travel, and more about them being able to receive transportation whenever they desire. More importantly, MaaS will likely have an impact on how people relate to the vehicles they drive, particularly when it comes to shared vehicles. At present, when people own their own cars and bicycles, they can sometimes build an arguably affectionate relationship with their vehicles, be it only psychologically or going so far as to modify and customise a vehicle to fit their personal desires. The rise of shared mobility largely removes this potential, as people

no longer feel that affectionate connection, as they no longer can consider those vehicles to be truly theirs. And so MaaS will certainly bring an important change there. MaaS would moreover likely affect the meaning and image of public transport and shared mobility, as it tries to make those types of travel the norm, and the way in which most people fulfil their basic transportation means. Lastly, there is an arguable change in the meaning and existence of the travellers as humans. MaaS turns the people who make use of it from free agents that choose their own way and routes, into almost pieces of data or cargo that are to be moved from one place to another by the most efficient, or fast, or sustainable route, rather than the route that they would themselves truly want. Even when the system gives them multiple options, there will inevitably be options that are left out of consideration, be it for practical, economic, or societal reasons, even if a particular user may well like to use one of those other options.

5.1.4. Above-the-head

The above-the-head quadrant contains three perspectives on whether the impact of a certain technology, and of technology as a general concept, can be seen as positive, negative, or neutral for society and the world. The lenses that these perspectives provide have been used to explore how MaaS can result in a more utopian or dystopian world, and how a balance can be found between these extremes.

Utopian technology

From a utopian viewpoint, MaaS has the potential of making wide transportation available, accessible, and affordable for everyone. No one will need to own their vehicles again, resulting in far less vehicles being on the roads, making the mobility system both more efficient and more sustainable. There will be less economic inequality. Governments will be able to fulfil their ambitions for efficient local transport. No longer having to worry about how to travel will take a large amount of mental pressure off of humans, resulting in happier and less stressful living. They will feel encouraged to make more trips, which will have a positive impact on cultural standing, and they will visit more often with friends and family, improving social connections.

Dystopian technology

A dystopian perspective of technology would indicate the larger societal risks of MaaS. By lowering the barrier to entry, MaaS will result in more people making use of the transport system, specifically through personal modalities like cars and bikes, thereby increasing the amount of congestion at busy traffic points. Many people will be unwilling to give up their own vehicles, which will result in shared and owned vehicles having to coexist at the same time, which means there will be more parking space needed for cars, scooters, and bicycles. The technology moreover compromises human dignity, by turning its users from free and autonomous agents, into mere cargo that is to be transported based on guidelines that the higher operator sets. People will lose their freedom and independence, and be robbed of their bond with their vehicles.

Ambivalent technology

Balancing the utopian and dystopian perspectives by way of an ambivalent frame, one can see some of the opportunities and challenges that exist for MaaS. To be sure, the systems can ensure that more people are able to travel from one place to another on a regular basis. However, the platforms need to be programmed in such a way as to ensure that transport is still effective and efficient. The value of personal freedom will need to be kept in mind so that users are enabled to use the technology to travel further and more regularly, resulting in cultural and social improvement, while also not forcing them to give up on their autonomy in choosing how

and when they wish to travel. The system will need to respect human dignity, and keep its users in control of their own lives and their own mobility. Particular care will need to be taken with regards to the question whether people should still be able to own their own vehicles, balancing the advantages like the personal freedom and affection those vehicles provide, with the disadvantages such as the detrimental effects on environment and on parking spaces in urban areas.

5.2. Ethical reflections on MaaS

The nature of how MaaS could develop, the governmental visions and plans that drive that development, and the user requirements that make it usable, raise moral concerns as to the good and the bad that MaaS can do. The ubiquity of mobility and transportation in human life means that interventions can have far-reaching effects. Governments and people working on mobility and MaaS make decisions that have a moral impact, meaning they themselves are moral agents (Shannon, 2006). As such, there is a need to assess the moral opportunities and pitfalls of MaaS and the previous findings on the governmental and user perspectives. Only then can a system be designed that is truly beneficial, and that aligns with our human values. To this end, the following section discusses four moral questions about MaaS. These questions are based on normative ethics, as described by Kagan (1998). Answers are sought through the lenses of ethical frameworks and theories.

5.2.1. Who may be benefited?

From a consequentialist standpoint, beneficence is contingent on an action's capability for promoting wellbeing (Kagan, 1998). This refers to the wellbeing of both individual persons and of groups. The primary general groups that would ostensibly be benefited by MaaS are the users. They will be given new options, and their travel will possibly be made cheaper, faster, and more comfortable. However, for a person to be a user of MaaS and thereby benefited by it, it needs to be truly available and usable for them. The availability of a service to a particular user is in turn dependent on the implementation and target group that has been chosen for it. Based on desert theory (Feldman & Skow, 2015), certain user groups are more deserving of being helped by MaaS than others. Those currently lacking mobility, that is to say those with mobility poverty, could be provided for with MaaS. Notably, amongst the municipalities studied in chapter 3 of this thesis, only Rotterdam explicitly mentioned an intention of dealing with this issue. Nonetheless, governments have a moral obligation to help these people (Anciaes & Thomopoulos, 2014). Similarly, solitary people living in social isolation may be benefited if providing door-to-door transportation is actually achieved. Their social inclusion would increase, by allowing them to travel more and to visit other people regularly.

Besides the users, there are other potential beneficiaries. MaaS would allegedly lead to more efficient and sustainable transportation taking place. This would be beneficial for the environment, and by extension for society as a whole, as a means of combatting climate change. The operators of the services will be financially benefitted from users' subscriptions and payments. These operators will likely be commercial private companies, considering the vast majority of governments discussed in this thesis intend to merely take a facilitating role in MaaS. The transport providers with whom agreements are made to be part of the service will likely see more use by travellers, as a result of wider endorsement. They would be giving up a part of their relative profits, as these get split between them and the service operators. It does however appear likely that on the whole, being part of MaaS is a net positive and more profitable for them.

5.2.2.Who may be harmed?

A morally benevolent MaaS system should not cause harm to undeserving people. There is a realistic risk of harm being done, if one looks at the governmental MaaS visions. Enschede for example indicated that they wish to try out new developments, and see along the way which obstacles show up. This means they may implement mobility policies without considering all the potentially harmful consequences ahead of time. If harm were to occur, it will be difficult for the government to observe this as a direct result of its policies, and it will be even more difficult to reverse the harm that was done.

As a result of mobility changes related to MaaS, vulnerable groups may be disadvantaged if they are not taken into account during development. If MaaS reaches widespread use, people will be reliant upon being included in the service to be able to participate in society. Exclusion from MaaS can therefore have greatly detrimental effects on a person. Those with mobility poverty could have their current access to what little mobility they have be reduced, if not outright losing it. Other people may be incapable of using the service. They may be aversive to technical systems like apps, they could lack a suitable phone, or they desire to not share unnecessary personal information. People may also get excluded as a result of payment options given. Apps like Whim require a user to have a credit card in order to use their services. People who do not have a credit card are thereby excluded from the service. Within the Netherlands, the majority of consumers does not possess a credit card, and those that do still prefer other payment methods (Kosse, 2009). More importantly, certain people are unable to get a credit card, as they are not eligible. Their income could be too low, or they could have outstanding debts. Ineligibility due to such circumstances also makes a person more likely to be dealing with mobility poverty, making them all the more important to be taken into account. It is harmful to consider all these types of users as merely secondary or as edge-cases (Monteiro & Castillo, 2019). All this contrasts interestingly with the intentions of Utrecht, indicated in its MaaS pilot and interview. Utrecht is focussing its services on high-income people with one or more cars. This target group is far less likely to be vulnerable to harm as others. Such targeting can cause vulnerable users, who are reliant upon the services to live their lives, to fall by the wayside.

In contrast to transport providers who become part of MaaS being benefited by its development and implementation, those with whom no agreements are made could suffer harm. They would get excluded from the service system that is used by nearly all travellers. As a result, they would have fewer users, and their profits would decline. Moreover, there is also a potential health risk involved for users, if door-to-door mobility is achieved through MaaS. Modalities such as walking or cycling may have reduced visibility in a service. This can be particularly true since the commercial institutions that operate the services will see fewer profits from travellers walking or cycling, than they would from other modalities. A user will also be less likely to walk or cycle to a bus stop or train station, if they also have the option of getting a taxi that could fulfil their whole journey, as part of their MaaS subscription (Pangbourne, Mladenović, Stead, & Milakis, 2019). This could relatedly also have a negative impact on sustainability, thereby infringing upon humans' universal right for environmental justice (Rawls, 2009).

5.2.3. How could it be abused?

Keeping in mind the potential good and harm that can be done by MaaS, it is imperative to consider how certain parties could intentionally abuse their position in the system to benefit themselves further and bring harm upon others. As a result of the prevalent intention amongst governments to serve as only facilitators, private companies could be taking a leading role in

operating and developing MaaS. Through rhetoric and promises, the companies emphasise the benefits that MaaS has to offer and the good that it can do. However, the accuracy of this rhetoric is at times debatable (Pangbourne et al., 2019). These companies will likely want to raise their profits from the service, which could come at the cost of users and society. If no true checks and balances are put in place, there is a high risk of serious harm and abuse being committed. Therefore, it is valuable to explore the possible results of entrusting MaaS to actors with potentially impure intentions and values, without proper oversight by government. It should be noted that though these possible abuses are here ascribed to commercial companies, they could also occur if for example governmental institutions serve as service operators. The motivations of such actors could be different, namely less focussed on profit, but this would not make the outlined abuse opportunities acceptable, nor reduce the need for checks and balances.

As Pangbourne et al. (2019) argue, commercial MaaS operators could use the systems to maximise mobility and movements taking place, rather than minimising it as is the intention of governments. This would have a detrimental effect on through-flow in cities, and on sustainability and the environment. They could design their services to encourage users to choose certain travel options that benefit themselves or a specific transport provider, even if the option in question is not to the benefit of the user or society. There is also a risk of the service using an exorbitant amount of data sharing, gathering, and trading. Under the pretence of creating a personalised user experience, that gives travellers suggestions that fit their individual needs, the service would require a large amount of personal data about users. This data gathering could then be exploited by the operators to benefit themselves at the cost of the wellbeing of the users to whom that data belongs (Crawford, Gray, & Miltner, 2014; Monteiro & Castillo, 2019). In addition, certain users will be more profitable for service operators to target than others. Operators could choose to prioritise the service for these high-profit users, over that of less profitable users. As mentioned earlier, the exclusion of certain types of users can have a very harmful effect. Conversely, it is also possible that the vulnerable user groups will not be excluded, but rather exploited for their vulnerability. If a person is fully reliant on the system to be able to go to work, provide for their family, and meet their social needs, then the operators have much power to make that person for example pay more for the service or to give up additional data.

5.2.4. How could it be (un)just?

The previous section has outlined the potential for abusive behaviour by MaaS operators to benefit their own ends to the detriment of others. There is a power disparity, as operators can use the system to profit from users' reliance on mobility, and from the gathering and use of their personal data. This disparity means an unfair distribution of power and of resources, and it is thereby unjust (Rawls, 2009). There is moreover also a general power disparity between the users and the mobility system as a whole, that is exacerbated by MaaS. People are reliant upon mobility options to live their lives. Within the current system, they do not always need the help of an external actor or service to fulfil their needs, as they can ride their own bike and drive their own car. Certain visions of MaaS intend to change this model, aiming for travellers to give up their owned modalities and instead fully rely upon shared and public vehicles. In other words, such a MaaS vision would reduce the independence and power of the individual travellers, making them further dependent upon the systems to fulfil their needs. An objection to this argument would be that the travellers are also fairly reliant on the larger system within the current model of owned vehicles, particularly in regards to cars. Driving a car is only possible if the proper physical infrastructure of connected roads is in place. There is furthermore also a dependency on fuel, and the infrastructure that provides it. As such, there is already an existing

power disparity. That said, road and fuel infrastructure are subject to government oversight and regulation, which are used with the intention to ensure everyone in society is fairly provided for.

The question then becomes how MaaS could be applied in a just, acceptable, and benevolent manner. It is clear that governments will need to do more than simply facilitating the work of commercial service providers (Pangbourne et al., 2019). They will need to take an active, or at least supervisory role in the system. As mentioned earlier, governments could also abuse the system and cause harm, both intentionally and unintentionally. However, they are comparatively more subject to public accountability than a commercial organisation would be. The three scenarios developed by Smith et al. (2018) offer an exploration of the options available for how the public sector could position itself in MaaS. The 'market driven' scenario comes fairly close to the vision of municipalities to only be facilitators. It has the public sector only taking care of public transport modalities. The roles of integrating the various transport offerings and of packaging and operating the service are given to commercial companies. While this scenario could enable faster innovation, it also has the risks of the harms and abuses described earlier. The 'public-private' scenario makes the public sector also responsible for integrating both the public and private transport offerings. Private commercial actors would still be the ones operating the actual service. The public sector is thereby positioned between the private service providers and the private and public transport providers. This could enable them to mitigate somewhat the power and risks for abuse on the part of the commercial companies, while still giving opportunities to benefit from the companies' expertise and innovative capabilities. The third scenario, called 'public-controlled', has the public sector act as both integrator and operator of MaaS. They would themselves develop and implement the systems, and provide the combined public and private transport options to users with advice and directions. This positioning would give governments the most control over the system, offering the best opportunities to work towards the public good and have the most beneficial effect on society. This would however sacrifice some of the flexibility that private actors have to adjust to user needs and wishes. Moreover, it could be unfeasible for governments to get actively involved to such a degree, as a result of their other responsibilities and projects taking up too many resources. Nonetheless, it is advised that the municipal governments get involved with the services in some way, through active participation or through concession agreements. By doing so, the opportunities for a fair and just MaaS system dramatically improve.

5.3. Conclusions

The evaluation of MaaS through the lens of philosophy of technology has offered useful insights for developing and implementing a desirable, effective, and responsible system. Analysis by way of the Product Impact Tool has explored the potential effects of MaaS on individual users and on society as a whole. Persuasive and coercive features, such as ranking or restricting the given options, should be applied to achieve the changes in travel behaviour that are needed for the goals set by governments. According to the results on the left side of the tool, it remains dependent on specific implementation whether MaaS will have a positive or negative effect on goals like sustainability. This is because MaaS could lead to more transport taking place, which can have a detrimental effect. To make the services possible, data-infrastructures will need to be in place to take care of all communications, and there is a need for trust between users and service providers. The deterministic potential of MaaS is that societal norms and values may change, including a shift in the meaning of the human user within the system. These effects need to be evaluated to ensure they are acceptable and desirable.

The ethical reflections have explored more in-depth both the beneficial and harmful potential of MaaS, how the systems could be abused towards unjust ends, and how a degree of justice and benevolence can be ensured. The primary factor in this is that the right type of travellers should be targeted and benefited by the services, for example people dealing with mobility poverty or solitary people. If there were to be harmful consequences of a MaaS product, such as exclusion of travellers that are reliant on current mobility offerings, the operators may not realise in time to act. It is therefore important to consider these factors before MaaS is introduced to replace the current system. The inclusion or exclusion of particular transport providers can also be beneficial or harmful, both for the users and for the concerning providers. There are risks that commercial actors could exclude or exploit vulnerable users, to fulfil profit-driven goals. This would lead to an unjust system. To counteract this, it will be necessary for public actors, namely government, to actively involve themselves in how the service is operated. This is contrary to the intentions that many municipal governments at present appear to have. The governments will either have to position themselves as participating actors in MaaS, or they have to put accountable checks and balances in place to mitigate the risks. They need to understand how the system works, and ensure that it is used to further the public good. This will require effective oversight.

5.3.1. Additional user requirements

Based on the results of the philosophical evaluations in this chapter, there are additional user requirements that are added to the compiled list in chapter 4. These requirements will be used as well for the design of the MaaS tool.

To be optimally beneficial for society as a whole, MaaS needs to be available for everyone. This includes all types of users, regardless of age, income-level, or physical ability. This is not only a matter of physical availability, but also about removing the systemic barriers to entry to the service's offerings. Relatedly, it is important that MaaS is made available in remote regions and available in low income regions. This will aid in the general availability for all users, as well as lower the risk of 'edge-case' users, like those with a low income or those living remotely, being excluded. To support users who do not possess the most recent technologies such as smartphones, whether due to for example economic concerns or by choice, the digital component should not be reliant on the most modern technology. This will again improve the inclusiveness of MaaS, thereby being more morally appropriate.

Answers to research questions:

4. What goals would municipal governments like to achieve through MaaS?

The findings in this chapter have certain implications for the goals that governments might like to achieve with MaaS. There are mainly uncertainties whether MaaS is truly assured to have the immediate impact that certain municipalities expect. This can firstly be attributed to a potential rebound-effect, wherein MaaS will actually increase the amount of transport taking place. This will have a detrimental effect on goals like sustainability, reduced congestion, and reduced car use.

There are advantages to vehicle ownership. There is firstly the emotional bond that certain travellers have to their vehicles. Owned mobility moreover offers personal freedom, and independence from a digital system. These advantages could be incongruous with governmental goals like reduced car use and reduced vehicle ownership.

From a moral standpoint, the ambitions of municipal governments should include maintaining availability and inclusiveness. These are already represented in the list of government goals developed in chapter 3 of this thesis. However, it may be necessary to prioritise these goals above others.

Finally, the plans of certain governments to take a hands-off approach to MaaS could be untenable, due to the risks involved with giving control of the systems to commercial providers. Governments will therefore need to get involved and provide oversight, to ensure MaaS is used to societally desirable ends, and reduce the risks of abuse by operators.

5. What are the requirements of users for MaaS?

MaaS will have an impact on how people live. Values like independence will be changed. The emotional bond that travellers have with their vehicles could be severed, as they no longer feel true ownership of those vehicles. The choices given to the traveller will inevitably have limitations. It needs to be assessed whether these changes are desirable, or if precautions need to be put in place.

Based on the moral concerns for availability and inclusiveness, the following requirements are added to the list that has been developed in chapter 4 of this thesis:

- Available for everyone
- Available in remote regions
- Available in low income regions
- Digital component not reliant on modern technology (e.g. new smartphone)

Part 2

Design of a MaaS Tool

6. MaaS tool concept design

Part 1 of this report studied both the governmental and user perspectives on MaaS. The governmental perspective shows the goals for mobility that MaaS can aid in fulfilling. Conversely, the user perspective indicates the requirements that need to be met for the service to be effective and accepted by its users. To connect these two perspectives, and to give insight into the challenges and opportunities that the relations between government goals and user requirements pose, a tool is developed. This tool is designed to support researchers and policymakers working on MaaS to set the requirements that need to be met, understand the apparent challenges, and determine possible solutions.

For the sake of clarity, and to distinguish them from the end-users of MaaS who have been designated as 'users' throughout this thesis, the users of this tool are from hereon referred to as 'policymakers'. It should be noted that the users of the tool nonetheless also include persons like researchers and (external) policy advisors.

Four research sub-questions are addressed:

6. *Which government goals and user requirements of MaaS complement each other?*
7. *Which government goals and user requirements of MaaS conflict with each other?*
8. *Which government goals and user requirements of MaaS are undetermined in their relation to each other?*
9. *How can policymakers use the relations to incorporate user requirements into their goals for MaaS?*

In this chapter, the development process of the MaaS tool is described. The tool has meet certain requirements itself to viably offer added value for the process of MaaS policy development. In chapters 3, 4, and 5 of this thesis, two lists of parameters were determined for government and user. For the tool itself, these parameters are placed into a matrix where their relations to each other are determined and illustrated. The visions and heuristics used for assessing the relations are described, as well as how new parameters could be inserted into the tool. This process results in a basic conceptual tool. Finally, the method for how this tool could be used by policymakers and advisors is explained.

6.1. Requirements for tool

The tool that is designed will support policymakers in their decision making regarding MaaS. It will have to offer them some type of added insight into the challenges and opportunities that arise from how their particular goals for MaaS relate to the wishes and needs of the future users, their residents. To do so, it will have to succesfully represent the findings of part 1 of this thesis, and communicate those findings effectively and coherently to policymakers. Moreover, for policymakers to be interested in accepting and using the tool, it will need to offer them both (perceived) ease of use and (perceived) usefulness (Davis et al., 1989). To this particular end, the following set of requirements has been determined that the designed tool will need to fulfil:

1. *Clear in communicating the purpose of the tool*
2. *Clear in communicating how goals and requirements relate to each other*

3. *Clear in explaining why goals and requirements relate a certain way*
4. *Clear in communicating how the tool is used*
5. *Induce thinking about challenges that could appear when implementing MaaS*
6. *Induce thinking about solutions to the challenges of implementing MaaS*

These requirements are used again in chapter 7 this thesis to evaluate the first concept of the tool. The evaluations of the requirements are then also used in chapter 8 to improve upon the tool with a new iteration.

6.2. Parameters and relations

The findings described in part 1 of this thesis indicate the range of governmental goals that a MaaS product can take a role in, and the user requirements that need to be met for a MaaS product to be successful and user-friendly. These findings were formed into two lists of parameters, shown in the conclusions of chapters 3 and 4, with additions being made to the list of user requirement in the conclusions of chapter 5.

6.2.1. Tool contents

Having determined these parameter lists, the relations and connections between the two categories are investigated. To do this, the parameters from both categories are first placed onto opposing axes on a matrix. The goals of government are placed on the horizontal axis. The user requirments are placed on the vertical axis. Following this, each combination of governmental goal and user requirement is assessed and given a colour based on whether they have no relation (grey), a complementary relation (green), an uncertain or risky relation (yellow), or an opposing relation (red). These relations refer to mobility systems, services, and paradigms as they exist currently or the way they are expected to develop in the current trajectory. Changes in the system would therefore result in the relations changing, for example changing a risk into a complementary one. The resulting matrix for the first iteration is shown on the following pages. This matrix is also the first rough draft for the MaaS tool itself.

The text in the coloured cells of the matrix provide underlying arguments for why the particular relation is assessed as such. This is done for relations where it is deemed not immediately obvious why a certain goal and requirement would interact a certain way. The size of a specific cell within the matrix therefore has no inherent meaning, as it is merely dependent on how extensively the concerning goals, requirements, and arguments need to be described.

As the current list of government goals might not cover the full range of plans and ambitions that municipalities might have, new goals could be added onto the horizontal axis. Similarly, further research could reveal that there are additional user requirements. These could be added onto the vertical axis. If that were the case, the relations for those new goals and requirements would need to be determined.

6.2.2. Heuristics used for relation assessments

The assessments are based on the insights and intuitions that have resulted from the research in part 1 of this thesis. Nonetheless, there is still a subjective component to the process. As such, it might be that a different assessor will decide on different relations between the parameters.

Government goals →

User requirements ↓

	Reduce car use	Increase bicycle use	Increase public transport use	Increase walking	Chain mobility	Reduce vehicle ownership	Keep cars out of inner city	Electric vehicles
Available for everyone	Not everyone has the freedom to give up the car							
High coverage rate of shared vehicles					High coverage rate would encourage people to use more varied modalities			
Early reservation system					Travelers will be more interested in a multimodal journey if they can be assured there will be vehicles available for them			
Vehicles remain reserved while in use								
Quick and effortless set-up								
Payment occurs after finishing trip								
Refunding of accidental payments								
Faster travel	Car will often be fastest	Could be less problematic if city planning is such to make cycling faster in city	Dependent on connectivity of public transport, it could be time consuming	Walking is generally not very fast compared to other options	Greatly dependent on the journey. Chain mobility could make the trip faster but it could also slow it down			
Up to date information			If the user knows when and where public transport departs, they are more likely to use it					
Information on how much is spent			If user knows how much they are spending on public transport, they might trust it more					
Fast and easy booking	If the booking process is easy, user may be more likely to use it	If the booking process is easy, user may be more likely to use it	If the booking process is easy, user may be more likely to use it		If it is fast and easy to book a multimodal trip, it will be more inviting			
Fast and easy payment, possibly automatic					If it is fast and easy to pay for a multimodal trip, it will be more inviting			
Support user finding shared vehicle					Additional support for finding a shared vehicle will make it more inviting if the multimodal trip has a shared vehicle as part of it.			
Comfortable vehicles	In certain situations (rain, tiredness, seating, etc.), car is most comfortable	Could go either way, dependent on how comfortable the bikes are	Dependent on how comfortable the public transport vehicles are					Entirely dependent on the vehicle
Sustainable travel			Somewhat dependent on how sustainable the public transport vehicles are		Chain mobility is not in itself more sustainable, that is dependent on the actual modalities used.		Lowering traffic in inner cities could reduce how concentrated emissions are in a relatively small area	Keeping in mind that the electricity used would have to be sustainable as well, and the environmental problems of the vehicles' entire lifecycle cradle-to-grave
Reduced congestion								
Reduced noise disturbance			Could go either way, since trains are very loud, but buses are generally more quiet compared to a larger amount of cars but still louder than bicycles					Electric vehicles are generally somewhat quieter than non-electric
Encourage walking					Sort of, in that a multimodal trip will likely involve some amount of walking			
Encourage cycling						Somewhat undetermined		Available e-bikes might increase the amount of cycling
Many travel options	Reducing car use would involve removing an option available to the user		Public transport offers a variety of options		If combinations of modalities get considered, the amount of options likely increases			
Wide range of transport providers			Public transport includes different providers		A chain mobility trip will likely have multiple different transport providers offering parts of it.			
Options to fit with personal style and image	Car is often part of person's image and style	Could go either way, some people make cycling part of their identity	Certain people could make it part of their image to use public transport (e.g. for sustainability), though others may dislike the image of being a public transport user			On the one hand, making travelers give up their owned vehicles makes them lose part of their image and lifestyle. On the other, a rental vehicle system could allow them to always get a vehicle that fits their current needs and image		Electric travel could serve certain travelers' lifestyle and image (e.g. sustainability)
Multiple payment options								
Return shared vehicles to locations different from pick-up								
Habit of single modality travel	For long distance, single modality travel, the car is a popular choice	Bicycle could be viable for a single modality journey	A trip by public transport will often involve multiple modalities, including getting to bus stop/train station/etc.	Most trips are not going to be viable to do with only walking			Keeping the cars out of inner cities can necessitate travelers into and out of the city to switch modalities.	
Habit of modalities being close to home	Cars are a modality many people have close to home	Many people have a bicycle at home	Access points for public transport will rarely be as close to home as options like an owned bicycle or				For people living in the inner city, keeping cars away from there means they can no longer park it in close to home	
Take into account personal circumstances		Physical circumstance can prevent a person from being able to cycle	Not all public transport options are perfectly usable for everyone, for example those in wheelchairs	Physical capabilities can limit ability for walking long distances			For some people, there may be no other options than to travel by car	
Cheaper travel	Usage of a car can be fairly costly	Cycling is comparatively cheap	Public transport can be fairly cheap	Walking is free	It could be cheaper but it could also turn out to be more expensive, dependent on the journey in question	Entirely dependent on pricing scheme, compared to common costs of an owned vehicle.		Electric vehicles are (currently) more expensive than alternatives, at least initially. Fuel costs are generally lower.
Available in remote regions	For remote regions, cars are often most viable option	Cycling is not always viable in a remote area, dependent on distance	It is not always viable to implement public transport access points in remote areas, where use is comparatively low	Walking is not viable for traveling from a remote area to another area. It does work fine internally to the remote area.	Chain mobility is what is likely necessary to connect remote regions to others	Users in remote regions are generally all the more reliant on the dependability of having a vehicle owned and always available		
Available in low income regions		Cycling could be a cheap option for low income users	Public transport could be a cheaper alternative for low income users	Walking is a free travel modality	Low income users may not be able to afford using a variety of modalities (e.g. if each demands a service fee to start)	Low income users are often very dependent on the mobility options they have available, and an owned vehicle is often most dependable		Electric vehicles are (currently) more expensive than alternatives, at least initially. Fuel costs are generally lower.
Easy to use interactions in digital component								
Digital component not reliant on modern technology (e.g. new smartphone)								

Use available resources (e.g. vehicles) efficiently	Enable mobility where public transport is unfeasible	Make mobility affordable	Make mobility accessible for all segments	Clean environment	Be seen as innovative	Focus on internal travel	Focus on external travel	Interesting project for commercial companies	Be seen as dependable and trustworthy
				There is a boundary where too many shared vehicles leads to an unclean environment	Visibility of vehicles increases the innovative image		High coverage rate is challenging for the large area involved in external travel		
		If the system is less prone for accidental or unused payments, this lowers the costs that are made							
		If accidental (and unused) payments are refunded, it lowers the costs of general travel							
		It is somewhat connected, in that awareness on how much a traveler spends could encourage them to travel cheaper							
		Could possibly lead to more accidental payments occuring, particularly if payment is ahead of trip, thereby raising costs							
The vehicles in question (e.g. WMO vehicles) might have comfortability issues but also benefits									
More efficient use of the resources could make the mobility system more sustainable	This would likely lead to more travel taking place, and thereby more environmental impact		Raised accessibility could lead to increased mobility, thereby raising environmental impact		Could complement, but could also contradict, since innovative travel is not always sustainable			Commercial company could be more interested in increasing transport, thereby reducing sustainability	
	This would likely lead to more travel taking place, and thereby more congestion		Raised accessibility could lead to increased mobility, thereby raising congestion					Commercial company could be more interested in increasing transport, thereby increasing congestion	
	This would likely lead to more travel taking place, and thereby more noise		Raised accessibility could lead to increased mobility, thereby raising noise					Commercial company could be more interested in increasing transport, thereby increasing noise	
		Walking is cheap			Walking is not very innovative, image-wise		Unlikely to be viable for external travel	Walking is not profitable	
		Cycling is relatively cheap (compared to e.g. car)			Cycling is not very innovative, image-wise	Distances are likely to be lower for internal travel	Unlikely to be viable for external travel	Cycling is not as profitable as other options	
The vehicles in question are currently not 'visible' and usable outside their conventional use, so making them part of MaaS would give new options	There will likely not be many options available, but there could be more than at present		More options could lead to raised accessibility	Focusing on a clean environment would likely involve limiting the amount of available options					
	There will likely not be many options available, but there could be more than at present		More options could lead to raised accessibility					Commercial companies could be most interested in only having a limited amount of providers, to reduce competition	
The types of vehicles generally have a certain inherent image, but this image could well be an undesirable one (e.g. old, handicapped, etc.)				Certain lifestyles and image, and the accompanying travel options, will have a negative effect on a clean environment	Could complement the image of a user wanting to be seen as innovative themselves				
	For areas that cannot be accessed by public transport, it is more important that a user is allowed to leave their shared vehicle at a more freely chosen location	Allowing the return of a vehicle to be at a flexible location will likely lead to journeys being shorter (both distance and duration), thereby reducing cost		Allowing the return of a vehicle to be at a flexible location will likely lead to journeys being shorter (both distance and duration), thereby reducing environmental		Allowing flexible return location could be viable for the smaller area involved in internal travel	Allowing flexible return location could be very challenging for a large area	Flexible return could increase the burden on resources of commercial provider	
	It would possibly place mobility access closer to home than it is currently (at least regarding public transport), but it will not								
Using the available resources more efficiently could lead to lowered costs	Could be cheaper than what is currently needed in the areas			Cheaper will not always be better for the environment, but also not necessarily worse				Commercial company would want to make a high profit	
						People in remote regions would be getting ignored			
								Low income users could be less profitable	
					Not using the most modern technology could limit the innovative capabilities				

Legend

- Complementary
- Risk
- Conflict
- No Relation

The broad vision and heuristics used for this iteration of the matrix are described below, to substantiate the reasoning for the decided upon relations. Other assessors could use those same visions and heuristics when reevaluating the current relations, or those of newly added government goals or user requirements. This could lead to the same results, but also to different ones due to the subjective nature of the process. Alternatively, they could apply their own vision and heuristics, different from those used now, to develop new insights.

The first factor that is taken into consideration is that a conflicting or complementary relation between goals and requirements can be mutual or only unidirectional. Moreover, if unidirectional, the conflict or complement can come from either direction. What that means is that firstly, the goal of the government can benefit or hinder the requirements and wishes of the user. For example, a goal to reduce the amount of car travel taking place would benefit the wishes of users for less congestion on the roads. Conversely for the other direction, a user's desires as described by their requirements can benefit or hinder the goals of the government. An example of this would be that the desire for cheaper travel from users could make them open to schemes that favour cycling, as it is generally a cheaper modality than traveling by car.

It is also considered that relations between goals and requirements could be indirect. There could be multiple degrees of separation that lead to either positive or negative effects one way or the other. For example, the user requirement for implementing shared vehicles to have a high coverage rate does not directly oppose a government goal to ensure more sustainable travel. However, ensuring a high coverage rate requires the production of a large amount of vehicles. Moreover, to maintain the coverage rate, it could be necessary to regularly have vehicles parked in one location moved to another where they are more needed, increasing the amount of transport taking place. These two indirect factors combined lead to a risk for a negative impact on sustainable travel.

Another recurring factor in the current assessment is that improving the user-friendliness of the services can be expected to encourage users to use the system more. Dependent on the goals that are trying to be achieved, increased system use can be both beneficial and detrimental. For example, making the process for booking a ride as easy as possible will make it more likely for users to rent a bicycle if available, which would correspond with a possible governmental goal for increased cycling. Conversely, if it is fast and easy for a user to rent a car, this could conflict with a municipality that wishes to reduce the amount of car travel taking place.

It needs to be kept in mind that different types of users have access to varying amounts of resources. Not everyone will be able to fit all the criteria for using a conventional MaaS system, if the system is not designed to accommodate them. For example, if the municipality's goal is to reduce the amount of car travel and ownership in the region, solutions need to be found for those people who due to varying circumstances are unable to give up their car. Similarly, not everyone is able or willing to buy and use the latest phone or wearable technology, which necessitates that MaaS is also able to work with comparatively older technologies.

Psychologically speaking, the vehicles that people own can come to form an important part of their personal lifestyle and image. There can be a significant amount of emotional attachment. This can lead to difficulties if the municipality's MaaS system focusses itself on shared vehicles or on public transport. If such were the case, solutions would need to be designed whereby the users can use the service to also express their own identity and image, or to customize it to their personal lifestyle.

6.3. How to use the MaaS tool

The matrix shown can be used as a rough tool for studying the user-related challenges when developing MaaS with a particular societal mobility goal in mind. It indicates the relationships between governmental mobility goals and the requirements of the end-users of MaaS. Policymakers can select the goals that are relevant for their municipality and local vision. Comparing these selected goals to the requirements of users yields an array of challenges, risks, and opportunities. Broadly speaking, for MaaS to be successful, MaaS and its supporting infrastructure and mobility system should be designed in such a way that risky and opposing relationships are changed into complementary ones as much as possible. In addition, MaaS will be more successful if the service and system can highlight the existent complementary connections, strengthening the benefits it has for users and thereby encouraging use. In the following section, this method for using the tool is further explained, and supported by examples.

6.3.1. Choosing goals

Policymakers using the tool need to determine what goals they plan to pursue through MaaS. These are based on a municipality's pre-existing mobility vision. Since most municipalities will only pursue a limited selection of the goals described on the horizontal axis of the matrix, the columns of those that do not apply can be ignored and removed for the rest of the analysis. A municipality like Enschede for example might be most interested in reducing its car use and increasing the amount of people that cycle to work. Conversely, they may have no explicit ambition to make mobility more affordable or attracting commercial partners. Therefore, they can ignore the information for the goals they deem irrelevant. This results in a matrix that bears only the information that is needed for the specific municipality's situation.

6.3.2. Determining challenges, opportunities, and solutions

After choosing the goals, the tool can be used to compare them to each user requirement, showing where there might be risks, conflicts, and opportunities. The risks and conflicts are challenges that solutions would need to be found for in order to have MaaS be as successful and effective as possible. Notably, not all such challenges necessarily need to be overcome, as shortcomings in particular user requirements can be compensated for by strengthening the added value from other requirements. For example, though there is a demand from users for fast travel options, a MaaS product that does not offer truly fast options might still be deemed acceptable if it can offer significant comfortability in vehicles for users. The direct conflicts indicated in red will likely require quite extensive and long-term solutions to be solved or worked around, compared to the risks in yellow. In seeking such solution directions, the goal is to change the system and situation in such a way as to change the risk or conflict into an opportunity, that is to say from yellow or red to green. Once the broad challenge and direction have been determined, concrete solution options can be sought and designed. For example, there is an apparent risk a governmental goal for reducing car usage in the municipality might conflict with users' desire for fast and comfortable travel, as the car will often be the favoured modality for speed and comfort. To overcome this, the challenge will be to make alternatives for the car comparatively faster and more comfortable. Knowing this challenge, solutions can be designed, such as more comfortable bus seating, changing schedules to make public transport faster, and providing a high enough number of shared bicycles so that there is always one available.

To strengthen the potential of a MaaS product further, the pre-existing inherent opportunities of complementary government goals and user requirements can also be used. The relations

indicated in green are such complementary combinations. These offer opportunities to make users more favourable to using MaaS, by emphasising these traits in the service design and communications. For example, the municipality and service can emphasise that by reducing the amount of vehicle ownership in the region, the residents and users will benefit by having to deal with less congestion on the roads. Such emphasis could be designing the system in such a way that specifically vehicles that are used during peak travel hours are reduced, thereby lowering congestion during those times. Alternatively or in addition, the marketing and public communications for the service can focus on telling potential users that it will lead to less congestion taking place, thereby making those users more interested in taking part.

6.4. Conclusions

Based on the parameters of governmental goals and user requirements for MaaS that were studied in previous chapters of this thesis, a conceptual tool has been designed. The concept consists of a matrix wherein the goals and requirements are placed on opposing axes, and each combination is individually assessed. These assessments result in a combination being deemed unrelated, complementary, risky, or conflicting, and they are coloured accordingly.

The contents of the tool thereby provide policymakers with insights on the challenges, opportunities, and context of implementing MaaS in their municipality. This will help them in their decision making. When they are specifying their mobility plans and requests for (commercial) MaaS providers, municipalities at present do not always understand the full user context that is involved. Use of this tool will allow municipalities to already foresee potential challenges ahead of time. It will give them the needed understanding to oversee the work of the chosen MaaS provider, and intervene if that work results in an ineffective or unethical system.

The tool is designed to align with the set forth requirements, which were based on ensuring adequate perceived ease of use and perceived usefulness. Below, each requirement is addressed in regards to how the designed tool is deemed to fulfil it. Requirements that are not yet fulfilled are addressed through chapter 7 and 8 of this thesis.

1. *Clear in communicating the purpose of the tool:* The requirement for clear communication of the tool's purpose is not yet fulfilled through this initial concept, as it is dependent on how the tool is presented to policymakers, and on the design of a frontend interface.

2. *Clear in communicating how goals and requirements relate to each other:* The tool communicates how goals and requirements relate to each other by way of the colouring within the matrix.

3. *Clear in explaining why goals and requirements relate a certain way:* The textual contents of the matrix give the arguments for why a particular assessment was made.

4. *Clear in communicating how the tool is used:* The requirement for clear communication of how the tool is used is not yet fulfilled through this initial concept, as it is dependent on how the tool is presented to policymakers, and on the design of a frontend interface.

5. *Induce thinking about challenges that could appear when implementing MaaS:* The tool induces policymakers to think about the challenges that might occur when they try to implement MaaS, by visualising for them the apparent conflicts with the user perspective.

6. *Induce thinking about solutions to the challenges of implementing MaaS:* By providing policymakers with the information about challenges, the tool aids them to consider possible solutions that could be implemented.

Answers to research questions:

6. Which government goals and user requirements of MaaS complement each other?

This question is answered through the contents of the designed tool matrix, in the relations that are coloured green.

7. Which government goals and user requirements of MaaS conflict with each other?

This question is answered through the contents of the designed tool matrix, in the relations that are coloured red.

8. Which government goals and user requirements of MaaS are undetermined in their relation to each other?

This question is answered through the contents of the designed tool matrix, in the relations that are coloured yellow.

9. How can policymakers use the relations to incorporate user requirements into their goals for MaaS?

The designed MaaS tool gives policymakers insight into the challenges, opportunities, and risks from the relations between their goals and the requirements of users of MaaS. Use of this tool will allow municipalities to already foresee potential challenges ahead of time. It will give them the needed understanding to oversee the work of the chosen MaaS provider, and intervene if that work results in an ineffective or unethical system.

7. Evaluation of MaaS tool

To determine whether the designed MaaS tool has the intended added value for the decision making process of policymakers, two evaluation workshops are organised with mobility policy advisors at Keypoint Consultancy. During these workshops, hypothetical municipalities are described that plan to use MaaS to fulfil their goals for mobility in the region. Participants are given the task to determine potential conflicts with user requirements, and solution directions for those challenges. Based on the findings of the evaluation, the tool is further refined and improved in chapter 8 of this thesis.

By evaluating whether policymakers are able to use the tool to incorporate the user perspective into ideas for MaaS, one research sub-question is addressed:

9. *How can policymakers use the relations to incorporate user requirements into their goals for MaaS?*

In this chapter, the evaluation process and its results are described. First, there is a discussion of the goals of the evaluation. Second, the evaluation plan that is used is defined. Finally, the outcomes and findings of the evaluation sessions are detailed.

7.1. Tool evaluation goals

The goal of the evaluation workshops is to test whether the MaaS tool as designed fulfils the set requirements for (perceived) ease of use and (perceived) usefulness. In particular, it is evaluated to what degree participants are able to understand the purpose of the tool, and how it is to be used. A further question is if participants understand and agree with the assessments of how certain goals and requirements relate to each other. Finally, it is determined whether the tool can make the participants think about the potential challenges for implementing MaaS when considering the incongruities between their goals and the requirements of residents, and whether they would from there also be able to think about potential solutions. In addition to these main goals, notes are made throughout the workshops of further observations regarding the ease of use and usefulness of the tool for policymakers.

7.2. Tool evaluation plan

The tool is evaluated through a qualitative process in the workshops. Participants of the workshop are mobility consultants working at Keypoint Consultancy. These mobility consultants are not strictly speaking themselves governmental policymakers. However, they do belong to the broader group of potential users for the tool that have in chapter 6 of this thesis been defined under the term 'policymakers'.

The participants' response and use of the first iteration tool is assessed through a case study of a hypothetical municipality. Participants are deliberately chosen to have differing levels of experience, affinity with MaaS, and thematic expertise. Two workshop sessions are organised, with two groups of three participants. Each session is planned for a one hour duration, and takes the form of a presentation with intermittent tasks and discussions. Throughout the workshop, notes are taken on how participants respond to the tool, and challenges that appear in using it.

Below, the procedures of each section of the sessions is described in more detail.

7.2.1. Introduction to the project

To introduce the participants to the overall project and the purpose of the workshops, the sessions starts with a short summary. The project is explained as being about researching how to connect government goals to user requirements in designing MaaS. The need for this is framed based on current MaaS offerings failing to meet the needs and wishes of users, thereby being ineffective and unable to fulfil the ambitions and goals of municipalities. The goal of the project is described as the development of a tool to support policymakers in understanding the requirements of their residents, and how they can connect their own goals to those requirements.

7.2.2. Municipal goals

A case study is introduced of a hypothetical municipality, with four predetermined municipal mobility goals. The two evaluation sessions use different case studies. The case studies are broadly speaking based on existing municipalities that were researched as part of this project. The municipalities that the cases are based on are not mentioned during the workshops, to prevent preconceived notions. The case studies are as follows:

Municipality X (based on Enschede)

-Wants to reduce the amount of car use in the region

-Wants to increase the amount of bicycle use in the region

-Wants to do something with electric vehicles

-Wants to be seen as innovative

Municipality Y (based on Groningen)

-Wants to increase the amount of public transport use in the region

-Wants to reduce the amount of vehicle ownership amongst residents

-Wants to keep cars out of the inner city as much as possible

-Wants to ensure a clean environment

7.2.3. Initial challenges

The participants are at this stage asked to consider and discuss potential challenges that could occur when considering the above municipal goals from a usability perspective. This is done without the use of the designed tool. Participants have to themselves come up with possible user requirements, and how those might relate to the municipality's plans. This is done in the form of an open discussion, with open notes being written down centrally based on important comments and insights.

7.2.4. Introduction to the tool

At this point, the designed tool is shortly presented to the participants. It is described as an overview of potential government goals and user requirements for MaaS, and the relations for each combination. It is asserted that for MaaS to be successful, the service and underlying sys-

tems need to be designed such that the yellow and red squares are made green. The entire matrix of the tool is shown, after which the irrelevant government goals and user requirements are crossed off, as they are not important for the current discussion. This results in a compressed and more usable matrix, which participants are also given on a printed handout.

7.2.5. Challenges from the tool

From the compressed matrices, three challenges are chosen ahead of the workshop sessions to serve as examples. The reasoning behind this is that the process that is used for the three exemplary relations could be repeated for other relations as well, and to keep the time of the workshops manageable. The participants are given the task to determine how MaaS and the infrastructure could be changed such that these are changed from challenges (red and yellow) to opportunities (green). Participants first do this individually on a printed handout. Next there is a central discussion of ideas and findings, with again open notes being taken centrally of comments and insights that are deemed important. The participants are also asked to discuss ideas for concrete solutions to the apparent challenges, as well as consider who could and should take responsibility for implementing those solutions. The chosen challenging relationships for each session are as follows:

Municipality X

-Reduce car use	⟷	Comfortable vehicles
-Increase bicycle use	⟷	Available in remote regions
-Be seen as innovative	⟷	Encourage cycling

Municipality Y

-Reduce vehicle ownership	⟷	Options to fit with personal style and image
-Increase public transport use	⟷	Habit of modalities being close to home
-Clean environment	⟷	High coverage rate of shared vehicles

7.2.6. Discussion and closing

To close the workshop sessions, there is a central discussion of the tool and its underlying ideas and vision. Participants are asked to give any final thoughts on the posed case studies and the challenges that result from the tool. They are moreover asked for their response on the perceived usefulness and usability of the tool. They are encouraged to discuss these themes amongst themselves, and to give arguments for their opinions. This provides insight as to the openness for using the tool, and improvements that would need to be made in its content and presentation.

7.3. Results from tool evaluation

During the workshops, notes and photographs are taken to document the results. The results are used to evaluate whether the tool fulfils its requirements for perceived ease of use and perceived usefulness. They also offer insights to determine how the tool is to be improved and changed in chapter 8. In this section, the results and findings are described and discussed.

Participants appeared to be somewhat sceptical regarding whether municipalities ought to be concerning themselves with issues like user requirements. This indicates that the tool currently falls short at clearly communicating its purpose to policymakers. The given opinion is that government should only be facilitating MaaS. A commercial MaaS provider would then in turn need to design a system such that it corresponds with the requirements of users, to thereby build their business case. According to these participants, as long as there is a market for MaaS, private providers will be able to build a business for themselves. As such, the government should only give the rules, and not take influence into details like the comfort or look and feel of modalities. There is a fear that governments will be pulling more towards themselves than they actually want or need to achieve their goals. Such scepticism was particularly apparent during the first workshop session. The way the tool was presented was therefore slightly adjusted in the second session, with a bigger focus given on what policymakers can gain from the contents. This appeared to have some amount of success, as when asked participants in the second session were better able to explain why the tool could be useful for their purposes. Participants in both sessions were moreover able to understand how the tool can be used, to gain insight into the challenges between goals and requirements for MaaS.

The tool is successful at showing how specific governmental goals and user requirements might relate to each other. Participants understood what type of relation the colours in the matrix signified, and what this meant for implementing MaaS. There were however disagreements about specific assessments that had been made for certain goal and requirement combinations. One participant for example believed that cycling is a fairly innovative modality, and therefore a potential user's desire for cycling is not in conflict with a municipality's goal for being considered innovative. These results imply that while the tool manages to clearly communicate how goals and requirements relate, it does not yet always convey successfully why they relate in that way. It is therefore necessary to review how certain relations were assessed for the first iteration, and potentially change these for an improved tool. Moreover, the arguments that explain particular relations within the matrix require rephrasing, to ensure policymakers understand why there might be conflicts and risks. It is expected that these improvements will mainly involve rephrasing, as once arguments for assessments were elaborated during the workshops in response to questions, participants generally agreed after all. It therefore appears that this shortcoming of the tool mainly lies in how certain assessments are explained and argued.

During the workshops, the tool was able to make participants think about potential challenges for implementing MaaS with the prescribed goals. Before the tool had been presented, the participants appeared to be already capable of coming up with potential challenges that might occur when considering the given municipal goals from a user-oriented perspective. However, after the tool was presented, they became able to go into more detail about specific problems,

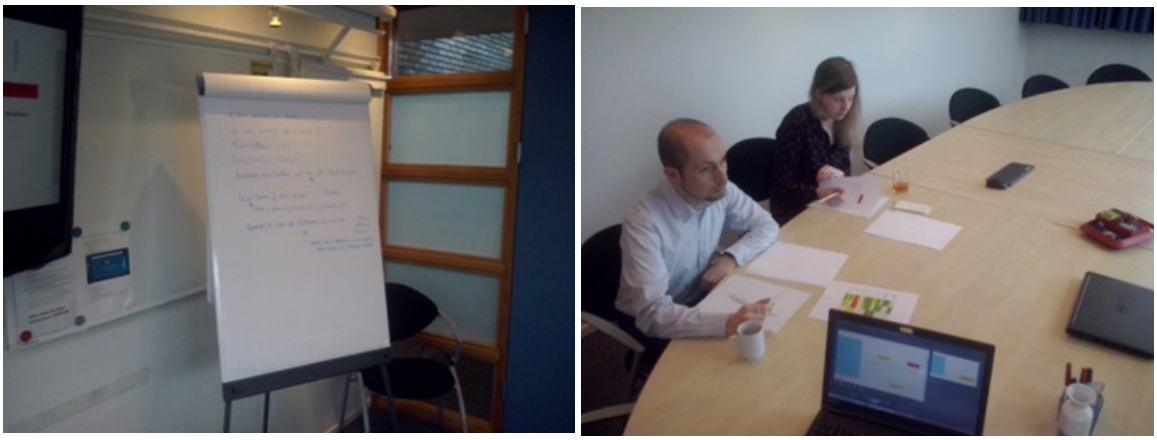

Figure 6 Evaluation sessions

and what would need to be done to either alleviate the risks and conflicts or even turn them into opportunities and strengths. As such, the tool successfully induced thinking about challenges that could appear when implementing MaaS. Once an overview had been made of these challenges, the participants were moreover led to ideate on potential solutions. They for example had the idea to focus on reducing the amount of transfers in public transport, to thereby increase its comfort compared to car travel. When prompted, they also considered which parties could be held responsible for implementing such solutions, although as mentioned, the prevalent answer for this was that the private parties that provide the service should be doing this. These considerations mainly resulted from collaborative discussions, for which the tool offered a starting point. On the whole, it appears that the tool successfully induces thinking about solutions to the challenges of implementing MaaS.

Beyond the main questions of the evaluations, there were additional observations and results that are of note for the perceived ease of use and perceived usefulness of the tool for policymakers. There were various comments regarding the phrasing and definitions used for the government goals, user requirements, and relations. The government goals that were given as examples were experienced by some as too vague, being catch-all terms. However, other participants thought it fitting that the goals were varyingly under-defined, as it in their eyes fit with the types of terms and plans that municipalities normally work with and use. There were similarly questions as to whether particular goals were not already somewhat solutions or means in themselves. For example, 'increase public transport use' could be considered a means of achieving 'clean environment'. Certain concepts were also deemed unclear in how they could be defined. Aspects like lifestyle, shared transport, and coverage rate could for example be understood in different ways. With this in mind, the definitions used for the concerning factors in the tool will need to be reviewed, and potentially redefined in an improved iteration.

7.4. Conclusions

The purpose of the evaluation sessions was to determine whether the MaaS tool concept is able to fulfil its requirements. The participants moreover gave their impressions of the tool's usefulness and usability. Based on the results, the tool does not yet fulfil the requirements for effectively communicating its purpose and added value. There was much scepticism regarding whether policymakers should be dealing with the user perspective. Dealing with this issue will mainly involve improving the way the tool is presented to policymakers, emphasising the relevancy and added value it has for them. While the tool adequately conveyed how goals and

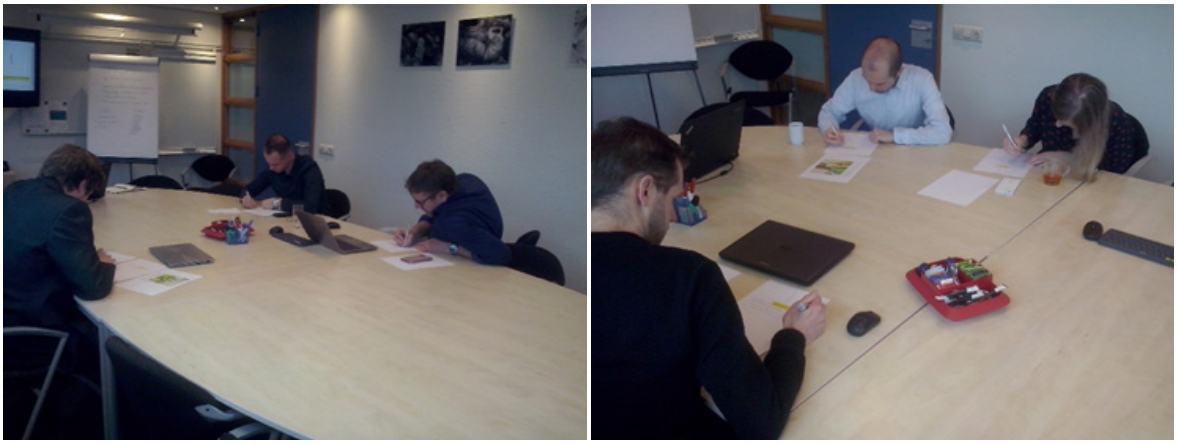

Figure 7 Evaluation sessions

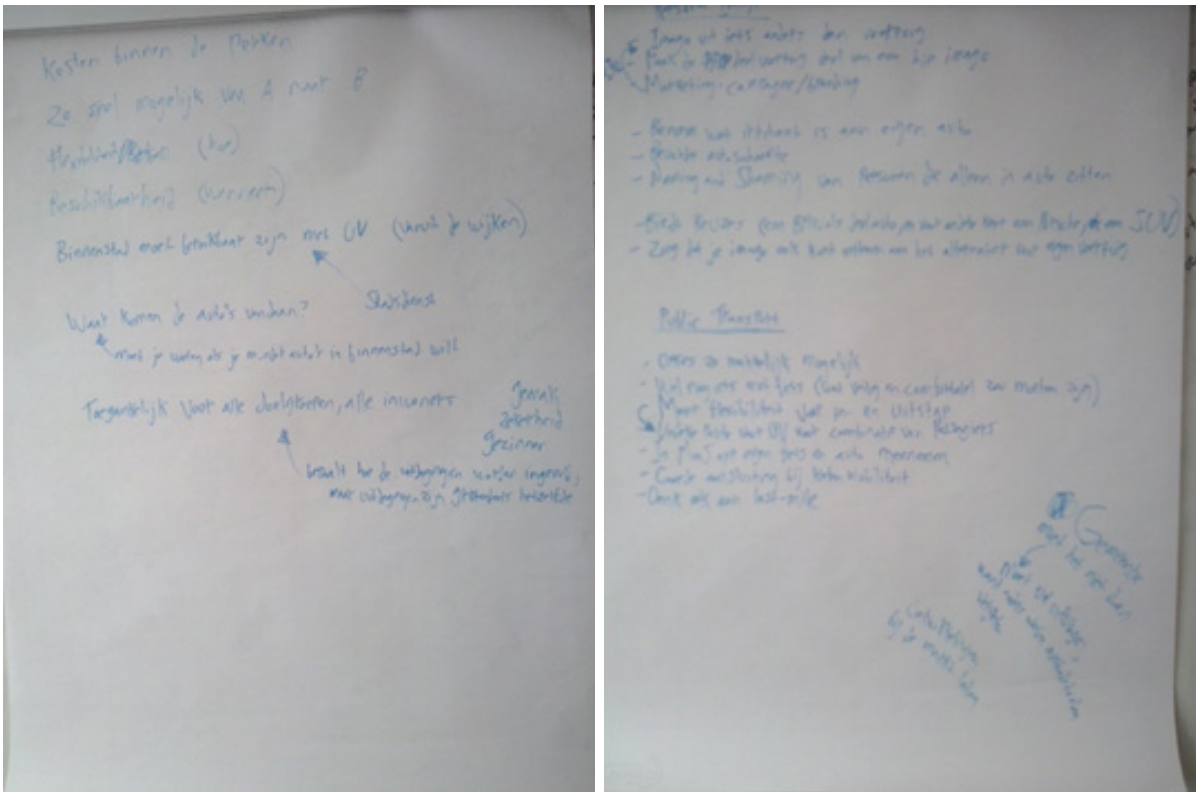

Figure 8 Challenges and solutions

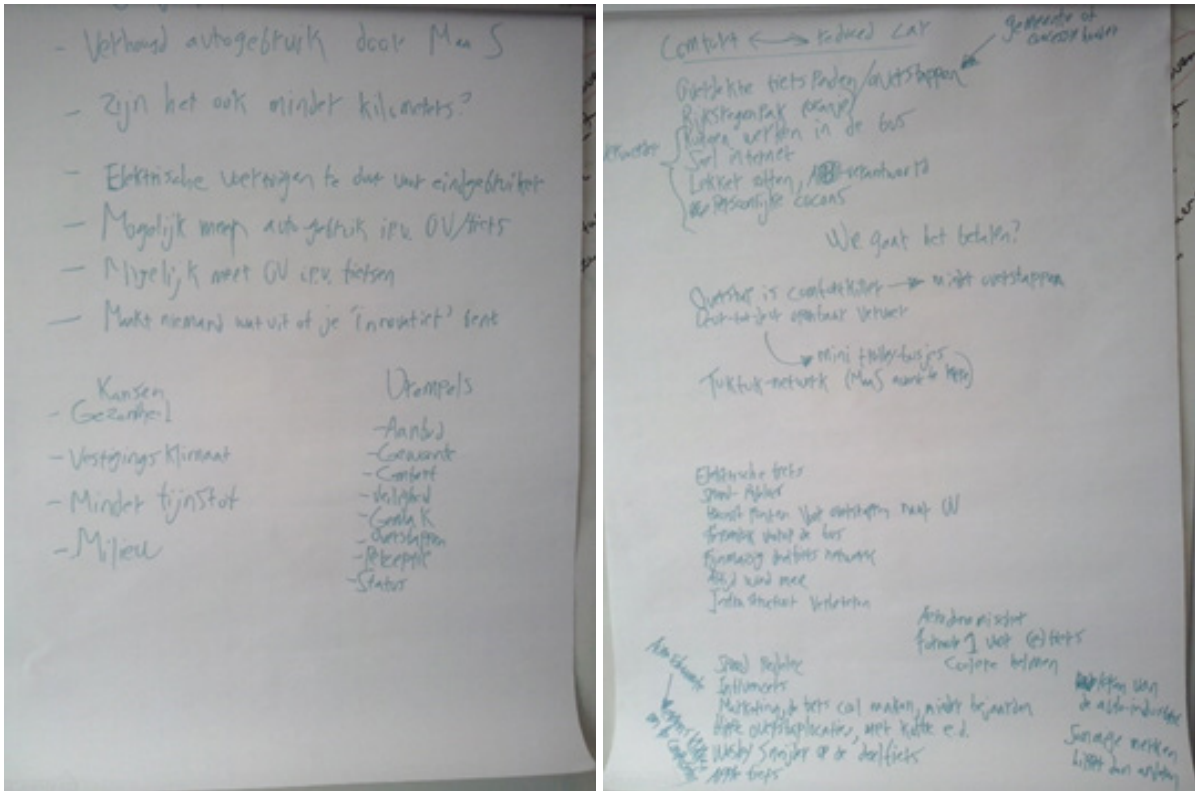

Figure 9 Challenges and solutions

requirements relate, the reasoning used will need further adjustments, to better explain and align with the understanding of policymakers. Finally, certain definitions, in regards to goals, requirements, and relations, will need to be rephrased to more clearly communicate their meaning to policymakers. These insights will be used to improve the tool for a new iteration.

Answers to research questions:

9. *How can policymakers use the relations to incorporate user requirements into their goals for MaaS?*

The evaluations have shown that policymakers are already somewhat able to use the designed tool concept to foresee challenges for implementing MaaS with their goals. They are moreover supported in thinking creatively about potential solutions to these challenges. The tool will however require adjustments to more convincingly convey its purpose and its contents to the policymakers, so that they are persuaded to truly take these challenges into account.

This research question is therefore thus far only partially answered through the designed MaaS tool.

8. Improved tool proposal

The evaluation described in chapter 7 of this thesis has provided insights for whether the designed MaaS tool fulfils the set requirements. These insight are in this chapter used to make improvements to the tool with a new iteration. Not only the contents of the tool are adjusted, but there also needs to be an adequate visual interface for the tool, that allows policymakers to get the information they need. All these improvements will lead to a more usable and useful tool being developed in this chapter.

Four research sub-questions are addressed:

6. *Which government goals and user requirements of MaaS complement each other?*
7. *Which government goals and user requirements of MaaS conflict with each other?*
8. *Which government goals and user requirements of MaaS are undetermined in their relation to each other?*
9. *How can policymakers use the relations to incorporate user requirements into their goals for MaaS?*

In the following chapter, the improvements for a new iteration of the MaaS tool are described, and the improved tool matrix is shown. Improvements are made to the contents of the matrix, to align with the feedback gathered during the evaluation workshops. In addition, layouts are designed for a visual frontend, to allow for a more pleasing, clear, and elegant interaction. Finally, to further demonstrate the use and purpose of the tool, the improved iteration is applied to a short design case of possible government goals.

8.1. Improvements made to tool contents

Based on the findings and feedback from the evaluation, the underlying contents of the tool are adjusted. This is done to improve perceived ease of use and usefulness for policymakers. Arguments for relations are extended and better explained where this was deemed necessary during the evaluations. Goals and requirements are phrased in more uniform ways. The limited examples given in the goals, requirements, and relations have either been removed, or been given more detail to substantiate their purpose. The improved tool in matrix form is provided on the following pages. Below, the main adjustments made will be discussed in more detail, and examples are given.

To ensure the tool better communicates why particular goals and requirements relate in a certain way, adjustments are made to better formulate the arguments in the matrix. This is to convince policymakers why the assessments that are made are accurate. For example, for the relation between the user requirement for comfortable travel and vehicles, and the governmental goal for reduced car use, additional factors like physical exertion and seating are given that could make the car the most comfortable modality. It is because of these factors that the relation is deemed a risk.

The decision was made not to change any assessments of relations, and as such the colouring for each combination remains the same. During the evaluations, there were comments about the accuracy of certain combinations being deemed risks and conflicts. An example of this was

Government goals →

User requirements ↓

	Reduce car use	Increase bicycle use	Increase public transport use	Increase walking	Increase use of chain mobility	Reduce vehicle ownership	Keep cars out of inner city	Do something with electric vehicles
The service needs to be available for everyone	Not everyone has the freedom to give up the car							
Shared vehicles have a high coverage rate in how many and where they are placed					High coverage rate would encourage people to use more varied modalities			
Mobility can be reserved ahead of time					Travelers will be more interested in a multimodal journey if they can be assured there will be vehicles available for them			
Vehicles remain reserved while in use								
Set-up of service is quick and effortless								
Payment occurs after finishing trip								
Accidental payments are refunded								
Travel is made faster	Car will often be fastest	Could be less problematic if city planning is such to make cycling faster in city	Dependent on connectivity of public transport, it could be time consuming	Walking is generally not very fast compared to other options	Greatly dependent on the journey. Chain mobility could make the trip faster but it could also slow it down.			
Up to date information is provided			If the user knows when and where public transport departs, they are more likely to use it					
Information on how much is spent is provided			If user knows how much they are spending on public transport, they might trust it more					
Booking of mobility is fast and easy	If the booking process is easy, user may be more likely to use it	If the booking process is easy, user may be more likely to use it	If the booking process is easy, user may be more likely to use it		If it is fast and easy to book a multimodal trip, it will be more inviting			
Payment is fast and easy, if not even automatic					If it is fast and easy to pay for a multimodal trip, it will be more inviting			
User is supported in finding shared vehicles					Additional support for finding a shared vehicle will make it more inviting if the multimodal trip has a shared vehicle as part of it			
Offered vehicles and mobiltiy is comfortable	In certain situations (rain, tiredness, seating, etc.), car is most comfortable	Could go either way, dependent on how comfortable the bikes are	Dependent on how comfortable the public transport vehicles are					Entirely dependent on the vehicle
Make travel more sustainable			Somewhat dependent on how sustainable the public transport vehicles are		Chain mobility is not in itself more sustainable, that is dependent on the actual modalities used.		Lowering traffic in inner cities could reduce how concentrated emissions are in a relatively small area	Keeping in mind that the electricity used would have to be sustainable as well, and the environmental problems of the vehicles' entire lifecycle cradle-to-grave
Reduce congestion								
Reduce noise disturbance			Could go either way, since trains are very loud, but buses are generally more quiet compared to a larger amount of cars but still louder than bicycles					Electric vehicles are generally somewhat quieter than non-electric
Encourage users to walk more					Sort of, in that a multimodal trip will likely involve some amount of walking			
Encourage users to cycle more						Somewhat undetermined		Available e-bikes might increase the amount of cycling
Offer a wide variety of travel options	Reducing car use would involve removing an option available to the user		Public transport offers a variety of options		If combinations of modalities get considered, the amount of options likely increases			
Offer a wide variety of transport providers			Public transport includes different providers		A chain mobility trip will likely have multiple different transport providers offering parts of it.			
Provide options to fit with personal style and image	Car is often part of person's image and style	Could go either way, some people make cycling part of their identity	Certain people could make it part of their image to use public transport (e.g. for sustainability), though others may dislike the image of being a public transport user			On the one hand, making travelers give up their owned vehicles makes them lose part of their image and lifestyle. On the other, a rental vehicle system could allow them to always get a vehicle that fits their current needs and image.		Electric travel could serve certain travelers' lifestyle and image (e.g. sustainability)
Provide multiple payment options								
Shared vehicles can be returned to locations different from pick-up								
Coordinate with current habit of single modality travel	For long distance, single modality travel, the car is a popular choice	Bicycle could be viable for a single modality journey	A trip by public transport will often involve multiple modalities, including getting to bus stop/train station/etc.	Most trips are not going to be viable to do with only walking			Keeping the cars out of inner cities can necessitate travelers into and out of the city to switch modalities.	
Coordinate with current habit of modalities being close to home	Cars are a modality many people have close to home	Many people have a bicycle at home	Access points for public transport will rarely be as close to home as options like an owned bicycle or				For people living in the inner city, keeping cars away from there means they can no longer park	
Take into account personal circumstances		Physical circumstance can prevent a person from being able to cycle	Not all public transport options are perfectly usable for everyone, for example those in wheelchairs	Physical capabilities can limit ability for walking long distances			For some people, there may be no other options than to travel by car	
Make travel more affordable	Usage of a car can be fairly costly	Cycling is comparatively cheap	Public transport can be fairly cheap	Walking is free	It could be cheaper but it could also turn out to be more expensive, dependent on the journey in question	Entirely dependent on pricing scheme, compared to common costs of an owned vehicle.		Electric vehicles are (currently) more expensive than alternatives, at least initially. Fuel costs are generally lower.
Service should be available in remote regions	For remote regions, cars are often most viable option	Cycling is not always viable in a remote area, dependent on distance	It is not always viable to implement public transport access points in remote areas, where use is comparatively low	Walking is not viable for traveling from a remote area to another area. It does work fine internally to the remote area.	Chain mobility is what is likely necessary to connect remote regions to others	Users in remote regions are generally all the more reliant on the dependability of having a vehicle owned and always available		
Service should be available in low income regions		Cycling could be a cheap option for low income users	Public transport could be a cheaper alternative for low income users	Walking is a free travel modality	Low income users may not be able to afford using a variety of modalities (e.g. if each demands a service fee to start)	Low income users are often very dependent on the mobility options they have available, and an owned vehicle is often most dependable.		Electric vehicles are (currently) more expensive than alternatives, at least initially. Fuel costs are generally lower.
Easy to use interactions in digital component								
Digital component not reliant on newest technology								

Use available resources (vehicles, infrastructure, people, etc.) efficiently	Enable mobility for areas where public transport is currently unfeasible	Make mobility more affordable	Make mobility accessible for all segments	Ensure a clean environment	Focus on internal travel	Focus on external travel	Create an interesting project for commercial companies	Be seen as a dependable and trustworthy municipality	Be seen as an innovative municipality
				There is a boundary where too many shared vehicles leads to an unclean environment		High coverage rate is challenging for the large area involved in external travel			Visibility of vehicles increases the innovative image
		If the system is less prone for accidental or unused payments, this lowers the costs that are made							
		if accidental (and unused) payments are refunded, it lowers the costs of general travel							
		It is somewhat connected, in that awareness on how much a traveler spends could encourage them to travel cheaper							
		Could possibly lead to more accidental payments occuring, particularly if payment is ahead of trip, thereby raising costs							
The vehicles in question (e.g. WMO vehicles) might have comfortability issues but also benefits									
More efficient use of the resources could make the mobility system more sustainable	This would likely lead to more travel taking place, and thereby more environmental impact		Raised accessibility could lead to increased mobility, thereby raising environmental impact				Commercial company could be more interested in increasing transport, thereby reducing sustainability		Could complement, but could also contradict, since innovative travel is not always sustainable
	This would likely lead to more travel taking place, and thereby more congestion		Raised accessibility could lead to increased mobility, thereby raising congestion				Commercial company could be more interested in increasing transport, thereby increasing congestion		
	This would likely lead to more travel taking place, and thereby more noise		Raised accessibility could lead to increased mobility, thereby raising noise				Commercial company could be more interested in increasing transport, thereby increasing noise		
		Walking is cheap				Unlikely to be viable for external travel	Walking is not profitable		Walking is not very innovative, image-wise
		Cycling is relatively cheap (compared to e.g. car)			Distances are likely to be lower for internal travel	Unlikely to be viable for external travel	Cycling is not as profitable as other options		Cycling is not very innovative, image-wise
The vehicles in question are currently not 'visible' and usable outside their conventional use, so making them part of MaaS would give new options	There will likely not be many options available, but there could be more than at present		More options could lead to raised accessibility	Focusing on a clean environment would likely involve limiting the amount of available options					
	There will likely not be many options available, but there could be more than at present		More options could lead to raised accessibility				Commercial companies could be most interested in only having a limited amount of providers, to reduce competition		
The types of vehicles generally have a certain inherent image, but this image could well be an undesirable one (e.g. old, handicapped, etc.)				Certain lifestyles and image, and the accompanying travel options, will have a negative effect on a clean environment					Could complement the image of a user wanting to be seen as innovative themselves
	For areas that cannot be accessed by public transport, it is more important that a user is allowed to leave their shared vehicle at a more freely chosen location	Allowing the return of a vehicle to be at a flexible location will likely lead to journeys being shorter (both distance and duration), thereby reducing cost		Allowing the return of a vehicle to be at a flexible location will likely lead to journeys being shorter (both distance and duration), thereby reducing environmental	Allowing flexible return location could be viable for the smaller area involved in internal travel	Allowing flexible return location could be very challenging for a large area	Flexible return could increase the burden on resources of commercial provider		
	It would possibly place mobility access closer to home than it is currently (at least regarding								
Using the available resources more efficiently could lead to lowered costs	Could be cheaper than what is currently needed in the areas			Cheaper will not always be better for the environment, but also not necessarily worse			Commercial company would want to make a high profit		
					People in remote regions would be getting ignored				
							Low income users could be less profitable		
									Not using the most modern technology could limit the innovative capabilities

Legend

- Complementary
- Risk
- Conflict
- No Relation

the relation between the government goal "Be seen as innovative" and the user requirement "Encourage cycling". For this particular relation, it participants felt that with the right interventions and branding, cycling could be seen as a fairly innovative travel modality. However, the assessments are made based on current circumstances, and the given suggestions involve new developments and interventions. Because of this, this particular relation is deemed to remain a risk in yellow. Similar considerations are made for other relations that raised questions during the workshops.

During the evaluation workshops, there were debates about the phrasing of certain goals and requirements. Some participants gave the opinion that certain goals were phrased too vaguely, whereas others believe that vagueness to be accurate for the way policymakers in government think and speak. As these latter arguments align with the findings of the research in chapter 3, the decision is made to not further detail or split these goals. However, the phrasing of particular goals and requirements has been changed so that they are more uniform with each other, and clearer in their meaning. For example, the user requirement for an adequately high coverage of shared vehicles is rephrased as "Shared vehicles have a high coverage rate in how many and where they are placed", as participants found it unclear what was meant by 'coverage rate'. Similarly, the governmental goal for chain mobility is rephrased as "Increase use of chain mobility", to align with the phrasing of the goals about car use, bicycle use, and public transport use. The image goals for municipalities are rephrased to "Be seen as a dependable and trustworthy municipality" and "Be seen as an innovative municipality". This is to make it explicitly clear that it is about the municipality itself needing to achieve that image. These two goals are moreover now placed next to each other in the matrix. The user requirements for healthy modality encouragement are similarly rephrased as "Encourage users to walk more" and "Encourage users to cycle more", to make explicit that (certain) users themselves want to have healthier behaviour stimulated.

8.2. Visual design of tool

In addition to the adjustments made to the backend contents, a visual frontend interaction is designed for the tool. This is to make the tool more pleasing, clear, and elegant in use for policymakers. Through this interface, the tool better fulfils the requirements for clear communication of purpose, goals and requirements, relations, and how the tool is used. A graphical design process is applied to seek an effective system and lay-out. Sketches and mock-ups are created of potential systematic setups and interfaces. The sketches from this process can be found in Appendix E. This results in the layouts shown in figure 10.

The tool would be taking the form of a computer or mobile app or website. On the main screen of the tool, policymakers can type their policy goals into the central field, which the tool can recognize as corresponding to particular goals in its system. Multiple of these goals can be added, after which they are shown in the field at the bottom of the screen. The added goals can also be removed from there by clicking on the particular goal's cross icon. Once the policymaker is satisfied with having added all the goals for their situation, they can press the arrow button in the bottom right to continue to the advice screen. On this screen, a list is given of each relation between a chosen government goal and any user requirement. Only relations that have been assessed as conflicts, risks, or opportunities are shown. The list can be scrolled through. By clicking on the information sign for a relation, further explanation of the assessed relation is given, such as reasoning or uncertainties.

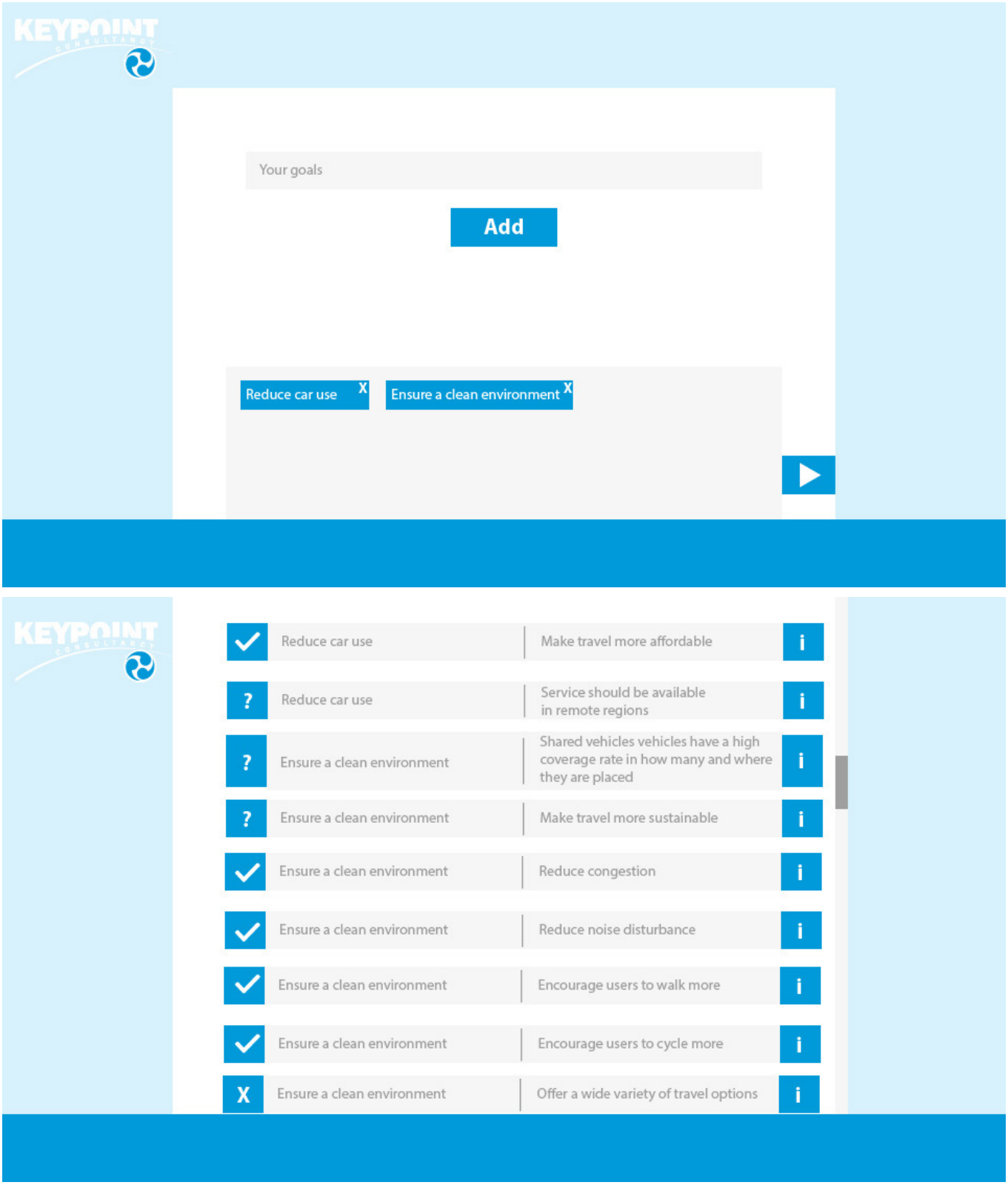

Figure 10 Visualisations of tool interface

8.3. Design case with improved tool

To demonstrate how the designed tool is used, and show its purpose and added value, a design case is conducted. For this design case, a set of government goals is chosen to focus in on. These goals are used to determine the requirements that a MaaS system would have to meet, and the challenges that would need to be overcome. This process results in a functional description of a MaaS system that could work for the goals set forth by the municipality, while also being effective and user-friendly.

8.3.1. Case government goals

For the sake of brevity, four government goals are selected as being most important for the municipality of this design case. These are the following:

- Increase use of chain mobility
- Reduce vehicle ownership
- Make mobility more affordable
- Make mobility accessible for all segments

8.3.2. Relations from compressed tool

Having determined the government goals that are the focus of this design case, the other goals can be removed from consideration. As a result, there will remain user requirements that are not relevant for this initial inquiry, as they are unrelated to the set goals. As such, these too are removed. This results in the matrix shown in figure 11.

At this stage, the insights from the tool are used to determine challenges for implementing MaaS. The means to overcome the challenges lie in designing solutions to change the conflicts and risks (indicated in red and yellow) into opportunities and strengths (indicated in green). For the purposes of this design case, this process will be the main focus. In a larger project, the system could also be designed in such a way as to make maximised use of the opportunities already indicated in green. Moreover not all challenges would need to be adressed, as certain challenges could be compensated for through other strengths. For this case, the resultant list of risks and conflicts to overcome is as follows:

- Chain mobility and reduced vehicle ownership is in direct conflict with people's current habits for travelling by way of one single modality.

- Chain mobility will be difficult to coordinate with people's current habits of having their travel modalities available close to home.

- Chain mobility may not be conventionally affordable for low-income users, if aspects like start-up costs are not designed with this in mind.

- If the municipality plans to reduce bicycle ownership, then this may discourage users from cycling, though it could also have the reverse effect if only car ownership gets reduced.

- A solution needs to be found for the fact that people use their vehicles as an expression of their personal style and image, which they will no longer be able to do if they are no longer supposed to own those vehicles.

- People's current habit for having modalities available close to home makes it difficult to

	Increase use of chain mobility	Reduce vehicle ownership	Make mobility more affordable	Make mobility accessible for all segments
The service needs to be available for everyone				
Shared vehicles vehicles have a high coverage rate in how many and where they are placed	High coverage rate would encourage people to use more varied modalities			
Mobility can be reserved ahead of time	Travelers will be more interested in a multimodal journey if they can be assured there will be vehicles available for them			
Vehicles remain reserved while in use				
Set-up of service is quick and effortless				
Payment occurs after finishing trip			If the system is less prone for accidental or unused payments, this lowers the costs that are made	
Accidental payments are refunded			If accidental (and unused) payments are refunded, it lowers the costs of general travel	
Booking of mobility is fast and easy	If it is fast and easy to book a multimodal trip, it will be more inviting			
Payment is fast and easy, if not even automatic	If it is fast and easy to pay for a multimodal trip, it will be more inviting		Could possibly lead to more accidental payments occuring, particularly if payment is ahead of trip, thereby raising costs	
User is supported in finding shared vehicles	Additional support for finding a shared vehicle will make it more inviting if the multimodal trip has a shared vehicle as part of it.			
Offered vehicles and mobiltiy is comfortable				
Make travel more sustainable	Chain mobility is not in itself more sustainable, that is dependent on the actual modalities used.			Raised accessibility could lead to increased mobility, thereby raising environmental impact
Reduce congestion				Raised accessibility could lead to increased mobility, thereby raising congestion
Reduce noise disturbance				Raised accessibility could lead to increased mobility, thereby raising noise
Encourage users to walk more	Sort of, in that a multimodal trip will likely involve some amount of walking		Walking is cheap	
Encourage users to cycle more		Somewhat undetermined	Cycling is relatively cheap (compared to e.g. car)	
Offer a wide variety of travel options	If combinations of modalities get considered, the amount of options likely increases			More options could lead to raised accessibility
Offer a wide variety of transport providers	A chain mobility trip will likely have multiple different transport providers offering parts of it.			More options could lead to raised accessibility
Provide options to fit with personal style and image		On the one hand, making travelers give up their owned vehicles makes them lose part of their image and lifestyle. On the other, a rental vehicle system could allow them to always get a vehicle that fits their current needs and image.		
Provide multiple payment options				
Shared vehicles can be returned to locations different from pick-up			Allowing the return of a vehicle to be at a flexible location will likely lead to journeys being shorter (both distance and duration), thereby reducing cost	
Coordinate with current habit of single modality travel				
Coordinate with current habit of modalities being close to home				
Take into account personal circumstances				
Make travel more affordable	It could be cheaper but it could also turn out to be more expensive, dependent on the journey in question	Entirely dependent on pricing scheme, compared to common costs of an owned vehicle.		
Service should be available in remote regions	Chain mobility is what is likely necessary to connect remote regions to others	Users in remote regions are generally all the more reliant on the dependability of having a vehicle owned and always available.		
Service should be available in low income region	Low income users may not be able to afford using a variety of modalities (e.g. if each demands a service fee to start)	Low income users are often very dependent on the mobility options they have available, and an owned vehicle is often most dependable.		
Easy to use interactions in digital component				
Digital component not reliant on newest technology				

Figure 11 Design case matrix

convince them to give up ownership of their vehicles.

-For remote regions, having an owned vehicle is often the most reliable option.

-Low-income users are very dependent on the mobility options they have available, and so it can be risky to take any vehicles they own from them.

-Making payment as easy and fast as possible can lead to more accidental payments occurring, which will in turn make the system less affordable as people have to put in time and effort to get their money back.

-Raising the accessibility of mobility could lead to more transportation taking place, which would in turn have a negative impact on sustainability, congestion, and noise disturbance.

8.3.3. Challenges to resolve

To increase the chances of MaaS succeeding in the suggested municipality, at least a significant amount of the conflicts and risks described in the previous section will need to be resolved in some way. To do so, the overall mobility system and MaaS product will need to be changed and designed such that the conflicts and risks are either circumvented or turned into strengths. Through a creative design process, ideas must be generated for how this could be achieved. For this design case, the following approaches for resolution are used:

- Chain mobility from vehicles not owned by the users themselves will need to be made fast and convenient enough to make it worthwhile for them to abandon their habits for single modality travel and for having their modalities close to home.

- The service needs to be designed without start-up service costs for various modalities, to keep chain mobility affordable for everyone.

- The system needs to be designed to encourage use of publicly available bicycles, to compensate for the reduction in owned bicycles.

- Public vehicles need to be designed to allow for expression of personal image and lifestyle, through variety of choice.

- The system needs to offer a truly functional and affordable alternative for the owned vehicle, in order to not leave remote and low-income users without the mobility they are relying on.

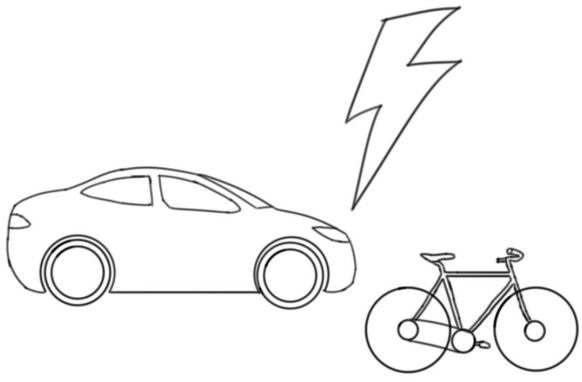

Figure 12 Electric fleet

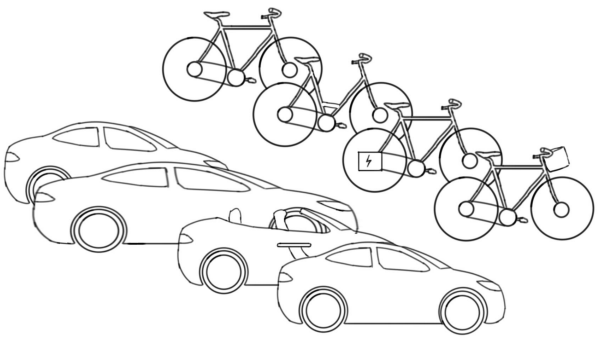

Figure 13 Variety in vehicles

- The risk of accidental payments needs to be minimized, and it needs to be easy and low-effort for users to get their money back if accidental payment does occur, to keep the service affordable.

- The majority of the transport offerings in the service needs to be sustainable, efficient, and quiet, so that even with an increase in transport taking place, sustainability, congestion, and noise disturbance are not too negatively impacted.

8.3.4. Service suggestion

Now that the challenges have been chosen for what a MaaS product will need to be for it to be successful, a more detailed functional description is designed. This will require a service design approach. In principle, the creation of a high-detail service concept can best be achieved through the expertise of professional service designers, be they acting as commercial market parties or under direct supervision from the government. Nonetheless, it is worthwhile for governmental policymakers to think creatively about what kind of service might fulfil the needs of their municipality, and what such a service would need to be able to do. By doing this ahead of requesting a service from an external organisation, the policymakers will understand better what it is that they truly want and need. What follows in this section is a functional description of a potential MaaS product, that should be able to overcome the challenges prescribed from the tool.

For this MaaS product, variety of options is a key component. To meet the requirement for sustainable, efficient, and quiet transport, a large majority of offered modalities is electric. This includes electric buses, trains, shared cars, taxi's, scooters, and bicycles. The 'fleet' of vehicles on offer is varied, both in image and look, and in utility and features. Users get to choose their personal travel experience for each journey. For example, they get to choose whether they would prefer driving a Porsche or a Dacia, a car with a lot of storage space, a city bike or a BMX, an e-bike or a granny bike, and so forth.

The service's vehicles are implemented at mobility hubs placed at key locations around the municipality. A sufficient coverage rate is important, to make sure the product offers a viable alternative to the owned vehicle. There are two types of hubs, mainly differing in size. Smaller hubs are greater in number, thereby covering a larger area of the region, and mainly offer bicycles and scooters. Larger hubs are placed at a smaller number of important locations, and offer not only bikes and scooters but also shared cars. They are moreover located near bus and train stations, so that there is a good connection to (electric) public transport. Vehicles rented from

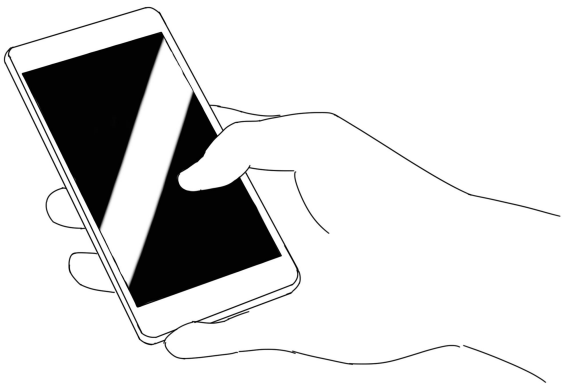

Figure 14 Accessed through mobile app

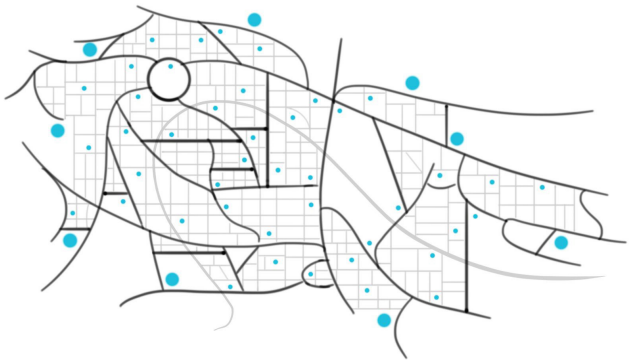

Figure 15 Hubs of varying sizes spread through city

the hubs can be parked at any other suitable hub. The bicycles serve as the connective tissue of the service, with the smaller hubs being within walking distance of the majority of users. Having reached a hub, users can cycle either to their destination, or to a larger hub where they can change over to car or public transport.

Users pay for their mobility through a central subscription that gives access to all modalities. There are no additional costs for changing between vehicles. The subscription in fact gives the users unlimited access to all modalities, to make the trips that they need. Since such a subscription is costly, low-income users receive financial support from the municipality to make it affordable. The service is accessed through a mobile app on the user's phone. The app can be used to check the availability of a particular vehicle at hubs, see the schedules for public transport, plan trips, and request a taxi. It also gives access to the shared vehicles, unlocking them for use when needed.

8.4. Conclusions

Based on the conducted evaluations, this chapter has described improvements that have been made to design a more effective, useful, and usable MaaS tool for policymakers. The feedback from the evaluations has been used to refine the contents of the tool's underlying matrix. To make the tool more presentable and communicative in its purpose and contents, a visual interface proposal has been designed. This proposal can be implemented in the design of fully digital prototype or final tool. The use of the tool has been demonstrated further through a design case study. This case study has shown that the tool can lead to new insights about the challenges for implementing MaaS, as well as make policymakers consider the possible solutions by incorporating the user perspective. The final result is thereby a tool that helps policymakers in the process of determining the requirements of a MaaS system that fits their goals, while also being user oriented.

Answers to research questions:

6. Which government goals and user requirements of MaaS complement each other?

This question is answered through the contents of the improved tool matrix, in the relations that are coloured green.

7. Which government goals and user requirements of MaaS conflict with each other?

This question is answered through the contents of the improved tool matrix, in the relations that are coloured red.

8. Which government goals and user requirements of MaaS are undetermined in their relation to each other?

This question is answered through the contents of the improved tool matrix, in the relations that are coloured yellow.

9. How can policymakers use the relations to incorporate user requirements into their goals for MaaS?

The designed MaaS tool in itself serves as the answer to this research question. The tool helps policymakers in the process of determining the requirements of a MaaS system that fits their goals, while also being user oriented. It capability for doing so has been demonstrated through the design case that has been conducted in this chapter, using the latest iteration of the tool. It capabilities will be even moreso effective if the tool is further developed with the suggested visual frontend interface.

9. Discussion

At this stage, a conceptual tool has been designed and proposed for giving municipal policymakers additional insight into the challenges and opportunities of incorporating user requirements into their governmental goals for MaaS. However, there remain points of discussion regarding the tool's scope, applicability, and representativeness. By discussing and reflecting on these matters, the constraints of this project's findings can be better understood, and aspects that demand further research are revealed.

The scope of this project was largely left to the municipal level. It is expected that looking at the governmental perspective at a different level, for instance provincial, national, or even international, would indicate different kinds of plans, visions, and ambitions for future mobility. As a result, a MaaS system designed from such a higher level perspective will have different relations with user requirements, and therefore also different challenges and opportunities.

In addition, the focus in the project has in practice been on larger municipalities, that already have some sort of idea or plan in place for whether and how they would like to develop MaaS in their region. Nonetheless, smaller less-populated areas might also wish to study and experiment with MaaS, or will at least be affected by it. The needs of residents from remote and less-populated areas of cities have been accounted for in one of the user requirements. Similarly, the research in chapter 3 has included policy documents from a selection of smaller municipalities. However, the limitations in the number studied documents could still lead to gaps in this thesis' findings for the goals of the smaller municipalities.

As the reviews of literature and government policy have shown, MaaS is still in development, with only short-term local pilot projects as its main implementation. There are still uncertainties and undetermined elements. Future changes in how and what is designed will have an impact on the goals municipalities want to achieve with MaaS, and the requirements that users have of it. These uncertainties therefore affect the verisimilitude and applicability of the tool.

So far, existing commercial MaaS systems have generally not managed to lead to results that fully satisfy the goals set by municipal government. As was seen through the practical tests, current systems are lacking in certain usability and user experience features. As a result, they are not widely used by travellers. This could be attributed to MaaS still being early in development, and so service providers need additional knowledge to create a better product. Alternatively, interviewed municipal representatives and evaluation participants informally offered the following hypothesis: It could be that with regional governments putting out requests and requirements for local MaaS systems, companies are only adding features to minimally comply with the set forth parameters. They would be doing this to get any subsidies available, and then abandon the system once there is no more government funding.

The evaluations conducted to test the effectiveness and acceptance of the tool have indicated there is scepticism. Policymakers may not be fully receptive to the idea of having to engage with the needs of users and residents for new technologies, such as MaaS. This does contrast with the findings of the interviews performed with representatives from municipal governments, particularly those in Enschede. The findings there showed there is at least an intent from policymakers to account for the user perspective, to ensure MaaS is accepted and used by residents. To achieve a similar understanding amongst more sceptical policymakers, a paradigm shift may be necessary. They need to be convinced of the importance of taking in this perspective at an

early stage of the process.

There might be goals and requirements missing from the tool. New insights through further research could reveal further parameters that need to be added. Upon doing so, relations need to be assessed for the new parameters. Relatedly, the relations in the tool have been based on the insights garnered through the present study. Explanations have been given for the viewpoint and vision from which was worked, and the heuristics that were used. They are substantiated by the research that has been conducted. Nonetheless, a different assessor could come to different results. It is expected that such differences will be fairly minor, and mainly about combination that were considered risky being deemed as not having a strong enough relation to be of note. However, the tool is provided in such a way as to allow for new parameters to be added, and for current parameters and relations to be changed as needed.

The tool in its current state has focussed on assessing the relations between individual goals and requirements. It does however not take into account the possible relations that might exist internally between government goals and between user requirements. That is to say, certain goals will likely complement, conflict, or lead to risks with other goals. For example, a goal for increased bicycle use could conflict with a goal for reduced vehicle ownership, as travellers will be less inclined to use a bicycle if they no longer own one. A goal for increased bicycle use could on the other hand complement a goal for sustainable travel. Similar relations will likely also exist between individual user requirements.

10. Conclusions and recommendations

The main question for this project was how user requirements can be incorporated into the goals of municipal governments in regards to Mobility-as-a-Service. The main conclusion to the study is a tool that aids policymakers in their decision making, informing them of the conflicts and opportunities of implementing MaaS towards their ambitions, supporting them to think and plan ahead. It encourages them to engage in creative thinking, and to anticipate problems that might arise before requesting a full service from an external party.

Reviews of literature on MaaS have been used to define MaaS as integrating into a single platform the multiple features and multiple modalities required to make a door-to-door journey. It offers multiple options in a demand-oriented service. The mobility used is not owned by the users but maintained and offered by an external organisation. The reviews show that current MaaS products have mainly integrated travel information, booking of transport, and ticket payment. They often fall short in offering a sufficient amount of available vehicles. Moreover, the amount of variety and choice of modality that a particular service offers is often limited. These findings were supported by practical tests of existing MaaS systems. The given shortcomings explain why current implementations of MaaS have not managed to attract a sufficiently high user base for achieving the goals set by municipal governments. Other factors include the image of shared and public modalities as being inflexible and unattractive, and travellers' current habits for single-modality travel, mainly by car.

Through a review of municipal policy documents, as well as interviews with representatives from four municipal governments, the mobility goals that governments wish to achieve through MaaS have been studied. Results show that improved liveability, accessibility, and sustainability are common governmental goals. Municipalities would furthermore like to change travellers' behaviour, mainly by encouraging them to cycle or use public transport rather than the car. City growth is a driving factor that leads municipalities to want to innovate with mobility. To align with these goals, MaaS would need to improve the spatial efficiency of transportation. It would need to encourage users to choose sustainable and healthy modalities over others.

A combination of literature review and practical tests of existing MaaS products was used to determine user requirements. For users it is important that a service offers sufficiently available modalities, that it is affordable, and that it provides sufficiently fast travel. The interaction between the user and the service moreover needs to be quick and easy, and it should offer a wide variety of modalities and options for the user to choose from. Reflections on MaaS through philosophical frameworks have also indicated the importance of making the service available and accessible for vulnerable user groups. Measures will furthermore need to be put in place so as to avoid undesirable conduct by the providers of the MaaS platform.

The reflections through the lens of philosophy of technology contributed to the assessments of relations between individual governmental goals and user requirements. They reframed the goals and requirements. It was shown that there remain uncertainties about MaaS' capabilities for directly achieving all goals set forth by governments. Moreover, it is advised that governments take a more active and overseeing role in MaaS, to ensure the system is put towards beneficial ends for society. Availability and inclusiveness are therein of importance. Foreseeing challenges and problems will allow them to act in time, preventing harmful consequences.

The findings from the preceding research were used to create two lists of parameters, one from the government and one from the user perspective. Through an analytical approach, applying insights from throughout this study as well as heuristics, relations were assessed for each combination of goal and requirement. It was determined whether a relation was complementary, risky, or conflicting. This resulted in a rough concept for a MaaS tool, that was evaluated through workshops with mobility policy advisors. These evaluations showed that the tool was effective at supporting participants to think creatively about the challenges of MaaS and possible solutions. The way that particular goals, requirements, and relations were defined needed to be fine-tuned, to clear up misunderstandings about terms like 'coverage rate', and explain certain assessments that were made. Based on the evaluations, an improved MaaS tool proposal has been designed. Included with the proposal is a concept for a digital interface of the tool, that allows policymakers to get the information needed for their particular situation. The tool's effectiveness for policymakers has been demonstrated through a case study.

10.1. Recommendations

Due to constraints within this project's research and scope, there are remaining questions as well as opportunities for further research. A first recommendation is to work out the concept tool into a fully functional digital version, with a pleasing and usable interface. The mock-up interface shown in chapter 8 and the sketches shown in Appendix E of this thesis could serve as a starting point. This will involve programming the needed software. It is important that the tool allows for adaptations, such as adding new goals and requirements, and changing the indicated relations between specific parameters. This will need to be accounted for in the programming.

Secondly, the study of the governmental perspective should be extended by researching smaller municipalities, and those that are more hesitant towards MaaS. This would likely lead to different kinds of goals that MaaS would need to meet. Similarly, the perspectives and goals from other levels of government should be studied. For example, provincial, national, and international governments will offer a new set of visions and goals. These new goals would replace the municipal ones in the current iteration of the tool.

Third, within this thesis, the ethical benefits, harms, and abuse risks of MaaS have been discussed. The harms and abuses have mainly focussed on services created and operated by commercial companies. Further study is recommended to determine the degree to which these or similar risks also apply to a system that is overseen by governmental organisations. Ostensibly, public entities will be more subject to public accountability, but harms could still occur.

Fourth, to further study the effectiveness and applicability of the tool, it would be good to test it out in a real MaaS project. This would involve cooperation with a municipality working on MaaS, that will use the tool to study its situation and determine what a system needs to be and do. This would also be an opportunity to study how policymakers could be made more open-minded and receptive towards creative thinking and evaluating the user perspective.

Finally, an important recommendation is to continue reassessing the goals, requirements, and relations in the tool. Based on new findings and knowledge, as discovered by future research, it will be necessary to add to or change the contents of the tool. For example, as MaaS is still early in development at this moment, changes will likely occur that impact what governments can achieve with it and what users need from it. As such, it is advised that global developments of MaaS are kept track of, and that changes are made to the tool accordingly. This could also include incorporating relations internal to the lists of government goals and user requirements, as mentioned in chapter 9.

10.2. Concluding remarks

The final result of this thesis is a tool that helps policymakers in the process of determining the requirements of a MaaS system that fits their goals, while also being user oriented. It helps them anticipate challenges and opportunities, and use this information when specifying the requirements of a MaaS product for external partners. The tool encourages them to use creative thinking, and to look at the issues from a user-based perspective. The policymakers thereby understand better what is needed of MaaS. In so doing, the tool aids in the design of effective MaaS products, that align with the goals for society and the wishes of its users. While the tool needs to be further finalized, its development presented in this thesis revealed important insights in the interdependencies between governmental mobility goals and user requirements. Therewith this thesis provides a contribution to a more human centred development of MaaS.

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Appendices

Appendix A: Existing MaaS system summaries

Name of the initiative	Place	Status	Modes	Type of mobility integration
moovel	Hamburg and Stuttgart, Germany	Operational (2015-)	Car sharing, taxi, urban PT, regional PT.	Level 2 (partial, payment integration).
myCicero	Italy	Operational (2015-)	Urban PT, regional PT, international PT, parking, permit for urban congestion charging zones.	Level 2 (partial, payment integration).
NaviGoGo	Dundee and North East Fife region, Scotland, UK	Operational (2017-)	Car sharing, taxi, urban PT, regional PT.	Level 2 (partial, payment integration).
iDPASS	France	Operational (2017-)	Car renting, taxi, valet parking.	Level 2 (partial, payment integration).
Tuup	Turku region, Finland	Operational (2016-)	Car sharing, bike sharing, taxi, urban PT, DRT.	Level 2 (partial, payment integration, ticketing integration to come in 2018).
Hannovermobil	Hannover, Germany	Operational (2014-)	Car sharing, taxi, urban PT, regional PT.	Level 2.
EMMA (TaM)	Montpellier, France	Operational (2014-)	Bike sharing, car sharing, urban PT, parking.	Level 2.
Business travellers cards: NS Business Card, MobilityMixx, Radiuz Total Mobility, etc.	The Netherlands	Operational (national coverage of these cards since 2013)	(Car sharing, parking, tank filling, electric car loading, taxi, car rental), bike sharing, urban PT, regional PT.	Level 2 (Business to Business), partial Level 1.
Smile	Vienna, Austria	Pilot (2014-2015)	Bike sharing, car sharing, taxi, urban PT, regional PT, parking.	Level 2.
WienMobil Lab	Vienna, Austria	Operational (2017-)	Bike sharing, car sharing, taxi, urban PT, parking.	Level 2.
SHIFT	Las Vegas, USA	Planned (2013-2015)	Bike sharing, car sharing, taxi, collective DRT, valet parking.	Level 3.
UbiGo	Gothenburg, Sweden	Pilot (2013-2014), version 2.0 in preparation	Bike sharing, car sharing, car renting, taxi, urban PT.	Level 3.
Whim	Helsinki, Finland	Operational (2016-)	Bike sharing (car sharing to come), car renting, taxi, urban PT, regional PT.	Level 3.

Figure 16 MaaS schemes (Durand et al., 2018)

Scheme (Area)	TransitApp (USA, UK, Canada, Europe, Australia)	Optymod (Lyon, France)	Mobility 2.0 services (Palma, Spain)	SHIFT—Project 100 (Las Vegas, USA)	UbiGo (Gothenburg, Sweden)	Mobility Shop (Hannover, Germany)
Status (Year)	Operational (2012–)	Operational (2012–)	Pilot (2013–)	Planned (2013–2015)	Pilot (2013–2014)	Operational (2014–)
Transport modes and related services	PT (Inc. local ferry) Bike sharing Car sharing Taxi Ride-hailing	PT Bike sharing Regional train Parking	PT Bike sharing Taxi	Bike sharing Car sharing Taxi Shared shuttle	PT Bike sharing Car sharing Car rental Taxi	PT Car sharing Taxi Regional trains
Tariff option	Pay-per-use	None	Pay-per-use	Monthly tariff	Monthly tariff	Fixed monthly membership to access discounted tariff
Platform	App/Web	App	App/Web	App	App	App
Available functionalities	Real time info. Trip planning Booking (shared modes/Taxi) Payment (bike sharing) Service alerts Departure alarms Stop notifications	Real time info. congestion Prediction Trip planning Booking (bike sharing) Service alerts Plane's arrival-departure time info	Real time info. Trip planning Service alerts Real time congestion monitor	Trip planning Booking Payment Invoicing	Trip planning Booking Ticketing Payment Invoicing 24hr customer service phone line	Real time info. Booking Ticketing Payment Invoicing Service alerts
Type of actors involved *Service aggregator*	Public and private actors *3rd party*	Public actors *Local authority*	Public and private actors *Local authority*	Private actor *3rd party*	Public and private actors *3rd party*	Public and private actors *PT provider*
Use of technologies	GPS / ePay (bike sharing only)	GPS	GPS	GPS / ePay	GPS / Smart card	GPS / ePay / Smart card
Demand orientation	Yes	Yes	Yes	Yes	Yes	Yes
Registration requirement	Yes, for booking and customisation	Yes, for customisation	Yes, for booking and customisation	NA	Yes, for usage and customisation	Yes, for usage and customisation
Personalisation	Store regular and preferred routes Saved location	Input personal address, preferable modes, and ownership of bicycle	Store favourite trips	Automatically Optimised trip planner	NA	Store favourites trips and recall previous trip
Customisation	Minimised walking option Disabled certain service/modes Link with calendar and personal contact	Select service subscription for news	Enable certain map sections and accessibility map people with special needs	Mobility budget with Top-up	Mobility budget with Top-up and roll over	Possibility to create individual mix of transportation Booking and payment cancelation

Figure 17 MaaS schemes (Jittrapirom et al., 2017)

Platform (Area)	Smile (Vienna, Austria)	Tuup (Turku Region, Finland)	My Cicero (Italy)	Moovel (Germany)	Whim (Helsinki, Finland)	WienMobil Lab (Vienna, Austria)
Status (Year)	Pilot (2014–2015)	Operational (2015–)	Operational (2015–)	Operational (2016–)	Operational (2016–)	Based on Smile project (2015–2016)
Transport modes and related services	PT (e-)Bike sharing (e-)Car sharing Taxi Parking garages Charging stations Regional trains and ferry	PT Bike sharing Car sharing Car rental P-2-P car rent Taxi and shared taxi Parking rent Freight service*	PT Taxi* Parking spaces Permit for urban congestion charging zone Regional rail and bus	PT Bike sharing Car sharing Taxi Ferry Regional rail	PT Rental car Taxi Regional rail Bike sharing* Car sharing*	PT Bike-sharing Car-sharing Taxi Parking garages
Tariff option	Pay-per-use	Pay-per-use	Pay-per-use	Pay-per-use	Three monthly packages and pay-per-use	Pay-per-use
Platform	App	App	App	App	App	App
Available functionalities	Real time info. Trip planning Booking (shared modes / Taxi / Regional train) Ticketing Payment Invoicing Service alerts	Real time info. Trip planning Booking Ticketing Payment (for PT, taxi, and shared taxi)	Real time info. Trip planning Booking Ticketing Payment Invoicing Municipality services	Real time info Trip planning Booking Ticketing Payment Invoicing	Real time info. Trip planning Booking Ticketing Payment Invoicing	Real time info. Trip planning Booking Payment Invoicing
Type of actors involved *Service aggregator*	Public and private actors *PT provider*	Public and private actors *Third party*	Public and private actors *Third party*	Public and private actors *Third party*	Public and private actors *Third party*	Public and private actors *PT provider*
Use of technologies	GPS / ePay	GPS / ePay (PayiQ)	GPS / ePay / e-Wallet	GPS / ePay	GPS / ePay	GPS / ePay
Demand orientation	Yes	Yes	Yes	Yes	Yes	Yes
Registration requirement	Yes, for usage and customisation	Yes, for usage and customisation	Yes, for usage and customisation	Yes, for usage and customisation	Yes, for usage and customisation	Yes, for booking and customisation
Personalisation	Optimised trip plan to user's profile (i.e. annual ticket, subscription and membership)	Optimised travel plan based on user's daily agenda	Store types of ticket Record and share journey	Store favourites routes Personalised notification on disruptions	Calendar synchronization Personal info sharing Social interaction	Save personal mobility profile Store car & bike sharing membership
Customisation	Enable mode filtering based on cost, time, and CO_2 footprint	Preferred modes, based on cost and CO_2 footprint	Preferred modes and payment Top-up	Link with social media accounts Booking cancellation	Cancelation Change of subscription Top-up	Preferred modes, based on cost, time, and CO_2 footprint

Figure 18 MaaS schemes (Jittrapirom et al., 2017) (cont.)

Appendix B: Interview documentation

B.1. Enschede

The city of Enschede is undergoing growth, with the amount of residents and visitors continuously increasing, resulting in the municipal government's challenge to make sure the city remains accessible. They aim to innovate with new mobility, such as 'Mobipunten', where people can change over to other travel modalities such as bus or shared bikes. These could moreover have additional facilities like package services. Enschede sees the potential of shared cars as serving as mobility out of the city. They would also like to see more cycling. Their overall approach is bottom-up. They try to do new things first and experiment, and then see what challenges show themselves along the way. They also try to keep in mind what the user wants, instead of just developing technologies in themselves. This is done by keeping it local and starting with the user, and checking with their wishes and needs. They admit it is a tough balance between a local scale, which results in a relatively small system that is not widely usable, and the larger scale, which results in a system that may not quite connect with users' wishes.

They believe that from a technical standpoint, everything is possible, but a lot of things just have not been implemented yet. The earlier thinking was that the market would take care of the implementations, but this did not happen. As such the municipal government feels obligated to do it centrally and with all participants together, in order to force change to occur. A primary challenge therein is to connect all the components together.

Enschede furthermore wants to use their available resources as efficiently as possible. An example they give for this is the smaller buses that are used to comply with the WMO. Currently, these buses are mostly used during peak hours, and at those times they mostly travel to the same location, namely the hospital. During non-peak hours, when a large portion of these buses are unused, they could be used for transport of regular people or other purposes.

The vision is that at some point in the future, everyone will have some kind of MaaS app on their phone, in much the same way as nearly everyone has for example has a news or messaging app on their phone nowadays. For this to succeed, such an app has to be really good and functional. It has to offer the user something worthwhile. It also has to be widely usable, that is to say not just in one specific location, but also when you happen to be somewhere else for a day. Moreover, the app and more importantly the overarching system have to be dependable. When the user needs a car, there needs to be a car available, or else the user will not use it.

As part of all this, Enschede wants to make things easier, and to spread information better. Currently, people might not know how to get a taxi, or how to use a particular bus, or they may not even know that that taxi or that bus exists, or what it costs. Such information needs to be more conveniently provided. People also need to for example know how an electric car works, if such vehicles are to be a part of the mobility systems. If they do not understand how actions like charging a battery work, they will be hesitant to use them.

The desired travel behaviour that Enschede envisions is that only traffic that has to be in the city will actually be going there. As part of this, they are also thinking about chain mobility, to move people from door to door, with the first- and last-mile, using multiple modalities. The main challenge with the change of travel behaviour that they see is that people want to be mobile, and so they demand good alternatives. Particularly if the ambition is to have people leave their car, or even only their second car, there is a great need for suitable alternatives to be offered. In this regard, the city is already trying to stimulate cycling, and at least in theory, everywhere in the city can be accessed by bicycle.

Within the municipal government of Enschede, MaaS is defined as being user-focussed, and as providing one central platform for planning, booking, and payment for transport, as well as making the reserving of vehicles possible. Such a service should be broad and available for everyone. This means that there needs to be more than one single shared car, because that would not be widely available, since it is unlikely to be there when a user needs it. Enschede is strongly convinced that there will be some form of MaaS in the future, and is working to make sure the city is ready and willing for this.

In addition to its general intention to innovate, and to explore new opportunities and options, Enschede is conducting a variety of larger projects that could be considered related to MaaS. Other than the 'Mobipunten' mentioned above, there is firstly the MaaS pilot in Twente, which is part of the seven national MaaS pilots that are taking place in the Netherlands (Ministerie van Infrastructuur en Waterstaat, 2018). As yet, it is still early in development, and will focus on the aforementioned WMO-transport. The plan is that the pilot can be scaled up in future to be usable for everyone.

A second notable project in Enschede is known as Stad-up. This project is currently only usable by employees of the municipality. The project offers electric bicycles and cars, as well as public transport tickets with which the users can travel to their work and appointments. The vehicles are accessed and unlocked through an app on the phone (Stad-up, 2019). The electric vehicles are currently placed at the municipal offices, where employees can make use of them. The ambition is that in the future, these vehicles and the accompanying services will be made available for use by everyone in Enschede, including both residents and visitors.

Third are experiments with systems and apps like GoAbout. This app too offers shared vehicles, that is bikes and cars, that users of the app can unlock and make use of. These vehicles are offered in multiple locations in the Netherlands, including in Enschede. The app did not entirely meet with the expectations of Enschede. Few people know that the app and its services exist, and so it sees little use in the city and surroundings. As a result, it does not meet the 'accessibility' requirement that Enschede incorporates in its definition of a sufficient MaaS system, since people are unable to make use of a service they do not know about. This shortcoming of GoAbout is ascribed to the service either not being positioned well in the market, or to there not actually being a real need on the end of consumers that the app could fulfil.

During the implementation of these and other MaaS and MaaS-related projects, Enschede faces certain challenges. A primary general issue is finding a service or concept that not only works as intended, but is also truly wanted by the users. An integral aspect of this will be the need for such a concept to be able to link together all the different components and services. Also related to this primary issue is the challenge to making sure people actually use the services, which is something Enschede admits government often falls short at. Part of ensuring that people use the implemented services is that they need to be made aware of those services.

Enschede sees both opportunities and threats when it comes to MaaS. An example that is given is the idea of electric scooters being offered as a shared modality. They think that these scooters would be interesting to experiment with, but the expectation is that they will be used at locations and for trips where the municipal government would rather prefer that people were to travel on foot or by bike. It is such a threat that keeps the municipality from trying this out.

One additional potential issue for MaaS that is given is that not everyone can use an app on their phone, and others might not be willing to do so. An example are elderly people, who would much prefer it if they could call a phone-number to make use of a mobility service. With such a challenge in mind, it becomes necessary to keep a broad perspective on how MaaS can be facilitated. It is not necessarily and not just an app, but also about a general system that can

for example make sure there is a bike available 'from the machine' when you arrive at your train station.

B.2. Utrecht

Utrecht is one of the fastest growing cities in the Netherlands, which poses its main challenge when it comes to mobility and transport. As a result, the city would like to set up mobility to be as spatially efficient as possible. Cars are not efficient when it comes to space, especially cars that are parked and standing still. Other modalities are generally better in this regard. By making mobility more spatially efficient, the city hopes to create a more open and attractive environment, rather than it being filled with features like parking space.

The above ambitions in mind, Utrecht main desired travel behaviour is to partially move people away from car usage. However, they also believe this is not always the appropriate plan, as for certain purposes like for example furniture shopping, a car is fairly essential. Rather, Utrecht would like people to be making conscious and thought-out decisions about their travel choices. The priority for which modalities are seen as most desirable depends on which section of the city is being discussed. These decisions are dependent on factors such as available space, and often healthy mobility is desirable everywhere. Moreover, they find that almost always a combination of multiple modalities is most appropriate.

To achieve these goals, Utrecht firstly names their cooperation with shared vehicle providers. They engage in campaigns to stimulate residents to make use of the shared vehicles. The successfulness of these campaigns is debatable. Currently, each of the shared bikes in Utrecht gets used once per day on average, which they consider a good start. The shared cars that have been placed are also getting more users. It is hoped that these developments keep growing. Utrecht is also trying to encourage alternative modalities by actively facilitating those other modalities, so that they are truly viable and usable, such as by building good cycling roads.

For the municipal government of Utrecht, MaaS in general is seen as somewhat of a 'magic word', and they only have the general vision that they do want to do 'something' with MaaS. They define MaaS as being a change from ownership to usership of mobility. Furthermore, they consider it taking a burden off people, providing them with the possibility to plan a trip from door to door, and doing the planning, booking, and payment within the system, and the system even supporting them throughout the entire trip. Shared mobility, as a component of MaaS, is given more active and specific enthusiasm. Departments in the municipality are considering how to integrate shared mobility in their projects, or what it means for them. By extension, one could say that MaaS is indirectly taken into consideration.

One of Utrecht's current projects with MaaS is their pilot in the area of Leidsche-Rijn. The city wants to know whether Maas will actually be able to change users' behaviours, by making them use their car less, travelling differently, and the conditions under which they will make use of it. The pilot focusses on the residents of that neighbourhood, but the plan is that eventually people can use the created service to transport themselves across the Netherlands. The target group that lives in the area is defined as having a relatively high income, and generally owns their own car. The expectation is that MaaS will have the greatest effect on them, by convincing them to leave their own car. In theory, the system is meant to also be usable for people with lower incomes. The pilot works in cooperation with the app Trips, which is seen as having potential to be the digital component of Maas. Incidentally, the potential of MaaS is largely seen in the apps, as that is where the solutions lie that can integrate all the necessary aspects. Currently, the pilot is in the soft-launch phase, with an online community testing out certain features, and

a group of 30 users giving feedback, a group that is planned to grow to 100 at some point, once the service is further in development.

A second MaaS development in Utrecht is the implementation of hubs, which would serve as the physical component. These are currently of interest for a new area in the city that is being densely built with low parking-norms. Due to this, the city is trying to provide the residents there with a full mobility concept, that no longer requires them to have their own car. The actual contents of these hubs are still being worked out. In theory it should have 'everything', so shared cars, shared bikes, shared scooters, and also features like child-seats that can be rented. Thus it will form a full service-concept.

The primary challenge faced by Utrecht for MaaS is the integration of all the component and the different mobility providers with all the necessary features. At present, an app that combines multiple modalities of other providers requires the user to download the other apps for those providers. Once these are downloaded, the central app is able to directly have the phone switch over to those other apps, when the user needs them. Part of the issue here is a matter of trust. The vehicle provider would have to entrust the system for unlocking the vehicle to an external party, namely the central MaaS provider. The providers moreover still need to see the value for themselves to cooperate, and to spend the necessary resources to ensure there is a good connection between their and others' services.

Further questions and challenges include deciding on which modalities are to be included in MaaS and other services. Moreover an appropriate scale for projects and experiments always needs to be determined. It is also difficult to make sure people actually use the offered services. This is seen as being reliant on the service being truly good, and having all the necessary modalities.

The response from the population to MaaS is described as mixed. The current test users are very enthusiastic. However they are admittedly not necessarily representative of the whole population of Utrecht. Responses from other people in the city have not really been gathered yet.

Overall, Utrecht largely envisions a facilitating role for itself when it comes to Maas. They do have a slight steering influence, in that they prescribe what modalities are to be integrated. They also set the programming standards that are to be used, which is mainly done to make upscaling in the future more feasible, and to ensure that the resulting service can interact with the results from the other national MaaS pilots, which also use those same programming standards. Relatedly, every MaaS pilot has the ambition to scale up to a national level, which could result in 7 different national services coming to exist. From the perspective of Utrecht, this is seen as acceptable.

B.3. Almere

The city of Almere was built with the principle of separating the different modalities that are used. Cycling facilities are separated from car facilities, and both are in turn separated from bus facilities. In the past, chain mobility did not use to be much of a concern, and so there was less attention for it. Within the city's mobility vision, sustainability is an important point, with special attention also being given to health, infrastructure and through flow, and cycling safety. Improving social inclusion is also considered important. The city wants to make sure that everyone has access to mobility, including elderly and disabled people.

In Almere, a fairly high percentage of movements are conducted using public transport. On the other hand, there is a comparatively low percentage of bicycle usage. In the eyes of the city,

there is no real desire to change much about this current situation. They would however prefer it that people would more regularly look at alternative travel methods, particularly alternatives for the car.

In the past, the primary concern when a new neighbourhood was built was to immediately set up a new bus connection. Nowadays, there is a shift towards setting up such systems only based on demand from the actual residents. Nonetheless, still when new living spaces are built, some amount of attention is paid that they are accessible by public transport and bike. Similarly, the municipal government discusses with employers and public transport providers to ensure a good public transport connectivity with new and existing business parks. They also use this to give employers and companies and incentive to move to a particular business in Almere, by assuring them that they will be easily accessible by public transport. Other than this, a large amount of responsibility over the system is given over to the public transport provider.

The term and concept MaaS is given very little attention in Almere. Within the municipal government, it is not seen as an important issue or subject. The city is hesitant, wanting to wait and see how it develops, and what other regions will be doing with it. This is also ascribed to it still being considered quite 'vague', and no one quite knowing how everything is supposed to work when it is implemented. It does see brief mention in the city's mobility vision for 2030, where it is considered a part of the general shift towards smart mobility. Almere broadly defines MaaS as the movement of a user from point A to point B whenever they want. Since Almere is not yet interested in MaaS and hesitant, no concrete project appear to have been set up thus far that can be ascribed to it.

B.4. Groningen

Groningen is becoming more densely built and populated, and with the building of new housing the city is growing as a whole. From the municipal government, there is the ambition to promote car usage taking place around the (inner) city, rather than within the (inner) city. In other words, cars are to be kept in the ring. Part of the thinking behind this is to make more space available on the street, that can then be use for more green, more playing, and such endeavours, thereby improving quality of life for the people living in the city.

Relatedly, there is a wish to promote 'healthier' forms of mobility. As such, walking and cycling is promoted and encouraged, particularly as alternatives for driving a car. The given challenge therein is how to translate such ideas into practice. Further travel behaviour desires are largely dependent on which section of the city is being focussed on, such as the wish to keep cars out of the inner city mentioned above. When considering these issues, they find it is necessary to look at why a certain vehicle, like for example a car, is used in a particular location or area, because only with such understanding can behaviour be adjusted.

The main idea that is named for achieving these ambitions is the planned placement of parking locations. The intention is to set up special parking spaces for cars, that are located purposefully outside the city centre, in order to encourage travellers to leave their cars there, rather than taking them deeper into the city. Similarly, underground parking areas are to be set up for bicycles, so that those can be taken into the centre, without the parked ones blocking up the streets and sidewalks.

As regards MaaS, Groningen holds the definition of MaaS being when a provider has created a platform that can be used by users to access services that are provided by others, but are combined and offered as a package by the central platform operator. According to them, somewhere in that system there should be a place for the government. They envision themselves somewhat

like users, but they could also be providers of shared vehicles if they want to be.

If they were to implement MaaS, which they are theoretically interested in doing, they want it to actually add something to the city. They do not want it just so they can say they have it. A suitable problem would have to be found, that MaaS could actually help with. An example that is given relates to companies approaching them with proposals for shared bicycles. These proposals generally do not fit the circumstance of Groningen, since there are already many bikes in the city, a large amount of trips is taken by bike. As a result, adding hundreds of rentable bikes will solve little, and rather cause more problems.

One potential venue for MaaS that gets named would be focussing on the movements out of the city, rather than into or within the city. This could be combined with the concept of mobility hubs, where travellers can change over between modalities. If these hubs were to located outside of the inner city, people would first have to move there using for example a bus. Then, they can from that hub take a (shared) car to make their trip to the external location. These hubs have already been somewhat implemented in the region, and they could also be further extended upon with further features. Examples of such features include package services and charging stations for electric (shared) vehicles.

Groningen is researching the potential of servicing new parts of the city with shared vehicle systems rather than parking space. Residents of the new areas would get a subscription from the municipality with which they can use these vehicles. They would ideally wish to involve potential users in this development, but this does not happen as often as would be desirable.

The MaaS-pilot in the region of Groningen focusses on WMO-transport, similar to the one in Enschede. Currently, the transport that is used for WMO is not very efficient, particularly when looked at through cost versus distance, and when compared to regular public transport. Resources like the small buses could be used better and more efficiently. But the system is unable to do so right now, because those buses and other related vehicles are not ‘visible’ for MaaS.

The main challenge Groningen sees for implementing MaaS is internal. It can at times be difficult convince people in the government to look at non-infrastructure solutions to problem they come across. There will often be alternative solutions available, but not everyone working in the government understands that and is willing to make use of those solutions.

A further challenge is also a lack of knowledge on the part of the users, when it comes to how MaaS systems and the accompanying modalities. An example is people not understanding how an electric car is supposed to be used. As a result, they feel a hesitation to use such a vehicle or its services, and so will not commit to MaaS.

Appendix C: Practical test steps

C.1. The Hague

Step	Action
1	Open TURNN website
2	Enter Museum Beelden aan Zee as destination
3	Enter bus stop Alfred Nobellaan in De Bilt as departure
4	Open Whim app
5	Enter Museum Beelden aan Zee as destination
6	Enter bus stop Alfred Nobellaan in De Bilt as departure
7	Compare suggestions to those of TURNN
8	Choose how to travel
9	Travel to Utrecht Centraal, paid with OV-Chipcard
10	Travel to Den Haag Centraal, paid with OV-Chipcard
11	Travel towards Museum Beelden aan Zee, paid with OV-Chipcard
12	Get off after 10 minutes, when it is revealed that the museum is closed that day
13	Open GoAbout app
14	Choose route planner
15	Enter Gemeentemuseum Den Haag as destination
16	Enter current location as departure
17	Open Whim app
18	Enter Gemeentemuseum Den Haag as destination
19	Enter current location as departure
20	Travel to Gemeentemuseum Den Haag using GoAbout
21	Open TURNN app
22	Enter Alfred Nobellaan in De Bilt as destination, with in-between stop at the Haagse Markt
23	Enter current location as departure
24	Open Whim app
25	Enter Alfred Nobellaan in De Bilt as destination, with in-between stop at the Haagse Markt
26	Enter current location as departure
27	Buy necessary train tickets with GoAbout
28	Travel to the Haagse Markt
29	Travel to Den Haag Centraal
30	Travel to Utrecht Centraal, with ticket in GoAbout
31	Travel to Alfred Nobellaan, paid with OV-Chipcard

C.2. Utrecht

Step	Action
1	Open Tranzer app
2	Enter Papendorpseweg 53 as destination
3	Enter bus stop Alfred Nobellaan as departure
4	Buy bus tickets
5	Travel to Papendorp P+R, with Tranzer's tickets
6	Open FlickBike
7	Search for nearby bicycle
8	Reserve bicycle
9	Walk to bicycle
10	Unlock bicycle
11	Ride FlickBike to Papendorpseweg 53
12	It is revealed that the appointment's location has been moved to The Village Coffee Science Park
13	Ride FlickBike to Papendorp P+R
14	Park and lock FlickBike
15	Open Tranzer app
16	Enter P+R Science Park as destination
17	Enter Papendorp P+R as departure
18	Buy bus tickets
19	Travel to P+R Science Park, with Tranzer's tickets
20	Open GoAbout app
21	Search for nearby bicycle hub
22	Walk to bicycle hub
23	Connect phone to bicycle
24	Unlock bicycle
25	Ride bicycle to The Village Coffee Science Park
26	Search for bicycle hub in De Bilt
27	Ride to bicycle hub in De Bilt
28	Park bicycle in hub
29	End trip in GoAbout and lock bicycle

Appendix D: Test scenarios

D.1. The Hague

With the weekend coming up, Thomas is planning to make a cultural daytrip out to The Hague. He would like to go visit one or more museums, and maybe take a look at the market that he heard takes place multiple days per week. In preparation, he looks up on the internet what might be a fun museum to visit, and the moments when the market in The Hague takes place. He finds out that next Saturday would be a suitable moment to plan his trip, and that he will then visit the Museum Beelden aan Zee near Scheveningen, and afterwards make a short detour by the market, which should be open on that day, before getting on the train back home. As he plans his trip, he remembers recently reading about the release of a mobility app called GoAbout. Supposedly, the app allows users to not only plan routes and trips, but also provides them access to the mobility required to complete those journeys, in the form of public transport tickets and public shared bicycles. Seeing this as an opportunity to try out such a service for himself, he decides to use the app when he is planning and completing his trip.

When the day arrives, he gets out of bed early to prepare. He already downloaded the app onto his phone the night before, and he also immediately opened an account with which to use and pay for the mobility options. After getting dressed, he opens the app on his phone so he can start by determining how he will travel. He chooses the route planner function, and firstly enters Museum Beelden aan Zee into the destination field, as this will be his first stop. At this point, he realises that the app only accepts full addresses for destinations, and so he will have to look up the museum's specific location. After having done so on his laptop, he enters the new information into the field. He then gives the bus stop at Alfred Nobellaan in De Bilt as his departure point, since he knows this to be the nearest bus stop. Based on this information, he lets the app calculate different options for how he could complete the journey. He now finds out that the app does not appear to take into account buses, nor does it allow for the purchase of bus tickets. As a result, it suggest Thomas to cycle to Utrecht Centraal, take the train to The Hague, and cycle the rest of the way to the museum from there. This is not quite what he had in mind, and so a bit disappointed he decides to change his approach. He knows that there is another route planner app called TURNN, which offers multimodal travel suggestions for trips, and compares them on different characteristics. Curious to give this one a try, he opens downloads the app onto his phone, opens it, and again enters the information for destination and departure locations. The app indicates that the fastest route would be to take the bus to Utrecht Centraal, take the train from there to The Hague, and then take a direct bus to the museum. This suits Thomas' wishes, and he decides this will be the route he takes. Since it consists fully of public transport, he can use his personal OV-Chipcard, the national public transport card in the Netherlands, both as a payment method and as his ticket. Satisfied, he leaves the house and makes his way to the bus stop.

Thomas timed his arrival at the bus stop perfectly, because just a few minutes later, his bus is there and he can get on it to Utrecht Centraal. He holds his OV-Chipcard in front of the scanner at the front of the bus, and with that, he can pay and get on. He is even able to get a seat, probably because it is still fairly early in the day. A mere 20 minutes later, the bus arrives at the train station. Before getting off, he holds his card in front of the scanner at the back, in order to 'check out', thereby finishing the bus trip and paying for it. He steps onto the escalator that goes up to the station, and it takes him to a large hall. To enter the station proper, he has to get through a series of metal gates, for which he can use his OV-Chipcard to open. Doing so and stepping through, he walks over to the central screen that shows departure times and platforms, and looks for the train to The Hague. Upon finding it, he goes to his platform and waits.

Everything seems to be going smoothly thus far. He does notice that it seems to be quite busy on the platform, and as expected, when the train to The Hague arrives it gets quite full, which means Thomas will not be able to sit. Fortunately, it takes only around 40 minutes for the train to get to his destination. He gets off the train, and takes a moment to orient himself, having not been to this train station very often. Looking around, he finds the exit gates, similar to those which he found at Utrecht Centraal, which he opens with his card and goes through. Beyond those, he goes through the front doors of the station, and finds the bus station directly to his right. He already knows which bus he will need to use, and so he walks to the correct platform and waits. The bus arrives, he checks into it with his card, and he sits down as it makes its way to near Scheveningen, where the museum is located.

As the bus is driving, Thomas strikes up a conversation with a fellow passenger. They talk for a bit, and eventually he is asked about his plans for the day. When he tells that he is planning to visit the Museum Beelden aan Zee, he is informed by the other passenger that that museum is actually closed today. This catches Thomas by surprise, and he for a moment does not quite know what to do. He asks the other passenger for a recommendation for a different museum to visit. He is told that the Gemeentemuseum Den Haag should be quite interesting. He takes this advice, and since the bus he is currently on is taking him in entirely the wrong direction he decides to get off at the next stop. At that bus stop, by pure coincidence, he finds a set of Go-About rentable bikes. He thinks this is an opportunity to give that app another shot. He opens the app on his phone, where it is luckily still installed, and chooses the route planner function. He enters the bus stop he is currently at as his departure point, and gives the address for the Gemeentemuseum as the destination. The app's primary suggested travel option is to take the bike there. Thomas expected as such, and proceed to use the app to open the digital lock of one of the bikes. He adjusts the seat to his preferred height and gets on. The route over to the museum involves a few bends, and he has to stop occasionally to check the map on his phone, but eventually he also starts seeing signs along the road indicating where he needs to go, and he manages to find his goal. He parks his bike in a regular bike rack, locks it using the digital lock, and heads inside to enjoy the art.

When he leaves the museum, Thomas finds that it is already getting somewhat later into the afternoon, and he needs to start thinking of how to get home again. Since he already has the GoAbout bicycle nearby, he figures he may as well make use of it. He decides that before going to the train station and going home, he wants to quickly check out the market square and take a look around there. He takes out his phone and opens the GoAbout app's route planner, and gives the information that he wants to go to the train station of The Hague, with a stop in between at the market. Annoyingly, the app does not allow him to add in-between stops, and so he will first have to plan the trip to the market, and then from there plan a trip the rest of the way to the train station. The app gives him the quickest route by bicycle to the market, and he gets on his way. Following the route the GoAbout app gave him, he arrives at the market, takes a look around, and does a little bit of shopping, getting lunch to feed his lingering hunger from the day. Once he is finished, he walks back to where he parked his bike, against a lantern post, and opens the GoAbout app to look up the second part of his journey to the train station. As it turns out, it is quite nearby, and he will be able to leave his GoAbout bike there. He follows the app's directions, and places the bike in the designated rack, locking it and ending his session with it. Payment should happen automatically based on how long he used the bike today. With that, he walks into the train station, and opens the metal gates with his OV-Chipcard. The card is for him the most practical way of taking the train ride, although as he is doing it he realises he could have theoretically also used the app. He looks on the screens for his train, makes his way to the platform, and waits for the train to arrive. Now he is back on his way home.

D.2. Utrecht

Tomorrow, Thomas will have a meeting with a potential business client in Utrecht. He received the company information by way of email a few days earlier, indicating their address at the business park Papendorp, and thus now has to plan his trip there. Since he has never been there before, he decides he should probably get there ahead of time, as well as figure out a suitable way of transportation for his trip. He expects a bus will be able to get him at least near to the business park, but does not yet know how to get from there to the company address. According to the email he received a few days ago, the company's address is Papendorpseweg 53, which appears to lie at the outskirts of the business park. A quick check of an online route planner tells him he could get there by bike, or through a combination of bus and walking. He thinks it a bit too far to have to cycle all the way from his house, but he also notices it would be quite a long way to walk from the bus stop the route planner shows him. He starts thinking that ideally he would like to take the bus to the business park, and then somehow get a bike there to cycle the rest of the way to the company. Suddenly he remembers as part of his research coming across a series of mobile apps that enable usage of public transport and shared bikes in various regions of the Netherlands, including Utrecht. Curious for this relatively new type of service, he decides this a suitable moment to try them out. He has read a bit about an app called Tranzer, which he chooses as his primary means of getting public transport. The app supposedly allows for the planning and purchase of public transport tickets, like bus and train. To find a bicycle he could use to go the rest of the way, he first looks into an app called GoAbout, which claims to offer shared mobility, as well as train tickets. He actually already has the app on his phone and an account with the service, as he needed a bicycle some weeks ago. Unfortunately, he finds out that the app does not have any bicycles in Papendorp, as its only implemented region in Utrecht is the Science Park and its surrounding area. Next, he looks up the service FlickBike, which also provides bicycles, in a free-floating system where bikes can be parked and picked up again at any point in the area. FlickBike's implementation covers only a small selection of neighbourhoods in the Netherlands, but these do include Papendorp. Thomas concludes based on this to use public transport, planned and paid through Tranzer, to get to Papendorp, and will then take a bike using FlickBike the rest of the way to the company.

To prepare the evening before his meeting, Thomas downloads the Tranzer app onto his phone, and fills in the information it asks for. He checks to make sure the app will allow him to use all the buses that he expects to need, to get to Papendorp and back home again, entering his house in De Bilt as his departure point and the company address as the destination.

The next morning, Thomas gets out of bed and gets ready for his appointment. Nicely dressed and having quickly eaten some cereal, he makes his way to the bus stop near his house. As he is waiting there, he opens the Tranzer app on his phone, and looks up his trip. He sees he will require two buses, changing over at Utrecht Centraal, to get to Papendorp. As the app shows him this information, he is immediately able to purchase the required tickets, as the app redirects him to an iDEAL page where he can pay through his bank account. After that, the bus tickets are loaded into the app. He waits a few minutes for the bus to arrive. When it does, he gets on and shows his digital ticket to the driver. The driver gives him a nod, and he goes to take a seat and look out the window as it takes him to Utrecht Centraal. He gets out of the bus, and does not even need to 'check out' like he is used to with the OV-Chipcard. At Utrecht Centraal, he walks to the stop where the next bus will arrive in a few minutes, which will take him the rest of the way. He sees there are a lot of people waiting there, and many of those also get on his bus. He again shows the digital ticket in Tranzer to the bus driver, and walks further in, where he unfortunately notices that due to how busy it is, he will not be able to get a seat. Luckily, the drive to Papendorp should not take too long, so he is fine with standing. After just a few minutes, the

screen shows that Thomas' stop is next, and he presses the stop button to indicate he wants to get off. The bus stops at the parking area of Papendorp, and Thomas gets out.

As the bus drives off behind him, Thomas first takes a quick glance around to orient himself. Taking his phone out of his pocket, he opens FlickBike to make sure there are actually bicycles available for him, and where he might find one. He sees there is one at the other end of the parking area, and that he is even able to reserve it for himself for 15 minutes. He presses the button to do so, and starts walking over there. Seeing the orange of the bicycle he is looking for, he checks its number with that given on the screen of his phone. Confirming it is the correct one, he uses the app to scan the bicycle's QR code. Immediately, the lock of the bike springs open, and he can get on to go to his appointment. Since he did not think to prepare a dedicated route planner on his phone, he opens Google Maps to navigate to the address, which turns out to be quite easy. Just a few minutes later, he manages to reach his destination. He parks the bike, and locks it, which makes it available once more for anyone to take.

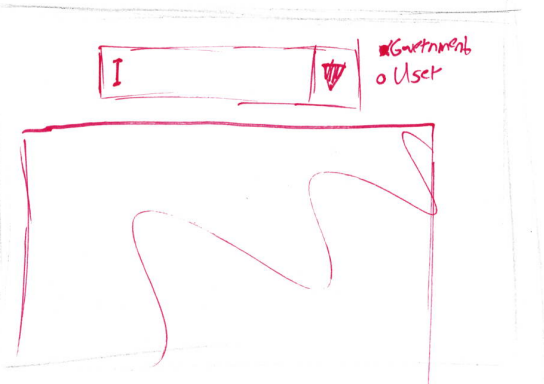
As he tries to enter the building, he finds the door to be locked. Confused, he tries again, but the door will not budge. He checks his emails again, to see if he had maybe forgotten about instructions on how to get into the building. When he does, he notices he actually received a new email from the client the evening before. He opens it, and sees that it was sent to inform him the appointment had moved location. Because the client had another meeting, at Utrecht University, Thomas was asked if their appointment could be moved to take place at The Village Coffee Science Park, at the Science Park of Utrecht University. Cursing himself for not having checked his email before leaving, Thomas is at least glad he calculated in extra travel time, so he should hopefully be only a couple of minutes late. He immediately gets back on the bicycle, and rides back to the bus stop. There, he parks the bicycle again, locks it, and walks to the stop. As he is walking, he opens the Tranzer app to quickly plan a new trip and buy some new bus tickets that can take him to Science Park. Just as he is finished with that, the bus arrives that will take him to Utrecht Centraal. After changing over to the second bus there, he manages to get a seat. He suddenly realises he will not have a bicycle available at Science Park, which might pose a problem. But then, he gladly reminds himself that GoAbout offers bicycles there, and he even still has the app and the required account. Relieved, he waits for the bus to get to the stop he needs to get off at.

The stop where he gets off is just across one of the university buildings, but he knows it to not be the one he is looking for. He opens GoAbout, and uses it to plan a route from his current location to the The Village Coffee Science Park, where his client is waiting. It provides him with a route to take, as well as telling him about nearby hubs with bicycles he can borrow. Noticing there is one just across the street, he walks over there, and as the app connects via Bluetooth to the bike's lock, he merely has to press a button to start and unlock it. Hurriedly, he gets on, and starts cycling as fast as he can to his destination, only stopping twice to check the route in the app to make sure he is going the right way. Once there, he parks the bicycle in a regular bike rack, and uses the app to momentarily lock it until he comes back. With that he heads inside.

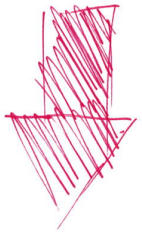
One and a half hour later, Thomas leaves the building again, happy with the outcome of his meeting. However, now he will need to figure out how to get home again. His current location is actually quite near his house in De Bilt, and since the weather is nice right now, it would be absolutely ideal if he could just cycle it. Curious, he checks the GoAbout app for hubs where he can return the bike, as well as rules about whether a bike needs to be returned to its original location. As it turns out, not only is there a possible drop-off point quite near to his house, but he is also allowed to leave the bicycle there rather than at its original location for no additional charge. Despite the rocky start to his morning, he is feeling a lot more satisfied at this point,

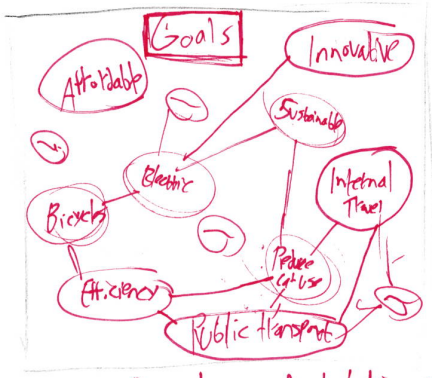
and he starts making his way home. He stops at GoAbout's hub, and places the bicycle in its designated rack. On the app, he presses the button to return the bike and end his trip. He locks the bike as the app tells him to do, and he is done. All that is left is a nice leisurely walk back home.

Appendix E: Tool interface sketches

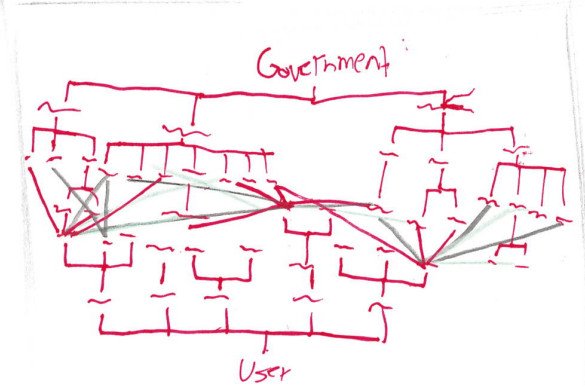


'Search box' where user can type in 'tags' for either Government goals or user needs (selected at the side). Or dropdown menu

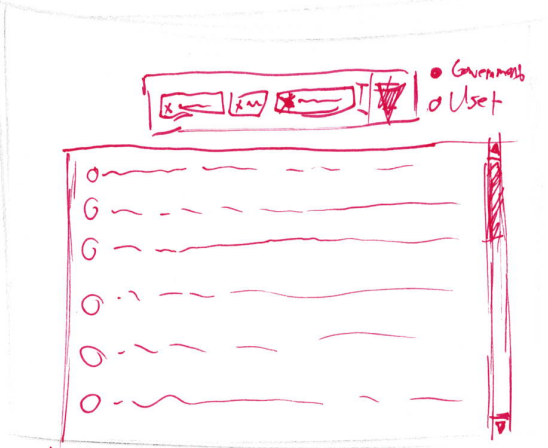




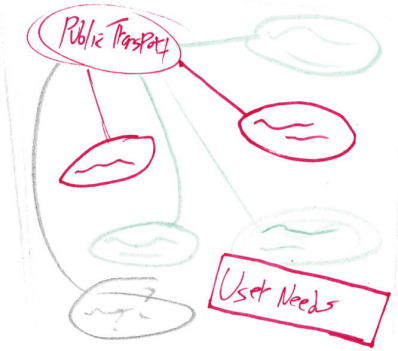
Web of goals, and relations between them are illustrated. Each goal can be selected for more info.



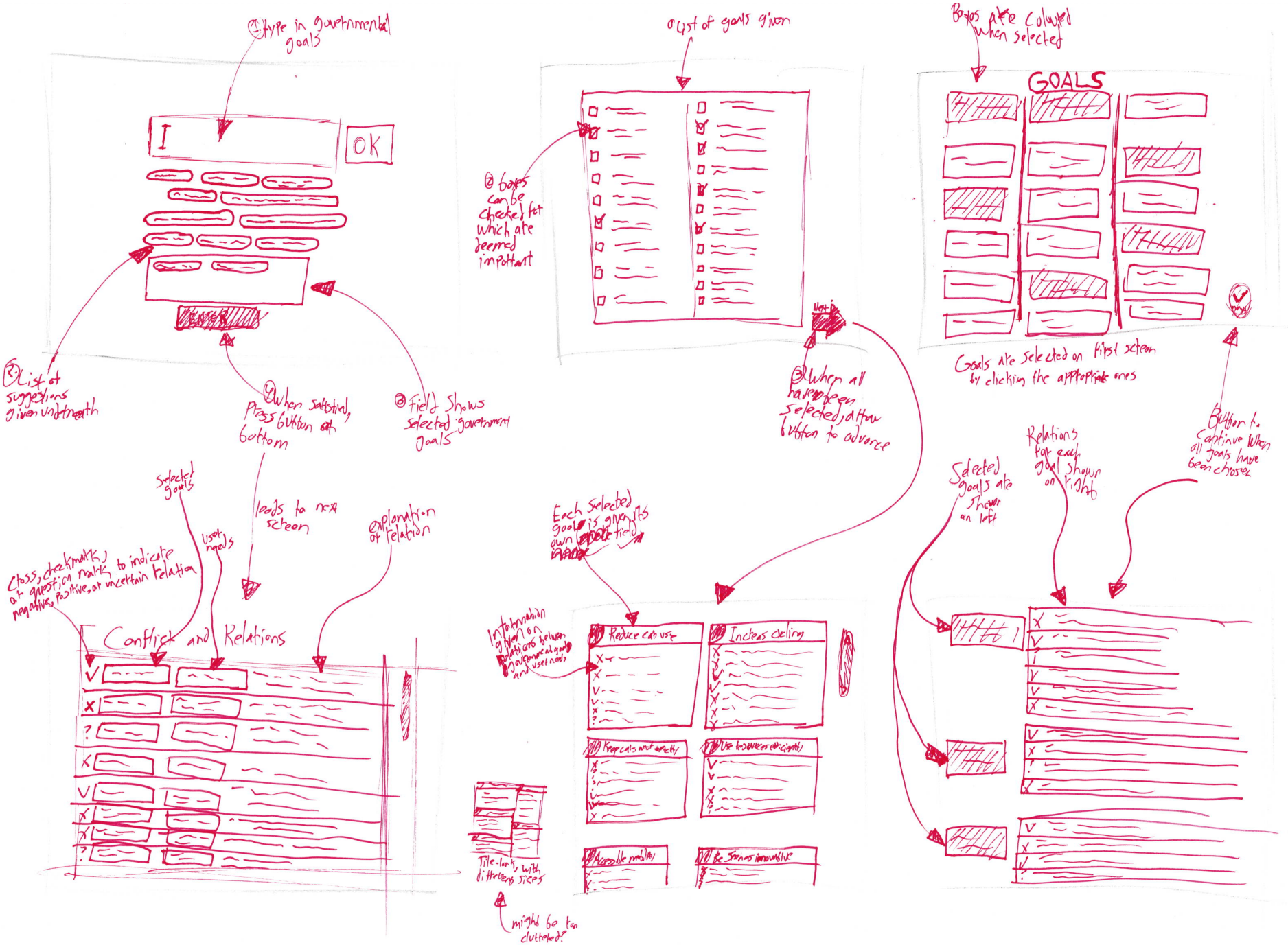
Two hierarchical trees. Lowest branches are connected by lines, colour indicating positive/negative/neutral

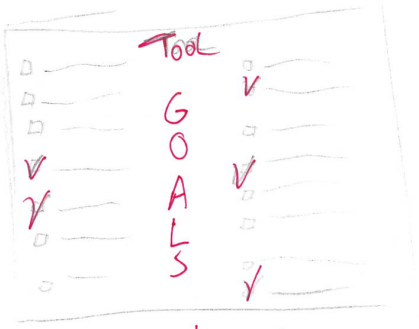


With 'tags' selected, box underneath shows things to look out for

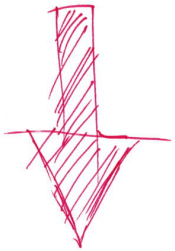


When a goal is selected, it shows important user needs that are related to it

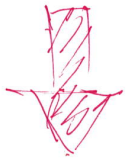

1. Type in governmental goals
I
OK
2. List of suggestions given underneath
3. When satisfied, Press button at bottom
4. Field shows selected government goals
List of goals given
2. Boxes can be checked for which are deemed important
When all have been selected, allow button to advance
Boxes are colored when selected
GOALS
Goals are selected on first screen by clicking the appropriate ones
Button to continue when all goals have been chosen
Relations for each goal shown on right
Selected goals are shown on left
Selected goals
User needs
leads to new screen
explanation of relation
Cross, checkmarks, ?, question marks to indicate negative, positive, or uncertain relation
Conflict and Relations
Each selected goal is given its own [illegible] field
Information given on relations between governmental goals and user needs
Reduce car use
Increase ridership
Keep cars moving
Use transit efficiently
Accessible mobility
Be transit innovative
Tile-like with different sizes
might be too cluttered?



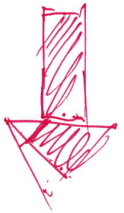
User can check the municipal goals

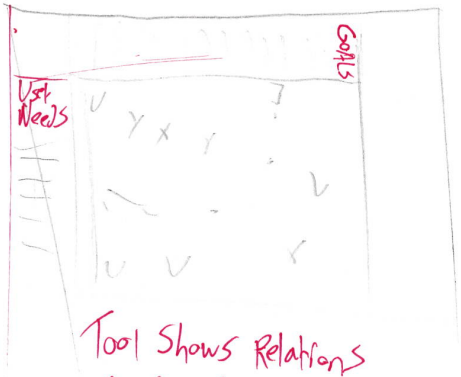


User can choose from profiles which fits best with their region/municipality

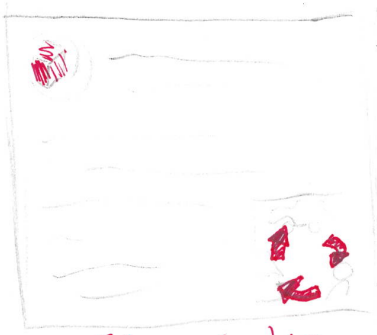


Main tool gives a more digestible and generalised matrix



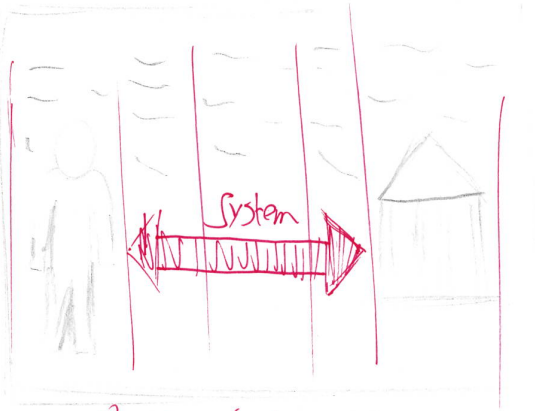


Tool shows Relations only for chosen goals

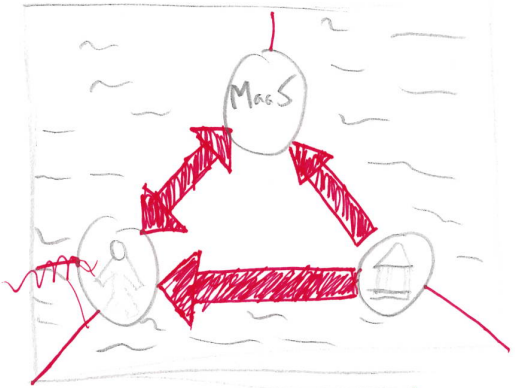


Tool gives advice and service suggestions for chosen profile

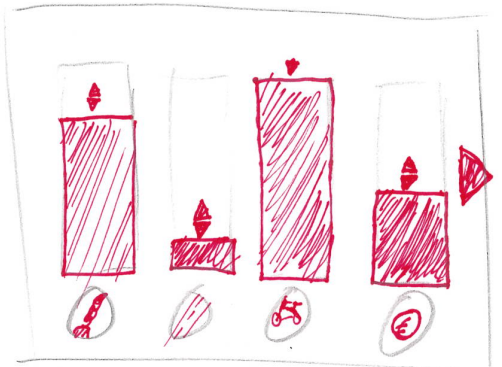
Bundled/Generalised groups can be expanded for more detail



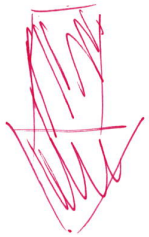
Reorder factors into 5 groups, and insert into infographic

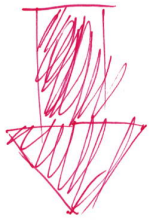


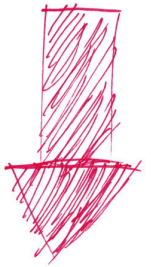
Factors entered into triangle of relations

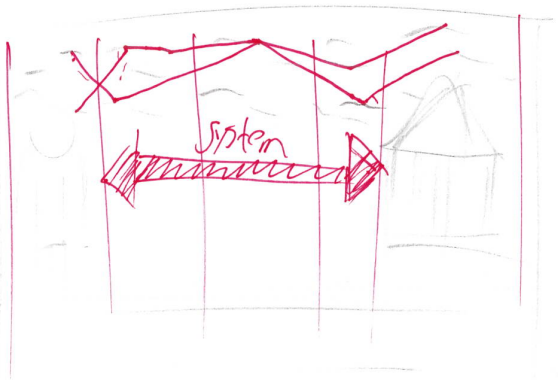


User can adjust bars for different themes of factors

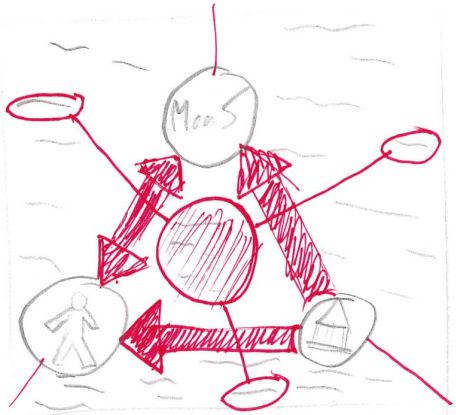




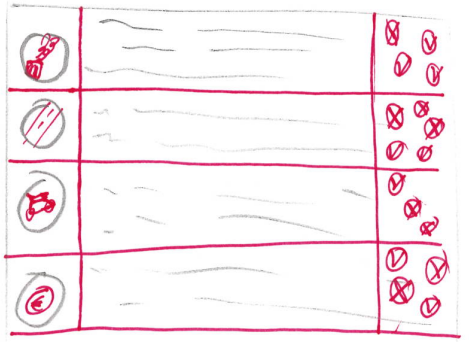




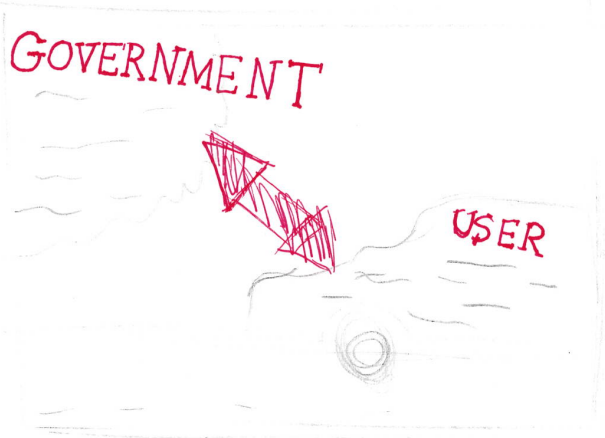
'paths' through the factors to indicate relations



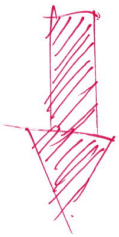
Selecting factors compares them in centre

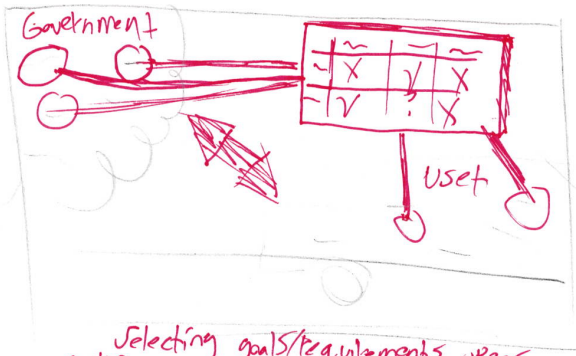


Tool gives advice and information based on inputs given for importance



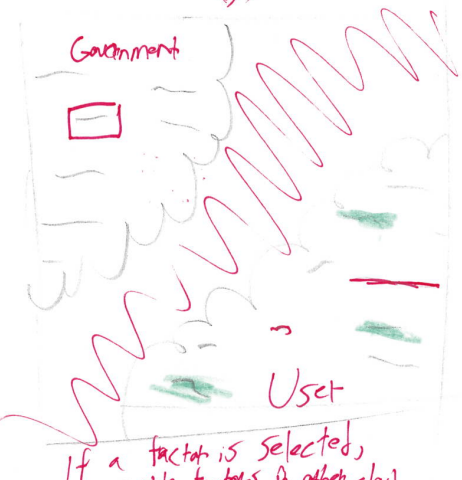
Intographic interface, with Government goals and User requirements against each other



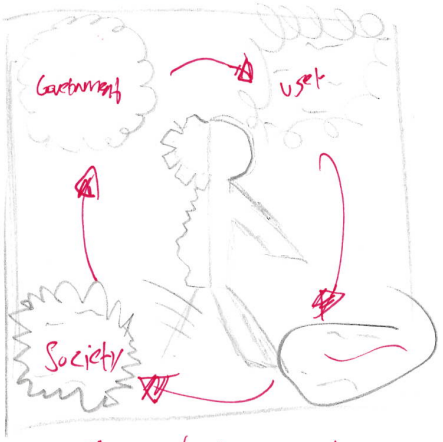


Selecting goals/requirements opens matrix containing them, showing relations

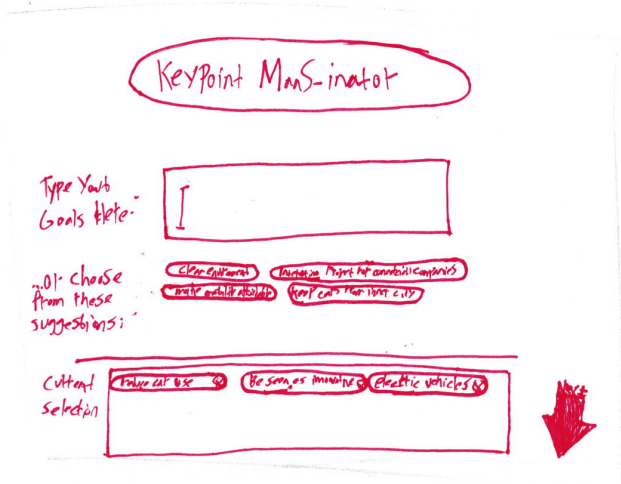
Factors from User and Government are bundled in clouds

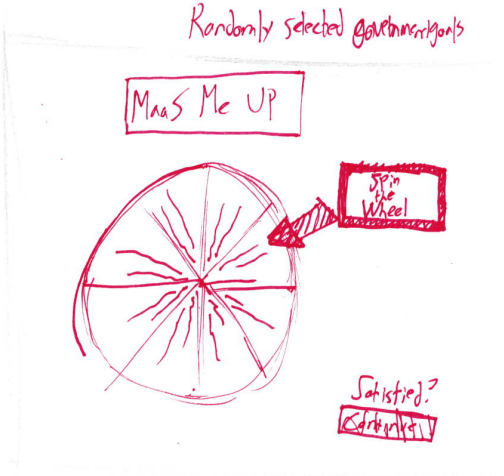


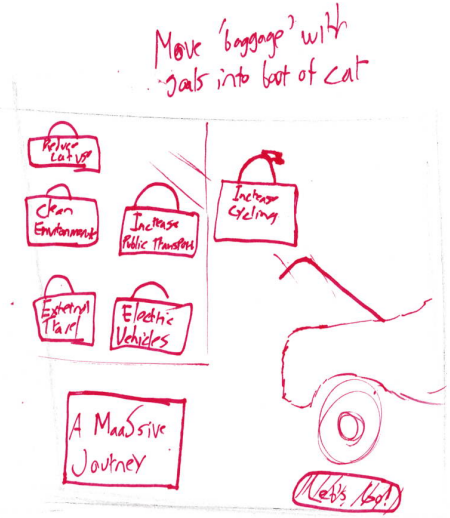
If a factor is selected, clouds mark factors in other cloud that match or contradict

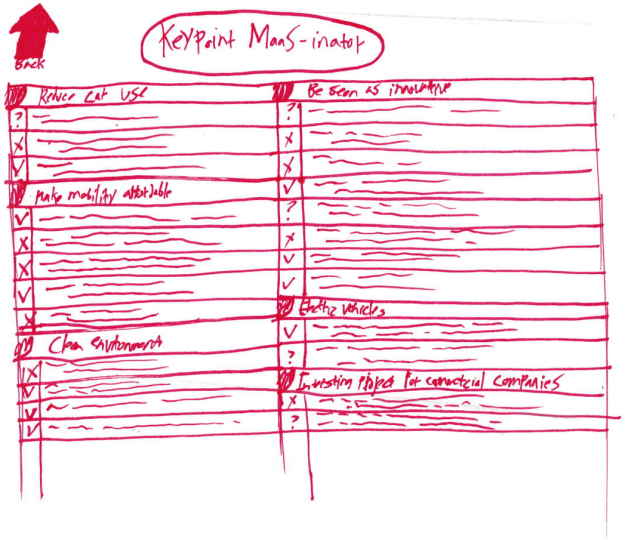


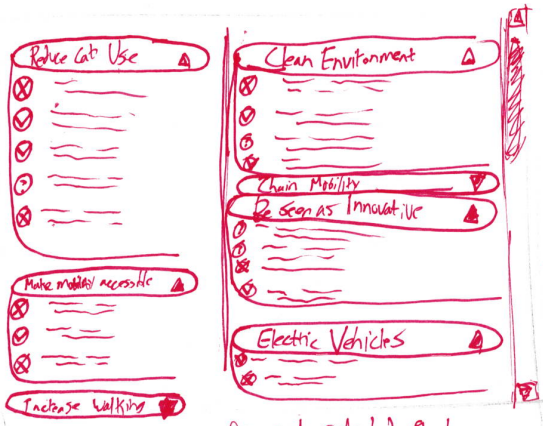
Theory of the model is summarised into one central image/intographic



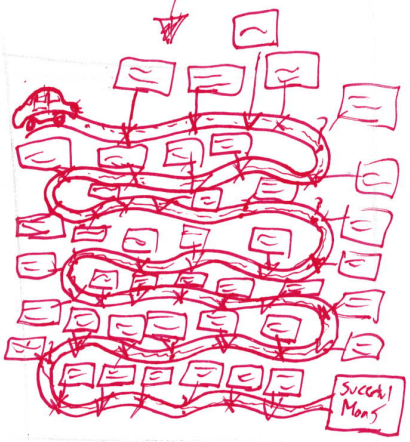








Dropdown-options for each selected goal, showing conflicts and relations with user needs



A 'journey' roadmap is shown, with compliments and conflicts displayed along the way as 'obstacle'