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Chapter 5

Emerging mobility technologies and transitions of urban space allocation in a Nordic governance context

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5.1 Introduction

The urban mobility landscape is currently undergoing an uncertain transition involving multiple emerging technologies, such as self-driving vehicles (SDV) (Blyth, Mladenovic, Nardi, Ekbia, & Su, 2016), on-demand microtransit (Haglund, Mladenović, Kujala, Weckström, & Saramäki, 2019), and mobility-as-a-service (MaaS) (Pangbourne, Mladenović, Stead, & Milakis, 2020). However, there are also other societal trends shaping this transition, such as the healthy, inclusive and sustainable cities movement, the digital and sharing economy, as well as the return to urban living and reduced car use by younger generations. Stemming from the fact that emerging technologies often develop through convergence and nonlinear dynamics with many interdependencies between built and digital environments, there is a need to understand potential combined implications from emerging mobility technologies on urban space allocation. Such understanding of the implications for urban space allocation can enable further deliberation about emerging governance and policy levers (Milakis, Snelder, van Arem, van Wee, & de Almeida Correia, 2017; Mladenović, 2019; Stead & Vaddadi, 2019). Understanding these multidimensional uncertainties requires an understanding of the relationship between digital technology, built environment and human behavior (Cavoli, Phillips, Cohen, & Jones, 2017; Litman, 2019; Mladenović, 2019; Stead, 2016). However, little research has been done to develop future alternatives that assume a combination of technological development and infrastructures or policies, as well as providing enough detail to understand a multitude of implications for urban form. In addition, this research is timely considering previous contributions do not have much focus on the Nordic region, so there is potential benefit

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in exploring possible and desirable futures in this democratic and geographic context. In particular, this chapter explores the case of Finland where there are a range of on-going developments of various mobility concepts which build on wider societal initiatives in digitalization.

This chapter aims to explore plausible future changes in space allocation from a qualitative perspective while taking account of the wider social and technological transitions in mobility, and ultimately providing recommendations for governance, policy, and planning actions. The centerpieces of technological aspects are rubber-tyred and road-based SDVs and emerging urban mobility services. With the aim of adding more detail to technological, infrastructural, and policy aspects in relation to previous research, this envisioning exercise draws from operating design domain (ODD) and local service scenario (LSS) concepts used in vehicle automation. To enable divergent envisioning as an approach to structuring the anticipation process, the intuitive logics scenario analysis method is applied to neighborhood level planning in Helsinki Capital Region (HCR), Finland. This chapter is divided into five main parts. The first part provides a short overview of previous envisioning studies focused on emerging mobility technologies, clarifying further the knowledge gaps. The second part presents the methodological steps and case context. The third part includes the elaboration of envisioning results. The fourth part discusses the policy and governance implications, while highlighting potential points of political conflicts between urban space allocation and technological development. The fifth part concludes with a summary of findings and recommendations for future research directions.

5.2 Scenarios on emerging mobility technologies and implications for urban space allocation

A small number of recent studies have focused on the development of mobility services (Enoch et al., 2020; Jittrapirom, Marchau, Heijden, & Meurs, 2018). Whilst these limited studies have taken an in-depth perspective on the development of urban mobility services, including public transport, they do not provide extensive consideration of urban form implications. In contrast a larger number of studies involving scenario-building exercises have been carried out in recent years to understand a range of possible impacts of SDVs (Meyboom, 2018). These studies include assumptions such as where and when SDVs will be allowed to drive in the city, whether SDVs can be operated alongside human-driven vehicles (or segregated), how car users (of both conventional and automated vehicles) will respond to the introduction of SDVs, whether SDVs will be primarily used as private or shared vehicles, and the degree of safety and security they manage to achieve (Stead & Vaddadi, 2019). While many of these primarily focus on the technical aspects of their introduction, relatively few studies consider the potential impact of AVs on the spatial development of cities. To date, research has been concerned with quantitative estimations from the introduction of shared/automated/electric vehicles based on simulations of hypothetical and real cities (Zakharenko, 2016). For example, these studies have concluded that parking demand could be substantially reduced under certain circumstances, such as a high deployment rate of shared automated vehicles and extensive reliance on public transport (Boesch, Ciari, & Axhausen, 2016; Chen, Kockelman, & Hanna, 2016; Fagnant & Kockelman, 2014, 2018; International Transport, 2015; Spieser et al., 2014; Zhang, Guhathakurta, Fang, & Zhang, 2015 and Milakis et al., 2017 for a review of relevant literature). However, research so far has focused on a dominantly quantitative approach for exploring future scenarios and is not sufficient given the high degrees of uncertainty associated with emerging technologies. In addition, in most studies, issues of urban form are mainly discussed as assumptions used to construct scenarios rather than being outputs or results from the scenarios, and most studies devote more attention to the small-scale impacts of SDVs on urban form (e.g., parking spaces and carriageway dimensions) rather than the larger scale impacts (e.g., suburbanization and the reallocation of developments to other parts of the city).

In their review of recent scenario studies concerning the introduction of SDVs and the relation with urban form and structure, Stead and Vaddadi (2019) distinguish between four main types of scenarios (in a global North context) according to their scope and content:

5.2.1 Business as usual (BAU)

These reference scenarios assume the continuation of one or more current trends (in mobility, urban development and/or demographics), without the introduction of SDVs. The business as usual (BAU) scenarios largely assumes that current trends, attitudes and priorities remain largely unchanged in the future. These trends refer amongst other things to changes in technology, economics, demographics, and politics. The underlying assumptions here are that technological innovations are not taken up to any great extent, particularly due to the high cost of the necessary infrastructure. Significant technological development does take place and is mainly restricted to efficiency gains in specific areas (Heinrichs, 2016). The scenarios generally assume that car ownership and travel gradually increase (Fulton, Mason, & Meroux, 2017).

5.2.2 Technology + non-shared (T)

The technology and non-shared (T) scenarios assume the introduction of AVs which are either solely or predominantly individually owned and used. These scenarios assume a gradual roll-out of SDVs and relatively widespread adoption from around 2020, and a rapid growth around 2025. A continuation of existing trends is assumed for vehicle sharing, public transport use, and urban planning

(Bouton, Knupfer, Mihov, & Swartz, 2015; Fulton et al., 2017; Röehrleef, Deutsch, & Ackermann, 2015). Meanwhile, vehicle ownership does not change significantly as individuals continue to be attached to the ownership of their own cars (Corwin, Vitale, Kelly, & Cathles, 2015; Gruel & Stanford, 2016; Thakur, Kinghorn, & Grace, 2016).

5.2.3 Technology + shared (T+)

The technology and shared transport (T+) scenarios assume a future state where SDVs are fully developed, (predominantly) shared, and the current mobility trends have changed and evolved along with the technology. Various mobility models such as ride sharing platforms, mobility on demand systems and car sharing platforms are expected to operate in cities. Almost all the literature reviewed contains one or more scenarios of this type.

5.2.4 Technology + shared + infrastructure/policy (T++)

The technology, shared and infrastructure/policy (T++) scenarios assume the introduction of SDVs, which are solely or predominantly shared in conjunction with supportive policies and/or infrastructures to actively promote the uptake and use of SDVs. In these scenarios, shared automated mobility is combined with substantial policy support for electrification, automation, shared-use mobility and urban planning to promote walking, cycling, and public transport use.

These scenarios do not explicitly include the use of technologies to reduce the need to travel such as home-working, remote medical care and e-government services. Although these technologies can potentially affect the uptake and use of SDVs, it is important to recognize that there are often rebound or unintended effects of such technology on travel demand (Biswanger, 2001).

5.3 Methodology

5.3.1 Methodological framework

The methodological framework of this chapter centers on scenario planning as a foresight-oriented approach where alternative scenarios are developed for a desired time horizon from the present situation. The methodological approach for scenario planning used in this project sits within the "Intuitive Logics School" (Bradfield, Wright, Burt, Cairns, & Van Der Heijden, 2005), in that the focus is on the insights and learning that arise from the process. The resulting four scenarios are qualitative narratives rather than quantifiable matrices of future conditions that could be retrospectively verified. The term scenario is used here as a hypothetical future purposefully built to highlight the policy dilemmas and societal tensions to be expected as the subject under analysis—full automation of road transport—transitions from being a theoretical speculation to becoming a daily reality which individuals can (or have to) directly experience. In accordance with the typologies of scenario building, a mix of exploratory (to think the unthinkable) and backcasting (to identify the critical decisions) approaches (Banister & Hickman, 2013; Stead & Banister, 2003; Sustar, Mladenović, & Givoni, 2020) are used. Scenario planning is adopted because of the complexity of the context, the wide range of potential future developments and the diversity of participant perspectives included in technological transitions processes.

As part of the methodological framework, the first step in the process were workshops using PESTLE analysis which allows key factors and driving forces influencing technological transition to be explored (Beecroft & Pangbourne, 2015). The PESTLE technique has its origins in strategic business planning (Fleisher & Bensoussan, 2003), and the approach requires factors to be categorized as political (P), economic (E), social (S), technological (T), legislative (L), and environmental (E). As widely used techniques in a business environment, the expectation is that this method would be accessible to participants with a minimum of experience. Although the boundaries between these categories are porous, the method is both accessible to participants and useful in generating novel conceptions of possible futures and ordering contributions in a participatory setting. Two PESTLE workshops were organized involving a total of over 80 participants. The participants included young and senior practitioners in the field of transport and spatial planning, from Finland and abroad, recruited online. The participants came from a range of educational background, mainly in engineering but other disciplines were represented, such as planning, geography, and social sciences. This diversity of backgrounds provided for a diversity of perspectives during the exploration exercise.

In the next methodological phase, the driving forces were assessed regarding the magnitude of their impact and the uncertainty of their future state. At this stage a scenario matrix was developed, describing extreme but plausible future states of urban space allocation. In addition to the four extreme scenarios presented in the scenario matrix (described in the results section below), exploration of possible future states includes identification of causal processes and decision points leading to those future states. As the last phase of the methodological process, the developed scenarios were presented and discussed in a focus group with five Helsinki Region Transport planners. This focus group discussion was used to validate the scenario design, as well as to reflect potential governance and policy responses.

The complete envisioning process described earlier focuses on the Otaniemi urban area in the HCR. During the PESTLE workshop process, participants were presented with a limited level of details for the future of Otaniemi, to avoid prescriptive constraining of the exploration process. For validation purposes, participants' prior knowledge of the plans for Otaniemi was tested, ensuring the minimization of bias. The focus on Otaniemi relates to the concept of ODD, which can be defined as operating conditions under which an automated driving system is designed to function, including such aspects as environmental, geographical, time-of-day restrictions, and presence or absence of certain traffic or roadway characteristics. In addition, the concept of LSS enables us to expand the reflection beyond the aspects considered in ODD, to include service design, with such aspects as scheduling, routing, and pricing. Thus the initial vision description included the following aspects:

- Integrated land use, transport, and energy infrastructure planning
- Self-driving electric shuttles with fixed and on-demand routes
- Proximity to high capacity transport nodes (i.e., metro)
- Emphasis on street design for walking and biking
- Restricting car access through parking management
- Public transport and pricing policy

5.3.2 Otaniemi case description

The Otaniemi neighborhood was selected as a representative area for assessing the futures in the HCR. Otaniemi is in the process of densification and diversification of land use, exemplifying the increasing urbanization across the HCR, as Finland is now catching up in the rate of urbanization in comparison to other Nordic countries. By 2050, the HCR is predicted to have a population of 2 million residents (compared with ~1.5 million at present), thus having a third of Finland's population. It is estimated that those residents will make 2.8 trips/day on average. The current mode split in HCR is 39% of car trips, 22% of public transport trips, 29% of walking trips, 9% of cycling trips, and 1% of other. In contrast, the recently completed Helsinki Region Land Use, Housing and Transport Plan (MAL 2019) has ambitious 2030 targets, such as reducing greenhouse gas emission from transport by 50% against 2005 levels, improving labor force accessibility by 10% from the current level, decreasing social segregation, and reducing the share of car trips to 30% in total.

To achieve these targets, urban growth in the HCR is directed to the existing built environment and to the areas that are competitive in terms of public transport (see also Chapter 17). Thus new development is located in areas of relatively high accessibility, enabling infill development, whereas securing the quality of the living environment and large number of green connections (Fig. 5.1). Major transport investments are made in rail and cycling infrastructure, while road transport is developed with a focus on freight and public transport. The densification of the Otaniemi area relies on the fact that the metro line has been extended westwards, as part of the larger public transport network overhaul toward a trunk-feeder system (Weckström, Kujala, Mladenović, & Saramäki, 2019). In addition, plans for Otaniemi include an introduction of a light rail line, which should further improve labor accessibility (see also Chapter 14). The current parking supply is a mix of private and public facilities, both on-street and off-street, and frequently including user and time restrictions. Parking policy is currently in transition towards both

FIG. 5.1 Otaniemi area built environment. *(Source: Open Street Map.)*

supply and demand control mechanisms, such as a higher degree of parking space centralization, reducing parking minimums, and introducing parking pricing. However, as can be seen from Fig. 5.1, the area still has plenty of distributed parking areas. Finally, from the perspective of policy and planning processes, Otaniemi is a good representative example as there are several layers of actors intersecting their domains of responsibilities, from private landowners, through city and regional spatial planning organizations, to national transport planning and other diverse stakeholders, such as various tech companies located in this area.

5.4 Results

5.4.1 PESTLE analysis

The PESTLE analysis identified that the largest magnitude of uncertainty is around aspects related to mobility service models. For example, parking could be potentially integrated into MaaS user packages, with a potential that parking pricing can be based on total trip length, time of day, route, vehicle type, residence, or to include a certain amount of parking credits provided by the city without pricing. Moreover, the development of MaaS user packages might need to address the question of integration between public and private parking facilities. In particular, there are four groups of technological and design factors affecting mobility service models. The first group include various aspects of usage schemes, such as pricing of SDV usage, which could vary based on user type, time, or with further advancements in carbon credits or mobility credits. Regarding user type, there has been discussion about pricing in relation to frequency of use or users capabilities, including dedicating special access to people with mobility impairment, elderly or children. Furthermore, usage schemes have been associated with fare integration and ticketing technology in the whole HSL region, as well as with travel information systems. The second group of factors relates to SDV route plans, which could vary between on-demand and fixed schedule operation, with several options for route alignment (e.g., circular clockwise, circular counter-clockwise, and diagonal), and stop locations and spacing in relation to trunk line proximity and land use, as well as driving range and charging requirements for electric SDVs. In this domain, drawing from previous examples of automation in rail transport, the discussion included a possibility to keep the human operator, as all driver's tasks will not completely disappear (e.g., disruptions due to extreme weather periods or suicide attempt), and some new tasks might appear as well.

The third group of factors identified in this methodological step relates to various aspects of business model, contracting, and operation. Various schemes for system ownership have been discussed in the workshops, including various options for sharing capital and operating costs across a diverse set of actors (e.g., SDV manufacturer, city, HSL, neighborhood association). In relation to this, aspects of advertising and savings in operating costs have been contrasted with insurance schemes and amortization costs, implying potential changes for the contracting models for service operators. The current high SDV purchase price and uncertain maintenance costs (i.e., technology deterioration curves) have been underlined as one of the major challenges in developing sustainable business models. As the fourth group of factors, a range of technical and system architecture aspects have been discussed in PESTLE workshops. These include path dependence from existing automotive standards, which could affect the interior of the vehicle through seat arrangement, or enable/prevent the use of in-vehicle cameras for emergencies. Moreover, there is a range of other infrastructural aspects, such as communication and charging infrastructure, which could affect the possibilities for stop design (e.g., closed stops), terminal space locations for parking or charging, and other general possibilities for vehicle-to-grid technology.

In addition to these aspects, there is a set of sociocultural driving forces that have been identified in this methodological step. An important aspect that has been underlined in the PESTLE workshops is the presence of the technical university (Aalto University), as many Otaniemi residents are students. Such a group tends to belong to the early adopters and creative class, with positive attitudes toward technological innovations. On the other hand, the same engineering (i.e., Teekkari) culture could also exemplify those societal aspects that would resist the technology, as it is associated with practical jokes that could stop SDVs, or conflict with the existing preferences for walking and cycling in Otaniemi. Further aspects of identity and image could relate to strengthening the brand of the new university (Aalto University is the rebranded former Helsinki University of Technology), while also improving the image of the public transport service. In contrast, some aspects of car driving as a culture could be an obstacle to reducing SDV ownership, such as long-distance family travel to remote parts of Finland for vacation in the summer cottages. Similarly, SDV users would need to adjust to a strange feeling of not being in charge of the vehicle, not being afraid of cyber security threats, or reactions of other vehicles around SDV, while also potentially gaining from added comfort in cold or rain conditions. Many workshop participants raised an important value of proximity to nature and its preservation, as crucial for accepting the technology. In particular, service design should be following the lines of clean technology, not requiring the further destruction of green areas in Otaniemi, while also reducing total energy consumption, in addition to emissions. Finally, job loss or shift discussions were also included in the workshops, raising the question of potential balance in jobs lost from driving to jobs gained to cleaning and maintenance of automated shuttles and remote vehicle operation.

5.4.2 Resulting scenarios

The main axes of the scenario matrix are the planning approach and service model (Fig. 5.2), while sociocultural forces have been taken as a third dimension for providing exploratory depth. These axes provide a useful degree of differentiation between the scenario quadrants, especially as transport is a domain where governance and social norms have a particular impact. In addition, as observed during the recent COVID-19 pandemic, sharing of mobility services is one of the highly uncertain future aspects. Scenarios one and four represent a small deviation from the current urbanization trajectory, whereas scenarios two and three represent direct opposites, with two being a radical path breaking scenario, and three being a radical lock-in.

5.4.2.1 Scenario 1: Concentrated-dispersed land use

In this scenario, the service model emphasizes individual, private, SDV use which goes hand in hand with no societal learning of sharing. Such sociocultural forces might be underpinned with such considerations as private property and privacy. In the same context, policy and governance attempts to take proactive,

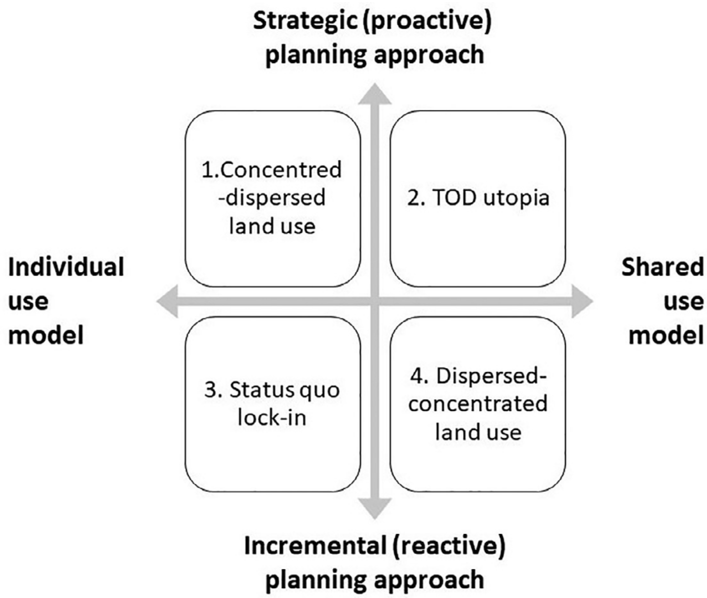

FIG. 5.2 Scenario matrix. *(Source: Authors' own work.)*

strategic actions to steer the urban development. However, the level of transport demand is not reduced, thus failing to achieve fast enough transition toward desired sustainability targets.

5.4.2.2 Scenario 2: TOD utopia

In this scenario, the service model emphasizes shared SDV use, meaning a significant shift in sociocultural forces. In addition, policy and governance takes a range of proactive, strategic, actions. Thus new services are not only supported by the public sector, but they are driven by the visions for sustainable cities and mobility. Such involvement included a range of existing policy levers and physical/digital infrastructure, while also enabling new governance levers. The level of transport demand is reduced and shifted to active modes, resulting in densified urban environment, including also adequate street infrastructure for the combination of new mobility services.

5.4.2.3 Scenario 3: Status quo lock-in

In this scenario, the service model remains focused on individual SDV use, accompanied by the lack of behavioral or cultural change. The governance approach is not able to establish long-term visions but spends most of its attention reactively dealing with immediate challenges, such as safety and liability. The result is a lack of any path breaking activities, but rather an even further increase in transport demand, and incoherence in urban form development, leading to significant failure in achieving sustainability targets.

5.4.2.4 Scenario 4: Dispersed-concentrated land use

In this scenario, service model emphasizes shared SDV use, which is largely driven by the commercial actors, focusing on the personal data as an important asset. In contrast, the public sector has failed to take the lead in development quickly enough, mostly taking reactive actions, such as creating legislation to open further the mobility sector for commercial service offerings. Hand in hand with such development, the trajectory of urban form has not focused on further organized densification and design. As a result, the level of transport demand is not reduced or shifted to active modes, thus failing to achieve fast enough transition toward desired sustainability targets.

5.4.3 Focus group discussion with transport planners

The focus group verified the four scenarios and concluded that scenario two (TOD utopia) is the one mostly in line with the proactive approach outlined in the MAL 2019 plan. In addition to the existing plethora of transport policy measures that are already implemented or evaluated by the Helsinki Region Transport, focus group discussion has highlighted several aspects to consider about data and algorithm governance as an emerging policy lever in the context of urban mobility technologies. One aspect is specifying data collection practices, following the informed consent principle from European Union's General Data Protection Regulation (GDPR), which includes describing to the user what is being collected and how it will be used. In addition, discussion brought up a need to evolve consent agreements, including summaries and searching capability, while specifying the level of aggregation and anonymization. The second aspect brought in the discussion includes the development of data sharing specifications, both from and to technology providers, developing data-for-data principle. For example, Helsinki Region Transport could share data on the infrastructural condition, traffic and public transport operations, and data from passenger surveys and trip planner. In return, technology providers could share data on routing, temporal distribution of pickup and drop-off points, pricing, and distribution of user profiles and their satisfaction. Furthermore, there should be development of specifications for access control rules over time, level of aggregation and responsibilities for actors involved in second-hand data use, and options for data removal or return to the users.

In addition to the set of questions relating to privacy protection, discussion also highlighted the need for developing governance approaches for service and algorithm development. Such rules would include digitally defining access points, preferred routes, speed limits, designated or forbidden pick-up and drop-off locations, and operating design domain area boundary per time and space. Moreover, governance should respond to technological development by expanding the design criteria, such as those that would be contrasted to operating efficiency, such as carbon emission and health effects. For expanding the design criteria a conclusion was that it is essential to place users at the center of this development, by actively involving them in open innovation processes, such as defining service offering and restrictions and defining performance measures for short- and long-term deployment of technology. Finally a conclusion from the discussion was that a wider set of ownership, financing, and taxation models should be evaluated, including both street and service infrastructure.

5.5 Discussion of envisioning results and governance implications

5.5.1 The complexity of implications from and for emerging technology

Similar to previous studies (Papa & Ferreira, 2018), this research also identifies an imminent political conflict between allocation of limited urban space and unguided technological development, especially given the diversity of needs of various social groups and the importance of walking and cycling for transition to sustainable mobility systems. If the trend is kept unguided, there is a threat of technological determinism (Mladenović, Stead, Milakis, Pangbourne, & Givoni, 2020), where technological opportunity is not used for supporting the wider systemic transition of the mobility system toward sustainability, but the existing mobility system is further locked into an unsustainable trajectory, thus limiting the opportunities for responsiveness and divergent visions of mobility futures. Here, it is important to underline that urban form and mobility directly pertain to human experience in the everyday life, shaping behavior and values, with direct consequences for well-being (Mladenović, Lehtinen, Soh, & Martens, 2019). In this complex setting, urban space allocation requires trade-offs between multiple conflicting goals, such as safety, physical activity, emissions, and energy consumption. Focus on one objective only (e.g., safety), simplifies the actual challenges of urban space allocation, and will thus result in societally suboptimal and unfair outcomes.

In relation to previous studies, even if urban form is one of the central aspects, the complexity remains a challenge (i.e., multitude of factors, interdependence, feedback loops, and uncertain effects) (Blyth et al., 2016; Cohen-Blankshtain & Rotem-Mindali, 2016). Previously most developed (T++) scenarios include supportive policies and/or infrastructures to actively promote the uptake and use of SDVs. In these scenarios, shared automated mobility is combined with substantial policy support for electrification, automation, shared-use mobility and urban planning to promote walking, cycling, and public transport use. Nonetheless, there is an argument for the need to expand the lens to the multitude of factors and implications around urban mobility futures. Fig. 5.3 includes a nonexhaustive summary of the implications identified during workshops, scenario building, and focus group discussion. The left side of the figure includes dominantly infrastructural, technical, and institutional aspects, while the right side includes dominantly behavioral and values aspects. Even if nonexhaustive, this list of factors shows that understanding of implications and possible response levers has to go beyond those outlined in the literature so far, and beyond the conventional transport or spatial policy and planning measures.

5.5.2 Networked and responsible governing of the technological emergence

Given the challenge of the irreducibly complex and dynamic system of urban form and mobility, a legitimate question to ask is whether the contemporary political conflict around urban form is a sign of a larger social justice challenge. And what are the essential aspects of responsible and coordinated governance that should be developed in the transition process? In general, having in mind potential windows of opportunity for fostering emerging innovations, Nordic innovation-friendly governance needs to have a systemic approach, capable of dealing with risks and ethical dilemmas, while achieving solutions to pressing societal challenges around environmental and social sustainability. However, decision-making in this domain of emerging mobility technologies faces a classic Collingridge double-bind dilemma. This dilemma contrasts the early stage of development, when change is easy but there is uncertainty about consequences, with the later stages of technological maturity, associated with a lock-in when the technology has become societally embedded (Genus & Stirling, 2018). This dilemma is at the core of challenges for steering development of an emerging technology, highlighting the need for governing responsible innovation processes that would avoid different types of technological determinism and lock-in. On the contrary, when emerging in the context of an institutional void, technologies also challenge the institutional landscape, structures, and patterns of interaction among actors in unanticipated ways, resulting in redistribution of roles, responsibilities, and power in hybrid institutional networks. Here a general set of guiding principles can be outlined, drawing from the responsible innovation concept (Stilgoe, Owen, & Macnaghten, 2013):

1. Anticipation—higher use of foresight not forecast methods, with higher degree of speculation about technological options beyond the path dependence from the existing system.
2. Reflection—opening up uncertainties, risks, assumptions, and speculating about unknown unknowns, including undesirable futures where society should not end up.

FIG. 5.3 Multitude of implications around urban form, land use, and emerging mobility technologies. *(Source: Authors' own work.)*

3. Deliberation—opening up visions, questions and dilemmas for collective and participatory deliberation processes with a wider range of stakeholders and the wide public.
4. Responsiveness—developing adaptive governance capacity by understanding the missing actors or relations between actors, as well as their developing roles and responsibilities.

Despite the fact that delayed urbanization across the HCR introduces challenges, this is also an opportunity for a proactive approach, relying on a deeper and more ethical understanding of social aspects of mobility technology. Such a proactive approach will inevitable need development of collaboration practices between a wide set of inter-administrative (involving different ministries and levels of governance) and cross-sectoral (public, private, and civil sector) network of actors that can develop comprehensive and fair policies, taking into account the ultimate goal of transition towards sustainable society. In the Nordic context, it is especially important that city and regional level authorities receive support from the national and EU level, while also advancing existing good practice of public engagement in urban planning. If the lack of active public participation in public experiments continues, unique opportunities for educational and co-creation activities will be lost, failing to develop a diverse set of requirements and avoid algorithmic bias (e.g., differential service provision and discrimination of certain user groups) in implementing these emerging technologies in urban areas. In addition, networks of actors will have to negotiate about ownership and business models, including defining financial flows for infrastructural investments, as well as insurance and taxation. Given a high emphasis on experimentation processes in the Nordic governance system, there is a need to elaborate data sharing and algorithmic responsibilities for different actors. In addition to ensuring essential safety requirements during experiments, it is important to establish an independent auditing authority for digital forensics to systematically analyze prior examples of algorithmic bias invention and reproduction, and continuously develop knowledge applicable for standards and recommendations that can be communicated back to technology developers. In addition, defining rules for multi-actor data exchange in experimentation processes should consider benefits from combination and exchange of data, as well as aim to protect user privacy, especially for the collection of georeferenced data. Here a basis is already established by EU-level GDPR but will still need to elaborated in the particular governance practice.

Reflecting further on the governance approach, attention cannot be focused on economic benefits only (Mladenović et al., 2020). Specifically, urban space for active and collective transport modes cannot be sacrificed for the sake of more individual vehicle-based modes, as this will conflict directly with both climate and well-being related goals. The principles of responsible governance of technology would suggest that the timetable for implementing these emerging technologies is not locked-in from the beginning, where the end date of technological options is chosen first and then the rest of the society is fitted to technology. Rather, decision processes should start with participatory development of the vision of a desired mobility system first, and then proceed into deciding what kind of technology and where it is needed to support that vision. The essential question then is - what are the challenges with the current mobility system that we cannot solve with already available policy or infrastructural measures, and that can only be addressed with the emerging technologies? For example, parking reform makes sense today, even without vehicle automation, as already argued by Guerra and Morris (2018). Similarly, there is plenty of opportunity for considering automation of urban rail (i.e., tram, light rail, commuter rail, and metro), even if these modes have their own specific features. In addition a question that must be clearly asked is—what are the user groups that exactly need further advancements in automation and digitalization of urban mobility technology? With these questions in mind, and given the already wide set of planning and policy measures available, it is essential to conduct an analysis of investment priorities, where investment into emerging technologies is one of the alternatives. So far, there is little evidence that investments into automation and digitalization are cost-effective measures for addressing climate and well-being goals, especially considering a range of spatial context and urgency to aid less fortunate groups of people. Finally, there is an important question remaining unaddressed—shall investments into emerging technologies for deployment in the Nordic context be decoupled from investments for deployment in specific international markets? This might be a necessary compromise if economic growth from innovation remains equally important to addressing environmental and social sustainability questions. Such an approach would eventually lead to specific visions of emerging technologies suitable for the Nordic context. At the same time, the approach would avoid colonization of those visions by imagined forms of social life and order (i.e., imaginaries) from other global regions investing heavily into SDV development (Mladenović et al., 2020).

5.6 Conclusion

The landscape of urban mobility is currently transitioning through a period of major uncertainties, largely driven by a multitude of emerging technologies. Such technologies include connected and self-driving vehicles, mobility-as-a-service, and shared micromobility, as part of larger societal trends of rapid digitalization and automation. Considering this context, this chapter has presented research which aimed to unpack the complexity of multiple factors related to urban space allocation, and to provide reflection on the governance implications for these dynamic and converging technologies. In contrast to previous studies, the scenario-based methodology centers on the concepts of operating design domain and local service scenario. These concepts enable consideration of more specific aspects beyond the generic assumptions such as automation levels or vehicle sharing while they also enable consideration of convergence for multiple technologies. Consequently the use of such concepts provides a higher resolution of details concerning the built environment, technology, institutions, and societal change, thereby illustrating the complexity of the challenge at hand. Even if this multitude of factors can seem overwhelming for decision-making, hiding away the complexity and uncertainty may only lead to even greater challenges later.

This research also underlines the need for developing innovation-friendly forms of policy and governance if smart mobility technologies and services are to contribute to the ongoing transition toward a more sustainable urban form and mobility system in the Nordic countries such as Finland. In contrast to previous research in this domain, such a governance approach cannot remain siloed within the conventional urban and transport policy measures. Even if these measures are important components of policy-packaging efforts, this research has identified the need for developing data and algorithm governance levers, including alternative organizational structures. Such aspects include developing of data collection and sharing regulation for networks of actors across sectors, as well independent bodies for auditing of algorithms for potential bias. Consequently the greatest innovation needed is not actually about the hardware/software/services but about the responsible innovation process itself. Such an approach has to be distinguished from conventional approaches to automation and digitalization in other domains not pertaining to everyday urban life, having implications for built environment, and consequently for environmental sustainability and well-being. Here the Nordic countries have an opportunity to lead the change in recognizing in practice that technological development is not solely a technical but ultimately a political choice. If these countries are to continue their transition of urban form development, there is a need for leading by example of how social innovation and welfare can go hand in hand. With this in mind, future research activities should work more closely with the local organizations to aid their responsiveness to emerging and converging mobility technology. Such co-creation activities should also be accompanied with further development of complexity mapping methods. The former offers opportunities for widening citizen participation and opening up the number of factors taken into consideration. The latter provides a means of systematically analyzing the factors under consideration.

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References

Banister, D., & Hickman, R. (2013). Transport futures: Thinking the unthinkable. *Transport Policy*, *29*, 283–293.

Beecroft, M., & Pangbourne, K. (2015). Future prospects for personal security in travel by public transport. *Transportation Planning and Technology*, *38*(1), 131–148.

Biswanger, M. (2001). Technological progress and sustainable development: What about the rebound effect? *Ecological Economics*, *36*(1), 119–132.

Blyth, P. L., Mladenovic, M. N., Nardi, B. A., Ekbia, H. R., & Su, N. M. (2016). Expanding the design horizon for self-driving vehicles: Distributing benefits and burdens. *IEEE Technology and Society Magazine*, *35*(3), 44–49.

Boesch, P. M., Ciari, F., & Axhausen, K. W. (2016). Autonomous vehicle fleet sizes required to serve different levels of demand. *Transportation Research Record*, *2542*(1), 111–119.

Bouton, S., Knupfer, S. M., Mihov, I., & Swartz, S. (2015). *Urban mobility at a tipping point*. McKinsey and Company.

Bradfield, R., Wright, G., Burt, G., Cairns, G., & Van Der Heijden, K. (2005). The origins and evolution of scenario techniques in long range business planning. *Futures*, *37*(8), 795–812.

Cavoli, C., Phillips, B., Cohen, T., & Jones, P. (2017). *Social and behavioural questions associated with automated vehicles: A literature review*. UCL Transport Institute.

Chen, T. D., Kockelman, K. M., & Hanna, J. P. (2016). Operations of a shared, autonomous, electric vehicle fleet: Implications of vehicle & charging infrastructure decisions. *Transportation Research Part A: Policy and Practice*, *94*, 243–254.

Cohen-Blankshtain, G., & Rotem-Mindali, O. (2016). Key research themes on ICT and sustainable urban mobility. *International Journal of Sustainable Transportation*, *10*(1), 9–17.

Corwin, S., Vitale, J., Kelly, E., & Cathles, E. (2015). *The future of mobility. How transportation technology and social trends are creating a new business ecosystem*. Deloitte: University Press.

Enoch, M. P., Cross, R., Potter, N., Davidson, C., Taylor, S., Brown, R., et al. (2020). Future local passenger transport system scenarios and implications for policy and practice. *Transport Policy*, *90*, 52–67.

Fagnant, D. J., & Kockelman, K. M. (2014). The travel and environmental implications of shared autonomous vehicles, using agent-based model scenarios. *Transportation Research Part C: Emerging Technologies*, *40*, 1–13.

Fagnant, D. J., & Kockelman, K. M. (2018). Dynamic ride-sharing and fleet sizing for a system of shared autonomous vehicles in Austin, Texas. *Transportation*, *45*(1), 143–158.

Fleisher, C. S., & Bensoussan, B. E. (2003). *Strategic and competitive analysis: methods and techniques for analyzing business competition* (p. 457). Prentice Hall.

Fulton, L., Mason, J., & Meroux, D. (2017). *Three revolutions in urban transportation: How to achieve the full potential of vehicle electrification, automation, and shared mobility in urban transportation systems around the world by 2050 (No. STEPS-2050)*. UC Davis Institute of Transportation Studies Report to the Institute for Transportation and Development Policy, University of California, Davis (CA).

Genus, A., & Stirling, A. (2018). Collingridge and the dilemma of control: Towards responsible and accountable innovation. *Research Policy*, *47*(1), 61–69.

Gruel, W., & Stanford, J. M. (2016). Assessing the long-term effects of autonomous vehicles: A speculative approach. *Transportation Research Procedia*, *13*, 18–29.

Guerra, E., & Morris, E. A. (2018). Cities, automation, and the self-parking elephant in the room. *Planning Theory & Practice*, *19*(2), 291–297.

Haglund, N., Mladenović, M. N., Kujala, R., Weckström, C., & Saramäki, J. (2019). Where did Kutsuplus drive us? Ex post evaluation of on-demand micro-transit pilot in the Helsinki capital region. *Research in Transportation Business & Management*, *32*, 100390.

Heinrichs, D. (2016). Autonomous driving and urban land use. In *Autonomous driving* (pp. 213–231). Berlin, Heidelberg: Springer.

International Transport, Forum. (2015). *Urban mobility system upgrade: How shared self-driving cars could change city traffic Corporate partnership board report*. Paris: ITF.

Jittrapirom, P., Marchau, V., van der Heijden, R., & Meurs, H. (2018). Future implementation of Mobility as a Service (MaaS): Results of an international Delphi study. *Travel Behaviour and Society*. https://doi.org/10.1016/j.tbs.2018.12.004.

Litman, T. (2019). *Autonomous vehicle implementation predictions. Implications for transport planning*. Victoria Transport Policy Institute.

Meyboom, A. (2018). *Driverless urban futures: A speculative atlas for autonomous vehicles*. Routledge.

Milakis, D., Snelder, M., van Arem, B., van Wee, B., & de Almeida Correia, G. H. (2017). Development and transport implications of automated vehicles in the Netherlands: Scenarios for 2030 and 2050. *European Journal of Transport and Infrastructure Research*, *17*(1), 63–85.

Mladenović, M. N. (2019). How should we drive self-driving vehicles? Anticipation and collective imagination in planning mobility futures. In *The governance of smart transportation systems* (pp. 103–122). Cham: Springer.

Mladenović, M. N., Lehtinen, S., Soh, E., & Martens, K. (2019). Emerging urban mobility technologies through the lens of everyday urban aesthetics: Case of self-driving vehicle. *Essays in Philosophy*, *20*(2). 1526-0569.

Mladenović, M. N., Stead, D., Milakis, D., Pangbourne, K., & Givoni, M. (2020). Governance cultures and socio-technical imaginaries of self-driving technology: Comparative analysis of Finland, UK and Germany. In *Advances in transport policy and planning*.

Pangbourne, K., Mladenović, M. N., Stead, D., & Milakis, D. (2020). Questioning Mobility as a Service: Unanticipated implications for society and governance. *Transportation Research Part A: Policy and Practice*, *131*, 35–49.

Papa, E., & Ferreira, A. (2018). Sustainable accessibility and the implementation of automated vehicles: Identifying critical decisions. *Urban Science*, *2*(1), 5.

Röehrleef, M., Deutsch, V., & Ackermann, T. (2015). *Scenarios for autonomous vehicles-opportunities and risks for transport companies. Position Paper*. Verband Deutscher Verkehrsunternehmen e.V. (VDV).

Spieser, K., Treleaven, K., Zhang, R., Frazzoli, E., Morton, D., & Pavone, M. (2014). Toward a systematic approach to the design and evaluation of automated mobility-on-demand systems: A case study in Singapore. In *Road vehicle automation* (pp. 229–245). Cham: Springer.

Stead, D. (2016). Identifying key research themes for sustainable urban mobility. *International Journal of Sustainable Transportation*, *10*(1), 1–8.

Stead, D., & Banister, D. (2003). Transport policy scenario-building. *Transportation Planning and Technology*, *26*(6), 513–536.

Stead, D., & Vaddadi, B. (2019). Automated vehicles and how they may affect urban form: A review of recent scenario studies. *Cities*, *92*, 125–133.

Stilgoe, J., Owen, R., & Macnaghten, P. (2013). Developing a framework for responsible innovation. *Research Policy*, *42*(9), 1568–1580.

Sustar, H., Mladenović, M. N., & Givoni, M. (2020). The landscape of envisioning and speculative design methods for sustainable mobility futures. *Sustainability*, *12*(6), 1–24.

Thakur, P., Kinghorn, R., & Grace, R. (2016). Urban form and function in the autonomous era. In *Australasian Transport Research Forum (ATRF), 38th, 2016, Melbourne, Victoria, Australia*.

Weckström, C., Kujala, R., Mladenović, M. N., & Saramäki, J. (2019). Assessment of large-scale transitions in public transport networks using open timetable data: Case of Helsinki metro extension. *Journal of Transport Geography*, *79*, 102470.

Zakharenko, R. (2016). Self-driving cars will change cities. *Regional Science and Urban Economics*, *61*, 26–37.

Zhang, W., Guhathakurta, S., Fang, J., & Zhang, G. (2015). Exploring the impact of shared autonomous vehicles on urban parking demand: An agent-based simulation approach. *Sustainable Cities and Society*, *19*, 34–45.