Analytical framework on everyday mobility practices and guidelines for interventions

Deliverable D1 of the SIMS project

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Foreword

This is the deliverable D1 *Analytical framework on everyday mobility practices and guidelines for interventions* from the project *Sustainable Innovative Mobility Solutions* (SIMS). The deliverable is the outcome of Work Package 1 (WP1) *Analytical framework and guidelines* and has been prepared by researchers from Aalborg University (AAU) and Roskilde University (RUC).

The analytical framework is based on existing knowledge within mobility and practice theory studies. The framework describes the dynamics within everyday mobility practices and provides guidelines on how to design the mobility interventions in SIMS. In this way, it informs the work of the later WP2 (in relation to the thematic focus of the pre-intervention site studies) and WP3 (guidelines on how to design practice-based mobility interventions).

The SIMS project is funded by the *Grand Solutions Programme* of *Innovation Fund Denmark*. The vision of SIMS is to develop sustainable and multi-modal mobility solutions that are adapted to citizens' everyday practices and needs, that incorporate future and existing resource-efficient transport modes, and that are co-developed within the wider urban physical development and social relations. For further information about SIMS, see www.sims.aau.dk.

Summary

This deliverable presents the analytical framework and guidelines for the upcoming work in the SIMS project for developing new solutions for sustainable mobility in cities. The analytical framework is based on existing knowledge within practice theory and urban mobility studies, whereas the guidelines outline how the design of new solutions will be approached.

The analytical framework combines the understanding of everyday mobility as a social practice with insight from studies within networked urban mobilities and studies of trends within mobility. The combination of these fields results in the identification of six guiding principles or "analytical statements" that will form the approach of SIMS regarding analysing citizens' existing mobility patterns and designing attractive alternatives to resource-intensive mobilities. The guiding principles are the following:

1. Understanding everyday practices should be the basis for designing new solutions: A key insight from practice theories is that we need to shift the focus from technologies or the "behaviour choices" or attitudes of individuals to focus on the everyday practices that people perform, of which mobility is an integral part.
2. Transport (trips) represents practice/mobility bundles: To obtain a comprehensive understanding of people's mobility behaviour, we should apply the concept of practice variants (i.e. practice/mobility bundles, such as shopping/driving, working/driving, school/biking, etc.). Each of these practice variants has its own specific character.
3. Practice elements are the basis for identifying mobility dynamics and designing new solutions: To better understand the dynamics behind mobility patterns when designing alternative solutions, we should understand mobility practices as constituted of separate but interrelated elements that should be addressed in our practice interventions.
4. A sustainable transition requires discouragement of unsustainable practices: It is not enough just to design attractive alternatives to existing, resource-intensive mobility practices. It is also necessary to discourage resource-intensive practices through physical, infrastructural, or institutional changes.
5. It is crucial to remember the interconnectedness of mobility practices: Mobility practices (e.g. driving or biking trips) have a dual identity. They are both practices in themselves and a

prerequisite for the performance of many other daily practices (e.g. working, shopping, childcare, etc.).

6. Regarding designing for the unknown future: The networked urban mobilities change all the time, but instead of trying to predict the future development (and create solutions for this), designing new, sustainable mobility solutions should take the shape of co-creation (i.e. the research and design activities should take part in shaping the sustainable future).

Following up on the last point regarding co-creation, SIMS will relate to three current development trends of electrified, shared, and autonomous mobility. The opportunities and possible risks of these new mobility developments will be studied and assessed in relation to the SIMS solutions to be developed at the three sites. The overarching approach will be to conceptualise across various solutions and to broaden the perspective to include the role of institutions and infrastructure (including spatial planning), which is at the centre of the sustainable mobility planning paradigm. In relation to this, the concept of Mobility-as-a-Service (MaaS) plays a key role as an underlying design ideal.

The guidelines for the design of the SIMS mobility solutions and the site interventions place the design approach as a hybrid of user-centred design and participatory design research. Following this, much of the designing will be based on existing knowledge or new research about the citizens and their mobility patterns at the three sites, whereas the citizens themselves will also be involved in reflecting upon relevant solutions (although to a more limited extent). The design process of the SIMS solutions and site interventions can be divided into three phases (pre-design, generative design, and evaluative design), which are detailed further in the table in Annex 1.

Chapter 1: Introduction

Urban lives, cultures, economies, the global climate, and the environment are significantly challenged by different mobilities and their related energy consumption and pollution (Urry 2000), and the future of urban mobilities has become a key topic. In the urban age, the question of how cities and regions manage and plan their physical infrastructures (and by doing so, the socio-material structures that shape and form social cohesion, interaction, participation, and social life) is essential. Planners and engineers tend to focus on feasibility based on existing data, models, and calculations. Through this, they envision what and how decisions on spatial development, technology implementations, and other forms of regulations affect carbon dioxide (CO_2) emissions, congestion, land use, and the consequences for ecosystems, among others. However, social aspects tend not to play a significant role when it comes to long-lasting decisions because the relevant data do not show up in the datasets, models, or simulations.

Based on this, at the outset of the SIMS project, creating sustainable mobility practices cannot be reduced to simple questions of technology substitution or the efficiency of the current system. Thus far, increased technological efficiency has been unable to balance the implications of growth in traffic, let alone deliver substantial emission reductions or mitigate other problems. Therefore, the SIMS project will apply social practice theories informed further by mobilities studies (e.g. Urry 2007; Banister 2008). Anchored within these disciplines, SIMS considers mobility practices to be deeply embedded in people's everyday lives (Freudendal-Pedersen 2009).

This means that changing the current automobility regime demands interventions in the multiple social practices that our everyday lives are organised upon (Shove et al. 2015). Thus, the socio-technical and organisational development of sustainable mobility solutions must consider the complexity of everyday practices. For example, the implementation of car- and ride-sharing faces challenges in adapting to the needs of families with small children if the demand for car safety seats or space for prams is not accommodated.

The social practices that mobility patterns are an integrated part of (e.g. commuting, shopping, and childcare) are determined via technological elements (including infrastructures), competences (e.g. how to use technologies), and understanding (e.g. cultural ideas about the right thing to do;

Shove and Pantzar 2005; Watson 2012). Thus, practice-theoretical studies emphasise the importance of addressing all three elements to promote a shift to more sustainable practices, including sustainable mobility. An illustrative example is how the fundamental norms of individuality, freedom, and flexibility are closely related to automobility and are difficult to change (Sachs 1992; Freudendal-Pedersen 2009). Thus, changing the norms of mobility requires policies and interventions that challenge the current, powerful understanding and notions related to today's mobility demand.

For the last 5-10 years, three new trends within the mobility field have attracted much attention as possible solutions to the transport problem of cities: shared mobility (ride- and car-sharing), autonomous vehicles (AVs), and electric mobility. The long-term aim of SIMS is to contribute to a sustainable mobility transition through detailed knowledge on sustainable mobility solutions that are tailored to the everyday lives of citizens and thus can become attractive alternatives to existing resource-intensive mobility patterns. As part of this, SIMS will address these new trends to explore how and under what conditions these might contribute to sustainable development. Here, an overarching concept will be Mobility-as-a-Service (MaaS), which describes a shift away from privately owned transport modes (in particular cars) to a multi-modal and seamlessly integrated mobility system that provides MaaS. The SIMS project aims to develop new solutions and insights on how a future MaaS system can be developed that considers the role of both social practices and the social-material context of cities.

In this report, which forms the analytical framework for designing sustainable mobility solutions, we will first describe the theoretical foundation for our understanding of everyday life and mobility practices (Ch. 2). On the basis of this, we develop a set of guidelines on how to design mobility interventions (Ch. 3), including an outline of how the design processes of SIMS will be organised. The report closes with a number of recommendations on how to ensure the long-term implementation of the SIMS results (Ch. 4).

Chapter 2: Theoretical foundation and analytical framework for everyday mobility practices

2.1 Mobility as everyday practices

Traditional policy approaches within the mobility field have failed to deliver significant reductions in energy consumption and the negative environmental consequences of mobility. This reflects a more general problem of conventional policy approaches targeting sustainable consumption, which has led an increasing number of scholars to propose practice-theoretical approaches (often termed *practice theories*) as a new social ontology to better inform governance interventions (Shove et al. 2015; Spurling and McMeekin 2015; Spurling et al. 2013; Strengers 2013; Watson 2012). In this section, we present the practice theories in brief, including how mobility can be understood within this theoretical framework.

Practice theories, as developed by Schatzki (1996), Reckwitz (2002), Shove and Pantzar (2005), Warde (2005), and Gram-Hanssen (2009), among others, shift the focus from individuals and their attitudes and behaviours to *social practices* as the core unit of analysis and policymaking. Social practices are understood as collective entities that are constituted by heterogeneous and interrelated elements, such as materials (objects), competences, and meanings (Shove and Pantzar 2005), and are reproduced regularly through the performance of these practices by individuals (practitioners). An example is driving a car (driving), which is a (mobility) practice that is made possible through a specific combination of elements. This includes *material* elements, such as the car itself, filling stations, roads, and traffic lights. Another element is *competences,* such as the ability to steer the car and to judge the distance to and speed of other road users and knowing the traffic rules and how to refuel the car. Finally, the last element is *meanings,* such as the cultural conventions of the car as the epitome of freedom, convenience, comfort, and safety.

How practices, such as driving, are performed is dependent on the individual elements and their combination. For example, faster cars invite drivers to engage in speedy driving, and changes in social norms regarding alcohol and driving have changed driving practices in relation to social occasions involving alcohol drinking. As hinted by the latter example, practice elements develop over time. As a result, they are essentially (historically) contingent, which means that they are open to re-evaluation and change. This key observation invites to new ways of thinking in relation to how to promote sustainable practices, including sustainable mobility practices.

In today's mainstream policymaking related to sustainable consumption, problem framing and governance strategies primarily focus on combinations of *technological innovation* and *campaigns* to change the attitudes, behaviours, and choices of the individual consumers (Shove 2010; Strengers 2013; Southerton 2012). This mainstream approach relies on a mix of rational consumer choice models, efficiency measures, and information-based behavioural change theory. In contrast, social practice theories emphasise that (energy) consumption is not a practice itself but "is rather a moment in almost every practice" (Warde 2005, 137). This means that (energy) consumption is intimately linked to people's performance of practices (Shove 2010; Halkier and Jensen 2008). For the same reason, it rarely makes much sense to people to focus on only energy consumption, which is often the case in mainstream policymaking, because this does not consider the complexity of the everyday life that the consumption is embedded within and dependent on. To achieve an adequate socio-technical transition by reconfiguring the current resource-intensive mobility patterns, social practice theories recommend scrutinising *why*, *when,* and *how* social (mobility) practices are performed by people across time and space (Shove et al. 2015).

Thus, in opposition to the focus on rational choice and efficiency within technologically and psychologically oriented approaches, practice theory scholars recommend exploring the practices related to (energy) consumption (Shove and Walker 2014) and focus on how today's mobility demand is produced (Shove et al. 2015; Spurling and McMeekin 2015; Watson 2012). Seen through this lens of theory, people carry certain mobility practices, which continuously reproduce, coproduce, change, and reinforce today's demand for mobility (Shove et al. 2012). Hence, practice theories offer a conceptual framing of mobility as a (dynamic) matter of "derived demand" by illuminating how the current mobility demand has become an outcome of spatially and temporally dispersed but interrelated practices (e.g. the division of work and home in modern work life or the development of the shopping centre with its dependence on car-based transport). As such, sustainable mobility transition should instead focus on the temporal and spatial relationships between social practices to reconfigure and change the bundles and interconnections between mobility-practice bundles (Spurling and McMeekin 2015).

The latter relates to the observation that mobility is not only a practice in itself (e.g. driving, biking, or walking) but is also integrated with other everyday practices made possible by mobility practices. For example, for many people, driving is embedded within the daily performance of other practices, such as working (commuting to and from work), shopping, recreational activities (e.g. driving to a sports centre), childcare (e.g. picking up children from school or day care), and so on. In this way, everyday practices are connected together in systems of practices (Watson 2012), and how these systems are connected (or interlocked) and develop over time has a great influence on how the demand for mobility changes and what modes of transport are favoured. Watson (2012) provides an example of this:

> The shifting character of grocery shopping is inseparable from shifting patterns of personal mobility, with out of town supermarkets co-evolving with patterns of personal car mobility, and with broader restructuring of the temporal rhythms of daily life that are enabled by, and make necessary, the convenience of provisioning a household with a single shopping trip to one destination. (p. 491)

This point of (analytical) departure implies that we need to acknowledge the interconnectedness and interlocking of contemporary mobility practices when developing alternative solutions and strategies for sustainable mobility in cities. Thus, Watson (2012) observes that sustainable mobility solutions require direct and/or indirect changes in the complexities of mobility practices, which might include changes in practices such as working, going to school, shopping, visiting friends and family, maintenance, and leisure.

2.2 Networked Urban Mobilities

The mobilities research offers a strong approach that bridges research disciplines and traditions to understand the complexity of mobilities (Sheller and Urry 2006; Canzler et al. 2008; Grieco and Urry 2011; Cresswell 2006). Mobilities encompass the large-scale movements of people, goods, capital, and information and the more local processes of daily transportation, communication, and travel of artefacts (Urry 2000) based on an understanding that these different scales together produce and reproduce the current mobility systems. These different mobilities are considered fundamental in framing modern social life and urban cultures. Through a mobilities perspective, it becomes possible to understand societal path dependencies, cultural transformations, and mobility practices.

The reason for using mobilities studies within the SIMS project is that cities cannot be separated from the mobilities that support and develop the modern lives within them. Today's cities are composed of complex settings of social, technological, geographical, cultural, and digital networks of mobilities (Graham and Marvin 2001; Sheller and Urry 2006). This interdependence has developed over time through a series of large-scale technological transitions in transport and communications. Through this, cities have changed in rhythm, speed, and reach (Sheller and Urry 2006). Understanding the flow in cities purely as individual choices, technological transformations, or economic forces overlooks the fact that practices and networks are culturally assembled when producing and performing in city space (Jensen et al. 2015). To make cities places of lived social, economic, and ecological sustainability, strong and socially coherent and inclusive mobility systems are needed that are more than just transport systems and connections.

Consumption is also increasingly mobilised today in the sense that it is grounded in mobility. This applies to shopping for groceries, clothes, electronics, furniture, and so on and to cultural events, education, and so forth. Modern lives are increasingly based on mobility and communication and increasingly on the internet. As American science writer Jeremy Rifkin put it, a transformative historical development is at work that is fundamentally and irreversibly changing the (human) conditions of the late modern culture:

> In the nineteenth century, steam-powered printing and the telegraph became the communication media for linking and managing a complex coal-powered rail and factory system, connecting densely populated urban areas across national markets. In the twentieth century, the telephone, and later, the radio and television, became the communication media for managing and marketing a more geographically dispersed oil, auto, and suburban era and a mass consumer society. In the twenty-first century, the Internet is becoming the communication medium for managing distributed renewable energies and automated logistics and transport in an increasingly connected global Commons. (2014, 28)

Understanding the interconnectedness of mobilities and the role it plays in planning thus becomes essential in many more everyday activities than we often realise. Therefore, any attempt to change practice must be rooted in understanding everyday life ordered through different mobilities with multiple functions.

2.3 Transforming mobility practices through practice interventions

Spurling et al. (2013) developed three intervention frameworks that draw on the theoretical and analytical approach of practice theories (see also Spurling and McMeekin 2015): recrafting practices, substituting practices, and changing how practices interlock. The three alternative frameworks represent different types and scales of ambition within policy approaches to consumer behaviour based on practice theories. In the following, we describe the three practice-based intervention frameworks, including examples related to mobility.

Recrafting practices

Within this intervention framing, practices are "recrafted" by changing one or more of the elements that constitute them. For instance, a sustainable mobility strategy might aim at replacing combustion-engine cars with electric vehicles to reduce the influence of driving cars on the climate. This is an example of a technology-oriented strategy, which does not necessarily involve significant changes in how the mobility practice is performed. However, studies (e.g. Friis 2016) have indicated that material differences between combustion-engine cars and electric vehicles, like the shorter driving range due to the limited battery capacity, influence how the practice of driving is experienced and performed by car drivers. Another example could be campaigns aimed at teaching car drivers how to drive more eco-efficiently, which is a strategy aimed at changing the competences of driving.

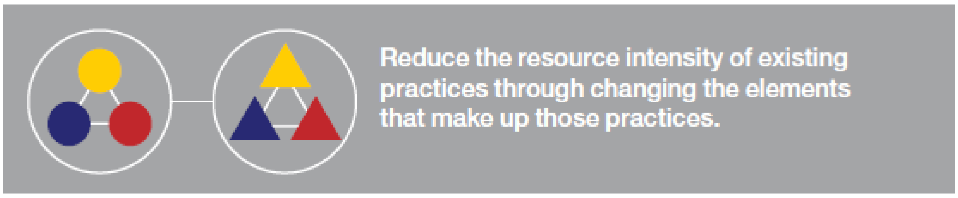

Figure 1: Recrafting practices. (Reproduced from Spurling et al. 2013; Spurling and McMeekin 2015).

As Spurling and McMeekin (2015) note, this practice framing is not much different from many of the present conventional intervention strategies within the mobility or (more generally) consumption fields, which have not yet been able to deliver significant reductions in the negative effects of automobility. "Within this style of policy, the scale and extent of an existing practice, for example driving, is not challenged, though its resource intensity is" (Spurling and McMeekin 2015, 80). For this reason, SIMS primarily addresses the second type of intervention: substituting practices.

Substituting practices

This intervention framing "focuses on discouraging current unsustainable practices and replacing them with existing or new alternatives" (Spurling and McMeekin 2015, 84). In relation to sustainable mobility policies, this framing resembles the classical strategy of "modal shifts", such as the shift from people driving a car to travelling by bike. Driving represents an unsustainable mobility practice, whereas travelling by bike represents a sustainable counterpart. Spurling and McMeekin write that this shift in the balance between competing practices is achieved by:

> Recrafting each of the practices in such a way as to stimulate fewer performances of the less sustainable practice, which means replacing them with performances of the more sustainable alternative. In terms of a goal for transport policy, rather than disrupting the current amount of movement that takes place, the approach seeks to change the mode by which this movement is achieved. As such, the overall need for mobility is not negotiated, though the means by which it is accomplished is. (2015, 80)

Even though substituting practices as a practice-intervention framing resembles conventional strategies promoting modal shifts away from less sustainable mobilities (typically driving), the practice-theoretical perspective offers two important insights that are not usually included in conventional policy approaches. First, it emphasises the importance of more than just making the alternative and more sustainable mobility form more attractive (e.g. by improving the conditions and safety for bicyclists in the city), which is a common strategy many places. Such initiatives must be done in concurrence with initiatives aimed at making it less attractive to perform the unsustainable mobility practice (e.g. by reducing the space for driving or car parking in cities). Second, and perhaps even more importantly, the practice-theoretical approach implies that mobility practices always need to be interpreted in relation to the specific everyday practices that they are related to or combined with. This means that it does not make sense to discuss *one driving practice* or *one bicycling practice*. Instead, many variants of driving, biking, walking, and so on exist. Spurling and McMeekin (2015) term these "practice/mobility bundles" (p. 86). Examples of such practice variants of driving include driving related to shopping (shopping/driving), work (working/driving), school (school/driving) etc. These practice/mobility bundles can even be combined, as Spurling and McMeekin note:

> Further, it is likely that these bundles take complex form – commuting-school/driving, shopping-school-commuting/driving and so on. Because the car is a multi-functional vehicle these variants are not easily observable, and thus become conflated into 'driving'. (p. 86)

Each of the practice/mobility bundles (and their combinations) involves specific elements and needs, which are important to consider when designing strategies aimed at replacing one unsustainable mode of transport with another less unsustainable mode. For instance, the practice variant of shopping/driving might involve the need to transport large bulk groceries, which the alternative variant of shopping/cycling should accommodate if the latter is recognised by people as a realistic and attractive alternative. Similarly, parents bringing their children to and from school by car (school/driving variant) involves elements of comfort, protection from the weather, and creation of a safe and intimate space for interactions between parents and children, which might not easily be transferred to the alternative practice variant of school/biking.

In conclusion, practice-theoretical framing emphasises that strategies aimed at substituting practices need to abandon the simplistic approach of conflating driving and other modes of transport into simplified and homogenous activities or services (means of transport) that can easily be shifted with each other. Instead, it is important to take the practice variants into account when designing solutions in support of practice substitutions. "We suggest that focusing on substituting practice variants (for example, commuting/driving and commuting/cycling) rather than generic modal shift, helps to identify opportunities for intervening in the elements of practices" (Spurling and McMeekin 2015, 87).

While interventions based on substituting practices can be regarded as more ambitious and thorough than recrafting practices, this framing does not bring the present levels of mobility need into question. This is done in the third and most ambitious type of practice interventions.

Figure 2: Substituting practices. (Reproduced from Spurling et al. 2013; Spurling and McMeekin 2015).

Changing how practices interlock

At the core of this practice intervention framing is to understand mobility practices as integrated into the performance of a variety of other everyday practices. For people, moving around is rarely an end in itself but is, in most cases, part of or a prerequisite for performing other practices (e.g. getting to work or doing the daily shopping). In this way, mobility practices are integrated (interlocked) with other everyday practices and, together with these, form systems of interrelated everyday practices. Following this, the spatial-temporal distribution of these practices and how they interrelate play an important role for the experienced need for mobility and the choice of transport means. In relation to this, infrastructure and institutions play an important role, as Spurling et al. (2013) write: "Infrastructures – which influences *where* activities take place, and institutions – which influence *when* activities take place, play a vital part in how practices interlock, and are therefore important targets for interventions" (p. 23).

With the framing of how practices interlock, the focus of practice interventions shifts from how to cover existing mobility demands to how to change the experienced need for mobility. "The focus shifts to recrafting those interlocking practices, such as how households are provisioned, where children go to school, and how work and leisure are organised" (Spurling and McMeekin 2015, 81).

As already indicated, spatial planning (e.g. related to infrastructure) can play an important role in promoting fewer mobility needs, for example, by decreasing distances between home and work or by ensuring a dense network of convenience stores close to residential areas to reduce the need for travel (and car use) for shopping. However, changing how practices interlock is not limited to spatial planning alone but also relates to temporal rhythms of institutions and the social organisation of working practices, shopping, and so on. One example, provided by Spurling and

McMeekin (2015) is how policies for sustainable mobility might take advantage of the increased flexibility of work and work life (partly supported by digitalisation and the internet) by promoting more people to work from home more often, which can reduce travel. This could be promoted through various types of initiatives, for instance by including space for working at home as a criterion in sustainable certification schemes for new housing developments, as suggested by Spurling and McMeekin (2015), or by promoting new ways of organising work tasks and staff resources at workplaces that makes it possible to work from home.

In SIMS, the broader perspective related to changing how practices interlock will be a significant part of developing sustainable mobility solutions, even though the main approach will be substituting practices. The interlocking of mobility practices will be central to identifying the crucial points of interventions and the discussions of the visions for future, sustainable mobility solutions by changing the current concepts of mobility norms and values in relation to driving and related practices.

Figure 3: Changing how practices interlock. (Reproduced from Spurling et al. 2013; Spurling and McMeekin 2015).

2.4 Urban mobility in transition – Automatisation, electrification, sharing, and MaaS

The integration of artificial intelligence (AI) in transport and mobility is expected to heavily influence society and particularly cities in the coming decades. Virtual mobilities already change spaces, interactions, movements, communities, identities, technologies, materialities, and the social fabric of the city (Freudendal-Pedersen and Kesselring 2018). Autonomous vehicles (AVs) have already been seen in simple closed systems, such as trains, shuttle ferries, and cars and trucks travelling on highways. The idea of AVs is almost 75 years old (Kornhauser 2013), but barriers to implementation, including the required immense adaptations to the built environment, have limited their use. Recently, with the invention of wireless communication and sensor technologies in combination with increasing data processing powers, the technical means to create autonomous cars have reached a new level (Lamon et al. 2006). The implementation of AVs is still in its infancy, so it is hard to give an accurate timeline in terms of when they will make up a significant share of the cars on the road. Moreover, several levels of car automation exist, each with varying amounts of human involvement. Some car makers expect to have Level 4 autonomation (autonomy in most situations) by the early 2020s (Fagella 2017), but few are able to estimate when Level 5 (autonomy in all situations) will become widely available. It will most likely take decades to replace all cars with AVs. Due to the slow rollout and varying costs associated with different levels of autonomy, it is likely that AVs with different levels of human involvement will be on the road at the same time. In 2016, the Danish Road Directorate made a prognosis of the expected dissemination of AVs at Level 3 or higher (results referred to in Ministry of Transport, Building and Housing 2018). This prognosis estimates that AVs will most likely not reach a market penetration of the car stock of 50% before in the mid-2030s. Another issue to consider is the love of the car and the feeling of control that people have been socialised towards for the last 100 years (Conley and McLaren 2009; Sachs 1992). It is an open question whether this attractiveness of driving and being a car driver might limit the rate of the dissemination of AVs.

Electrification represents another technology trend that poses huge opportunities and pitfalls for the transition toward sustainable mobility. Currently, road transportation emits almost a quarter of the global greenhouse gas emissions and is the main cause of air pollution in urban centres (European Commission 2017, 7). Over the last decades, various initiatives have been undertaken to decarbonise mobility practices, including exploring the potential of electromobility (e-mobility) comprising privately owned electric vehicles (Friis 2016; Richardson 2013) and hybrid electric vehicles that use electric-powered drivetrain technology to reduce fossil fuel consumption and carbon gas emissions. Although these ongoing initiatives are expected to deliver decarbonisation and reduce local air and noise pollution (Kester 2018), ensuring the adoption of electric vehicles remains challenging. In addition, electric vehicles do not solve problems of congestion, traffic jams, or rush hour or reduce the need for mobility. Rather, some studies are concerned about the risks of electric vehicles to strengthen the automobility regime by supporting the increasing demand for mobility (Friis 2016).

Another trend, which has attracted considerable attention within recent years, is new forms of shared mobility. Shared mobility is part of the sharing economy, which took off around 2010 (Frenken and Schor 2017; Freudendal-Pedersen and Kesselring 2018). New forms of shared mobility include car- and ride-sharing. Several persons share a car (but not at the same time) in car-sharing, whereas several persons share a car for (at least part of) a ride in ride-sharing.

How to define the sharing economy and, more precisely, shared mobilities has been much debated. However, Schor and Fitzmaurice (2015) identify at least two specific characteristics that make the modern form of sharing different from previous types of sharing practices. First, modern sharing is characterised by “sharing between strangers, rather than among kin or within communities” (p. 415), and the authors conclude that “the ability to facilitate sharing between strangers is a defining feature of institutions and practices that are part of the emergent sharing economy” (p. 417). Second, the authors find that modern sharing economy has a strong reliance on digital technologies, which help to establish trust and transparency between people (e.g. on the basis of ratings) and facilitate the coordination of needs and resources in an effective manner. Following Schor and Fitzmaurice (2015), sharing economy solutions, including shared mobility solutions, can be organised in different ways according to the dimensions of market orientation (non-profit or for-profit) and organisation (peer-to-peer or business-to-peer). For instance, Uber represents a for-profit, peer-to-peer ride-sharing service, while a city bike-sharing scheme like Bycyklen is an example of a non-profit, business-to-peer bike-sharing service.

To date, car- and ride-sharing have gained some foothold (e.g. LetsGo, GreenMobility, and GoMore in Copenhagen). However, only a minor share of the total traffic work comprises shared mobilities. Studies also provide different conclusions regarding whether and how much shared mobility solutions lead to lower environmental effects. For instance, calculations made by the Danish consultancy firm COWI for the Danish Government show that, if five per cent of the Danish transport need is covered by ride-sharing in 2025, this would result in an annual reduction of 420,000 metric ton CO_2-equivalents, which corresponds to about three per cent of the emissions from the transport sector (Regeringen 2017a). However, CONCITO (2015) concludes that reductions are highly dependent on the extent that car-sharing displaces existing private car ownership. On a policy level, the Danish Government presented a sharing economy strategy in 2017 (Regeringen, 2017), which contains a few measures relevant to shared mobilities, including simplifying tax rules for peer-to-peer car-sharing with the aim of "promoting digital solutions that integrate public transport services with e.g. cabs and car sharing" (p. 11, our translation from Danish to English).

An overall framework cutting across the mentioned trends is the Mobility-as-a-Service (MaaS) concept (Jittrapirom et al. 2017). Ideally, MaaS combines innovative payment schemes with a digital multi-modal journey planner. As a recent innovative concept, MaaS contributes to sustainable urban mobility planning with the purpose of providing models for seamless trips over one interface by combining different modes of transport and services. There are numerous ways to develop and integrate MaaS solutions in urban areas in and around European cities. Moreover, MaaS can be thought of "as a concept (a new idea for conceiving mobility), a phenomenon (occurring with the emergence of new behaviours and technologies) or as a new transport solution (which merges the different available transport modes and mobility services)" (Jittrapirom et al. 2017, 13).

In a literature review on the MaaS concept, Jittrapirom et al. (2017) extract a set of core characteristics to describe the selected MaaS schemes and existing applications around the world. The core characteristics underline which common areas are addressed in the variable MaaS implementation of sustainable mobilities in urban planning: transport mode integration, tariff options, one platform, multiple actors, technology use, demand orientation, registrant requirements, personalisation, and customisation (Jittrapirom et al. 2017, 16). The ideal behind MaaS is to create an attractive and efficient alternative to today's widespread transport modes based on private ownership (in particular the private car). However, until now, only a few full-scale trials have been conducted with MaaS solutions, which leaves much of the discussion of MaaS based more on theoretical ideas than empirical evidence (Ho et al. 2018). Among the few large-scale trials is the MaaS project *Whim* in Helsinki (see section 3.1).

On the face of it, the idea of the seamless integration of shared mobilities (including "traditional" public transport) sounds attractive and "seductive", but in reality, it might turn out to be more challenging to coordinate journeys across these transport modes in ways that are both convenient and that fit well with the practical everyday needs of people. This calls for more studies on how to design MaaS solutions that fit the users' everyday practices and needs (Hesselgren et al. 2019).

Sustainable mobility planning

As the above brief review of current development trends within urban mobility indicates, the literature warns against naive trust in automation, electrification, or sharing as “one-shot” solutions to the growing car traffic and its derived negative effects. These solutions might possibly result in even further increases in automobility due to enhanced convenience, a shift from public transport to car- or ride-sharing, and new possibilities of multi-tasking while commuting in autonomous cars (e.g. working from the car). This underpins the need to develop comprehensive and nuanced planning approaches towards the design of future sustainable urban mobility systems.

This new approach can be termed sustainable mobility planning (SMP). In contrast to solely focusing on low carbon mobility (e.g. electric vehicles), this approach requires a completely new set of planning principles (e.g. Spurling and McMeekin 2015). Moreover, SMP implies a move away from the classical “predict-and-provide” planning methods towards understanding mobility practices related to urban development, the mix of transportation modes, and the structuration of everyday life mobilities. The focus becomes how smart city development can contribute to more sustainable mobility practices, so that fewer trips and modal shifts are needed for shorter distances to overcome daily life challenges and, in turn, to create more liveable cities.

The EU (2016) Cooperative Intelligent Transportation Systems (C-ITS) aims to promote a strategy for implementing smart transportation systems across Europe, with autonomous vehicles (AVs) included. With advanced regional development and connected and automatic transportation systems, the EU has promoted new and significant transportation services. The Eurocities Mobility Forum, a network of European cities, positions how planning AVs should emphasise liveability as part of the urban transportation systems, rather than the technically driven planning of the EU (C-ITS). Neither the EU C-ITS nor the Eurocities Mobility Forum considers the full potential of shared and MaaS solutions, not to mention SMP.

It has been proposed that new systems of AI and autonomous mobility can offer solutions to many of the issues that the world is currently facing (Dennis and Urry 2013). However, we need to be careful not to forget the interconnections between social and technological innovations and to not end up staying in a modern “techno-centric” planning paradigm (Hajer 1999), in which “seamless mobility" seems to be the unchallenged principle for the efficient organisation of societies and cities (Tickell and Peck 2002). In transport and mobility, AI is often discussed within the concept of smart cities, and Hajer (2015) reminds us that what we need is smart urbanism rather than smart cities. In this lies an understanding of all the things cities are and not only which technologies we can implement in them. The mainstream policy framing with its focus on efficiency and technology has failed to mitigate carbon emission, which emphasises the need for alternative framings.

Chapter 3: Designing sustainable mobility solutions: Status of MaaS in Denmark and Europe and design implications of the theoretical framework

In this chapter, we will first give a more detailed introduction to the status of European Mobility-as-a-Service (MaaS) and how MaaS relates to sustainable mobility planning (SMP) (next section). This is followed by the presentation of a number of guiding principles developed on the basis of the theoretical perspectives presented in this report and that should inform our work on designing mobility solutions and site interventions in SIMS (Section 3.2).

3.1 MaaS solutions and sustainable mobility planning in Europe

The following overview of the current status regarding MaaS and SMP in Europe is based on our own SIMS study (Grindsted et al. forthcoming), which is a review of 39 reports on climate, smart cities, and transportation planning from 10 European capital cities. The planning documents from the 10 cities have been surveyed regarding the stages of advancement for the planning of MaaS solutions. The review study finds that all surveyed cities plan policy interventions that have shifted away from car ownership (planning, implementing, or testing solutions) and have set standards for integrating the sharing of mobility services with public means of transportation.

Helsinki city is in the forefront of MaaS interventions, and a study by Rambøll (2019) finds that, here, among other things, MaaS is integrated into the public transport system to consider the dominance of the car in future cities. By way of illustration, planning documents from the City of London (2018) also show their awareness of not solely relying on car-based solutions:

> Car dependency and traffic dominance have many significant impacts on cities and their residents. These range from health impacts – increasing inactivity and road danger, worsening air pollution and noise, and creating severance between people and communities – to congestion. Many new technologies aim to resolve some of these problems – electric vehicles will reduce some types of pollution and autonomous vehicles may reduce road danger – but no car-based approach to transport can solve them all (p. 277).

In relation to public transportation, which plays an important role within MaaS, the 10 surveyed cities stated the importance of increasing public transportation as the overall city transportation.

To city planners of cities like Copenhagen, the relation between autonomous vehicles (AVs) and public transport is presenting a paradox. The Danish Road Directorate transportation model shows that AVs increase mobility and CO_2 emissions (City of Copenhagen 2017, 4). In addition, the length and number of trips per day increases, as the passengers enjoy the comfort of being able to use the time for other purposes. Thus, when replacing ordinary cars with AVs, it is estimated that traffic increases by 14% in cities and by 20% on highways. This results in further congestion and increases in delays by 15% and in an overall increase in travel time. As a consequence, AVs can have a negative effect on the public means of transportation and the health conditions of citizens (City of London 2018, 279). More people will shift from less polluting modes of transport like walking, cycling, and public transportation towards AV mobility services with negative health effects as a result (City of Copenhagen 2017, 9). While many of the planning documents of the 10 capital cities adress autonomous transportation, no city has set standards or regulatory frameworks that demand AVs to be integrated with MaaS and public transportation systems (Grindsted et al. forthcoming). In this way, the MaaS solution is not considered together with AVs as a new mobility trend in cities.

Following the ideas behind the approach of SMP, a hierarchy between different modes of transport systems exists in achieving sustainable cities (Figure 4). The figure is best captured in the London Transportation Plan (City of London 2018, 277). As such, SMP proposes that the physical planning of the city should favour walking and cycling over other means of transportation, then public transport and, lastly, cars (regardless of fuel type or technical system). Figure 4 also demonstrates a convergent dimension in that speed (km/hour) increases downwards, but travel time increases, and speed drops the more the automobile dominates the share of the cities' total transportation work. Moreover, land use required for the different modes of transportation increases downwards, with cars leading to urban sprawl. If private ownership continues, urban mobility dysfunctions will remain (Canzler and Knie 2016, 59).

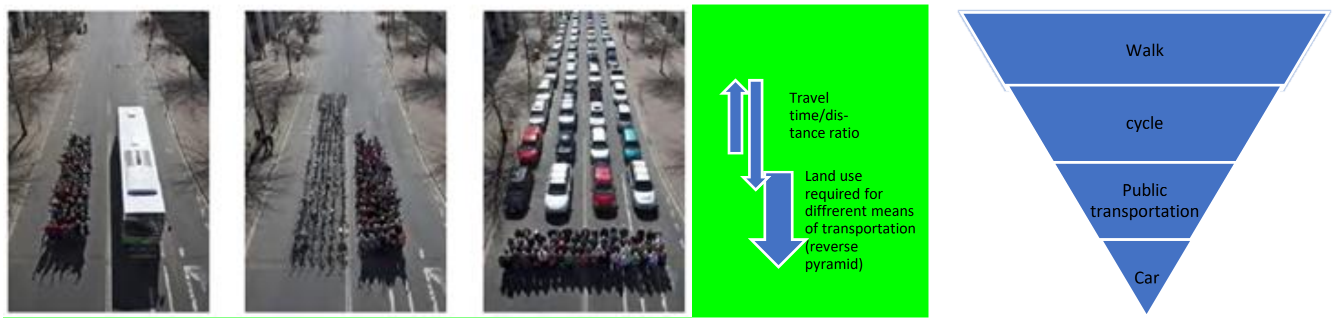

Figure 4: Road space required for different means of transportation (the photos show how much space is required to transport 67 people by bus, bicycle, and car). (Reproduced from City of London 2018, 277; photos are originally from the Cycling Promotion Fund ©). The triangle on right side shows the mobility planning hierarchy (drawing made by the authors).

The mobility planning hierarchy implies that “soft mobility modes” like walking and biking should always be preferred over cars, whether privately owned or shared, fuelled by electricity or petrol/diesel, or driven by humans or automated, because cars roughly require 10 times the land use as bikes (City of London 2018, 277). Therefore, the City of London’s (2018, 281) transport policy intervention involves planning that does not lead to a growth in car use and instead promotes walking, cycling, and public transport.

Results from Helsinki, one of the first cities implementing MaaS solutions (the Whim project), suggest that users of MaaS use public transportation much more than their counterparts (compared to non-users of MaaS), which can replace 38% of their daily car trips (Rambøll 2019, 42). Thus, the main result of implementing the Finnish Whim project is that public transport should be the backbone of MaaS because 68% of all MaaS trips in the Finnish capital occur along public transportation corridors (Rambøll 2019, 40). Furthermore, Whim shows that MaaS users are “multimodalists” and that MaaS is helpful to solve the first and last mile problems.

In the Danish context, in 2018, the Ministry of Transport, Building and Housing asked the consulting company QVARTZ to examine the potential and barriers of MaaS in Denmark within the existing framework conditions. According to QVARTZ (2018), a significant potential exists for users, actors, and society in integrating different modes of transport and functionalities into one on-demand mobility service. However, one of the main challenges in implementing MaaS in Denmark will be to establish cooperation between the wide range of transport providers in economically sustainable business models (which is also an international challenge, e.g. in Whim in Finland). QVARTZ further considered the development of platforms such as Rejsekort and Rejseplanen to be of great potential for implementing coherent MaaS solutions across existing Danish private and public actors in the field of urban mobilities. In this respect, Denmark might have an internationally unique opportunity with the well-established journey planner Rejseplanen and the public travel payment card Rejsekort, which both cover journeys with all public transport in most of Denmark (QVARTZ 2018).

The QVARTZ report underlines preconditions for MaaS that include the following: (i) cooperation between competing transport providers is established, (ii) competences in digitalisation, information technology, and systems are implemented, (iii) adequate supply of first and last mile transport services is available, and (iv) a clear commercial, technical, and regulatory framework is created (QVARTZ 2018). These conclusions are similar to the main findings of a MaaS review based on scientific papers by Utriainen and Pöllänen (2018).

In SIMS, we use existing knowledge and experiences with MaaS to inform the methodological and theoretical framework of the solutions and interventions in the project.

3.2 Design implications of analytical insight from practice theories and mobility studies

On the basis of the theoretical framework and insights described on the previous pages, especially in Chapter 2, a number of guiding principles can be developed to inform the work on designing the SIMS sustainable mobility solutions. This will be done below through six analytical statements.

1) Understanding everyday practices should be the basis for designing new solutions

A key insight from practice theories is that we need to shift focus from technologies or the “behaviour choices” or attitudes of individuals to focus on the everyday practices people perform, and which mobility is an integrated part of. When people move around in cities, this is both a practice in itself, which involves a number of elements, and a part of the performance of other everyday practices (like working, shopping, or engaging in sports). Thus, the designing of new sustainable solutions should be based on the citizens and their mobility-related practices. This can happen in two different ways:

1. By actively involving the citizens in designing the new solutions *themselves* (e.g. through design workshops);
2. By other actors designing solutions *for* the citizens on the basis of detailed knowledge about the citizens' mobility-related practices (e.g. based on qualitative research, many years of experience in the field, interactions with the citizens/actors, or in some other way).

In SIMS, both approaches will be applied in the design process, although the main emphasis will be put on the second option through WP2, *Pre-intervention case studies*, which should inform the development of the first ideas for solutions that will then be subject to further development with the direct involvement of local citizens (in WP3, *Design of mobility intervention*). In addition to the research-based knowledge about the citizens' mobility practice collected through WP2, SIMS will also draw on the insights of the site partners in relation to mobility patterns (practices) and local key actors of the respective sites. Finally, the citizens' experiences and involvement during the trial period are expected to improve the design of long-term workable mobility solutions for the future (in WP4). In addition, in Chapter 4, further details are available on the design approach of SIMS and how the prospective users (citizens) of the SIMS solutions are involved.

2) Transport is not just transport – Transport as practice/mobility bundles

In continuation from the above, it is important to avoid a simplistic approach of conflating driving or other modes of transport into simplified and homogenous activities or services ("means of transport") that can easily be substituted with each other. This understanding is misleading and does not acknowledge the complexity of transportation, which has important implications for the design of attractive and workable alternatives to car-based transport, for instance. To better understand and describe this complexity, it seems promising to apply the concept of practice variants developed by Spurling and McMeekin (2015) (i.e. the practice/mobility bundles, such as driving related to shopping, work, school, etc.). Each of these practice variants has its own specific character, including different meanings. For instance, working/driving (driving to/from work) might be done in solitude (one person in the car) but involve intensive mobile-based communication with work colleagues on the way to work (making the drive part of working time), while the drive home from work might be characterised by contemplation or relaxation (e.g. listening to the radio or just silence). Similarly, driving children to and from sports activities might involve concentrated and meaningful togetherness between parents and children with time for longer conversations.[1] As these examples illustrate, acts of transport are not only about moving bodies from a to b, but they often include a diversity of meanings or related practices that are not related to the functionality of getting from a to b but are nevertheless important for people's everyday mobility experiences. This complexity needs to be considered in designing alternative solutions to car-based travel.

A practical approach to how to incorporate sensitivity to the complexity of transport in SIMS is to identify those practice/mobility bundles related to driving that are particularly dependent on the car as a mode of transport. As already indicated, this could be the car as an intimate space for togetherness between parents and children or for relaxation/recovery after a tightly scheduled workday. These critical car use situations are important to identify and consider to develop competitive alternative mobility designs. The identification of critical practice/mobility bundles can be based on both existing knowledge (previous empirical studies of everyday mobility) and empirical studies conducted as part of WP2 in SIMS.

3) Practice elements: The basis for identifying mobility dynamics and designing new solutions

To explore the socio-technical dynamics behind the citizens' mobility practices before and during the trial, the simple conceptualisation of the three practice elements developed by Shove and Pantzar (2005) is applied. Translated into the specific sites of intervention, this involves the *material elements*, such as the specific technologies (e.g. sharing solutions, physical mobility hubs, and the Rejseplanen app), the *competences* of the citizens/participants (e.g. skills and know-how related to using the materials in everyday mobility practices), and the *meanings* in the shape of understandings, ideas, and aspirations related to the citizens' performance of daily mobility (Shove et al. 2012, 14). The study of these elements will be the analytical basis for identifying potential changes and reconfigurations of everyday mobility.

Despite its simplicity, the conceptualisation by Shove and Pantzar (2005) can be challenging to put into concrete use when designing new socio-technical solutions (as is the aim of SIMS). Here, Entwistle et al. (2015) introduced the contextual wheel of practice (COWOP) to help researchers and designers to better understand practices to design effective interventions and facilitate collaboration between a variety of interdisciplinary actors. Entwistle et al. emphasise that COWOP,

[1] These examples are inspired by the empirical findings by Christensen (2008).

in particular, is a useful framework to explain the practice-theoretical orientation to collaborators who are used to designing on the basis of the classical understanding of the user as a rational agent, similar to what has been termed the “Resource Man” within the context of smart energy (Strengers, 2013). The aim of developing the research framework COWOP is to “provide a concrete tool for applying practice theory in a more exploratory and explanatory way to support designer’s reflective practices” (Entwistle et al. 2015, 1127). The COWOP model is configured by four constitutive elements of what affects daily practices, each representing a quadrant in a wheel: societal structure, infrastructure, near materiality, and the individual (Entwistle et al. 2015, 1126). Compared to the model by Shove and Pantzar (2005), it is in particular worth noticing that the COWOP framework separates material elements into two distinct categories (near materiality and infrastructure) to better account for the complex relationship between these elements. This distinction relates to the shared vs individual dimension that the COWOP model introduces. Another dimension is the abstract vs physical dimension. Entwistle et al. organise the four elements of COWOP according to these two dimensions (see Table 1).

Table 1: The four elements of COWOP organised by two dimensions: shared-individual and abstract-physical. Based on the work by Entwistle et al. (2015).

	Shared	**Individual**
Abstract	Social Structure	The Individual
Physical	Infrastructure	Near Materiality

When applied to practices related to mobility, the *societal structure* element of COWOP refers to broadly accepted social norms and expected standards of mobility (comparable with Shove and Pantzar’s element of meanings). *Infrastructure* refers to the physical environment, such as roads, buildings, means of mobility, etc., that are not under individual control. The element of *near materiality* refers to the (material) environment and technologies that are close to the individual user and that are under individual control, such as using the Rejseplanen app on one’s smartphone or a privately owned car or bike. Finally, the fourth element, *the individual*, encompasses personal values, such as desires to live more sustainably (e.g. by avoiding driving) and the knowledge and skills required for pursuing these values. The COWOP framework highlights the *context* of practices as essential to how the performance of practices varies across different contextual settings and situations. Similar to the work by Shove and Pantzar (2005), the interrelation and interdependence between the COWOP elements illustrate how change is never a simple cause and effect process and that it is crucial to understand the relationship between the elements that constitute practices in different situations.

The COWOP approach illustrates how the practice elements can be modified according to the specific research and design framework. Hence, the above interpretation demonstrates how a design team, such as the SIMS partners, who come from a variety of different disciplinary backgrounds, can profit by a common understanding of how to design new practice-based solutions. Furthermore, compared to the work by Shove and Pantzar (2005), the COWOP approach dedicates more space for action at the individual level (cf. the element of the individuals).

4) Sustainable transition requires discouragement of unsustainable practices

The analytical basis of SIMS recognises the critical need of recrafting unsustainable practices, such as driving a privately owned combustion car, if these will be replaced by sustainable alternatives. Hence, designing, developing, and implementing alternative and workable mobility solutions require simultaneous intervention in the unsustainable practices by limiting the scope of performing them (e.g. by substituting conventional car spaces in urban space with sustainable mobility hubs or green areas and by establishing private car parking spaces at a longer (walking) distance from the travel start and destination). Therefore, the design approach of SIMS highly recommends designing attractive and sustainable mobility alternatives along with simultaneously discouraging existing and unsustainable practices of conventional driving. In terms of this, the design process clarifies existing driving practices at the sites and their related elements (e.g. social norms and physical arrangements) to identify points of disruptions and/or interventions.

5) Interconnectedness: Remember the wider interrelations of mobility practices

Another important observation that adds further complexity to the previously described practice/mobility bundles is that mobility practices are typically also part of other practices. In this way, mobility practices have a dual role. On one hand, we can identify and describe people's daily acts of mobility as practices *on their own*. For instance, we can discuss driving, biking, or walking as something we do. However, these individual acts of mobility are also integral parts of the performance of numerous other everyday practices, such as working (getting to work or using the car during work), shopping (e.g. driving to the local supermarket and bringing goods home in the car), recreational activities (such driving to one's second home on weekends), etc. The latter aspect of mobility practices is important to consider when designing alternative mobility solutions for driving because, today, many everyday practices are dependent on cars and driving for their successful performance.

All of this relates to the point made by Spurling et al. (2013) regarding the practice-intervention strategy of changing how practices interlock. Thus, the focus of practice interventions should include a critical examination of the present infrastructures and institutions, which influence where and when practices take place, to develop new infrastructures and institutions that imply less need for transport and/or make it possible to cover this need through alternatives to resource-intensive modes of transport such as the car.

It is evident that such design strategies need to work over longer time scales because changing institutions and infrastructures involves a wide spectrum of actors and considerable effort. This makes it challenging to apply such strategies in one separate project like SIMS. However, the acknowledgement of the interconnectedness of mobility practices plays a role in two ways. First, it is important to consider interconnectedness "a given fact" when designing SIMS solutions that can be attractive alternatives to car-based transport. These alternatives should ideally incorporate the needs related to the variety of everyday practices and their related practice/mobility bundles of the citizens, such as shopping, picking up children, working, etc. Second, we also challenge some of the institutional and infrastructural elements of everyday practices and their related transport needs through social and physical interventions at the sites, which also involves discussions of the future visions for sustainable mobility in cities (cf. WP5, *Visions on integrated, sustainable and smart mobility*).

6) How to design for the unknown future?

The (networked) urban mobilities are changing continuously. Some changes happen very quickly, such as the recent surge in sharing schemes with micro-scooters in many cities, including Copenhagen, and the rise in the peer-to-peer ride-sharing services of Uber a few years ago. These types of changes often attract considerable public attention. Other changes are much slower, such as the transition from combustion-engine cars to electric vehicles. When designing sustainable solutions for future mobilities in cities, it is a basic condition and key challenge that the future is unknown. The answer to this is not to try to predict the future but instead to identify current socio-technical development trends within urban mobilities. We have identified three such trends (electric, shared, and autonomous mobilities) in the previous sections. In addition, we have identified Mobility-as-a-Service (MaaS) as an overall concept for developing sustainable mobility solutions.

These trends are not “set in stone” or developed as if they follow some kind of “law of nature”. In contrast, the trends are the outcome of specific paradigms, ideas, norms, technological developments, political struggles, and power balances/imbalances of the present societies. In this way, the future paths of these trends are to be co-constructed through the active involvement of many actors. In relation to this, it is a strength of SIMS to have a variety of actors within the urban mobility field represented in the project.

In relation to creating a future sustainable mobility system for cities, it is of particular importance to create a reflexive and experimental approach that trials various alternative routes to study the positive and negative implications of alternative mobility solutions. In addition, it is important to conceptualise the approach across various solutions and to broaden the perspective to also include institutions and infrastructure (including spatial planning). This type of approach is at the centre of the sustainable mobility planning (SMP) paradigm, which also informs the approach of SIMS.

Final conclusions on the analytical design implications of practice theories and mobility studies

Linking the epistemes of practice theory with mobilities and planning studies to study the transition toward sustainable innovative mobility solutions holds several analytical implications. More specifically, SIMS combines the perspectives of practice theory with the theories of networked urban mobilities to improve the potential of developing MaaS-oriented solutions.

A key theoretical basis for SIMS is that mobility practices always need to be interpreted in relation to the specific related everyday practices. For example, it does not make sense to discuss one driving practice or one bicycling practice; many variants of driving, biking, walking, etc., exist. Throughout the site interventions (testing developed SIMS solutions), SIMS develops qualitative interpretations based on citizens' experiences in integrating MaaS solutions into their everyday lives. This analytical framework provides the basis for our understanding of the connections between mobilities, everyday life, social practices, and systemic conditions. Particularly, the analytical statements outlined above (1 to 6) will inform the design of the SIMS solutions. With the outlined analytical framework, we conclude this report by presenting the overall approach to the design process in SIMS.

Chapter 4: The design process

An essential part of the SIMS project is the development of smart mobility solutions to be trialled at the three intervention sites. This is done throughout the first two years of the project in relation to WP2 and WP3. It is no trivial task to design workable mobility solutions that are tailored to the local neighbourhood and the needs and practices of the users while integrating different mobility modes and mobility operators. Thus, the design of the solutions depends on detailed knowledge about everyday mobility practices and the local sites and the close collaboration between the SIMS partners on the conceptual and practical designing of the solutions.

Given this, it is important to carefully consider how to organise and facilitate the design process from the very first conceptualisation of the possible design ideas to the final realisation of the SIMS solutions to be trialled for one year at the three sites. It should be a recurrent activity throughout the design process to reflect on how the work and collaboration are proceeding, including identifying possible risks or challenges and how these might be addressed. In this chapter, we will first outline our approach to the design process (next section), which is then followed by detailing the design phases of the SIMS project (Section 4.2).

4.1 The design process approach of SIMS

The SIMS project adopts a middle-ground position between the design traditions of *user-centred design* and *participatory design research* (Sanders and Stappers 2008, 2014). In both traditions, the *user* of a new product or service (the outcome of a specific design process) is the focal point that guides the design process. However, a key difference between the two traditions is *how* the (prospective) user is represented or integrated into the design process. Thus, in user-centred design approaches, the user is typically not directly involved in the design process but is typically represented through the results of studies that are conducted by researchers to uncover the experiences, needs, or habits of the users. In this way, even if the user is placed at the centre of the design process, this is done through treating the user as a (research) subject. For this reason, the design processes of user-centred approaches are also often led by research. Opposite this, the prospective user is instead “invited” to take part in the design processes within participatory design research approaches (i.e. the user is understood as a partner or *co*-designer). Often (but not always), processes within this tradition are led by design, which means that, in addition to the designers and researchers, they involve a broad range of actors or roles relevant to the design process to achieve "creative acts of making":

> *Designers* creating probe packages, *respondents* creating interpretations of its ambiguous questions and answering them, *design researchers* making generative toolkits, *participants* using these toolkits to make expressive artefacts and discussing those, and *codesigners* creating and evaluating prototypes, often in iterative cycles. (Sanders and Stappers 2014, 6; emphasis added)

By drawing on the design traditions of user-centred design and participatory design research, SIMS acknowledges the importance of designing mobility solutions that are tailored to the specific practices and needs of the citizens living or working within the three neighbourhood sites in SIMS. However, by adopting a middle-ground position between the two design traditions, we want to include the users (citizens) to some extent as active co-designers of the solutions. That said, we also decided to anchor the design process in existing and new research knowledge about the specific sites and on everyday mobility practices in general. In this way, the design process of SIMS is primarily led by research, with the prospective users of the mobility solutions playing roles as both subjects (for research and mapping activities) and partners in specific situations. The users will act in the latter role as partners and co-designers in focus group/workshop discussions of the initial outlines of the SIMS mobility solutions and through the trial of the solutions during the site interventions.

Design phases

One of the approaches within the participatory design tradition is *co-designing* (Sanders and Stappers 2008, 2014), which is a design-led approach that actively involves a wide range of actors and roles in the design process. Sanders and Stappers (2014) describe the process of co-designing as an interactive development, which typically moves through four successive phases called pre-design, generative, evaluative, and post-design. A design process is initiated by a *pre-design phase*, in which the focus is on understanding people's experiences in the context of their lives. The aim of this phase is to uncover the needs, problems, or dreams of the users and their contexts, which can be made the centre of the following co-designing of solutions or other improvements. As presented by Sanders and Stappers, this is a phase that is often biased towards being led by the designers and researchers, with a less active role assigned to the users. However, this changes with the next phase, the *generative phase*, in which the goal is to produce insights, ideas, and concepts that may then be designed and developed (as part of the same phase). This is typically an iterative process involving the development of many ideas and opportunities, which are gradually focused on one or a few specific design ideas. In the co-designing approach, the generative phase involves active participation by several actors (including the users), often as co-producers of ideas and concepts, along with designers and researchers.

At some point, the co-creative design process leads to the identification of a design opportunity, which can be viewed as a closure of focus and discussions on one specific concept, idea, or solution. This is then the basis for developing one or more prototypes that can be trialled through the next design phase, the *evaluative phase*. The purpose of this phase is to assess the effect of the developed solutions (prototypes). The experiences from this phase can result in a number of further adjustments of the design before the final result (product) has been reached, which marks the point at which the designed item is put into use (the *post-design phase*). The key focus of the four phases is summarised by Sanders and Stappers as follows:

> Pre-design research focuses on the larger context of experience while post-design research looks at how people actually experience the product, service or space. Generative design research leads up to the design opportunity decision, and evaluative research takes place during the subsequent design development process. (2014, 10)

As mentioned, the generative design phase is characterised by an iterative and open-ended creation of ideas and solutions. Due to the open-ended character, Sanders and Stappers (2008) also term this the “fuzzy front-end” of the design process, which plays a key role because it is here that the key design decisions are made regarding the final design:

> The front end is often referred to as ‘fuzzy’ because of the ambiguity and chaotic nature that characterize it. (…) The goal of the explorations in the front end is to determine what is to be designed and sometimes what should not be designed and manufactured. (p. 6-7)

In SIMS, the relevant design phases are pre-design, generative, and evaluative, while the fourth phase (post-design) follows after the completion of the project. Section 4.2 provides further details of the content of the different design phases in SIMS.

Design tools

Various types of tools are assigned a key role within most participatory design approaches, including co-designing. Sanders and Stappers (2008; 2014) identify three types of tools that play different roles and are related to different design phases: probes, generative toolkits, and prototypes. Probes and generative toolkits are typically used within the pre-design and generative phases to generate instances of creative design thinking. While probes relate more to the expert-led variant of co-designing, generative toolkits relate to the participatory variant in which the user is considered a co-producer of solutions.

Probes invite “people to reflect on and express their experiences, feelings and attitudes in forms and formats that provide inspiration for designers” (Sanders and Stappers 2014, 7). Probes are developed by designers and/or researchers with the specific aim of provoking or eliciting responses from the users. The reactions are then used to inspire the designers to make further improvements in the design. Probes can be many things, such as diaries, instructions, games, or scenarios. In comparison, generative toolkits invite much more active involvement of users and stakeholders. The toolkit typically consists of a number of components, such as pictures, words, shapes, and phrases, which are used by people “to make artefacts about or for the future” (p. 9). The toolkit is developed by the designers/researchers and is then used by people through facilitated workshops and so on. Whereas probes tend to be used in the pre-design phase (but not solely in this phase), the generative toolkits tend to be used in the generative design phase (but not solely in this phase).

The third type of tool, prototypes, is closely related to the evaluative design phase. Prototypes “are physical manifestations of ideas or concepts” and they “range from rough (giving the overall idea only) to finished (resembling the actual end result)” (Sanders and Stappers 2014, 9). The prototypes are made by the designers, and the idea is that they enable detailed feedback from users (and other stakeholders) through their active involvement with the prototypes.

As SIMS adopts a middle-ground position between more classical user-centred design approaches and participatory design approaches, SIMS draws on generative toolkits to a lesser extent. Generative toolkits are typically used in connection with the co-designing/participatory approach described above. Instead, more emphasis will be put on research-informed design processes involving probes. Finally, the prototype is key to the site interventions in SIMS (i.e. the evaluative phase of SIMS).

4.2 Overview of the design phases of SIMS

Based on the design approach outlined in Section 4.1, the key characteristics of the individual design phases of SIMS are presented in Annex 1. We will not go into detail on the content of the individual phases because the details can be found in Annex 1. However, it should be pointed out that the first two phases (pre-design and generative) are partly overlapping in time, which indicates that these two phases will be mutually inspiring to some extent.

The above outline of the SIMS design approach, including the details of the purpose, content, and methods applied in the specific phases in Annex 1, will guide the design work. If needed, the approach and phase descriptions will be updated on a recurrent basis to reflect important insights from the work on designing the SIMS mobility solutions. In this way, this framework should work as a practical tool to guide the design work of SIMS.

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Annex 1: The phases of designing the SIMS mobility solutions

	Pre-design (WP2)	**Generative design (WP3)**	**Evaluative design (WP4)**
Time (months)	M1-M12	M4-M24	M25-M42
Purpose and focus	- Develop a knowledge base for designing solutions - Map mobility challenges and options from a sustainability perspective	- Develop ideas for solutions to be trialled at sites - Prepare (set up) these ideas	- Evaluate solutions (prototypes) developed in WP3 through site interventions focusing on *how* the prototypes are experienced and their *effect* on mobility patterns - Translate results into suggestions for further design improvement
Content (What we do?)	- Map sites (social and technical), including existing mobility practices - Clarify the theoretical framework and key concepts	- Carry out workshops/seminars focusing on creating and concretising ideas - Between meetings: detail ideas and prepare drafts before meetings	- Households (citizens) test specific solutions (prototypes) - A continuous dialogue with households (citizens) about experiences (evaluative research)
a) Which actors are involved? b) Involvement approach?	a) Primarily researchers and site partners b) Dialogue about challenges, possibilities, and first solution ideas (on a conceptual level)	a) All partners perhaps divided into smaller groups focused on the development of specific ideas/solutions. Users are also included b) Dialogue: Both open-ended (idea creation) and later focused on concretising solutions	a) Primarily participating households/ citizens b) Dialogue and documentation of user experiences based on research methods *Towards the end of the phase: Involve all partners in final discussions of possible further improvements of mobility solution designs (a final "generative design loop")*
Tools	- Mapping/dialogue - Research (explorative) methods	- Probes (developed on the basis of the pre-design phase/WP2) - Generative tools	- Prototypes