Understanding smart mobility experiments in the Dutch automobility system: who is involved and what do they promise?

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Abstract
In this paper, we aim to understand what ICT-related automobility experiments are initiated in the Netherlands, who is involved and what promises they make, in order to get a better understanding of the magnitude and direction of change. We show an example of how to study a large variety of experiments to understand the emergence of niches before predetermining these as analytical constructs. By analyzing 118 experiments, we can identify the emergence of two niches: an automated mobility niche and a mobility services niche. The automated niche is characterized by large involvement of incumbents and a strong technological orientation. The services niche focuses more on organizational innovations and involves many new entrants. The involvement of a third actor category, ‘mature entrants’, applies to both niches and concern those actors that fall more or less in-between the common ‘incumbent-new entrant’ dichotomy. In general, experiments in the automated niche seem to strengthen the dominant role of the car in the automobility system, while services niche experiments mainly portray an altered role of the car in an alternative mobility system. We conclude that we gained a better understanding of the experiments and emerging niches, but at this stage, developments can still head in different directions. Nevertheless, the involvement of mature entrants in both niches, we argue, can be an important indication that more substantial change is likely to occur.
1. Introduction

The automobility system is the main contributor to climate change and other sustainability challenges (Arrow, 2007; Nieuwenhuis, Vergragt, & Wells, 2006). It furthermore faces more immediate problems such as road congestion and competition for public space. Despite a plethora of interventions and the latest detachment of the young generation from traditional cultures of automobility (Engels & Liu, 2011), the prevailing automotive industry and the wider system of mobility appear impervious to radical change (Geels & Kemp, 2012; Steinhilber, Wells, & Thankappan, 2013; Wells & Nieuwenhuis, 2012). Indeed automobility has been expanding rapidly on a global basis – in part because cars are more than just ‘transport’ but also symbolic signifiers of wealth and freedom (Sperling & Gordon, 2009).

Despite the obdurate character of the mobility system, evidence of change has emerged. The combination of digitization with the growing need for flexible mobility choices alongside CO2 emissions reductions has enabled the development of a range of new mobility initiatives such as automated driving or car sharing services (Cohen-Blankshtain & Rotem-Mindali, 2016; Geels, 2012; Jeekel, 2014). The increased use of the information and communication technologies (ICT) in the mobility field (Bishop, 2005) and the larger disruptive potential started to evoke a promise of solving both the grand and the immediate challenges that the automobility system faces.

The Netherlands has, in the past three years, been branded by various policymakers and practitioners, as a perfect test environment for such initiatives (Holland, 2016). The country has expressed explicit ambitions to become a frontrunner in ‘smart mobility’, a new conceptual area championed to encompass the various ICT-related mobility innovations. In support of the development, the country has already established several programs (e.g., Roadmap Better Informed On The Road) and organizations (e.g., Traffic Innovation Center), to experiment with cooperative intelligent transport systems, automated driving, and car sharing services (Connecting Mobility, 2017). Although some call for caution (Wells & Xenias, 2015), these activities and the emergence of a variety of alternative mobility forms are potentially profoundly transformative to the automobility system. Without a doubt, they create new dynamics in the Dutch automobility system. The field, however, is still relatively new and seriously understudied. What specifically remains unclear, is the magnitude and direction of this phenomenon and whether or not it will lead to a more fundamental change of the automobility system. Before such grand questions can be answered, however, it is important to first better understand what initiatives are launched, with what purpose and by whom. In this paper, we aim to address these issues by mobilizing insights from transition studies. The main research question is:

*What ICT-related automobility experiments are initiated in the Netherlands, who is involved and what promises do they make?*
Since they can provide the starting points for a (more radical) change (Raven, 2006) of the automobility system, we frame the ICT-based mobility initiatives as experiments in transition (Sengers, Wieczorek, & Raven, 2016). To get a better grip on what experiments have been initiated recently (2015-2016) in the Netherlands, and what they are about, we collate them into a comprehensive database. We analyze who initiates them and who is part of the experimental network. We interpret the alternative mobility forms, whether technical such as automated vehicles or organizational such as car sharing schemes, as niche applications with the potential to destabilize existing socio-technical ensembles (Geels, 2012; Wells & Xenias, 2015). In doing so, we follow the distinction made in the transition studies between less developed technological and more specialized market niches (Coenen, Raven, & Verbong, 2010; Hoogma et al., 2002; Schot & Geels, 2008; Schot, Hoogma, & Elzen, 1994). To better understand who is involved and what the experiments promise to accomplish, we mobilize respectively insights from network theory (Borgatti & Foster, 2003; Coleman, 1990; Granovetter, 1973) and the sociology of expectations (Borup et al., 2006; Brown, Rip, & Van Lente, 2003; Van Lente, 1993). The overarching aim of this paper is to inform policymakers and practitioners, who are struggling with a plethora of grand challenges and immediate problems, and who are attempting to redefine their roles in response to the new circumstances created by this unfolding change.

The paper is structured along six sections. Section 2 gives a brief overview of existing literature on the topic. Section 3 presents relevant theoretical insights about transitions, experiments, actor networks, and expectations. Section 4 outlines methods used in this research. Section 5 presents results, which are discussed and concluded upon in Section 6.

2. Smart mobility experiments for transformative change

The paper builds on the existing literature of the transportation and transition fields. Smart mobility and ICT-based developments have mainly been studied from a technological viewpoint in the transportation literature. Herein Computer Sciences and Engineering perspectives dominate. With the introduction of ‘smart cities’ also social sciences started to engage more with ‘smart mobility’ (Benevolo, Dameri, & D’Auria, 2016).

Some scholars have focused on the possibility for smart mobility to trigger larger changes in automobility by analyzing future scenarios (Epprecht et al., 2014; Fraedrich, Beiker, & Lenz, 2015). They have nevertheless not considered the specific role of experimentation in achieving such changes. Transition literature provides a perspective on the potentially transformative role of experiments in the mobility field. Transition scholars have investigated mobility experiments in non-OECD contexts (Ghosh et al., 2016; Sengers, 2016; Wells & Lin, 2015), and the developed world for the purpose to develop theory (Hoogma et al., 2002). Others have studied mobility experiments in the context of reflexive learning (Brown et al., 2003), transition management (Kemp, 2007).
Avelino, & Bressers, 2011), the role of design (Ceschin, 2014), and governance dilemmas (de Bruijne et al., 2010).

There is, however, no specific attention to ICT-based automobility experiments in the Netherlands in this literature. Additionally, the studies have largely focused on sustainable pathways for transport, while we are interested in first understanding the directionality of unfolding activities. The direction of the developments can be in the direction of a more sustainable transport system, but it can also be different. Furthermore, the studies focus on a small number of cases. The case-study based approach has been the general approach in transition studies, but Sengers et al. (2016) suggest that new approaches dealing with multiple experiments form a promising research direction in this field. Building on work of Wieczorek, Raven, & Berkhout, (2015), Castán Broto & Bulkeley (2013), and Van den Heiligenberg et al., (2017), this paper contributes to transition literature by showing how a larger number of experiments can be studied and how this reveals some insights into the magnitude and direction of change.

Drawing from the various strands of literature we already have an understanding of possible directions wherein change is unfolding. Roughly speaking there seems to be emerging a technology-oriented niche and a niche focusing on organizational changes. Although we do not want to predefine these niches we use these directions as guiding principles in exploring the various smart mobility experiments.

3. Theoretical building blocks

In this paper, we adopt the transition studies lens to frame our research on emergent ICT-based automobility initiatives. Transition literature studies elements needed for fundamental changes of systems, such as the automobility system, from a socio-technical perspective (Elzen, Geels, & Green, 2004; Markard, Raven, & Truffer, 2012). This perspective emphasizes strong interdependencies between social and technical elements of the systems which often lead to their ‘lock-in’ and ‘path dependence’. Many innovations will, therefore, follow incremental paths. More radical innovations generally come to occurrence in spaces called niches that protect these from the selection environment of the incumbent system (Geels, 2005). Niches are therefore considered loci for new socio-technical trajectories (Raven, 2006). They are triggered by the experimentation of actors with alternative technologies or alternative social or organizational constructs. Actors play a crucial role in the translation of gained knowledge and experience from context-specific and locally performed experiments to lessons for wider niche development (Geels & Raven, 2006).

Different from classical innovation experiments, which take place in controlled lab settings and are driven by technical problems, experiments in the context of transitions take place in real-life, uncertain settings, are driven by societal challenges and embed a larger variety of societal actors (Sengers, Wieczorek, & Raven, 2016).
Experimentation is essential according to transitions studies because it facilitates learning about the potential of novelties in real-life environments, it stimulates participating actors to articulate and constantly negotiate their expectations towards the innovation, and to form a network, which can become a basis of a new socio-technical configuration. The three processes of learning, articulation of expectations, and social networking are considered internal niche processes and are seen essential for successful niche development (Kemp, Schot, & Hoogma, 1998; Schot & Geels, 2008; Smith & Raven, 2012).

Niche formation occurs in phases. Technological niches are technology-oriented and characterized by frequent involvement of policymakers, greater uncertainty and less clarity about possible advantages and application of the technological innovation. A market is still lacking and has yet to co-evolve with the promising technological innovation. When there are more certainty and clarity about advantages of the novelties and market demand, the niches can develop into market niches (Coenen et al., 2010; Hoogma et al., 2002; Schot & Geels, 2008; Schot et al., 1994). Market niches often hold small shares of the total market and do not require as much protection from the selection environment as technological niches. Market niches are more stable with steady rules, aligned expectations, and a broad supportive actor-network. During the different phases, social network formation, articulation of expectation, and learning within and across experiments remain crucial to create mature niches. Experimentation can be geared both towards the creation of technological niches as well as the exploitation of market niches (Sengers et al., 2016).

Transition studies study the type of actors and networks involved in the (technological or market) niches and promises made by either. To distinguish between the different type of actors, Geels (2002) proposes a typology of producer network, public authorities, user groups, societal groups, financial network, research network, and suppliers. The underlying idea of the typology is that a broad variety of actors plays a relevant role in reinforcing or transforming a socio-technical system, as it is a multi-actor endeavor. Transition studies furthermore distinguish between incumbents and new entrants to categorize actors. The distinction is made on the base of the actors’ vested interests in the existing system due to their invested time, money, resources, etc. (Mourik, Raven, 2006). Since incumbents are actors who have strong vested interests, they are more likely to follow incremental innovation paths. Contrary, new entrants have less vested interests in the existing system and are therefore more likely to initiate radical innovation and typically operate in niches, according to transition literature. Some also differentiate between new entrants and incumbents by referring to actors’ size and years of operations (Hockerts & Wüstenhagen, 2010). Incumbents are typically active on the market for a longer time, and they are larger regarding the number of employees, revenues, etc. We propose to add a third category to the distinction between incumbents and new entrants, which concerns those actors that fall more or less in-between this dichotomy. It concerns those actors that are large, mature, and are entering a new domain, such as established ICT companies that start operating in the mobility domain. We, therefore, name these actors ‘mature entrants’.

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To get a deeper understanding of the network of actors, transition studies are often complemented with other strands of literature. Social Network Analysis (SNA) is a popular approach to understand interactions between actors. These studies generally aim to understand the innovative capacity of a network by studying its structure and the connections (Borgatti & Foster, 2003). Dense networks with many connections are important for circulation and sharing of knowledge and can contribute to successful innovation (Caniëls & Romijn, 2008; Coleman, 1990). However, some scholars argue that actors involved in dense networks might become too aligned with their beliefs and actions which decreases the overall creative capacity (Burt, 2004; Granovetter, 1973). Loose networks, including outsiders, therefore perform better regarding radical innovation.

To better understand the role of expectations in transitions and to assess the direction of the unfolding developments, often links with the Sociology of Expectations field are made. Expectations, visions, and promises are defined there as “real-time representations of future technological situations and capabilities” (Borup et al., 2006, p.286; Van Lente, Spitters, & Peine, 2013). In early innovation phases characterized by great uncertainties, expectations are heavily negotiated among the participating actors (Smith et al., 2014). Actors strategically use the initial promises to attract attention and resources to their projects. The accumulation of niches is, amongst others, an outcome of a socio-cognitive buildup of expectations regarding both the performance of the innovation itself and regarding future markets and future societal needs (Bakker, van Lente, & Engels, 2012). The process of niche formation is regarded as even more powerful when expectations are coupled to societal problems and are shared, specific, and credible (Hoogma et al., 2002; Kemp et al., 1998; Konrad, 2006). Alignment helps to create strong and mature niches (Geels & Raven, 2006; Geels, 2002; Geels & Schot, 2007; Truffer, Voß, & Konrad, 2008). Expectations can be studied regarding different forms and shapes. Some expectations might, for example, express ideas about the near future, while other expectations express long-term visions. Van Lente (1993) distinguishes three levels of expectations: at a micro-level relating to promises made about the project’s performance (project expectations); at a meso-level relating to promises about the function the project would fulfill (function expectations); and at a macro-level accounting for broader societal promises (societal expectations).

This paper mobilizes the above-discussed insights in the following way. First, we frame the studied ICT-based automobility initiatives as experiments in transitions. We make an inventory of these experiments to assess what projects are set in the Netherlands. We reflect ex-post whether the collected projects in the database qualify to be termed so or not. We use the notions of technological and market niches to study what the experiments are about. We verify in this way some of the claims made in the transportation literature about the existence of technological (e.g., automated cars) and organizational (e.g., car sharing services) niches, and we reflect on their characteristics and potential. Second, we categorize initiators and make use of a novel network analysis to be able to assess what actors are involved in experimentation. Third, we make use of Van Lente’s (1993) typology of expectations to understand what the experiments promise.

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4. Methods

The data collection and analysis is structured along the three elements of the main research questions, and the three discussed theoretical insights: (i) what experiments are initiated, what they are about; (ii) who initiates them and who is involved; (iii) why are they initiated, what do they promise (Table 1).

<table>
<thead>
<tr>
<th>Elements of the RQ</th>
<th>Theoretical insights mobilized</th>
<th>Data collection methods</th>
<th>Data analysis methods</th>
</tr>
</thead>
<tbody>
<tr>
<td>(i) What experiments?</td>
<td>- Definition experiment in transition</td>
<td>- Existing databases</td>
<td>- Content analysis</td>
</tr>
<tr>
<td>What are they about?</td>
<td>- Technological and market niches</td>
<td>- Screening of academic and grey literature, websites, LexisNexis, newsletters, etc.</td>
<td>- Mapping experiments</td>
</tr>
<tr>
<td></td>
<td>- Verifying qualitative interviews</td>
<td>- Verifying qualitative interviews</td>
<td></td>
</tr>
<tr>
<td>(ii) Who initiates?</td>
<td>- Actor typology</td>
<td>- Screening of experiments’ websites, leaflets, etc.</td>
<td>- Network analysis using connectionist approach</td>
</tr>
<tr>
<td>Who is involved?</td>
<td>- Incumbent, new or mature entrant analysis</td>
<td>- Network analysis using connectionist approach</td>
<td>- Visualization in Gephi using Fruchterman-</td>
</tr>
<tr>
<td></td>
<td>- Network analysis</td>
<td></td>
<td>Reingold method</td>
</tr>
<tr>
<td>(iii) Why initiated?</td>
<td>- Expectations in transitions</td>
<td>- Screening of experiments’ websites, leaflets, etc.</td>
<td>- Content analysis using MAXQDA software</td>
</tr>
<tr>
<td>What promise?</td>
<td></td>
<td></td>
<td>- Visualization in Excel</td>
</tr>
</tbody>
</table>

Table 1. Overview of theoretical insights and methods

4.1 Inventory and content of experiments

Types of experiments included in this analysis comply with the following criteria. Thematically, they must relate to ICT and personal automobility in the Netherlands, meaning that the projects should either concern automobility or an alternative travel service in which the car plays a role. Initiatives related to the transportation of goods or other transport modes are only included if they have close links to personal automobility. Sole public transport experiments or slow mode projects are not taken into account, neither is aviation or shipping. Furthermore, following transitions studies, the projects should contain novelty, such as testing of a new technology or service and they should have taken place in a real-life setting. Due to the novelty of the field only recent projects that started, ran or ended in the period from June 2015 until June 2016 could have been included.
We have used the following sources to gather the experiments. As a starting point, we used the experiment overview of Connecting Mobility, the Dutch monitoring organization of smart mobility activities (Connecting Mobility, 2017). For additional experiments we screened relevant mobility newsletters, platforms and events (CROW kennisplatform, 2017; DITCM, 2017; Intertraffic Amsterdam, 2017; Parkeer24, 2017; Verkeer in Beeld, 2017), public newspapers (LexisNexis, 2017), European projects (European Commission, 2017), and academic literature (Elsevier, 2017). The search within the different sources was limited to the listed selection criteria. The repetitiveness of experiments found in the various sources was a signal that we have saturated the sample. Furthermore, the sources, as well as the specific experiments, were verified using five qualitative interviews with actors in senior positions from the mobility sector: the Ministry of Infrastructure and Environment, the Municipality of Eindhoven, Connecting Mobility, Eindhoven University of Technology, and the Traffic Innovation Centre.

The final compliance check resulted in a total of 118 experiments. The experiments were included in an Excel database. For every experiment, we filled in information concerning the experiment’s content, actors, and promises. To gather this information we mainly consulted the experiments’ websites and available leaflets as important public communication channels. To identify what the experiments are about we performed a content analysis. We searched for ‘common denominators’ characterizing the experiments with specific attention for the technological and/or organizational novelty. In an iterative process, we mapped the experiments according to two dimensions, one concerning the type of ICT they develop (physical hardware, data or service) and the other concerning the organizational change in how the car is used in future (automated, as part of a multimodal system, or shared).

We furthermore mapped which type of actors initiated the experiments. We categorized the initiators by following the typology of Geels, (2002): producer network, public authorities, user groups, societal groups, financial network, research network, and suppliers. Although not every actor category applies perfectly, we use the typology to get a sense of potentially dominating or underrepresented groups. We mobilize these categories as follows. The producer network category applies to different market parties, such as start-ups and ICT companies. The supplier category applies to industrial market parties. The public authority category applies to different public authorities, such as national governments and municipalities. The user and societal group categories apply to, respectively, civil society groups, and NGOs. The financial category applies to financial institutions such as banks and insurance companies. Finally, the research network category applies to knowledge institutes like universities.

We furthermore distinguished between incumbents, new entrants, and an additional third category ‘mature entrants’. We categorized incumbents and new entrants based on their vested interests in the existing system. Although all actors could be somehow seen as new entrants in a novel emerging field (ICT & automobility),
we defined actors with high inclusion in the existing automobility system as incumbent actors. Other actors, such as the ICT companies, are in that sense new entrants, but some were already quite active in the early stages (e.g., TomTom), or some are difficult to see as a new entrant due to their enormous size and resource capacities (e.g., Google). We therefore also consider actors’ age and size like Hockerts & Wüstenhagen (2010), and we name these specific actors ‘mature entrants’.

4.2 Network analysis

To understand niche characteristics we look deeper into who is involved. We, therefore, conducted a network analysis using Gephi software (Gephi, 2017) but in a novel way. Traditionally, actor networks are visualized from the perspective of actors, meaning actors form the nodes, and their interactions form the lines between the nodes, i.e., the edges. We use a variation of this method by considering the experiments as nodes. Consequently, the links between the experiments represent the involvement of the same actor in different experiments. This allows us to identify better who dominates the experiments and gives insight into the type of actors involved in experimentation. For visualization, we used the Fruchterman Reingold method (Fruchterman & Reingold, 1991). This method displays force-directed graphs in an aesthetically and intuitively attractive manner. Force-directed graphs visualize networks based on physics by assigning forces to the relations between nodes and edges. In these graphs, edges have more or less the same length and edge crossings are minimized. Force-directed graphs then use algorithms to find an equilibrium between nodes and edges that uses minimal energy. A Fruchterman Reingold visualization, therefore, demonstrates nodes that share links closer to each other and in a more central position in the network than nodes with less or no links. Experiments that share the involvement of several actors will, therefore, be mapped more centrally and nearer to each other. In contrast, experiments that do not share any involvement of the same actor with other experiments will be mapped at the periphery of the network.

4.3 Expectations analysis

To identify what promises are made in the two niches, we screened the texts about experiments’ aims and goals and performed a content analysis using the qualitative coding software MAXQDA (MAXQDA, 2017). This software allowed to code every potential expectation manually. We first applied open-coding approach, resulting in 882 specific codes. The specific codes were then aggregated and analyzed using the levels of expectations of Van Lente (1993) (Table 2). For each expectation level (project-, function-, and societal) four categories (aggregated codes) of expectations have been identified. We further analyzed every level of expectations separately to get a richer understanding of the differences and similarities between the niches.

<table>
<thead>
<tr>
<th>Expectation level</th>
<th>Applies to</th>
<th>Example</th>
</tr>
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5. Results

5.1 Inventory and content of experiments

We have identified 118 experiments that match the selection criteria. We were informed by the idea of the existence of two possible directions, technological and organizational, and therefore we have used these to categorize the experiments. To acknowledge the socio-technical nature of the experiments we avoided a one-sided approach wherein an experiment is either classified as technological or organizational. To first understand what image emerges we have mapped the experiments according to a technological and organizational dimension (Figure 1). The labels in the figure correspond to the names of the experiments.

The technological dimension concerns the type of ICT developed in the experiment (vertical axis in Figure 1) and includes experiments developing hardware (physical), experiments focusing on data communication (data) and experiments developing mainly software (services). Although there are many interdependencies between these three categories, we can use it to distinguish between more and less technologically advanced experiments by mapping their main technological focus. The organizational dimension refers to the change in how the car or its facilities are used in the future (horizontal axis in Figure 1). This dimension covers experiments about vehicle and infrastructure automation (automated), experiments that offer multi-modal solutions (multi-modal), and the shared use of vehicles and facilities (shared). Also here the position of the experiment in one category does not exclude it from also engaging in another category. The classification gives, however, a first impression based on the experiments’ main focus.

Table 2. Typology of expectations in experiments

<table>
<thead>
<tr>
<th>Project-level</th>
<th>Function of experiment</th>
<th>“What is being developed?”</th>
<th>“Experiment X contributes to the development of real-time traffic information service.”</th>
</tr>
</thead>
<tbody>
<tr>
<td>Function-level</td>
<td>Function of the experiment in automobility system “For what purpose?”</td>
<td>“This will reduce emissions and smoothen traffic flows.”</td>
<td></td>
</tr>
<tr>
<td>Societal-level</td>
<td>Function of the experiment for society “What societal needs are fulfilled?”</td>
<td>“A connected mobility system will boost the local economy.”</td>
<td></td>
</tr>
</tbody>
</table>
Figure 1 – An overview of 118 ICT-based automobility experiments and their initiators.

The specific position of the experiments gives insight into what they are about. Experiments categorized as shared are about on-demand services and sharing vehicles, rides, or even parking spaces. Experiments categorized as multi-modal focus on combining data flows of different transport modes, offering multi-modal trip planners or provide services to stimulate other modes than the car. Experiments categorized as automated focus on the integration of different data flows, collection of data by using vehicle sensors, or improvement of data communication between vehicles and infrastructure. Other experiments in this category experiment with...
traffic systems, vehicle technology, semi-automation or fully autonomous vehicles. There are also experiments that provide real-time information services, about, for example, the traffic situation or available parking spaces.

Furthermore, when we look at the position of the experiments, an interesting image emerges from the overall mapping. First of all, some areas remain empty in the figure. The empty spots seem to make sense since the organizational change is much more relevant for experiments categorized as multi-modal or shared. Although technology plays an important enabling role, these experiments, especially in the shared category, mainly experiment with new services and business models. Contrary, in experiments at the left-side of the figure, categorized as automated, the organizational novelty plays a smaller role, and these experiments are typically more technological.

Figure 1 also demonstrates what kind of actors initiated these experiments. The symbol next to the label denotes its initiator. The form of the symbol describes which actor group the initiator belongs to: public authority, producer network, financial network, societal group, or user group. No initiators were identified that belong to the supplier or research category. Hence these categories are not mentioned in the figure. The shade of grey of the symbol makes a distinction between incumbent initiators and new or mature entrants. Regarding initiators, the experiments are dominated by producer network actors and public authorities, such as start-ups and service providers, and national and local governments. Other types of actors are underrepresented in experiment initiation. More interesting is that (almost) a similar aggregation pattern can be observed for initiators as for the content of experiments. When comparing the experiments, we can find that the involvement of public authorities is larger for experiments categorized as automated compared to experiments categorized as multi-modal or shared. Experiments in the multi-modal and shared categories seem to contain more variety among the initiators as some experiments are initiated by the user and societal groups. Additionally, a majority of the experiments categorized as automated are initiated by incumbent actors whereas the majority of shared and multi-modal experiments are initiated by new entrants. Interestingly, mature entrants, such as mature ICT companies, play an almost similar role among different types of experiments. Approximately one-fourth of the total number of experiments are initiated by these actors. See Figures A.2 and A.3 in Appendix A for a more detailed overview.

Based on the initial mapping, an emergence of a number of niches could be expected but most prominent are two niches: an ‘automated mobility niche’ (further referred to as automated niche) including experiments on the left side of Figure 1, and a ‘mobility services niche’ (services niche) containing experiments in the middle and right side of the figure. The automated niche seems to bear characteristics of a technological niche. The experiments in this niche have a strong technological orientation. The niche contains experiments (at the left top of the figure) wherein services are developed, but often this is conducted with the idea that these are stepping stones for further automation. Many of the experiments in the automated niche are not ready for
market introduction as there are large uncertainties about the potential benefits and what technologies to invest in (e.g., autonomous vehicles vs. cooperative vehicles, cellular communication channels vs. short-range communication). There is a limited variety of initiators within the automated niche. The niche is characterized by the large involvement of public authorities due to various policy programs. Furthermore, due to government’s traditional responsibility for roads and roadside systems, many experiments typically focus on traffic information and traffic management.

The services niche carries characteristics of a market niche. Although this niche also relies on physical ICT applications, the novelties are more about the different travel services and business models that are being developed. The experiments are less asset-dependent, and many of the services are already available on the market while experimenting. More different initiator categories are represented in the services niche compared to the automated niche, but some categories, like the producer network, are better represented than others, like user groups. Also due to the large variety of experiments in the services niche, it seems there are still many uncertainties about future markets and user needs. Although both niches do not strictly apply to either a technological or market niche, this distinction helps us to understand the directionality of the niches. What is also interesting to note is that the automated mobility niche seems more populated than the mobility services niche, see Figure A.1, Appendix A for a detailed overview.

5.2 Actor network

The experiments often involve more actors than only one initiator. Hence it is important to consider the actor involvement network as well. Findings show that the Ministry of Infrastructure and Environment (I&M) and their executive body (RWS) are involved in approximately one-third of the experiments of both niches, probably related to a large number of experiments being undertaken within governmental programs. To get a deeper understanding of the actor involvement in both niche, we first performed a check to see whether there are actors involved in experiments of both niches. We found out, however, that when an actor is involved in multiple experiments, these experiments belong most often to the same niche. This finding verifies the existence of two different emerging niches. Although there are some exceptions, we considered it therefore valid to analyze the niches separately in more detail.

Figure 2 and 3 visualize the networks of actor involvement in experiments of the automated and services niche respectively. This is not a traditional actor analysis, but a version where the experiments constitute nodes and the edges represent the involvement of the same actor in more experiments. Experiments that share the involvement of the same actor(s) are mapped as nodes near to each other. Experiments as nodes in the middle of the figure share more often the involvement of the same actors than experiments that are placed as nodes at the periphery of the figure. In other words, nodes in the middle of the figure represent experiments wherein
multiple actors are involved who are also involved in other experiments. To the other extreme, nodes at the periphery represent experiments wherein an actor, or multiple actors are involved who are not involved in any of the other experiments.

Figure 2 demonstrates the network analysis of actors involved in several experiments of the automated niche. The figure shows the five most involved actors in color and all the other actors, who are involved in two or more experiments, in grey. Knowledge institutes (TNO, TUD) and public authorities (I&M/RWS, Province North Holland, Amsterdam Region) dominate in this niche. From the producer network, NXP, TomTom, Imtech, Dynniq, and V-tron are actors with the largest involvement in several of the experiments. The nodes that are not connected show that less than 20% of the experiments are driven by actors who are not involved in any of the other experiments. This also means that more than 80% of the experiments involve at least one actor who also participates in an other experiment, which is displayed by the connected nodes. Furthermore, we can conclude that a substantial number of experiments of the automated niche is developed by just a few large actors.
Figure 2 – Network of actor involvement in experiments of the automated niches.

The network of actor involvement for the services niche looks quite differently (Figure 3). Also, this figure shows the five most involved actors in color and all the other actors in grey. Public authorities dominate in this niche, mainly due to the high involvement of I&M/RWS and the Province North Brabant. These two actors are involved in more or less the same experiments as the province initiated several projects within a national mobility program. The other most involved actors are small service developers (GoAbout, OVinfo, ShareNL). Around 50% of the experiments are being developed by actors who are not involved in any of the other experiments. Moreover, the experiments are often driven by single actors, mainly start-ups.

Figure 3 – Network of actor involvement in experiments of the services niches.

In conclusion, there seem to be some clear differences between the niches regarding actor involvement. There is a difference between the percentages of experiments per niche that are developed by actors who are not involved in any of the other experiments. This percentage is much larger for the services niche as there are less connected nodes. Furthermore, public authorities are involved in both niches, but there are differences in the
other actors that dominate the experiments. In the automated niche, knowledge institutes and technology companies are highly involved in several experiments, while in the services niche this is the case for small service developers.

5.3 Expectations

The expectation analysis gives an impression about promises made by ICT-experiments for automobility, especially by distinguishing between project-, function-, and societal-level. At a project-level, experiments are expected to mostly contribute to the development of information services, such as parking information, traffic information, and speed advice. It is also expected that the experiments lead to improved and novel travel services, such as multi-modal travel planners and vehicle sharing services. To the same degree, it is expected to develop data management processes or systems with improved interoperability, effective traffic management systems, and exploitation of new data sources. Lastly, some expectations are expressed about in-vehicle and roadside technologies, such as vehicle automation and cooperative driving.

At the functional-level expectations are mostly expressed about improving the travel experience by for example reducing travel costs, improving travel convenience and increase travel flexibility. Almost to the same degree, promises are made about improved accessibility consisting of expectations such as traffic jam prevention, improved time efficiency, and reduction of cruising traffic in urban areas. Promises about improved livability relate to energy-efficiency, CO2-emissions reduction, and reduction of noise and local air pollution. To a lesser degree, but still considerable, promises are expressed about improved traffic safety.

Expectations at the societal level are fewer than at the two other levels. These promises are most often about the socio-economic relevance of automobility. Other expectations at this level are about ICT-solutions as a way to keep cities livable. Lastly, some expectations were found about the link of the automobility sector with other domains, such as electricity grids (“Vehicle-to-grid”) and the telecom network (“Internet-of-Things”).

In the end, we identified 822 expectations at three different levels: 343 at a project level, 403 at a function level and 76 at a societal level (Table 3). For every level, we distinguish four types of expectations as a result of aggregating the 822 expectations. Every expectation is counted as a hit, so in cases where one experiment mentions several expectations, these are all counted.

<table>
<thead>
<tr>
<th>Expectation level</th>
<th>Expectation type</th>
<th># of expectations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Project-level (# 343)</td>
<td>Information services</td>
<td>145</td>
</tr>
<tr>
<td></td>
<td>Data management</td>
<td>81</td>
</tr>
</tbody>
</table>

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Most remarkable is that there are considerably fewer expectations being expressed at a societal-level. It seems to suggest that the experiments mainly focus on more immediate problems rather than long-term societal-challenges. The findings suggest some subtle differences between the niches but, with few exceptions, the expectations are not clearly articulated or too little to analyze. It is therefore difficult to differentiate between the two niches at this level of expectations.

At a function-level, some subtle differences between the niches start to appear. We identified promises about improved accessibility, travel experience, livability, and safety. In both niches, promises are being made about improvements of the first three. However, promises about improved accessibility dominate in the automated niche, while improved travel experience and livability are more prominent in the services niche. Furthermore, traffic safety expectations are almost only articulated in the automated niche. The findings suggest that experiments in the services niche not only consider issues directly related to transport as the automated niche does. Social factors, like user experience and livability of cities, receive much attention too in the services niche.

Differentiating between the niches becomes clearer when promises on a higher level are coupled to the articulated expectations at a project-level. At a project-level, we identified expectations about information services, data management, travel services, and in-vehicle and roadside technologies. This finding is obvious as it overlaps with the categories found during the process of experiments’ mapping. It is, however, relevant to repeat here as it points towards the fundamental differences between the niches. Although in both niches information services and data management expectations are articulated, the automated niche has a clear technological orientation while the services niche has an organizational orientation. This means that shared

Table 3 - Overview of expectation types found in the 118 analyzed experiments

<table>
<thead>
<tr>
<th>Function-level (# 403)</th>
<th>Societal-level (# 76)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Improved travel experience</td>
<td>Mobility as economic opportunity</td>
</tr>
<tr>
<td>Improved accessibility</td>
<td>Mobility for social activities</td>
</tr>
<tr>
<td>Improved livability</td>
<td>Mobility for livable cities</td>
</tr>
<tr>
<td>Improved safety</td>
<td>Mobility connected to other domains</td>
</tr>
<tr>
<td>139</td>
<td>30</td>
</tr>
<tr>
<td>132</td>
<td>27</td>
</tr>
<tr>
<td>87</td>
<td>14</td>
</tr>
<tr>
<td>45</td>
<td>5</td>
</tr>
</tbody>
</table>

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promises such as improved accessibility are expected to be reached in fundamentally different ways according to the two niches. We can, therefore, conclude that at project-level there are some clear differences between the expectations in experiments of the two niches. For a more detailed overview of differences between the niches at different levels, see Figure A.4, A.5, and A.6 in Appendix A.

6. Discussion and conclusions

6.1 Discussion
This research has been a first step to reduce some of the uncertainties about the magnitude and direction of the changes ICT-based initiatives could have on automobility in the Netherlands. Although an understanding of the dynamics and processes of niche development requires a more detailed analysis, this section discusses first insights into the characteristics and potential of the niches.

6.1.1 Experiments
By analyzing multiple experiments, we have been able to identify and verify the emergence of an automated niche and a services niche. The first niche contains characteristics of a technological niche due to the technological orientation. The latter contains some characteristics of a market niche, due to the focus on organizational innovation. The analysis shows however that especially the latter category cannot easily be applied. We discovered that many services are already available for users while experiments are still characterized by great uncertainties, and actors’ expectations and networks are unstable. Smart mobility’s ICT-character challenges the notions of technological niches and more stable market niches. The application of ICTs for organizational innovation is much less asset-based, making it easier to experiment with in real-life context. Furthermore, we find that mature ICT companies are present in both niches and play a significant role, which challenges the common distinction between incumbent actors versus new entrants in transition studies.

Additionally, we analyzed all initiatives as transition experiments, since we were interested to understand their potential for (radical) change. By selecting practice-based initiatives, we assumed these could apply as transition experiments as the real-life environment stimulates actors to engage with stakeholders, articulate societal benefits, and stimulate systemic learning. However, the experiments in the two niches cannot be classified according to the experiment definition of Sengers et al. (2016). Involvement of societal actors seems,
for example, limited, and most experiments lack a long-term perspective. Experiments in the services niche seem to perform slightly better regarding being societal-challenge led and involving multiple actors. Thus these experiments possibly have a greater potential to stimulate learning about alternatives for long-term systemic changes. Nevertheless, there was no experiment that was fully designed as a transition experiment. Hence, in practice, we are likely to find hybrid forms of experiments, with both short-term goals and a potential to stimulate long-term changes, which raises questions about how to study this form and what it implies for the transformative potential.

6.1.2 Actor involvement

Regarding initiators, the substantial involvement of mature entrants in both niches is promising. Following the transition studies rationale, we can argue that mature entrants are more likely to propose radical innovations than incumbents, because they have less vested interests in the existing automobility system. They are furthermore more powerful than new entrants. The involvement of mature entrants in both niches, we therefore argue, can be an important indication that more substantial change is likely to occur. Additionally, the services niche seems to have a higher potential for radical innovations since many experiments are initiated by new entrants, compared to the high involvement of incumbents in the automated niche.

The network analysis confirms the higher potential for radical innovations since different actors initiated a large variety of experiments. On the other hand, the involvement of the same actor in several experiments suggests that lessons of one experiment are more likely to be used in the other experiments wherein the actor is involved. Such actors could be seen as ‘gatekeepers’ of experiences and lessons which is crucial for further niche development according to the theory. As a large number of automated niche experiments involve the same actors, the niche could benefit from better knowledge sharing compared to the services niche which is comparatively less well connected. Additionally, the most dominant actors in the automated niche are often involved in the same experiments. They might, therefore, gain more experience in collaborating and sharing the same lessons, which could facilitate expectation negotiations and cooperation in other experiments. However, as noted before, this could come at the cost of innovativeness. The analysis gave us some insights, but we do not know if lessons are being shared and what lessons are being circulated. As the analysis of experiments suggests, many experiments have a hybrid form and focus on the development of a specific product/service which could hamper learning processes for larger changes.

Furthermore, the involved actors are likely to reflect the specific context of the Netherlands in relation to automobility.¹ For example, the lack of an indigenous car manufacturing industry in this country explains the

¹ We would like to thank one of the reviewers for pointing this out.

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little involvement of car manufactures in smart mobility experiments in the Netherlands. While, on the other hand, the strong public influence in traffic management and traffic information explains the large involvement of public authorities. It requires further research to draw conclusive arguments about the impact of the spatial context on the character of experimentation, but the findings suggest that it plays an important role in the type of smart mobility experiments that are being conducted.

6.1.3 Expectations analysis
The niches show clear distinctions in expectations at the project-level, as the automated niche is characterized by a focus on the development of technologies and the services niche with an emphasis on organizational innovation. While this result is obvious, differences in promises at the function-level are less straightforward. Within both niches, promises about improved accessibility are mentioned, for example. The niches differ however radically in the aim of how to achieve this. In both niches, the car itself forms a part of the solution to automobility’s immediate problems and grand challenges, but the foreseen role of the car differs. The majority of automated niche experiments seem to strengthen the dominant role of the car in the automobility system, while in the services niche solutions are proposed with a changed role of the car in an alternative mobility system.

We should note that expectations come in different forms and shapes. Considering experiments’ websites means that the analyzed expectations are likely to be positively framed, polished versions, as these websites serve as public communication channels. It is furthermore difficult to retrieve whose expectations are mentioned on the experiments’ websites and whether all involved actors agree, or whether the expectations mentioned on the websites were the result of a contested negotiation process. These questions require a much deeper understanding of the expectations of different involved actors, which is beyond the scope of this paper. We were, however, able to get a first impression about the directionality of the niches.

6.2 Conclusions
In this paper, we aimed to understand what ICT-related automobility experiments are initiated in the Netherlands, who is involved and what promises they make, to get a better understanding of the magnitude and direction of change. We analyzed 118 Dutch smart mobility experiments and contributed to the transition literature by showing how one can study multiple experiments, before predetermining specific niches as analytical constructs. We were able to verify the emergence of two niches: an automated mobility niche and a mobility services niche. While the first has a strong technological orientation, the latter focuses more on organizational changes. We furthermore conclude that smart mobility seems to lead to a proliferation of activities, largely focusing on solving immediate problems. Sustainability issues and other grand challenges are rarely mentioned. The services niche seems, however, more promising in the context of a sustainable,
transformative change of the existing automobility system. We cannot be conclusive about the magnitude and direction of change as developments are ongoing and have not institutionalized. Different trajectories and combinations are therefore still possible, such as self-driving vehicles for private use, following incremental paths, or radical forms like ‘mobility as a service’. Although not considered in this research, combinations with the field of electric vehicles can potentially emerge. Such combinations open up possibilities for these niches to address sustainability issues, gain critical mass, and provide a mature alternative to the existing (auto)mobility system. A crucial challenge for policymakers and practitioners is how to balance and nurture the potential of different niches and stimulate learning processes between and across experiments of different niches.
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Appendix A

Figure A.1  Number of experiments in the automated and services niches.

Figure A.2  Number of initiators per category of experiments in the automated and services niches.

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Figure A.3 Incumbent, mature entrant, and new entrant initiators of experiments in the automated and services niches.

![Bar chart showing expected numbers of experiments in automated and services niches.]

- **Automated Niche**:
  - In-vehicle and roadside technologies: 200
  - Travel services: 150
  - Data management: 100
  - Information services: 50

- **Services Niche**:
  - In-vehicle and roadside technologies: 200
  - Travel services: 150
  - Data management: 100
  - Information services: 50

Figure A.4 Project-level expectations in the automated and services niches.

![Bar chart showing expected project-level improvements in automated and services niches.]

- **Automated Niche**:
  - Improved safety: 200
  - Improved livability: 150
  - Improved travel experience: 100
  - Improved accessibility: 50

- **Services Niche**:
  - Improved safety: 200
  - Improved livability: 150
  - Improved travel experience: 100
  - Improved accessibility: 50

Figure A.5 Function-level expectations in the automated and services niches.
Figure A.6 Societal-level expectations in the automated and services niches.