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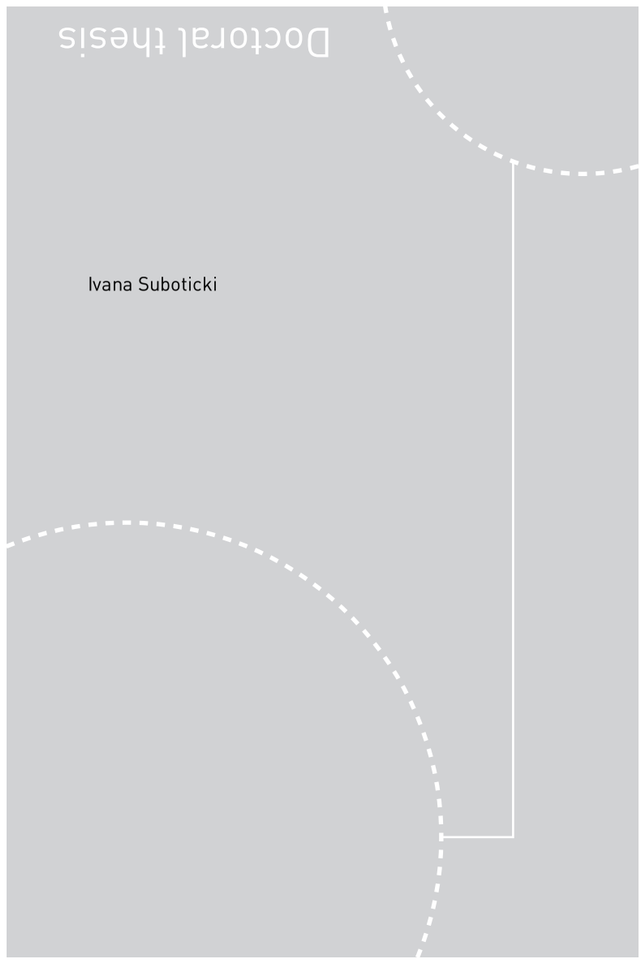
Ivana Subotićki

The multi-politics of urban transformations

The shaping, disruption and liminality of transport technologies



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Trondheim, March 2019

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PART A: Tie-up essay

1. Introduction

Urban technologies, including infrastructure and built environment, are vital to everyday life in cities. They are also important with respect to mitigate climate change and to handle other environmental issues, a trend that is increasingly reflected in national and international policy-making. Urban technologies are designed and implemented through the work of planning and construction experts yet cannot be considered as neutral and independent of social interests. This means that the social shaping of urban technologies needs to be studied. As I show in this dissertation, such analysis is not straightforward as interests are negotiated in context, and their translation into design and implementation is contingent on complex assemblages of human and non-human actors. Consequently, even when we try to explore the effects of widely shared benign goals such as the increased sustainability of cities, we cannot assume that such goals actually shape urban technologies.

In science and technology studies (STS) there is a longstanding tradition of analyzing the social shaping of technology, in particular the politics of technological developments (Mackenzie and Wajcman, 1985; Williams and Edge, 1996; Sørensen and Williams, 2002). In this respect, the field has produced a number of important insights as well as diverging models of the ways in which we understand the effects of politics and policy-making upon technology. This dissertation builds on this tradition and proposes a more fine-grained approach, based on an analysis of the politics of transformation in urban technology in the context of the city of Belgrade in Serbia. It consists of three papers, each exploring a case of transformation, followed by this tie-up essay that represents an effort to frame, synthesize and integrate the findings of the three papers.

The three papers offer different vantage points from which to view urban transformations in this capital city. The first explores how urban planners, traffic engineers and other professional workers in the transport planning sector in Belgrade perceive the spaces and conditions for their everyday epistemic work. This paper illustrates that their situation is

quite challenging because of heterogeneous and instable political agendas that continually disrupt transport planning actors' professional practices and makes their work risky, for instance with respect to their job security. As one interviewee figuratively depicted it, they must "swim with crocodiles" in their everyday work. Politics, in this case political actors such as politicians and politically appointed professionals, was not experienced as an ordering mechanism. To accommodate for these observations, the paper proposes a *multi-political model* to understand the shaping of technology as it extends existing STS ways of understanding the politics of technology. The proposed model, we argue, makes it easier to see and understand the possibly non-linear, heterogeneous, unpredictable and contingent, effects of politics that this paper observes with respect to Belgrade's transport planning community.

The second paper shifts the gaze to one particular transport system - the Belgrade metro. What is unique about this case is that the metro has been 'under development' for almost a century. It has not been fully constructed nor has it been abandoned; thus, it remains liminal. The paper introduces a *liminal technology framework* to explore characteristics of this quasi object (Latour, 1993). I argue that the concept of liminality contributes to analysis of urban technologies because it underscores the conditions necessary for technologies to advance from the planning phase.

The third paper focuses on the design and use of an urban technology in Belgrade's public space - an elevator for cyclists. Contradiction of the intentions behind its design, an operator with a lunch break, a transient community of fishermen, a fragile hydraulic system, and daily negotiations with users, all add up to illustrate how this seemingly simple urban technology is highly complex. Its politics are hardly more simple. To better understand the politics of this artefact, the paper introduces the term *interstructure*, which highlights a myriad of connective and disruptive dynamics.

Together, these three case studies provide a rich picture of Belgrade's urban transport development that is arguably relevant to the understanding of urban transformation more broadly. I return to this issue later. A more extensive summary of the papers will follow in section two. In this tie-up essay, I particularly want to show how the three cases may illuminate the dynamics related to politics of sustainability transformation as an extension of the politics

of technology addressed in the papers. The reader should therefore not see this essay as an introduction to or conclusion of the three papers. Rather, it is an effort to substantiate and complement them by re-thinking their findings in a new light. Thus, the reader may find it fruitful to read the three papers first (part B), and then return to the tie-up essay.

Linking the more open topic of the politics of urban technology to sustainability transitions literature, has partly to do with the pressing need to better understand the complex workings of such transformation processes. Climate change and environmental problems are arguably the most pressing priorities on the international policy agenda.[1] This may include social and economic sustainability, but environmental sustainability is especially pertinent to urban transformations in Europe. There are however many challenges to defining what should count as a concern in terms of environmental sustainability in practice. It has indeed proven hard for actors to agree on a definition of the concrete problem and its potential solutions. *Sustainability* is often referred to as a set of 'wicked problems' (Rittel and Webber, 1973). Skjølsvold (2013) illustrates how framing practices are political processes whereby multiple "sustainabilities" (Skjølsvold, 2013: 1278) are spoken for, depending on the actors in question. Given this controversial and political nature of transformations to sustainability, I find the three articles also relevant to such discussions because sustainability issues may be addressed without sustainability as such being addressed. Similar to how sociotechnical transition perspectives, most notably the multi-level perspective (MLP) (Rip and Kemp, 1998; Geels, 2002), are central to the sustainability transition literature, arguments regarding the politics of urban transformation may speak to the politics of urban transformation to sustainability.

The three papers do not explicitly address the topic of sustainability transformations, but this concern is far from new to my Ph.D. project. When I first embarked on this Ph.D., my research interest concerned the ways in which environmental mechanisms related to the European Union (EU) integration proceedings work in a day-to-day institutional setting. Calls for action to mitigate climate change are pressing worldwide, but in Western Balkan countries

[1] Intergovernmental Panel on Climate Change – IPCC's (2018a) most recent Special Report on Global Warming urges the international community and governments to take action to limit global warming to 1.5°C: https://www.ipcc.ch/sr15/ (09.12.3018).

like Serbia, adaptation to EU's *acquis communautaire* is the biggest driver of institutional reform, including those concerning the country's environmental agenda and regulations like, e.g., Chapter 27 of the *acquis,* Law on Spatial Planning and Social Impact Assessment (SIA). EU progress reports[2] and policy-oriented research (Elbasani, 2013; Lazarević-Bajec, 2011; Maksin-Mićić et al., 2009) describe these types of transformation efforts through top-down and normative narratives. In such narratives, there is little information about how actors are 'doing' this transition work. Therefore, my initial aim was to use analytical tools from STS to shed light on how micro-practices shaped environmental transformation processes.

I chose urban transport development as a strategic research site for this endeavor. Cities are a key target area for sustainable transformations on the international policy agenda.[3] They account for more than 70% of global CO_2 emissions and consume about 2/3 of the world's energy.[4] Cities thereby function simultaneously as the sources of environmental problems and possible arenas for solving them.[5] Belgrade, the capital of Serbia with about 1.6 million inhabitants, is an important city in this regard. Although it is considered a relatively sustainable city, with public transport accounting for about half the modal share,[6] the transport sector was projected as the fastest growing emitter in Serbia. Moreover, estimates suggest that the mobility rate in Belgrade will grow considerably by 2021.[7] Steady growth of greenhouse gas emissions since late 2000s has also put Belgrade in category 3 of air pollution in cities, far below accepted EU and WHO criteria.[8] Both national and local strategies recognize these trends and propose efforts to mitigate their negative effects. Belgrade's city development strategy for 2021 aims to develop a transport system that will contribute to ecological

[2] E.g., European Environmental Agency (EEA), 2015, State of the Environment Report Serbia or European Commission (EC), Serbia 2018 Report
[3] For instance, the United Nations (UN) the New Urban Agenda adopted in 2016, the EC's (2010) Europe 2020 Strategy and Amsterdam Pact, and the 2012 Global Covenant of Mayors.
[4] IPCC's Climate Change 2014: Mitigation of Climate Change
[5] The newest IPCC report (2018b) urges urban policy-makers to support research and development (R&D) of technological innovation and give incentives for their market uptake
[6] WSP and Juginus, 2015: Belgrade, Smartplan
[7] According to Belgrade's General Urban Plan (Sl.list br.11/2016) the mobility rate will increase from 2.18 per inhabitant to between 2.5 - 2.7.
[8] Health and Environment Alliance (HEAL) (2014) Zagađenje vazduha i zdravlje u Srbiji. Činjenice, brojke i preporuke. [Air pollution and health in Serbia. Facts, numbers and recommendations].

optimization of the city.[9] The General Urban Plan for the City (2015), the Smartplan (2008) and the Sustainable Urban Transport Plan (2013) contain similar objectives.

Thus, when I embarked on my fieldwork in Belgrade in early 2016, my aim was to study how transport planning actors translated these types of policies through their practices. In other words, the ways in which they enacted sustainability concerns through their everyday work. The research design was set up as an explorative agenda. Neither the initial interviewee sample nor the interview guides were meant to assume what sustainability or environmental knowledge meant in the local setting. Rather, they were more open, focused on a few transport systems in Belgrade and questions regarding everyday practices of those working with them. I will give a more detailed account of methodological choices at a later stage (section 7). Here, I want to highlight how my bottom-up research agenda was challenged by interviewees' own perceptions of their work.

When I started interviewing the first respondents, few addressed the notion of 'transformation to sustainability' or any other environmental criteria when describing their work. Although I expected considerable challenges, I did not expect to encounter the extent to which environmental concerns only marginally featured in the first interviews. After asking explicitly, interviewees referred me to specific people responsible for sustainability issues, people who worked either in SIA or for the Secretariat for Environmental Protection. These 'environmental actors' were however only responsible for particular segments of plans and not their totality. A few specific urban sustainability projects were mentioned, but interviewees described them more as ad hoc initiatives that dissipated upon completion. Often, interviewees met my inquiry into sustainable transport planning with sarcastic remarks. "We don't have that here…", "it's only on paper", "it's only for show" were common remarks. A key interviewee expressed this skepticism towards environmental issues like this:

> You can take whatever plan into your hands and see that structurally it includes *the environment*. But if you go deeper into the text, aaaaah, if you have any understanding of it, you will see that it doesn't mean anything. [Environmental sustainability] is not even

[9] Urban Planning Institute and Palgo Center (2011), *Belgrade City Development Strategy*.

> planned. You will never find the words: "progress in environmental protection until 2004…", "the Danube basin will be cleaned by so and so …" That's not what will stand there. It will say: "Purifying sewage water, which is a major problem, will be solved in accordance with regulation nr. 446718". "It will be solved", it doesn't say "it's going to be solved". And that's phenomenal! (…) You can't say: "They don't care about the environment." They do, they have it inside [the document]. But the way they put it inside doesn't have to mean that it will have an effect.

In this quote, the interviewee makes salient a common claim about the Serbian institutional setting, namely, the discrepancy between formal plans and informal practices. In most cases, interviewees attributed the lack of implementation to lack of political will. Politicians, they said, were usually more interested in keeping agendas, and thus their commitments, as open as possible. In the context of deeply antagonistic political actors who gave little explicit support for sustainability, planners had little opportunity to prioritize sustainable solutions.

Lack of political commitment is generally a recurring trope used to explain the lack of sustainable transformation. What is interesting about such statements from an STS point of view is the assumption that politics can shape technology and conversely, that technology has political effects. This type of linear understanding of politics, sustainability and technology, can be illustrated in the following way:

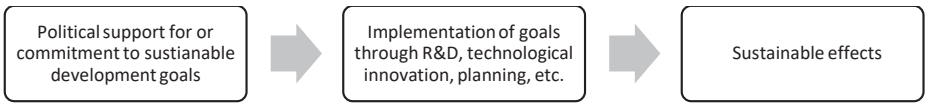

Figure 1: Linear model of political shaping of technology and its outcome

In this model, two key assumptions are important. First, there is the belief that political agendas or politicians shape technology. In Belgrade, this means that in principle such political commitment would orient planning towards sustainable transport options, incorporation of environmental knowledge in overall knowledge work, or design towards sustainable transport technologies or innovations. In other words, the assumption is that certain normative political commitments to environmental concerns will be directly translated into the development of

particular urban technologies. The second assumption is that, once built, these technologies have transformative power. STS scholars often refer to this belief as a 'technological fix', usually articulated as a technological determinist view of technology. Determinist assumptions do not problematize the content of technology and assumes that they develop according to an inner logic, often based on 'technical' criteria (Williams and Edge, 1996). Looking at these two assumptions together, this linear model displays inherent contradictions. For example, it assumes political support as a key factor in sustainability transformations while the process of developing technological solutions is itself seen as non-political. Conversely, it also assumes that sustainable effects will be univocal.

STS provides ample evidence that a simple causal understanding of the ways in which technology influences society and vice versa is deficient (Williams and Edge, 1996). Returning to the three papers that comprise this thesis, each one points to a higher degree of complexity operating in the relationship between politics and technology. I argue that this is the case also with respect to sustainability and urban technology. The papers describe technology development processes where politics of technology is highly intricate. Simple causal explanatory narratives pointing to a lack of political support or investment only tell part of the story.

The insufficiency of simple one direction causal explanations is certainly highly visible in the case of urban transformations in Belgrade. As previously mentioned, the first paper of this thesis introduces a multi-political model for understanding the shaping of technologies. The model highlights the presence of heterogeneous and unstable politics, which influence epistemic spaces for the development of new transport technologies. Instability in the political realm has been shown to characterize Serbian politics more broadly and to extend beyond the Belgrade city government. Since the Serbian democratic reforms of the early 2000s, the relationship between political leadership and public administration has been marked by instability and persistent political turmoil. Political alliances have consistently changed through the establishment of new parties, party switching, and change of political agendas. This volatility has also influenced institutional arrangements at the local level, which can be seen in the formation of new agencies (e.g., Agency for investment) and secretariats (e.g., newly

formed Secretariat for public transport) as well as politically appointed Directors of all these main public bodies. Moreover, corruption remains a problem in Serbia's public procurement, fraud in services and abuse of office,[10] which tends to muddy the distinction between politicians, investors and non-partial public administration employees. In this setting, the perpetually shifting actors, timeframes, and outcomes that govern transport planning are unclear, at least not as much so as the linear model of political influence assumes. Moreover, Serbia's transition from a socialist to a neo-liberal economy as it prepares for EU accession introduces a wide set of pressing concerns. Sustainability is just one among many pressing transition efforts, including democratization, economic liberalization, institution building, etc. Thus, singe-goal politics, focusing only on environmental sustainability, are particularly difficult to implement.

Moreover, both the metro and elevator for cyclists' case studies suggest that delimiting environmental sustainability concerns is not an easy task. Even if sustainability was not the only or necessarily most outspoken concern in the planning of the metro and the construction of the elevator for cyclists, it did have a role to play. Shove and Walker (2007) fruitfully argue that framing sustainability, defining successful sustainability transitions, and deciding who is involved in sustainability innovations is a political matter. Exploring how politics plays into the design of urban technologies, and the role of sustainability in this design is or becomes a political matter, is then fruitful. A juxtaposition of the three papers may yield fruitful insights. As mentioned, they speak to STS debates on the politics of technology and, as I will show, a juxtaposition can provide new insights into such relationships, based on the specificities introduced by the Belgradian context. Considering the political and controversial nature of sustainability, the next step is to explore these insights into the politics of transformations to sustainability.

One strand of STS literature has been critical of technology due to its innate political features. "[T]echnology, once seen as the preserve of dispassionate engineers committed to the unambiguous betterment of life, now has become a feverishly contested space in which

[10] Transparency International, 2014, Serbia: overview of political corruption and Center for Liberal-Democratic Studies (CLDS), 2014. Corruption Assessment Report: Serbia.

human societies are waging bitter political battles over competing visions of the good and the authority to define it" (Jasanoff, 2006: 758). As previously mentioned, some of the main STS approaches to technology development grew out of a critique of technological determinist framings where technology is considered neutral. This is especially evident in the critical theory approaches adopted by STS that offer a cautionary view on technological development and its possibly malign, oppressive and destructive characteristics (Feenberg, 1991; Winner, 1980, 1986). The goal, then, is to open black boxes and make visible the who, the why and the how of technological design.

With the development of the STS field, debates regarding how politics shape technology and how it should be elicited through empirical inquiry have been persistent (Bijker, 2006; Brown, 2015; de Vries, 2007; Latour, 2007). In the early 1980s, scholars were especially interested in pointing out the political and normative dimensions of choice in the design of technology (Williams and Edge, 1996). MacKenzie and Wajcman (1985) explore the organizational, political, economic and cultural aspects of technological design processes, including several papers that identify how political handicraft has served to steer design choices. Opening with Langdon Winner's (1980) famous paper asking 'Do artifacts have politics?' is an affirmation of the importance given to retracing political processes in the development of technology. Retracing political processes is not only a matter of politics in the traditional sense, but also of the politics of professional work and how it shapes technologies (Abbot, 1988; Whalley, 1986). In Winner's example of the political bridge, he demonstrates how it was the politics of urban planners (that of Robert Moses in particular) that needed to be uncovered.

In social construction of technology (SCOT) and actor network theory (ANT) approaches, political power is considered to be more interactional and relational. SCOT focuses on micro-political interactions where relevant social groups struggle for definition power over new artefacts (Bijker, 1995; Pinch and Bijker, 1984). ANT stresses how politics and power are produced in associations between actors (both human and non-human) (Latour 2005). However, as in the previous perspectives, the research agenda aims to uncover 'hidden' politics. This is particularly challenging in the case of ready-made technologies because as their

interpretations stabilize (SCOT) or the controversies surrounding them fade (ANT), their politics are no longer visible. Others have called for more attention to institutional forms of power such as power symmetries (Klein and Kleinman, 2002), historically entrenched power relations (Berg and Lie, 1995; Hess, 2007), and overlooked, silenced voices (Star, 1990).

In conclusion, the STS understanding of politics tends to be that of a negative, hidden, and possibly malign force. There is an overall assumption that there is something wrong with politics (Sørensen, 2004), and technologies are then often treated like Frankenstein monsters (Andersen and Sørensen, 1992). Opening black boxes is then one possible strategy to democratize technology and science (e.g., Bijker, 1995; Brown, 2015; Nahuis, 2007). In turn, by making the development of technology transparent, we might also influence innovation in directions that cater to societal needs such as sustainable development. In Belgrade, the situation seemed to be far less clear. Politics did not appear to be hidden or stable, and thus, not in need of being uncovered. What the democratization of technological development would mean in this overt and changing political climate requires further discussion.

Dominant socio-technical approaches to sustainability transformations, on the other hand, usually characterize politics as benign. Transition management (TM) (Loorbach and Rotmans 2006, 2010), strategic niche management (SNM) (Kemp, Schot and Hoogma, 1998; Hoogma et al., 2002), and multi-level perspective (MLP) (Geels 2002) all favor strong political objectives and goals as necessary and useful to govern development. In the past decade, however, scholars have called into question the somewhat innocent and uncomplicated character of such politics of transitions (e.g., Shove and Walker, 2007; Jasanoff, 2018). Including for instance, how technology and engineering appear as politically neutral and technocratic (Bjørkman and Harris, 2018: 246).

Sustainability transition scholars have responded to this critique by explicitly addressing politics (Meadowcroft, 2009, 2011; Smith and Raven, 2012; Smith, Sterling and Berkhout, 2005; Smith and Stirling, 2010; Voß and Bornemann, 2011). Nevertheless, systems theories in general tend to interpret political dynamics to be about relationships between societal levels, while actors and practices central to enacting transitions remain of lesser relevance. Actor and action-oriented perspectives (e.g. Åm, 2015; Jørgensen, 2012; Sørensen, Lagesen and Hojem,

2018) on the other hand, say relatively little about potentially disruptive and conflicting political effects. Again, this shows the need for more refined discussion on instable, conflicting and contingent politics, as they appear in Belgrade.

Until now, I have briefly presented several controversies surrounding the politics of urban transformation in Belgrade, the implications for politics of sustainability transformations, and how such topics can be viewed in light of current theoretical debates in STS and sustainability transitions scholarship. Luque-Ayala and co-authors' (2018) recent call to rethink the role of politics in urban sustainability transitions supports my contentions regarding the implications of the case studies from Belgrade. They argue that "[a]cknowledging multiplicity and contestation in the design, practice and mobilization of the low carbon city is likely to better equip us for both researching and advocating for the much needed environmental, societal and political transformations of the contemporary world" (Luque-Ayala, Marvin and Bulkeley, 2018: 10). Thus, the questions that drive the analysis in this tie-up essay are: What is the contribution of the three papers to understanding the politics of urban transformations? How might this contribute to understanding the politics of urban *sustainability* transformations? In practical terms, how might these insights improve current models for governing sustainability transformations regarding urban technologies?

The thrust of my argument will rest on the notion of multi-political shaping of urban technology. The multi-political model helps to uncover the complexity of the politics of sustainability transformations. Most notably, it challenges the productiveness of approaches that argue for the sufficiency of alignment of visions, consensus on norms, and protection of innovation processes.

The outline of this tie-up essay (part A) is as follows. In the next section, I will present a summary of the three papers that comprise this dissertation, including the main arguments and discussions of each paper and serving as the empirical background for a new thematic discussion about the politics of sustainability transitions. Section three consists of two parts. The first part introduces some of the main socio-technical approaches to sustainability transitions and the main work on politics and power in these processes. In the second part, this literature is juxtaposed to the sub-field of urban sustainability transitions. In section four,

I delineate four different conceptualizations of the politics of technology in STS . I claim that there is more room to extend the ambivalent and heterogeneous politics of technology model. In section five, I present a crosscutting analysis of the three papers. I start by discussing how a re-reading of all three papers help strengthen the multi-political model of technology, after which I examine what this means for current theorizing on politics of sustainability transitions. In the conclusion, I summarize the main argument. Lastly, in section seven, the methodology of my project is annexed to the tie-up essay as it presents the reasoning behind and an outline of the methods of the Ph.D. research undertaking as a whole.

2. Summary of three papers

This dissertation consists of three papers, all of which deal with different aspects of urban transport technology development and use. They examine the topic from different points of view: (1) the consequences of shifting and conflicting political agendas on epistemic living spaces and the epistemic practices of Belgrade's transport planning actors, (2) the liminal dynamics of a technology-in-development—a metro, and (3) the design and domestication of an elevator for cyclists. The empirical focus moves from the planning and development stages, which take place in the arena of public administration, to concrete urban technology in use. Moreover, each paper engages with different theoretical perspectives. Together, however, they address aspects related to transformations of urban environments and their politics.

Paper 1: "Swimming with crocodiles" - when a challenging epistemic living space interlaces with politics of technology[11]

In the first paper, we explore the political, social and material features that characterize the everyday epistemic spaces of professionals working in the transport sector in Belgrade. The objective is to understand how planning and design is shaped by politics. As opposed to professional spaces in academic circles or service-oriented companies, political leadership is more closely connected to the knowledge work of public administrations. We therefore ask: How do politics shape the epistemic environments for the design of urban technologies?

We use the concepts of epistemic living spaces (Felt, 2009; Felt and Fochler, 2012) and epistemic practices (Knorr Cetina, 1999) as analytical entry-points to unpack some important characteristics of this community. Epistemic living spaces constitute the knowledge environment within which researchers, or in my case transport planning actors, live and work. They represent "structures, contexts, rationales, actors and values which mould, guide and delimit" (Felt and Fochler, 2012: 136) their work and their possibilities for action. Following Felt (2009), we construct an understanding of such spaces through transport planning actors'

[11] This paper is co-authored with Knut H. Sørensen.

own perceptions. Further, we use Knorr Cetina's (1999) concept of epistemic practices to delineate key strategies for how professional transport actors strategically maneuver in this space.

We base the analysis on qualitative interviews (N=25) with actors whose professional backgrounds are primarily in architecture and traffic engineering and who work in the transport planning sector in Belgrade. The sample consists of actors from the official public administration arena (Mayor's Office, Secretariat for Transport, Secretariat for Environment), as well as important planning institutions and companies (Institute for Urban Planning, private consultancy companies). In order to capture the interviewees' perceptions of their epistemic living space and its consequences, we use thematic narrative analysis (Holstein and Gubrium, 2011) of the interview data.

As the title suggests, interviewees' narratives depict highly challenging epistemic living spaces. One interviewee described her daily reality as one in which she has to repeatedly jump in and "swim with the crocodiles". The crocodiles in this story refer to politicians and other political actors (e.g. investors, politically affiliated public administrators) that are highly antagonistic and disruptive. Interviewees' narratives depict a space where it is difficult to gain and maintain epistemic authority and conduct what they considered to be professionally valid work. Unstable and shifting political and economic agendas and actors continually threatened their epistemic living spaces and eroded the distinction between political and professional work.

In this changing space, interviewees depicted four dominant epistemic practices. First, a *hard* practice, which reflected determined efforts to translate knowledge and establish authoritative epistemic objects (e.g., plans, criteria). Second, a *soft* practice that centered on creating spaces for negotiation of knowledge and non-knowledge. Third, a *minimalist* practice that depicted practices in which actors avoided any meaningful engagement with epistemic work. And lastly, a *submissive* practice that highlighted situations where planners had to follow orders. These practices reflected a more potent need to manage politics, as opposed to management of knowledge work. They are therefore in many ways as much strategies for

maneuvering in dangerous epistemic living spaces as they are epistemic practices for enacting professional work.

We suggest a model of *multi-political shaping of technology* to capture the heterogeneity and instability of the involved politics. It highlights the complexity related to the materialization of political ideas in urban technological designs and planning. The ordering power of politics was partial, contingent; sometimes constructive yet mostly destructive, resulting in compartmentalized epistemic living spaces where epistemic practices were often centered on mediation work (Latour, 2005) to deal with the political situation. The multi-political model is thus a sensitizing tool for a non-linear understanding of politics-technology relation, which may be relevant for diverse cases of technology development.

Paper 2: Framework for exploring the life of Liminal Technologies

The second paper explores the case of a metro that remains liminal—it has never been completed nor has it been abandoned. Its main contribution is a *liminal technology framework*. The framework represents an effort to move beyond linear, evolutionary and stage-like models of technological development. I suggest that liminality is an effective conceptual entry-point to unpack characteristics of technologies-in-development because it places transformations, rather than resolution of controversy or stabilization, at the center of inquiry. Moreover, I find liminality to be a productive exploratory tool to unpack the case of the Belgrade metro. For discursive simplicity, I referred to technologies like the metro as *liminal technologies* – a technologies that cannot be reduced to a 'failed' project (because they are still technically under development), to successful materialization (because their resolution is unknown) or merely to a vision (because their socio-material elements go beyond imaginaries).

Drawing on anthropological and STS literature, the framework proposed consists of four conceptualizations of liminal technologies. First, we have the notion that a given technology may be in a period of shielded transition ('growing up'). This understanding draws on classical anthropological theory concerning liminality (van Gennep, 2011[1909]; Turner, 1967, 1969) and suggests that some technologies are liminal because they are separated from

broader societal and technological structures and are consequently in a temporally bound and shielded space. Second, technologies may be liminal because they are under construction through negotiation ('made to fit'). Here, I draw on theories of standardization (Bowker and Star, 2000; Timmermans and Epstein, 2010) and obduracy (Latour, 1992, 2005; Hommels, 2005) and suggest that some technologies may be liminal because they are misaligned from existing standards and obdurate structures, and yet to be stabilized. Third, I conceive liminal technologies as technologies that are morphing between worlds ('being discovered'). These technologies are liminal because they are continually transformed in different social worlds. This understanding builds on literature that explores the flexibility of entities when they start interacting with users (Anderson and Lundvall, 1988; Hyysalo, Pollock and Williams, 2018; Pinch and Trocco, 2002;). The fourth lens conceives of technologies as lost in liminality ('remaining immature'). In this understanding, liminality is more of a permanent character (Turner, 1969; Szakolczai, 2014) and refers to technologies that are in waiting and where the possibility of getting out of limbo might require 'divine' intervention. Together, these four conceptualizations serve as diagnostic tools for understanding liminal technologies. I then use the Belgrade metro case to explore the analytical strength of working with this framework.

In the main empirical part of the paper, I go through each conception of liminal technologies, analyzing their tenants in relation to document and interview data collected on the Belgrade metro case. I find that neither one of the four conceptions of liminality completely encompass the Belgrade metro case. Rather, they all highlight different aspects of liminality and show how such characteristics change over time. The framework helps to contrast different aspects of the development that both produce and maintain liminality, and thus also, represent possible avenues to put an end to the liminal state. It shows how efforts to create protected spaces for the metro development only worked at times, never leading to a completion of the project. Negotiation efforts around almost all features of the system kept the project alive, but never allowed it to become an integral part of the city's transport system. To some degree, the metro was morphing between worlds (e.g. project teams, political parties), but these worlds were highly antagonistic, which made it difficult for the worlds to co-exist. The fourth liminal understanding did not align with the highly active development of the

project, yet, it opened an inquiry into the possible need for drastic intervention in order to end liminality.

I end the paper by arguing that the liminal technology framework is a fruitful tool for exploring technology development. On an empirical level, it helps highlight the divergent and unruly aspects of development efforts. On a theoretical level, it also highlights the strength of combining different analytical vantage points in order to understand technologies that are between conception and completion. Well-established explanatory frameworks such as SCOT, ANT or transition studies perspectives have mainly looked at retrospective case studies, focusing on the stabilization and resolution of controversies. Studying technologies such as the metro, which are unruly and take a long time to develop, may require more attention to the diverse ways in which liminality is preserved. The framework thus helps move beyond procedural trajectory where actors aim to finish and stabilize a development process and methodological biases on closure and stabilization. Lastly, in the more practical sense, expanding this understanding of technological development can be used to better understand the politics of liminal technologies.

Paper 3: Designing and domesticating an interstructure: exploring the practices and politics of an elevator for cyclists[12]

This paper examines a very specific urban technology—an elevator for cyclists. I encountered the elevator during my first field visit to Belgrade, and it sparked the interest of the authors with regard to both the content and the politics of this somewhat peculiar technology. The elevator is public and is located on Branko's Bridge in Belgrade. At first sight, it looks quite average. However, it is designated as an elevator for cyclists, and it has a manual (human) operator and working hours; it often overheats and malfunctions, and its scripted users and uses are ambivalent. How then, does this case speak to the politics of technology as captured by Winner (1980), Joerges (1999) and Woolgar and Cooper (1999)?

[12] This paper is co-authored with Knut H. Sørensen.

The paper starts by questioning the 'infra' qualities of urban technologies commonly framed as infrastructures, as well as their political properties. We propose to analyze this case as an 'interstructure', highlighting the connective and aesthetic qualities of the technology rather than its (in)visibility. This shift of focus was an effort to overcome the shortcoming of Star's (1999) conception of infrastructure and articulation work (Star and Strauss, 1999), which was mainly developed in relation to knowledge infrastructure. Several scholars (e.g. Dalakoglou and Kallianos, 2014; McFarlane, 2010; Velho, 2017) fruitfully highlight how we need to move beyond an idealized understanding of infrastructure where visibility is connected to breakdown. We deploy a material semiotic framework that draws on concepts of script (Akrich, 1992) and program/anti-program (Latour, 1992), and on domestication theory (Sørensen, 2006), to understand the everyday use of the elevator and how this was co-constructed with its politics

The remainder of the paper provides an analysis of the design and use of the elevator. The main data was collected through interviews with the developers and the manager of the elevator, short interviews with users and operators, and observational data from the elevator, all collected during a field visit to Belgrade in September 2016. The first empirical part of the paper describes the design of the elevator and illustrates how the elevator's script was ambivalent. The designers wanted the elevator to be aesthetically pleasing but also seamlessly integrated into the background. It was intended as an efficient technological fix but was attributed an operator, which introduced certain limitations. Most notably, it was specifically designed for cyclists but did not exclude other user groups. The second empirical part details what happened when users began to engage with the elevator. Here, we find that numerous anti-programs challenged the initial script. Neither use nor users around the elevator stabilized, whilst the operators and the technical elements that were supposed to be disciplining factors often worked unequivocally. The collective domestication of the elevator was thus ongoing, shifting, conflicting, and involved considerable articulation work, making orchestration of the interstructure and its use decentered and flexible.

We conclude by bringing these findings back to the question: What were the politics of the elevator? By exploring the elevator as an interstructure, we argue that disruptions may

occur in several ways and by exploring connective rather than visibility aspects of interstructures, we highlight how the politics of urban technologies can be transparent and ambivalent. In the case of the elevator in Belgrade, continual negotiations both disrupted the elevator and contributed to its ongoing survival, albeit with changing political outcomes. With this, we align with Woolgar and Cooper's (1999) ambivalent articulation of politics but in a more agency-related sense. By this, we mean that politics is ambivalent due to negotiations between multiple parties with partial views. We propose that many transport technologies, or interstructures, might have similar characteristics - both good and bad qualities, be both enabling and oppressive, and be both controlling and contingent.

Summary

The three papers can be read as different vantage points on how the transformation of new technologies works in practice. Paper 1 highlights how the epistemic living spaces in which urban technologies are designed are spaces of contingent chaos. Paper 2 shows an example of a technology caught between conception and construction. Paper 3 is an example of a built urban technology that remains unclear in practice. How do these empirical examples of the politics of concrete urban technological transformation speak to current understanding of politics in sustainability transitions?

3. Politics of sustainability transitions

In this section, I present sustainability transition scholarship's pivotal position on politics. As previously noted, I am interested in understanding the effects of politics and policy-making on urban technologies. This overview will help clarify the implications of my research on the broader effort to design more sustainable urban technologies and cities. The first part delineates power and politics in the main socio-technical transition frameworks, whilst the second part links these discussions to the urban context. This overview acknowledges important achievements in current debates concerning politics' role in sustainability transitions while arguing that there is room to rethink the more heterogeneous and plural effects of politics in the design of low carbon futures.

3.1. The politics of socio-technical transitions: from rival systems to actors in action

Sustainability transition scholarship has grown exponentially in the past two decades (Loorbach, Frantzeskaki and Avelino, 2017; Markard, Raven and Truffer, 2012). Although there is no consensus on what constitutes (successful) sustainability transitions, a common understanding has emerged that such processes involve large-scale changes in socio-technical systems (Scoones, Newell and Leach, 2015). Markard and co-authors (2012) define sustainability transitions as "long-term, multi-dimensional, and fundamental transformation processes through which established socio-technical systems shift to more sustainable modes of production and consumption" (Markard et al., 2012: 956). This is a good working definition because it points to the comprehensiveness, complexity and longevity of transformation processes, and because it highlights the link between social and technical aspects (represented by the hyphen) of such efforts.

Transition studies have carved out an important new field for a multifaceted debate concerning how transitions should be studied, how they can be fostered, and what the role politics has or should have in such efforts. Given that my main interest lies in the politics-technology relationship, I will focus on key socio-technical approaches in transition research:[13]

[13] Other approaches can be defined as socio-institutional and socio-ecological (Loorbach, Frantzeskaki and Avelina 2017), as well as socio-economic, action-oriented or integrated assessment modelling approaches (European Environmental Agency, 2017).

multi-level perspective (MLP), transition management (TM), strategic niche management (SNM), practice-oriented approaches (practice theory), and lastly, more actor-network inspired approaches such as arenas of development (AoD). Systems and action-oriented perspectives represent the most contrasted approaches. Systems perspectives tend to focus on the dynamics between different levels of society, while action perspectives take a flat ontological approach and focus on the dynamics between actors and practices.

In response to critique for a lack of due attention to controversies and politics (Avelino et al, 2016; Meadowcroft, 2009, 2011; Smith, Stirling and Berkhout, 2005; Shove and Walker, 2007), important scholarly work has started to explicitly address the dynamics of politics and power in transitions. In line Scoones, Newell and Leach (2015), I will in this overview argue that further discussion of politics is needed, and that more attention to politics in action perspectives is a particularly promising avenue to explore the day-to-day politics of transition efforts.

The dominant perspective in socio-technical transition theory is the multi-level perspective (MLP). The central assumptions of MLP are that such systems consist of three interrelated levels – niches, regime and landscape (Geels, 2002, 2005; Geels and Schot, 2007; Rip and Kemp, 1998). The landscape level (macro) refers to the overarching trends in society such as environmental issues, economic pressures, norms and values. The trends that make up the landscape level are therefore the slowest and most difficult to change. The socio-technical regime (meso) is more dynamic than that of the landscape. Regimes refer to the dominant configurations of social groups, rules, practices and technologies that stabilize and reproduce current socio-technical systems e.g. dominant knowledge practices, governance structures, and manufacturing processes. The niche level (micro) gather smaller actor networks that work towards goal-oriented innovations that can foster transitions. When fostered in protected spaces, niches can foster radical innovations. Socio-technical change co-evolves simultaneously on these three levels.

MLP builds on evolutionary economics, economic history (e.g. Abramovitz, 1986; Fagerberg, Mowery and Nelson, 2005) and innovation studies (Bergek et al., 2008; Carlsson et al., 2002; Lundvall, 1988), but tries to avoid the dichotomous perspective whereby change is

fostered by either new technical products (the 'reformist' position) or large societal changes (the 'revolutionary' position) (Geels et al., 2015). For instance, Geels (2002) shows how multi-level dynamics prompted the evolutionary reconfiguration of sailing ships to steamships during the period 1780-1900. Niche experiments with steam engines allowed the steamship to break-out through a series of regime adaptations (market formation, growth of passenger and mail transport, new policies), while landscape development of European migration gradually led to a "shifting mosaic of elements" resulting in the radical innovation of sea transport (Geels, 2002: 1272). This example illustrates how socio-technical change is a multi-level process and thus needs to understand in terms of dynamics *between* levels. Although MLP is concerned with socio-technical change in general, it is also central to current understandings of sustainability transitions. The destabilization of fossil fuel-based mobility and development of low carbon energy systems are two significant contemporary examples (e.g. Di Lucia and Ericsson, 2014; Geels, 2012; Nykvist and Whitmarsh, 2008). Recent attention to politics in MLP has thus also attempted to understand the ways in which power dynamics lead to or constitute barriers to sustainability transitions.

In this way, one strand of literature explores how niche innovations can be fostered to destabilize incumbent power regimes. I will return to TM and SNM frameworks that specifically address these types of innovation arenas, but here I want to highlight MLP scholarship that focuses on operationalizing the dynamics of power, particularly between niche and regime (Geels and Schot, 2007, 2010). Hess (2016) offers an understanding of how niche organizations might overcome regime power constraints through strategies such as regime coalition, party alignment, and industrial power. Naber and co-authors (2017) stress how social networks, expectations and reflexive learning are important for upscaling—growing, replicating, accumulating and transforming—smart grid experiments and pilots in the Netherlands. Moreover, a number of political science rooted contributions try to operationalize different aspects of power across levels. Grin (2010), for instance, proposes that power is relational at the niche level, dispositional at the regime level, and structural at the landscape level. Avelino and Rotman (2009, 2011) delineate different typologies of power (e.g.

constitutive, innovative, and transformative power) and actors can mobilize this power across levels to foster change and destabilize equilibrium.

A related subject is then to explore how incumbent regimes resist change. Through a case study of UK's incumbent fossil fuel regime, Geels (2014) delineates four different mechanisms of resistance or forms of power: institutional, material, discursive and instrumental (Geels, 2014). He argues that a successful transition cannot focus on (niche) innovation alone, but that policy and research need to target the destabilization of regimes as well. Adopting similar politico-economic perspectives, several studies stress the importance of regime power for transitions: how state and corporate elite power was an instrumental driver of energy transitions in South Africa (Baker, Newell and Phillips, 2014), how socio-economic externalities influenced biofuel transitions in Nigeria (Osunmuyiwa, 2017), or how developing countries can get locked into a broader developmental and socio-political regime that makes it hard to tailor alternative routes (Swilling, Musango and Wakeford, 2016). An interesting example is Normann's (2015) study of a failed energy transition in Norway. Using an agenda-setting model, he shows that government conflicts limited ambitious transition objectives. Together, this body of work illustrates how regimes create locked-in pathways, which renders them powerful and difficult to change.

In sum, MLPs approach to politics in sustainability transitions is instrumental. MLP is concerned with finding political spaces through which transition pathways can be steered in a sustainable direction. Such opportunities are especially pertinent in relation to niche-regime dynamics. Scholars have both been interested in understanding how niches can foster change and how unsustainable regimes systems can be destabilized. This scholarship has provided important insights into possible power dynamics between levels, but although there is a growing attention to actors who populate these levels (e.g. Normann, 2015), they offer limiting understanding of how politics is enacted in practices e.g. how actors construct, negotiate and enact political agendas and the concrete, situated effects of these actions.

Both transition management (TM) and strategic niche management (SNM) focus more explicitly on sustainability goals of socio-technical transitions and the nitty-gritty of such efforts. With this aim, they are more prescriptive in character, albeit in distinctive ways. One

of the central goals of TM is to create arenas for new practices of learning, reflexivity, experimentation, adaptation and shared sustainability visions (Kemp, Loorbach and Rotmans, 2007; Loorbach and Rotmans, 2006). As a system-level approach to governance, TM offers various suggestions for how arenas should be managed, for example in terms of the strategic definition of visions and goals, plans and strategies for pathways, activities (actions), and reflexivity to adapt these processes (Loorbach, 2010). In this way frontrunners (Loorbach and Rotmans, 2010) play an important role in TM because they have different tools at their disposition to foster transitions and, thanks to their position, they work outside regime environments.

Although TM has a pronounced instrumentalist steering agenda, initial TM scholarship did not address sustainability as an overarching political objective embedded in political contestations. Shove and Walker (2007) famously characterized it as a 'voyeuristic' approach, issuing several cautionary remarks against assuming effective rational and deliberative political interventions. They call upon TM scholars to recognize the "deep ambivalence of sustainability as a category of power as legitimizing discourse" (Shove and Walker, 2007: 766). What is a good transition? Who should be managed and by whom? Who should be reflexive? are some important political questions that need to be addressed. Similarly, Voβ and Kemp (2006) raise doubts about the capacity of policy instruments to tackle the high degree of ambiguity and uncertainty of socio-technical transitions. Overall, scholars challenged the idea of de-politicizing transition efforts and management.

This critique opened up for several contributions that highlight the connection between the political context and reflexive governance. Smith and Stirling (2007, 2010) call attention to the power dynamics between those inside and those outside transition arenas and the need to address questions regarding authority, legitimacy and accountability. Hendriks and Grin (2007) illustrate how the socio-political context (rather than unpolitical reflexivity) legitimizes some forms of reflexivity over others, and how the lack of democracy in sustainability transition policy and management can promote elite theory and technocracy (Hendriks, 2009). To address politics and overcome consensual and technocratic approach to politics, TM thus needs to recognize the politics of policy (Kern and Rogge, 2018; Scrase and Smith, 2009), as

for instance in the political interaction (political lobby, political support, party politics, and powerful interests) necessary for transitions (Meadowcroft, 2009). However, even if policies are re-politicized, the central political model of TM remains the same: namely, to analyze and propose ways of steering transitions in a more sustainable direction. When successful, they become examples of well-managed sustainability intentions.

In comparison to TM, SNM explores how radical innovation can be fostered in protected spaces (Kemp, Schot and Hoogma, 1998). SNM is complementary to MLP in its focus on necessary processes for niche innovation and its diffusion. SNM finds three interacting processes to be of special importance for the growth of new technological solutions: socio-technical, the formulation of expectations and visions, and the establishment of social networks. Once aligned, they can foster momentum and facilitate the growth of niches (Geels and Raven, 2006). Moreover, Smith and Raven (2012) stress that niches need to be protected, nurtured and empowered to be effective. This includes a process of connecting niche actors to political discourses relevant to regimes (Smith and Raven, 2012), which is essentially an expansion of the systems model whereby regimes either positively impact or constrain niches (Van de Poel, 2000; Grin, 2010). In many ways, SNM provides is a step towards more understanding of actors in transitions (Farla et al., 2012).

Raven et al. (2016) extend this inclusion of both system and actor-oriented perspectives in a special issue on the politics of protected spaces. With aims to include evolutionary, relational and institutional perspectives on protected spaces, they argue for the need to study the politics of the innovation process. They write: "the physical and social spaces in which these technologies develop and are deployed are infused with politics, in the sense of advocates needing continually to justify the expanding reach of their activities in the wider social world" (Raven et.al. 2016: 102). In effect, the lessons drawn from the collective contribution point to a wide variety of dynamics that go beyond system dynamics e.g. patience and persistence of advocacy work, heterogeneity in relation with opposing coalitions, narratives, etc. This wider inclusion is an important step towards recognizing actors' roles and the diverse avenues for understanding the design of sustainable technologies and their politics.

A focus on actors and their practices, without assuming predefined distinctions between levels, still remains a more marginal approach in transition scholarship. One example is the arenas of development (AoD) model (Jørgensen, 2012). As opposed to innovation occurring within protected niches, the AoD model argues that sustainable transitions take place in networks of actors, or arenas, with multiple identities. Tensions and controversies between actors lead to new configurations and alignments of arenas. The central focus is then on understanding how discourse, claims, materiality and visions assemble in particular arenas and lead to socio-technical change. Pineda Valderamma and Jørgensen (2008, 2016) illustrate how transformations to sustainable mobility, as for instance in the metro construction in Copenhagen, relied on established actors, technologies and interest groups. In new arenas of development, various actors facilitated the negotiation between the new and old system in the city, facilitating the stabilization of a new metro system. Hence, AoD helps highlight the importance of actors' engagement in political conflicts and sense-making to transformations (Jørgensen, 2012: 1008). And conversely, how transformations are not only reliant on shared visions and goals, but extensive political controversies.

A few other contributions focus on actors and their everyday strategies for translating sustainability politics into practice. A productive example is Åm's (2015) study of solar scientists. She describes them as transition actors that actively construct sustainable innovation through strategies to improve the efficiency of solar energy or by challenging existing perceptions of solar energy. Some of them also see the need to influence policy makers. Sørensen, Lagesen and Hojem (2018) stress that consultancy engineers enact transitions through different types of 'transition work'. They observe that sustainable technological problem-solving practices were core to socio-technical change, while various types of persuasion, mediation and institutional work supported this agenda. In both cases, the authors trace socio-technical change to concrete practices and politics to their everyday enactment. These studies are fruitful for the ways in which they show how actors address concrete conflicts and controversies, but they are more concerned with subpolitics than with questions related to how socio-technical change is a political achievement.

Drawing on practice theory, Hoffman and Loeber (2016) illustrate through their study greenhouse innovation in the Netherlands that shared visions and understanding might be neither purposeful nor necessarily for transformation. As the above actor-centered perspectives make clear, controversies and political struggles are important to socio-technical change. Walker and Shove (2007: 223) argue that "…the critical political challenge is to design forms of governance that foster and sustain ambivalence at the various locations and moments that it appears and emerges over time." These authors thus show that shared, linear and clearly goal-oriented pathways to transformation exclude some relevant processes of transformation suggesting that we may need to carefully attend to ambivalence in the transformation process.

In sum, actor and action-oriented perspectives suggest a more complex trajectory for the sustainable shaping of technology than is usually observed in the more linear- and steering-oriented systems approaches. Such a trajectory also suggests an unruly and perhaps less clear political shaping of technology. Several authors therefore promote a focus on plural *transformation processes* rather than singular *transitions* (Jørgensen, 2012; Stirling, 2015). Pel Avelino, and Jhagroe (2016) stress that an undue focus on plurality may threaten the critical and normative position of transition studies. They write: "…once transitions theory starts to obscure the diversity of possible transition pathways and the attendant political choices, it will lose its critical contents" (Pel, Avelino, and Jhagroe, 2016: 455). However, some of the examples above suggest that ignoring such plural pathways, may overlook some important dimensions of transformation efforts. However, what this means in terms of political engagement and sense-making needs further discussion.

Another reason to refocus on transformations as plural pathways may be given by technological development perspectives that highlight that socio-technological change does not end with the successful materialization of technology. For instance, domestication and socio-technological learning perspectives (Sørensen, 1996, 2006) illustrate how technologies continue to transform through user-technology interactions. Geels (2014) also argues for the possible productiveness of attention to ongoing and broader social interactions in reconfigurations towards more sustainable systems. Together, these insights complicate the picture of transitions and show the need to understand the politics of such non-linear and

complex processes. Urban studies scholarship on sustainability transitions offers important contributions in this direction.

3.2. Urban sustainability transition: conflict, struggle and rhizomatic pathways

As stated in the introduction, both scholars and political leadership increasingly recognize the role of cities in the governance of sustainability transitions (Bulkeley, Castán Broto and Edwards, 2015; Rutherford and Coutard, 2014). The study of urban sustainability transitions is currently a subfield of transition studies, while there is even talk of a 'transformative turn' in urban studies (for a review, see Koch, Kabisch, and Krellenberg, 2017). Urban transition scholarship overlaps with the above frameworks and studies of matters such as energy, mobility and food, but taking the city as a unit of analysis also opens transition studies to multiple, messy and unclear transition pathways and real-world contexts. Moreover, urban studies have been highly sensitized to the connection between politics and urban infrastructures and technologies (Braun and Whatmore, 2010; Farias, 2011; McFarlane and Rutherford, 2008).

Certainly, much of this research is in line with the aforementioned dominant systems perspectives. For instance, one important scholarly avenue has been to explore the city's role as a socio-political niche with transformative potential. Following MLP, cities and their local administration are important niches because they are not pressured by incumbent regimes (Betsill and Bulkeley, 2004; Hakelberg, 2014). They have both financial means and decision-making power, giving them a degree of autonomy from national level political actors. Cities therefore offer more flexibility for sharing and transferring innovation between cities and can be important sites for developing visions, making concrete interventions, or mediating capacity building (Bulkeley, Castán Broto and Edwards, 2015; Hodson and Marvin, 2010). Similarly, there also exists scholarly work aimed at understanding the political dimensions of lock-in pathways. For instance, the link between materialities and agency in the possible transformation of city energy infrastructures (Rutherford, 2018) or the political historical effects of market competition, energy security and sustainability, which make it difficult to carve alternative pathways (Moss and Francesch-Huidobro, 2018).

A prominent body of work is concerned with urban experimentation and laboratories that work outside normal planning initiatives and funding institutions (Bulkeley, Castán Broto and Edwards, 2015; Bulkeley and Castán Broto, 2013; Evans and Karvonen, 2010; Karvonen and van Heur, 2014; Raven, Karvonen and Evans, 2016). Experimentation literature has led to new research areas like the management of niche innovations and transport transitions (Evans and Karvonen, 2014; Gossling 2013; Hoogma et al., 2002; Sengers and Raven, 2014, 2015) and multi-level governance (MLG) of sustainability transitions (Bestill and Bukeley, 2005). In an overview of experimentation and urban laboratory research, Bulkeley and Castán Broto (2013) illustrate how politics is far from straightforward. They show how experiments actually create their own political spaces. Here, distinctions between public and private authority blur and produce new forms of governance (not linked to plans and policies) through social and technical practices. Given the multiple outcomes of such interventions, they stress the need to research diverse practices and their politics.

Similarly, in a recent anthology on urban sustainability transitions, Frantzeskaki et al. (2017: 16) call for researchers to move beyond the "usual suspects" in transition theory (e.g. MLP, TM). This expansion, they claim, will enrich the field by introducing epistemological pluralism. They also stress the need to pay special attention to the politics of transition efforts, to avoid single case study explanations of urban transitions, and to include agency perspectives.

I read this call as a response to empirical research in urban studies literature that shows very concretely the complexity of transformation efforts. First, the field of urban studies illustrates how transitions are open to dispute, struggle and conflict. In cities, political processes are central to negotiating interests and the possible consequences of climate change. The centrality of the political process means raising important questions regarding what actors should be included in transition efforts, or what visions should foster future development (Bulkeley and Bestill, 2013; Frantzeskaki et al., 2017). Second, urban sustainability transition studies literature has also highlighted the politics of the material and spatial dimension of cities; for example, how material networks can transform cities (Rutherford and Coutard, 2014; Moss, 2014) and how politics are embedded in current infrastructures, a matter largely ignored in public policy discourses (Miller and Levenda, 2017: 346). Inquiries into who takes part in

transitions should then include agents, objects, mechanisms and techniques in practice (Luque-Ayala, Marvin and Bulkeley, 2018: 21).

One interesting avenue that explores the co-construction of actors, knowledge and politics is transition literature that looks at the politics of epistemic practices. They point to the politics of making the urban fabric 'knowable' and 'visible'. Hence, when cities materialize through plans and studies, they are simultaneously made governable (Shove and Walker 2007). Cashmore, Jensen and Späth (2018) therefore underlie the necessity for critical research on knowledge rationales, devices and practices, that enact sustainable transformation processes. Through a knowledge-politics perspective, they underlie the need to study mundane practice of knowledge production and how they interlace with political rationalities. In effect, they demonstrate how transition governance may not only be connected to vision and experimentation, but also epistemic devices and procedures (Jensen, Cashmore and Späth, 2018: 173). Jensen, Cashmore and Elle's (2017) study of how calculative practices related to cycling in Copenhagen is an illustrative example. Here they describe how knowledge production played a key role in shaping new urban environmental governance. In this case, politics is embedded in specific knowledge producing instruments.

Another important avenue in recent urban sustainability transitions scholarship is attention to conflict and struggle from a relational and situated perspective. Such studies highlight contradictions as engines for change. Conflict can then help reconfigure low carbon interventions (Castán Broto, 2015) and help reassess boundaries and meanings attached to transformations (Fratini and Jensen, 2017). For instance, processes of power struggles to control visions can be productive in forming new identity politics and sustainable visions for cities (Hodson, Marvin and McMeeking, 2018; Ingeborgrud, 2018a; Paterson and Mueller, 2018). Jensen, Fratini and Cashmore (2016) also give an illustrative example of how conflicting urban and national-level framings of the wastewater systems in Denmark influenced transition trajectories through tensions. In another example from Denmark, Jensen and colleagues (2015) also demonstrate how junctions, sites of tension and ambiguity, can lead to reconfigurations and transformations. Through a case study of the opening the Copenhagen harbor to bathing, the authors depict how conflicts between actors who were part of the

existing regimes (infrastructural systems, groups and interests), and thus not protected niche innovation, led to broader urban transformations. Although this example does not focus explicitly on sustainability transitions, it illustrates how conflict and hybrid collectives can bring about urban change.

The conflict-oriented perspective to urban transformations challenges some assumptions about planning and steering of transitions. An interesting example is this regard is Robracher and Späth's (2017) study of low carbon transitions of urban hydropower in Graz and energy-efficient heating in Freiburg. They claim that heterogeneous arenas can be hotspots for enacting new collectives of actors and sociomaterial arrangements. According to them, alignment of goals and visions in plans and policies only points to one aspect of transitions. "What we observed were not transitions 'according to plan' or other forms of coordinated transformation processes; such paths and plans were just one element of intervention in a constant process of renegotiating what sustainability could mean *in concreto*, and to what extent these normative orientations could accommodate various actors' interests, power structures and political strategies in cities" (Robracher and Späth, 2017: 230). Conflict can thus lead to socio-political reconfigurations and their sustainability objectives, and are thus important, yet understudied, dynamics of transition. Moreover, this exemplifies how sustainability transition are not always well-planned and managed efforts. Similarly, Bulkeley et al. (2015) describe how transitions can be highly fragmented and not necessarily direction oriented. They stress the need to map transition actors and empirically explore how they go about enacting change. Späth and Rohracher (2015) also show how conflicts over urban transformations, especially when involving political actors, do not necessarily reflect rational arguments, nor do they end in consensus. In light of these ongoing controversies in urban transformations, politics needs to be understood as a continually negotiated and renegotiated aspect of transition process.

Hence, in terms of temporality, much urban sustainability transition literature emphasizes the maintenance of transition efforts. In other words, the ongoing nature of transitions. This partly aligns with insights from urban studies, which have underscored the importance of the yet overlooked work of repair and maintenance of urban infrastructures and built environments (Graham and Thrift, 2007; Ureta, 2014). A similar argument is made

in relation to urban climate experiments (Bulkeley, Castán Broto and Edwards, 2015) suggesting that transitions are not 'finished' but need to be maintained over time. Transitions, then, may not need to be scaled up or transferred in order to 'count' as successful, but need to take into account "the multiple ways in which they are mobilized to achieve particular social, economic and political ends" (Bulkeley et al., 2015: 26). Stirling (2011, 2015) stresses that transformations are more plural and unruly, where the 'end' or 'accomplished' transition is unclear. A productive way to get out of the success-failure binary can thus be to attend more to transformation processes (Luque-Ayala, Marvin and Bulkeley 2018: 26). Some scholars' strategically use the term transformation (Brand 2016, Kock et.al. 2017, McCormick et al., 2013) as a way to emphasis process and implementation rather than the end game of transitions.

3.3. Summary

This overview outlines the ways in which transition scholarship offers a breadth of perspectives and analytical tools for understanding the politics of socio-technological change towards more sustainable societies. Most notably, it illustrates the challenges associated with such efforts. Systems perspectives like MLP, SNM and TM, highlight the dynamics between levels and how their various forms of power can both create and hinder opportunities for change. A closer look at actors and their actions adds important insights into the complexity of transitions in practice by articulating how actors' strategies can be contradictory and how politics infuse their everyday actions. By focusing on actors and their transition practices, we also see some difficulties associated with attributing particular actors to a particular level. This complicates system theory's focus on power through level dynamics. Urban transition scholarship addresses this complexity by pointing to the heterogeneous ways in which politics plays out in the urban setting, including difficulty in carving out clear low carbon transition and new conflicts and struggles for urban renewal.

Recently, scholars have called for more research and conceptual clarification in order to better understand these complex dynamics and politics of transitions (Miller and Levanda, 2018; Scoones, Leach and Newell, 2015). Miller and Levanda (2018) in particular argue that

we need more research to understand how politics and sustainability are shaped in practice. To this end, Miller and Levanda (2018) stress that there is currently too much emphasis placed on policy discourse and governance toward sustainability and not enough focus on the political dimensions of sustainability. STS's long strand of research on technological change and the intricate complexities of such transformation can in this regard be an important contribution to transition studies. In what follows, I specifically explore how STS debates on the politics of technology might offer a new avenue for exploring the politics of sustainable transformations.

4. Theorizing the politics of technology in STS

The relationship between politics and technology is an important cornerstone of STS theorizing and empirical studies. STS criticizes deterministic views of technological development and dominant views concerning the impact of technology on society (Williams and Edge 1996: 868–873), which assumed the unidirectional power of technology on society. While STS scholars have a relatively united front based on this initial foundation, the actual conceptualization of politics remains in dispute.

Winner (1993) famously criticized social constructivist approaches for not explicitly addressing politics or making normative judgements. He referred to their accounts of technological development as 'colorful' but ultimately 'hollow' because of their failure to address political issues (Winner 1993: 375). Critical theorists, particularly feminist technoscience scholars, have similarly raised questions regarding the lack of scholarly commitment to the question of justice and equality in STS (Feenberg, 2017; Wajcman, 2006). De Vries (2006) criticizes STS in general for its lack of operationalization of 'subpolitics' (Beck, 1997), and conversely, its narrow conception and 'careless' use of the term politics. Such critiques have sparked several relevant debates and made STS-ers take a more explicit position in relation to politics, including several initiatives that attempt to draw up taxonomies of politics (see for instance Bijker, 2006; Jasanoff, 2006; Latour, 2007; Nahuis and van Lente, 2008). In spite of these outlines, Brown (2015) finds that they only reflect on different meanings of the political and not what it means for science (and thus also for technology) to be political (Brown, 2015: 5). Therefore, he says, STS still needs more work to unpack what 'politics' and the 'political' mean (Brown, 2015: 4).

An important question in this regard is who gets to determine what counts as politics. According to Brown (2015), it is most fruitful to open up for a dialog between analysts' and actors' accounts of politics. In the discussion that follows, I will engage with politics on a more conceptual level. I depart from a few notable preconceptions concerning the features of politics. First, my understanding of politics is a constructivist one, meaning that I do not assume that there exists an essence of politics. Second, I think that there is an important distinction to be made between what can be considered the classical understanding of politics

(politics with big P) and the more mundane everyday understanding of politics (politics with small p). The former is concerned with the governmental rule-directed politics of politicians and political apparatuses. The latter looks at subpolitics, the less apparent, concealed politics of everyday practices and objects, as a form of micro-political struggle in various realms of society (Beck, 1997). Lastly, I see technology as a mediator of politics and power. How it does so, however, requires empirical investigation.

Based on my reading of the field, I delineate four models for understanding the effects of politics on technology: 1) Technology as an extension of interests, actors and scripts, 2) an institutional gaze on technology and politics, 3) political power wielded through the stabilization of meanings and resolution of controversies, and lastly, 4) the contingent and ambivalent politics of technology. These models are not existing frameworks, but what I see as heuristic ways of understanding the relationship between politics and technology. In line with Brown (2015), I find that different conceptualizations of politics in STS serve different proposes. My aim is to highlight differences in the ways in which STS scholars have addressed the politics of technology as well as their analytical goals in so doing. Consequently, I aim to use these conceptualizations as a starting point to determine what new insights the three papers add to understanding the politics of technology.

4.1. Model 1: Technology as extension of interests, actors and scripts

This first model for understanding the effects of politics on technology posits that certain actors are privileged with respect to technological choice, that is, they can order (a form of discipline) users through technology. In this respect, technologies can be viewed as political because they mediate the interests and intentions of specific actors. Even through this model might focus on designers and engineers, going beyond traditional political actors, it aims to uncover how political interests and agendas in technological development processes have concrete political effects. Several early social shaping of technology (SST) studies specifically explore how politics, including social and economic interests, influenced technological design (MacKenzie and Wajcman, 1985).

Winner (1980, 1986) argues that powerful actors can inscribe their politics into artefacts. This translation of politics might be viewed as intentional or unintentional, but regardless, it results in technologies being an extension of political interests. In his example of the Long Island bridges, Winner (1980) describes how urban planner Robert Moses designed low bridge overpasses with the aim to prevent economically and racially marginalized social groups who use busses from reaching popular beach areas in New York. This example clearly represents a politics of exclusion. In a different example, Winner describes how McCormick's choice to introduce pneumatic molding machines to his manufacturing plant was not only a way to improve economic efficiency (a commonly held narrative explanation). Rather, it represented a direct effort to win a battle with the workers' union.

While Winner (1980, 1986) traces identifiable interests and intentions back to individuals, another set of scholars identify concrete actor groups. Historian Noble (1984), for instance, argues that the American automation of the metalworking industry (through the development of NC technology) was an outcome of an interplay of corporate, university and military interests. Corporate leaders wanted to gain more control over the production processes, researchers wanted to advance a new and modern research field, and the Air Force needed to improve the precision and strength of the production of airline parts. Cowan (1985) traces the history of the refrigerator back to the America of the 1920s, illustrating how the transition from gas to electric fridge was not a simple matter of 'common sense' (at the time, the gas fridge was more efficient and reliable), but the outcome of the social and economic interests of electricity companies who aimed to dominate the energy market. In these accounts, technological choices can then be traced to effort to control markets and productions, as well as struggles between different actor groups.

An important body of work in STS explores how designers translate intended politics to artefact through configurations of users (Woolgar, 1990) and scripts (Akrich, 1992; Latour, 1992). This literature provides concrete analytical tools for understanding why and how technological designs create both opportunities and constrains for users. Woolgar (1990) sees machines as texts, by showing that the way designers characterize users, or configure users, has an effect on how users 'read' machines. Designers thus have configuring power over users'

interpretations of technology, and consequently their use of the technology. Building on a similar notion, the script model (Akrich, 1992; Latour, 1992) highlights the various ways designers anticipate and create scenarios for future use of technology. They do so by inscribing certain qualities within it thus providing its users with programs of action. Latour and Hermant (2006) for instance, illustrate how Parisian city planners deliberately built narrow tracks for the inner-city rail network to prevent national trains from entering the city.

Overall, this literature stresses that technological choice is not neutral. Specific actors and groups can embed politics into the technological artefact, making it inherently political. Actors involved in the technological design can thus order and structure the world (Winner, 1980, 1986) or discipline users (Latour, 1994). The interest of the analyst is therefore to retrace actors' normative aims and render visible how they achieve their desired outcomes.

However, authors differ with respect to their view of the stability of the effects of such materialized politics. Winner (1980, 1986) stresses that technology has ordering power independently from its designers. Similarly, the configuration of users and script models how technology imposes programs of action on its users. According to Latour (1994), technologies do mediation work. He illustrates this with the speed bump that disciplines drivers by creating an obstacle to moving vehicles above the speed limit. There is an important distinction offered between the script model and Winner's (1980, 1986) examples, namely that users can challenge or resist scripts. Users can have anti-programs (Latour, 1992) that lead to subscription and re-inscription of technologies and the technology's politics (Akrich, 1992).

This understanding of the politics of technology shares some instrumental conception of politics with sustainability transitions literature. Most notably, it assumes the malleability of technology. According to Raven and colleagues (2016: 102) however, literature on the social effects of technological choices was insufficiently developed to cater to political agendas like sustainability, resulting in the mobilization of innovation system theories. Nevertheless, several critiques raised against this way of understanding the politics of technology can also be seen as cautioning against assumptions whereby, if powerful enough, actors can translate sustainability interests to technologies. For instance, extensive debates about the historical accuracy of Winner's bridge example and whether or not Moses was indeed a racist urban

planner (e.g. Joerges, 1999; Woolgar and Cooper, 1999), point to the difficulty of empirically retracing the intentions and interests of actors. Domestication literature (Lie and Sørensen, 1996; Sørensen, 2006) also suggests that the effects of technology usually undergo changes through use. It is then limiting to put too much focus on politics in the design of new technology. Moreover, as the next model stresses, some scholars argue that technology always works in a particular cultural context, which means its effect is contingent on the context in question.

4.2. Model 2: Institutional gaze on technology and politics

The second model stresses how the interplay between social, institutional, and economic relations shape technological development. It overlaps with the previous model in that, as Winner (1980) himself argues, broader societal relations create conditions that favor a specific interest over another. Moreover, both models share elements with a critical theory agenda, which is to uncover the mechanisms of oppressive technological power. The main goal of the institutional or structural gaze, however, is to highlight the contextual and systemic aspects of the politics of technology. Feenberg (2017) stresses that critical theory is distinct because it is interested in how cultural values are embedded in technology, as opposed to how specific individuals or groups translate their interests into technology. Thus, there is more attention to context in the shaping of technology, and the societal values and practices surrounding it. These perspectives mainly understand politics as the political effects of unequal power relations in society: either in the sense that inequalities and divisions in society are translated to technology through their design processes, or that technologies mediate oppressive, marginalizing and/or exclusive social relations.

The difference between this and the previous approach to the effects of technology is well captured by Joerges's (1999) critique of Winner's (1980) bridge example. He stresses a need to empirically examine what technologies do and "how they are both authorized and institutionalized" (Joerges 1999: 411). We should thus not assume unjust effects or direct control of technologies but explore the social relations around such artefacts and how these

co-construct control. Politics and power are thus not independently materialized in the technological artefact under study.

Wajcman (2006: 718) writes: "Technologies embody and advance political interests and agendas and they are the product of social structure, culture, values, and politics as much as the result of objective scientific discovery. They can indeed be constitutive of new gender dynamics, but they can also be derivative and reproduce older conditions." Wajcman, as other technofeminist analysts, is interested in the co-construction of political interests and broader social arrangements, for instance, the effect of gender inequality on technological design processes (Cockburn and Ormrod, 1993; Lie, 2003; Wajcman, 1991, 2006). Oudshoorn's (2003) study of the contraceptive pill provides an interesting example. Although a male pill was a probability in the 1970s, she shows how configurations of gender identities and existing testing technologies and practices hindered the development of a male contraceptive pill. Attention to the 'broader context' thus includes both material and social arrangements. In Oudshoorn's (2003) example, this included existing laboratories and epistemic devices used in testing. Another example is Mol's (2002) study of the diagnosis and treatment of atherosclerosis in Dutch university hospital. Here she shows how local circumstances, the hospital in this case, have performative power. This power is not only related to who has access to the hospital, which is a traditional politics of exclusion or marginalization perspective. She takes her analysis a step further, and explores how, once inside the hospital, the setting shapes the opportunities for action.

Jasanoff's (2004) theory about co-production is another way to conceive of this institutional gaze on the relationship between politics and technology. She argues that normative positions in science (and its artefacts) are co-produced with representations, identities, discourses, and institutions (Jasanoff, 2004). The unit of analysis goes beyond actors directly involved in design of technology. The co-production research agenda is investigating how the making of identities, institutions, discourses, and representations orders society.

The ordering power of institutions and broader social arrangement on technology has some parallels to MLPs' conception of regimes or landscape (Geels, 2002; Rip and Kemp, 1998). In MLP, these levels consist of obdurate social relations which are difficult to change.

An important difference is that STS conceptions of context and institutions depart from a constructivist understanding in which analysts do not assume the context to be an a priori ordering power but explore rather how it is produced. It is more dynamic than the way MLP systems are usually depicted (Geels, 2002; Geels and Schot, 2007). A challenge to MLP, but also to these constructivist approaches to context, is avoiding reductionist representations of context.

Feenberg (2008) and Asdal and Moser (2012) propose some productive ways to overcome reductionist representations of context. However, some dangers in the focus on the institutional and contextual characteristics of politics that remain. For instance, political power is often connected to the inclusive and exclusive effects of politics, which fails to consider the myriad ways that context might co-produce a wide range of orders. The other danger is that centering an analysis on context often calls analytical attention to their stability. As I will also argue in the following section, focus on stability and order may overshadow important contextual characteristics and a politics of instability and change.

4.3. Model 3: Political power through stabilization of meanings and resolving of controversies around technologies

The third model posits political power as an effect of stabilization of meanings or embeddedness of actor-networks. This model builds on SCOT and classical ANT literature, specifically on their position with respect to stabilized interpretations (Bijker, 1995) and assemblages (Latour, 2005). It also intersects with what Hommels (2005) refers to as different ways of conceptualizing the obduracy of technological artefacts. STS usually separates these approaches and considers them as analytically distinctive, but I combine them here because they focus on technological design as a process that moves from complex to more unitary stable entities. While the previous two approaches focused on traditional interest-politics and conflicts, these approaches focus on the ways in which heterogeneous actors produce politics through interaction or associations around technological design. These scholars are more interested in subpolitics, which is why they have been criticized for their lack of concern with politics (de Vries, 2006; Winner, 1996). Both perspectives highlight subpolitical dynamics in

two ways. The first relates to micro-political struggles between actors and groups involved in design processes. These struggles can be understood as political because, depending on the outcome, they shape society. Hence, the second aspect of politics is the effect of stabilized interpretations of artefacts and networks.

To understand the politics of artefacts according to both perspectives, we need to open black boxes and retrace controversies and struggles that are no longer visible. Each perspective posits a different analytical procedure for such an endeavor. SCOT is a procedural framework with a more stage-like explanatory narrative than classical ANT. The starting point of analysis is social groups that were relevant to or interacted around a particular artefact when the initial discussions about its construction began. Interpretative flexibility develops as relevant social groups ascribe different meanings to an artefact. In this process, they compete for semiotic power. In other words, they struggle to gain the power to define the initial artefact. The stabilisation of interpretative flexibility is achieved either by way of compromises or competition between groups (Pinch and Bijker, 1984; Bijker, 1995).

Bijker (1995, 2010) introduces the concept of technological frames to understand why certain stabilisations take place. Technological frames influence group interactions around artefacts, and, indirectly, their understandings and interpretations of artefacts. They entail distinct goals, problem solving strategies, knowledge, vocabularies, values, techniques and other elements that influence group interaction, and, in turn, a way of thinking about artefacts (Bijker, 1995: 168). Accordingly, artefacts can be intertwined with semiotic power in two different ways: 'closed-in hardness' and 'closing-out obduracy' (Bijker, 2010: 69-70). The first refers to frames that make it difficult to think otherwise, while the second speaks to how it might be difficult to overcome such framing if one is excluded. Inclusion or exclusion of individuals and social groups in technological frames thereby creates constraints and opportunities for further interaction. This is well illustrated by Hommel's (2005) research on the obduracy of urban sociotechnical systems. She shows how difficult it might be to change certain urban structures due to dominant sociotechnical frames. The political aspects in SCOT analysis are therefore the dominant interpretations and the cognitive structures formed as the outcome of semiotic struggles between relevant social groups.

In classical ANT, analysis focuses on retracing processes of translation and identifying associations that form assemblages (Callon, 1984; Latour, 1987). In other words, understanding how apparent 'immutable mobiles' (Latour, 1987) or technologies that appear stable, were assembled. Translation refers to how actors make their interests, visions, and problem definitions valid in networks through strategies of interessment and the enrolment of new actors. As new actors are enrolled in actor-networks, previously held controversies diminish. This emphasis on translation in ANT has been described as a Machiavellian conception of power. Nevertheless, as opposed to the first model of politics described above, this use of ANT is not concerned with the intended interests of actors (or intended programs of actions), but with how actors build relations and stabilize controversies. The strength of the network depends on the embeddedness of social and material elements in the network.

As I previously argued, a focus on actor and actions provides very fruitful and detailed accounts of how actors actually 'do transitions' (e.g. Sørensen, Lagesen and Hojem, 2018, Hojem and Lagesen, 2011). I argued that this actor orientation can be especially useful in delineating a different type of controversy and struggle related to transition efforts. The shortcoming of the analytical procedures presented above is that they often overlook the politics of transformation processes that are yet to stabilize. SCOT- and classical ANT-inspired empirical studies are predominantly interested in somewhat linear depictions of technological development e.g. from controversy and struggle to stability and order. Although this might indeed often be the case, discussions around the fluidity of sociotechnical forms (Williams and Edge, 1996) suggest that it might often not be the case. Moreover, although the perspectives are agonistic in the sense that they explore power struggles and controversies, narratives tend to end in consensus and relatively peaceful conclusion to development processes. As Singleton and Michael (1993: 232) note in relation to actor networks, they appear 'clear and clean'. In contrast, the following model emphasizes the more contingent and ongoing effects of politics on technology.

4.4. Model 4: Contingent and ambivalent politics of technology

The fourth model understands the effects of politics on technology as ambivalent and multiple. Instead of retracing the ways in which certain actors' interests, interpretations or social relations translate to technology, this model explores the contingent and multiple character of politics of technology. Such an emphasis on ambivalence and heterogeneity is not uncommon in STS. Conceptual tools like heterogeneous engineering (Law, 1987, 2011), ontological multiplicity (Mol, 2002), oligopticon (Latour, 2005), and enacting the social (Law and Urry, 2004), all highlight multiplicity, partiality and ambivalence. The agenda here, however, is to explore what this means in terms of politics. This model also understands the more subpolitical aspects of the design of technologies, most notably, the effects of controversies and struggles in such processes. As opposed to the previous models, this model stresses the situated and highly complex political effects of technologies.

If we first look at the design process, a few scholars focus on the multiplicity of politics and how such politics might work in both productive and destructive ways. Hård (1994: 409) criticizes social constructivist perspectives that "play down the conflict dimension involved in technological development." Hård (1993, 1994) underlies that technologies are part of power struggles, often overlooked by focus on consensus-driven closure and stabilization perspectives. Moreover, he stresses that conflict is central to technological development — innovation, diffusion and application alike. Not just stable, but also asymmetrical power dynamics are central to his thesis of technological change. Power is expressed in a variety of ways: antagonistic, disintegrating, manifest, conscious, and direct. Similarly, Singleton and Michael (1993) aim to expand an ANT approach to ambivalence. They stress that ambivalence may in fact reinforce and not threaten networks. Problematization (ambivalence, multiplicity, un-black-boxing, marginalization etc.) can also work to create durable networks or help reproduce networks. Through fieldwork on the UK Cervical screening program (CSP), they show how general practitioners were dependent on the CSP structure and stability, yet continuously challenged and re-ordered their position without endangering the network. These cases highlight a productive outcome of conflict and multiple politics.

Latour's (1996) study of the Personal Rapid Transit System in Paris—Aramis—illustrates a less productive outcome of conflict and multiple political agendas. A multiplicity of actors and their agendas resulted in the abandonment of the construction all together. Through an ethnography of this quasi-technology Latour (1993) describes how a large number of actors attempting to negotiate the system failed. Both technical elements and the human actors such as engineers and politicians were not able to agree and eventually gave up the negotiations (or as Latour phrases, they did not love it enough). Here, multiplicity is connected with the different actors involved in the process and the multiplicity of politics.

A different way to characterize multiplicity is by looking at political effects. Woolgar and Cooper's (1999) response to the debate around Winner's (1980) 'discriminatory bridge' is a good example. They argue that the artefact's politics is inherently ambivalent because the politics are dependent on how artefacts are made, used, when and by whom. Building on material semiotics, they claim that the politics of technologies are always situated. Moses' bridge is then never one thing with specific political effects, but always redefined through new relations. The script model builds on some of the same principles, but it is more dichotomous, focusing on causes for scripts and their effect (disciplining or resisting). Woolgar and Cooper (1999) also introduce a temporal dimension into the analysis of politics. Politics is thereby dependent on the moment in which it is studied.

Williams and Edge (1996) describe how the space between the conception and application of technology is not linear nor is it necessarily path-dependent, but is rather a "spiral process" (Williams and Edge 1996: 874). Social learning (Sørensen, 1996) and learning by struggle (Fleck 1988) continuously redefines technologies and their politics. Brown (2015) remarks that, just because some technologies have politics, it does not necessarily mean that they are political. Sørensen (2004) introduces the concept 'cultural politics of technology' to highlight the relation between culture, politics and technology in order to better grasp the contingent character of politics, that is, the way it may or may not be connected to technology. In this sense, politics is not something that happens at a specific time or through specific action or is just part of society but is continually renegotiated. The analytical lens here is not on stabilization or opening up black boxes, but on examining these multiple political moments.

The account above offers a number of ways in which politics can be both ambivalent and multiple. As such, it offers a productive starting point to engage with sustainability transition research that calls for a recognition of plural pathways for transformation (Luque-Ayala, Marvin and Bulkeley, 2018; Stirling, 2015), and those emphasizing social learning (Geels, 2014). A shortcoming, however, is that there are still relatively few empirical studies of both technologies in the making and technologies where politics has not stabilized.

4.5. Summary

The four models offer different ways of understanding the politics of technology. In this overview, I have mainly focused on the mechanisms for political shaping of technologies. The outlined perspectives offer quite different explanatory narratives, types of questions, and units of analysis. Since conflicting, heterogeneous, and instable characteristics of politics feature prominently in the empirical data from Belgrade, I find the fourth model especially effective as a starting point for the re-analysis of the three papers. This model can help capture the unruly as well as the ordering qualities of politics in technological development. The multi-political model introduced in paper 1 has many similarities with model 4, but further discussion is needed to understand what its contributions is toward expanding a contingent and ambivalent understanding of the politics of technology.

The above overview also briefly commented on the meaning of each model in the debate on shaping of technology towards sustainability, and subsequently, an understanding of politics in sustainability transitions. As we can see, STS models mainly depict the negative, hidden or oppressive, effects of politics on technology. Sustainability transition scholarship has stressed the possibly positive and productive outcomes of politics. Here again, the fourth model of the politics of technology may cater to a more open-ended discussion on the effects of politics in urban transformation.

5. Cross-cutting analysis

In this cross-cutting analysis, I explore the implications of the three papers for discussions on the politics of technological design. Furthermore, these insights help to better understand the politics of transformations to sustainability. As previously noted, sustainability transformation scholarship has the potential to benefit from STS insights into the politics of technology. What can we learn about the politics of technology if we re-read the three papers collectively? What do these insights tell us about the politics of sustainable transformations?

This re-reading of the three papers is not a re-analysis of the empirical data, but a conceptual discussion around the main findings of the papers.[14] I do this by adopting a two-step process. First, I discuss the multi-political model introduced in the first paper. I relate this model to the previously outlined theoretical overview and explore the possible gains in terms of re-examining this model in relation to papers two and three. Second, I explore what a multi-political model means for understanding the sustainable shaping of urban technologies and thus the politics of sustainable transformations.

I will argue that the multi-political model offers a fruitful way to understand the heterogeneous and ambivalent politics of technological transformations. Consequently, attending to multi-political aspects of technological change calls attention to the processes and mediation in sustainable transformation efforts. Although the three papers analyze seemingly extreme examples of unstable urban transformations, they help explicate both theoretically and empirically relevant understandings beyond these cases.

5.1. Making sense of the politics of urban technology through a multi-political model

The first paper in this dissertation introduces a *multi-political model* in order to better understand the shaping of technology. This model builds on an understanding of politics that is sensitive to conflict, lack of compromise, the shifting of control of the design process, and sometimes paradoxical outcomes of politics. In other words, it is sensitive to a technological design

[14] Reminder: Paper 1: "Swimming with crocodiles" - when a challenging epistemic living space interlaces with politics of technology; Paper 2: Framework for exploring the Life of Liminal Technologies; Paper 3: Designing and domesticating an interstructures: exploring the practices and politics of an elevator for cyclists

process in which the political shaping of technology is not straightforward. On the contrary, political involvement (i.e., political actors, political goals and interests, concrete agendas) in the design process may be disruptive as well as constructive and may therefore not necessarily lead to a new construction.

As previously stated, the multi-political model shares several commonalities with the fourth model for understanding the politics of technology that I presented in the theoretical section. The fourth model stresses the contingent, ambivalent, heterogeneous and unstable politics of technology. However, in paper 1 we highlight some additional political dimensions that require further conceptualization.

Paper 1 introduces the multi-political model in order to make sense of the unstable effects of politics on urban planning work in Belgrade's city administration. The study's interviewees described the invasive nature of the diverse political actors and agendas, stating how they consistently challenged continuity and undermined the planners' authority over their epistemic work. This situation resulted in what they described as the highly fragmented knowledge environments within which transport planning actors live and work, their epistemic living spaces (Felt, 2009). They described an environment characterized by a lack of procedure and consistency in the way politics related to administrative work. Although the interviewees did not think planning should be closed off, they thought political actors or political deliberations should only be involved at specific stages during the planning process. They claimed that political actors should first establish clear priorities for urban design. Urban planners should then use these priorities as a general frame for their research and planning. Once they finished a plan or study (casework), political discussions should resume. This depiction reflects clear boundaries between political spaces and planning actors' epistemic living spaces and epistemic practices. I summarize this narrative in Figure 2.

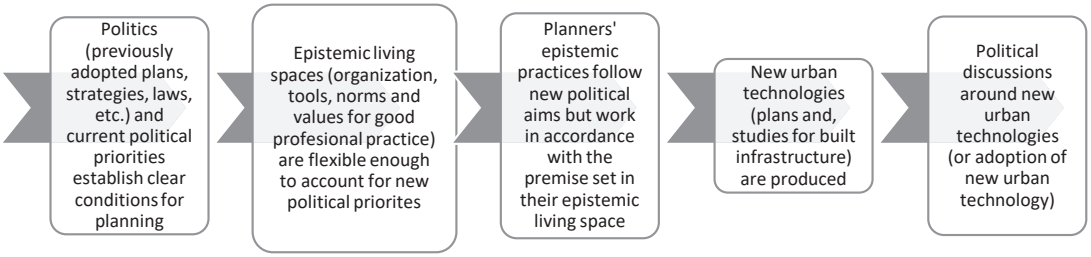

Figure 2: Common understanding of political and planning procedure

This outline conveys an ordered picture of how political actors can translate their norms and values into technological design. In many ways, this overlaps with the linear understanding of the political shaping of technology presented in the introduction. However, in paper 1, the respondents depicted a strikingly different everyday planning reality.

Since the transport planning sector spans across several organizational and institutional boundaries, both disunity and the challenges introduced by the heterogeneity of actors and knowledges were to be expected, similar to the 'disunity of science' in academia (Galison and Stump, 1996; Knorr Cetina, 1999). However, the interviewees' accounts described the heterogeneous, conflicting, shifting, unclear and often uncompromising political interests and actors as the most challenging dimension of their everyday work. In some cases, political actors would directly steer the epistemic work of urban and transport planning professionals. Most often however, the actions of political actors were difficult to predict. For this reason, the interviewees would continually try to adapt their epistemic practices in order to manage diverse political actors and their potentially shifting profile and interests.

In these unpredictable environments, professionals were constantly part of political conflicts. I call these political conflicts rather than conflicts of professional opinion because the professionals involved risked possible penalties for their actions (see Brown, 2015: 21). I will not go further into detail here, but the main point is that the lines of division between politics and professional administrative casework was neither clear nor stable. Moreover, it was not linear in the sense that politics ordered professional work. The interviewees depicted

epistemic living spaces in which both the authority of political goals and professional knowledge was continually shifting.

Significantly, the multi-political model tries to explicate and extend the fourth model for understanding the politics of technology. To start with, the multi-political model complicates the outcome of conflict and ambivalence. Using model four, I presented examples where conflict and ambivalence can have both productive and destructive outcomes on technological design processes (Hård, 1994; Latour, 1996; Singleton and Michael, 1993). Paper 1, however, testifies to more paradoxical and unclear outcomes. In some cases, it shows that conflict and ambivalence may be a goal in their own right. For instance, intentionally keeping laws and regulations around planning unclear and open to interpretation, challenging previous plans and projects based on the criteria that a competing political party instigated them, or an overall lack of clear political articulations as means to avoid accountability are all relevant examples. The multi-political model thereby sensitizes the analyst to look beyond the outcome of technological design (e.g. if a technology is constructed or abandoned) and directs the analyst to pay more attention to the effects of conflict and ambivalence in the technological design process itself.

Moreover, the multi-political model aims to capture the multiplicity and contingency of politics in a new light. Ontological politics (Mol 1999, Woolgar and Lezaun 2013) or ambivalent politics of artefacts (Woolgar and Cooper, 1999) could be used as conceptual tools to capture the dynamic political context in Belgrade where multiple and ambivalent social worlds seem to be continually shifting. However, paper 1 describes a more immediate and situated way in which politics effects epistemic living spaces in Belgrade. Woolgar and Cooper's (1999: 443) claim posits the essential ambivalence of artefacts, but in paper 1 it was important to highlight that multiplicity and contingency were not just essential qualities, but rather, they were continually performed in very concrete ways. The effects of multi-politics on the urban planning sector created a space of 'contingent chaos'. In this environment, the interviewees described various efforts to make urban technologies governable, although with varied success. The multi-political model therefore tries to capture more concrete outcomes

of multiplicity and ambivalence, such as how design processes can go back and forth without necessarily impelling or diminishing controversies and ambivalence.

Before I move on to discuss the multi-political model in relation to the remaining two papers of this dissertation, I want to comment on the implications of developing this model by using Belgrade's transport planning sector as the main unit of analysis. By analyzing an epistemic living space, paper 1 explores an arena where various urban technologies are under development. It does not focus on a single case in particular. In this sense, the model does not necessarily refute that artefacts have politics (Winner, 1980. 1986) or that designers may try to translate certain politics through artefacts (Akrich, 1992; Latour, 1992). Indeed, paper 1 shows that planners often had to design transport solutions according to concrete political instructions, predominantly in professionally unsatisfactory ways. Yet, this only captures certain situations and often in an incomplete manner. Similar observations can be attributed to the possible stabilization and standardization of politics around artefacts (e.g. Bijker, 1995; Latour, 1987). Of course, there were many black boxed urban technologies and epistemic objects that were part of the transport planning sector. For instance, neither planners nor politicians questioned the use of maps. Nevertheless, the interviewees' narratives underlie that, more often than not, there was insecurity regarding the authority of such epistemic objects. Lastly, it may also be possible to describe the marginalization and insecurity of the epistemic authority of transport planning actors as a characteristic of wider power inequalities in the local government (e.g. Feenberg 2008; Jasanoff, 2005; Wajcman, 1991). But again, paper 1 demonstrates that planners are only marginalized in some instances. In sum, the multi-political model does not refute other ways in which politics may shape urban technology, but it captures politics under certain conditions which need to be explicitly addressed.

Although the political and legislative turmoil in Belgrade might be considered extreme, the multi-political model may be an important sensitizing tool beyond this example. Particularly, I would argue, for the design of urban technologies where the complexity of planning is more the norm than the exception (Czarniawska, 2002; de Roo and Silva, 2010; Hommels, 2005; Ingeborgrud, 2018b). As a first step, I will initiate this discussion in relation to the two urban technologies I have studied – the metro and the elevator for cyclists.

Together, they expand the thesis thus far by explicating some important temporal and socio-spatial dimensions of multi-politics.

The metro case (paper 2) depicts a technological design process that has been ongoing for almost a century. On one side, this case is an example of the multi-political shaping of technology. Paper 2 illustrates how continuous political shifts have led to a lack of continuity in the development of the metro. The metro project was at times under development, then put on hold, started again, slightly changed, then redirected, and so forth. In contrast to Latour's (1996) Aramis example where a 'lack of love' led to a failed project, the metro was kept alive through a 'love and hate' relationship. The multi-political model helps capture how political disputes have both disrupted and put the development of the metro on hold, and how they have reinvigorated it and kept it alive – kept it liminal. This model shows how conflicts can work in a paradoxical way. In fact, the metro was most notably 'under-development' when it was part of political debates, for instance during local government elections. The overall planning process was thus highly susceptible to changing political agendas.

This example also adds an important temporal dimension to the multi-political model. Paper 1 mainly described multi-politics through interviewees' narratives on epistemic living spaces and epistemic practices, limiting insight into the way multi-politics plays out over time. All technologies may go through shorter or longer periods of time when actors are grappling with what the technological design in question is or should be. In paper 2, I use the term 'liminal technology' to refer to types of technologies that are in the midst of transformation processes. The metro case explicates the non-linear work of politics in such cases. For instance, how the metro project started as an innovative idea, how it became part of a national agenda, how it was put on hold in favor of other national priorities, how it was rekindled to help Belgrade gain the status of a European metropolis, and so forth. Different political agendas were often directly working against one another. In this process, disputes around different metro concepts and technical features of the metro were politicized (or became political games). Brown (2015) notes that although artefacts might have politics, they might not always be political. The metro clearly became a politically charged and controversial artefact at different times during its long history, but none of the conflicts in which it was

implicated were ever resolved. It is fruitful then to look at how these different politics were related to one another over time. Retrospective studies of technological development, as well as stability-oriented STS approaches (e.g. SCOT and classical ANT) tend to overlook such political dynamics.

The metro case also illustrates the effects of multi-politics beyond the metro project i.e. techno-political effects. Interviewees from Belgrade's transport sector talked about how the metro halted other development projects in the city, how plans had to be adapted to a possible future metro, or how alliances between city planners shifted through the various metro disputes. This shows how a technology 'caught in' a multi-political dispute (a liminal technology) can have effects even though it is not black boxed or stable.

Until now, I have mainly discussed the multi-political model through case studies in which I explore the more conventional role of political actors in governing urban transformations. Paper 3 offers a different vantage point. It discusses micro-political struggles or subpolitics around an elevator for cyclists. Furthermore, as opposed to the other two case studies, the elevator represents an urban technology in use today. Still, paper 3 demonstrates how political struggles continue to transform the elevator even though it has materialized. What can the multi-political model gain from discussing a rather small and contested elevator?

By re-reading paper 3 alongside the two previous papers, I find several shared political characteristics. Paper 3 describes relations that are unstable, disruptive, paradoxical, heterogeneous, and unpredictable as well as capturing political disputes between various user-groups and their anti-programs (Latour, 1992). It shows how ambivalent scripts were part of the construction from the start, and how this ambivalence played out through the collective domestication (Ask and Sørensen, 2018; Sørensen, 1996) of the elevator. Operators, cyclists, pedestrians, tourists, managers, and the bridge itself, all had ideas about the elevator. The elevator was therefore an object of continuous scrutiny, its aims and purposes debated from the perspective of several programs. I describe this situation as 'political' because it required users, on a moment-to-moment basis, to negotiate what the elevator is, what it should do and for whom.

This instability adds an important socio-spatial dimension to the multi-political model. Although the elevator was a materialized urban technology, situated in Belgrade, its politics were often highly unpredictable. Depending on the particular constellation of actors engaged in debate, the situation shifted. In the paper, we focus on the connective effects of multi-politics (or what we refer to as the *inter*-qualities of so-called *infra*structures). For instance, which groups, spaces or symbolic meanings the elevator elicited. As a result, a multiplicity of anti-programs, ambivalence of scripts, and disorderly everyday life, all revolved around the elevator, revealing multi-political dynamics around a situated single-case study of urban technology. We argue that the relationship between use-related programmes and anti-programmes should be seen as circular with a pattern of repetition rather than as a linear sequence of new actions. In socio-spatial terms, this meant that all users had to engage with articulation work, often through negotiations between multiple groups in the same setting. Alignment and misalignment of multiple values, goals and interests, was thereby a continuous effort. Orchestration of multi-politics can then be, as in the case of the elevator, decentered and flexible.

This case also highlights the paradoxical outcomes of conflict, but in a different way than the previous two cases. Paper 3 posits that the elevator would probably not be working today if its programs for action, and subsequently its politics, had stabilized. Politicians would likely not support an elevator destined for a marginal number of cyclists, neither would they support an expensive, but normal, public elevator. It would also break down and overheat had the operators univocally implemented one form of use. The operators were necessary to protect the elevator, but they also challenged users' expectations of the elevator, leading to conflicting concerns that kept the elevator running, albeit inconsistently. Hence, there is also a productiveness of multi-political shaping of urban technologies.

To summarize, a re-reading of the three papers explicates a number of characteristics of the multi-political model. The model does not dispute previous theorizing, but it helps sensitize analysts to political dynamics easily overlooked by relatively stable models of the politics of technology. It highlights how multiple political interests and agendas can both disrupt and sometimes productively help keep alive technological development. It is a model

that is open to capturing how unclear and short-sighted goals can drive technological development, without necessarily progressing technological development towards either construction or abandonment, or, diminishing of multiplicity over time. In the case described, the politics of technology was not hidden, by relatively overt and visible. Consequently, it stresses that even when politics are not stabilized, they still have political effects. The model may be summarized as follows, with a focus on the processual, temporal and socio-spatial features:

Processual	Interlacing of multi-politics with the design and building of technology
	Conflicts and lack of compromise
	Alignment and dis-alignment of political, economic and social interests
	Shifting of control of the design process
	Constructive and disruptive politics on design
	Multiplicity and ambivalence of politics
	Visible politics
Temporal	Unclear, shifting, and contradicting goals can drive technological development but not necessarily progress development
	Back and forth of political ordering and disordering
	Multiplicity and ambivalence do not diminish over time
	Mechanisms that keep technological development in a loop
Socio-spatial	Collective and situated
	Multiple partial views in the same space
	Outcomes of negotiations shift from moment to moment in the same space
	Orchestration of politics decentered and flexible

Figure 3: Processual, temporal and socio-spatial features of the multi-political model

In the next section, I explore the implications of the multi-political shaping of technology model on the understanding of politics in transformations to sustainability.

5.2. Multi-political shaping of transformations to sustainability

So far, I have analyzed the politics of transformation through three case studies of urban technological design in Belgrade. I presented a multi-political model that integrates the insights gained from the three papers. I will now discuss what the multi-political model might mean for the understanding of sustainable transformations and how they should be enacted. What are the consequences of this multi-political understanding of politics for sustainable transformations? And inversely, what does sustainability concerns contribute when they interfere with the multi-political model?

Sustainability transitions scholarship increasingly recognizes the complexity of sustainable transformations. Actor and practice-oriented perspectives in particular yield insights into complex actor configurations (Jørgensen and Pineda Valderamma, 2012), diverse and ambiguous practices (Walker and Shove, 2007), intricate transition work (Sørensen, Lagesen and Hojem, 2018), or the possible productive outcomes that arise from conflict and struggle (Rohracher and Späth, 2017) over sustainable transformations. As a consequence, such efforts have contributed to a more sophisticated and nuanced understanding of politics. The above outlined multi-political model contributes to this line of inquiry by challenging linear, well-defined conceptions of pathways to low carbon futures.

To start with, the multi-political model complicates the idea of materializing sustainability goals through new technology. Unlike STS models of politics where programs of action can be translated through artefacts (e.g. Winner, 1980; Latour, 1992) or stabilized through sociotechnical relations (e.g. Bijker, 1995, Latour, 1987), the multi-political model destabilizes the relationship between technological design and its (sustainability) effects to emphasize the need for continuous interventions.

The three urban transformation cases from Belgrade invite the rejection of a linear conception of politics, that is, an understanding where politics works as an ordering device for both technological design processes and technological effects. On one side, both paper 1 and

2 illustrate the conflicting, sometimes disruptive, and often shifting politics of technological development. The status of sustainability concerns in these design spaces was not clear. In the epistemic living spaces of planners, both political sustainability goals and the authority over environmental knowledge were insecure. Even actors directly responsible for sustainability concerns stressed that sustainability could be enacted only *pro forma*, that it is often intertwined with or side-stepped by other priorities and concerns, or that sustainability goals on their own have little effect. Similar difficulties in the framing of sustainability (Shove and Walker, 2007; Skjølsvold, 2011) feature in the metro case (paper 2). It shows how politicians and planners only recently have started to argue 'sustainability' as a value in the metro development project. Conversely, a few interviewees remarked that they had 'been doing sustainability' for a long time, without referring to it as such.

Both the case of the metro and that of the elevator for cyclists point to the multi-political effects of technologies. The transformative potential of the metro remains highly controversial, with some interviewees even claiming that it hindered the development of other, more sustainable transport options. In this way, although the metro may be a 'revolutionary' intervention in Belgrade's transport system, both its possible effects and the type of transition it enacts remain unclear. The bicycle elevator improved cycling infrastructure in Belgrade and was therefore part of a low carbon mobility mode. Yet, it also created some problems, and its day-to-day politics did not always favor cyclists. As such, the elevator for cyclists could be framed as a fragile and imperfect low carbon technology. It was a modest contribution to Belgrade's transformation towards low carbon mobility, easily overlooked from a system transition perspective on transitions. Overall, these examples illustrate the difficulties of claiming that goal-oriented sustainability objectives shaped urban transformations.

In the dominant system theory perspectives (MLP, TM and SNM), such complexity problems can be solved by creating, shielding and empowering goal-oriented niche spaces for technological innovation. From this viewpoint, the three examples from Belgrade could be said to confirm the need to protect initiatives of sustainable technological development from the regime of the traditional planning sector. I will nonetheless argue that such a separation is problematic.

As other studies have shown, it is often analytically difficult to separate actors in terms of levels of society (e.g. Åm, 2015; Hoffman and Loeber, 2016; Jørgensen, 2012). The bicycle elevator (paper 3) for instance, in many ways appeared to be a niche innovation. It was a grassroots initiative and resulted in an experimental, shielded cycling technology initiative (Sengers, Wieczorek and Raven, 2016). If we look at the actors involved however, we see that the initiator was an established traffic engineer in Belgrade's transport planning sector, and the elevator was in the end approved by the Mayor himself. In effect, the design of the elevator had to accommodate both concrete cycling concerns and broader city development goals.

Similarly, the metro project (paper 2) was at times organized in protected spaces: for instance, in the 1960s when a separate Metro Sector was formed or in the 2000s when a number of metro project teams and groups were formed. Even then, however, broader political discussions and disputes around the metro halted its construction. Changes in political control of the process also hindered continuity. Clearly, a large-scale transport project like the metro requires political backing from the highest level to be economically feasible. Paper 1 illustrates a different challenge to the focus on level dynamics. Given how the epistemic livings spaces of transport planners were in constant change, to assume stable and powerful incumbent regimes and actors (e.g. Geels, 2002; Geels, 2014; Grin et al., 2010) would not be productive. Instead of assuming separation between levels and politics, these cases suggest that more attention to how diverse actors cooperate and create new connections or disrupt each other is needed.

Non-linear temporal characteristics of multi-politics challenge the focus on accelerating or speeding-up low-carbon innovation (e.g. Sovacool, 2016). The three papers highlight political dynamics that do not resolve, diminish or stabilize. Speeding up transformations in these types of conflicting technological design environments may then not necessarily be favorable. For example, according to many interviewees, finishing and actually constructing the metro may not have been the most sustainable solution. Sustainability concerns may thus work in a destructive manner. In Belgrade, several transport planners thought the metro project halted more realistic transport solutions. The bicycle elevator case shows that even if the low-carbon technology has materialized, its transformation may

continue into the present. In either case, a focus on speeding up transformation processes departs from the assumption that consensus around goals and norms is possible, which is neither the case in the examples from Belgrade, but also unlikely in other urban settings (see for instance, Späth and Rohracher, 2015).

Understanding the multi-political shaping of technology in the context of sustainable transformations thus complicates the idea of locked-in, goal-oriented, consensus-driven one-directional transition pathways. Plural approaches to transition (Luque-Ayala, Marvin.and Bulkeley 2018; Stirling, 2015) cater better to the heterogeneous, unstable and conflicting characteristics of transformations like the ones observed in Belgrade. We thus need governance models, as Walker and Shove (2007) argue, that do not disregard or overlook conflicts, but address how intellectually to cope with and manage continuous political struggles and ambivalence.

Prescriptive and reflexive governance models (e.g. Voβ et al., 2006) for dealing with this type of complexity and risk are not well adapted to account for a technological design environment in which the relationship between politics with big P and small p is unstable. By this, I mean environments like the transport planning sector in Belgrade where mechanisms such as laws and regulations lack authority, and where political actors destabilize planners' livelihoods. Reflexive governance aims to cater for flexible and adaptable stakeholders that can respond to the complexity of sustainability, but this is not enough to cater to the complexity of situations characterized by multi-political dynamics.

Analysis of the politics in sustainability transitions thus needs to move beyond multi-level power relations and attend to multi-action dynamics. Actor oriented approaches (Jørgensen, 2012; Jensen et al., 2015; Späth and Rochracher, 2015) do this to a greater extent. The multi-political model adds to this literature by exploring the effects of conflicts that may be resilient to closure. Conflicts may not be resolved by hegemonic power, the creation of new arenas, or careful navigation. I argue that studying how unstable politics can have transformative effects even when they do not result in stable outcome, as we have seen in both cases of technologies under development (paper 2) and in use (paper 3).

Analysis, as others argue (e.g., Rohracher and Spath, 2017), needs to attend to transitions in-the-making by putting ongoing process of sustainability transformation efforts at the center of empirical inquiry. I do not mean to say that outcomes and results are not important. Rather, I think that we as analysts also should be wary of analytical preferences for stable outcomes. In many ways, the liminal technology framework presented in paper 2 is one possible avenue in which to engage with such processes. It puts transformation characteristics at the center of inquiry, rather than stable outcomes. A focus on transformation processes in-the-making can also take into account ongoing socio-technical changes, which certainly is relevant in cases like the elevator for cyclists, where the domestication and social learning of the technology (Lie and Sørensen, 1996; Sørensen, 1996, 2006) continue to transform the technology even after materialization. Ongoing engagement in political negotiations and re-negotiations around urban technologies is thus necessary to account for the multi-political dynamics like those relevant to sustainability transformations in Belgrade.

Instead of managing well-defined transition goals and visions in protected spaces, transformation efforts may then require wielding of transition concerns. Luque-Ayala and colleagues (2018) invite us to rethink transitions through an open category of development thinking (rather than strict greenhouse gas emissions). They write: "Transitions, rather than being the result of clean and purposeful ways of scaling niches, are contingent and politically contested processes where a multiplicity of systems, agents and scales come together in an attempt to reconfigure social interests, political arrangements and technology" (Luque-Ayala, Marvin.and Bulkeley 2018: 18). While these authors emphasize how multiple reconfigurations open up multiple roads to low carbon futures, I think it might be useful also to explore how multiple pathways may be brought together. This means that analysts also need to engage with more mundane transformation settings and not only with well-defined, strategic, radical sustainability projects.

Consequently, a better understanding of mediation work (Latour, 2005) and politics in mundane transformation settings can support current theorizing on the politics of sustainability transitions. The papers in this thesis argue that political handicraft effect day to day transition efforts and is vital for both their success and failure, more than is recognized by

current sustainability transition theory. As we see in paper 1, actors involved in urban planning could have a difficult time navigating the political situation, often needing to adapt their mediation strategies to avoid being externalized. We see this type of practice through actors who use a 'soft' mediation strategy in their everyday epistemic work. They were in each situation open to adapt various plans, priorities and knowledges, implying that sustainability goals are not univocal. I do not mean to suggest that they should not be prioritized, but that analysts should engage more in processes about how they are negotiated. Such negotiations align in many ways with studies of processes like navigational governance (Jørgensen, 2012; Jørgensen, Jørgensen and Jensen, 2017) and articulation work (Sørensen, Lagesen and Hojem, 2018). However, the multi-political model suggests that more exploration of antagonistic politics is needed, where transition actors are also vulnerable and take on a great deal of personal risk in such work.

In sum, sustainability concerns add a normative dimension to the multi-political model. It is not only a question of the effects of multi-politics, but of how a multi-political model may help cater to more realistic and thus more effective sustainable transformations efforts.

6. Conclusion

This tie-up essay represents an effort to synthesize the findings from the three research papers of this dissertation and situate them within discussions regarding the politics of sustainable transformation. Understanding how sustainability concerns and interests are or can be translated into urban technologies requires a careful examination of the shaping of the latter. This dissertation has explored such processes through three cases of urban transformation in Belgrade: a study of transport planners' understanding of the epistemic living spaces in which they design new urban technologies, a study of the Belgrade metro perpetually in-the-making, and the study of an elevator for cyclists. Unruly political dynamics characterized all three transformation processes. I therefore use this tie-up essay to discuss possible ways of understanding the effects of politics on technological design, and what this means for sustainable transformation. So, what have we learned in re-reading the three papers with this focus in mind?

To start with, this cross-cutting analysis contributes to the STS debate on the politics of technology. All three papers detail diverse empirical accounts of how unruly politics unfold, but together their synthesis provides input to a multi-political model for understanding the relationship between politics and technology. The analysis shows how antagonistic, unstable, and uncompromising political dynamics complicate the translation of interests and concerns into technological design. Politics in this context can have both destructive as well as constructive effects. Such effects are not new to STS literature. STS scholars describe technological development processes in which conflicts and multiplicity have led to both failed designs (Latour, 1996) and productive outcomes (Hård, 1994; Singleton and Michael, 1993). The multi-political model, however, highlights how destructive and constructive political effects can work off (or with) one another in the same context or in the same design process. Moreover, multi-political dynamics might not lead to a clear outcome, as for instance in the metro case, but it may keep technologies liminal. In this way, the multi-political model extends a contingent and heterogeneous way of understanding the politics of technology (e.g. Woolgar and Cooper, 1999) by pointing to their non-linear effects.

Analysis of the multi-political dynamics in technological transformation processes has implications for current discussions on the role of politics in sustainability transition literature. These discussions problematize the process of translating sustainability interests and goals into the design of technology. The three case studies demonstrate how multiple political aims, including sustainability, play out in technological design processes, and claim that these do not always interact in a productive manner. For instance, actors involved in transport planning in Belgrade described how they continually had to adapt their epistemic practices to accommodate and maneuver around shifting political actors and agendas, generating discontinuity in the planning processes and insecurity in the epistemic authority of professional planning knowledge. The multi-political model thus helps to highlight the role of political handicraft in sustainable transformations. Political handicraft is not only important for setting sustainability goals and manifesting the political will to pursue sustainability concerns. It is crucial for achieving a continuous engagement with sustainable transformations. In the cross-cutting analysis, I have argued that in this way, sustainability scholars need to pay more attention to sustainable transformations as ongoing processes and be particularly attune to mediation work and the efforts of brokering between various transition concerns.

A multi-political understanding of sustainable transformation draws attention to the intricate and sometimes paradoxical effects of politics and policy-making. The conceptual contributions in this thesis do not offer simple explanatory tools; they offer sensitizing instruments to better account for the complex politics inherent in these processes. These sensitizing optics complicate both an understanding of planning for and steering of sustainable transformations. In the remainder of this conclusion I will discuss what is accomplished by this mindset shift to the multi-politics of urban transformation in more practical terms. What do these insights tell us about governing urban technological design aimed at fostering low carbon futures?

First and foremost, the multi-political model gives a better and more realistic starting point for planning sustainable low carbon futures. In a discussion of agency in sustainability transitions, both Rip (2006: 94) and Shove and Walker (2007: 768) argue that there is a practical usefulness of the 'illusion of agency' of steering transitions, i.e., the belief that technological

choices and the reasons behind these choices can have desired sustainability effects. Some might argue that a multi-political understanding of sustainable transformations impedes those seeking to carve clear, actionable and effective pathways to sustainable futures. However, the interviewees in Belgrade's transport planning sector had little if any 'illusion of agency'. During my fieldwork, the interviewees had a hard time formulating visions for Belgrade's future, sustainable or otherwise. To them, talking about visions seemed alien, unattainable, and a bit discouraging. They were seeking acknowledgment of their situation and a realistic look at their context for sociotechnical change, instead of trying to 'cover it up' with progressive transition narratives and action plans. At very least, the interviewees were seeking more hands on and tangible ways of working with sustainability. Attention to and acknowledgment of multi-political dynamics may help planners and policy makers to engage more modestly, yet realistically, in sustainable transformations.

A more modest approach to transitions that takes into account the mundane and messy transition work is needed, as for instance described in Sørensen, Lagesen and Hojem (2018) or in paper 1 on the daily management of expectations in the transport planning sector. Sustainability transition literature has started to account for the messy and plural outcomes of such political processes, particularly actor approaches to urban transformations (e.g., Rohracher and Spath, 2017; Jensen et al., 2015). Nevertheless, dominant perspectives in transition studies still rest on radical, prescriptive, rational, and consensus-driven models of politics.

Geels (2007: 630) criticizes STS scholars and the policy relevance of their work, arguing that difficult jargon and concepts, the emphasis on local situatedness and complexity, and aversion to instrumental contributions, limits the impact of STS on policy. This tie-up essay and the three papers here within respond point for point to Geels' (2007) critique. My dissertation proposes several new concepts and ways of understanding technological development that embrace complexity, ambivalence and unpredictability. Although middle-range theories such as MLP and SNM sacrifice some empirical accuracy, Geels (2007) argues that they are more productive avenues for making research findings relevant outside the STS field. The current recognition of MLP in EU discourse certainly supports such perceived

relevance (EEA, 2016, 2018). However, as the cases from Belgrade illustrate, there is also a danger lying within these perspectives, in the same sense as STS warns against reductionism in general (e.g., Latour, 2005).

Although well intended, there is a practical danger in focusing on radical innovation and transition over more modest mundane day-to-day transformations. Specifically, such a focus overlooks the difficulty or in some case impossibility of enacting radical innovation in a context of the unruly and muddled effects of political interests and policies (paper 1). Moreover, it overlooks the techno-political implications of liminality (paper 2) and the ongoing socialization and politics of technologies (paper 3).

By acknowledging the multi-politics of urban transformations, and indeed its complexity, municipal actors may be better equipped to deal with conflicts and power struggles in their everyday work. Rohracher and Späth (2018: 231) argue that unplanned, situational and partial change processes need actors that can "govern from within" and "more consciously participate in collective sense-making processes about sustainable urban futures." This is certainly the case for transport planning in Belgrade where top-down approaches through either policies and regulations or direct involvement of politicians had a highly destabilizing effect. Jensen et al. (2015) illustrate how navigational actions can lead to urban transformations without clear and coordinated strategies, albeit not accidentally. Transformation, even if unplanned, is the outcome of long periods of struggle and contention. However, a consideration of the multi-politics of urban transformations as enacted in Belgrade also points to the need to be reflexive about the unpredictability of political struggles and how they may ultimately play out. For example, currently, conflicts in Belgrade are often highly disruptive and create more chaos than transformation.

Scholars cannot expect to resolve such situations definitively or comprehensively. However, we should be careful and avoid creating illusions about politics producing particular outcomes, benign or malign. In this way, we may help prepare planning professionals or designers so that they may be the objects of directive as well as disruptive political interventions.

7. Methodology

In this last part of this tie-up essay, I will discuss the strategic choices I've made with respect to gathering and analyzing the empirical data. The choice to place the methodology section after the conclusion might seem somewhat unorthodox, but the reason is rather simple. In this section, I will reflect on the methodology of the dissertation as a whole, and not only the individual articles or the cross-analysis. Had I presented it earlier in this chapter, the comprehensiveness of my objective would have been lost or confused in the narrative progression of the tie-up analysis. Since each paper addresses the methods and analytical approaches specific to the subject in question, the objective here is to reflect on the research design as a whole. In this way, the three papers are understood as an outcome of a broader research endeavor. In what follows, I will reflect back on the three-year period of this Ph.D.

Before I start, I want to position my own intention within this presentation. First, I understand methods as tools that produce a reality (Law, 2004). They are part of the epistemic machinery (Knorr Cetina, 1999) that sets boundaries for the type of knowledge produced in this thesis. Following the constructivist tradition, I do not see methods as tools to gain access to an objective 'reality', but as performative tools that help produce a reality (Law and Urry, 2004). Second, in what follows I present the methodological choices retrospectively, meaning that the methodological choice may appear more ordered and procedure-like than the messy daily reality of enacting methods (Law, 2004). In the interest of generating the most transparent possible discussion of the methodological choices, I will be as descriptive as possible in my account.

I will start from my initial research idea and discuss how the research design evolved over the course of the research, especially with respect to the case studies. The following two sections focus on gaining entrance to the field, designing a sample and recruiting informants, and data collection. The fourth section elaborates on the analysis of the data, while also summarizing select analytical choices for each individual paper. I end this chapter with my reflections on the limitations of the approach and possible avenues for future research.

7.1. Towards a research design

From the outset, my interest was in sustainable transformation processes in the Balkans. When I wrote the initial research proposal, I was living in Belgrade, Serbia, and working for a social science think tank focused on improving socio-economic development in the region. I became interested in exploring how mechanisms of EU integration proceedings and European homogenization (Europeanization) of the environmental agenda work in a day-to-day institutional setting. The aim was thus to study the implementation of new EU environmental regulations and environmental knowledge. Western Balkan countries are strategic research sites for this endeavor because of the centrality of institutional reform aimed at EU requirements.

My work in the think tank, specifically on gender equality and social inclusion, convinced me of the importance in attending to the mundane aspect of 'implementation'. Rather than identifying factors that cause transformation or serve as barriers to it, I wanted to know more about how micro-practices shape transformation processes. As both technology and knowledge production are central to such practices, an STS approach fit well with this agenda. It explicates both socio-materiality and constructivist knowledge production in such processes. With this interest in the mundane and given the lack of previous STS research on the topic in the region, an explorative agenda and qualitative research design were best suited.

To narrow down the scope and gain access to the day-to-day practices of sustainable transformation efforts, I chose to focus on urban development. Urban projects are connected both to normative and strategic discussions on development, and to the nitty-gritty of enacting laws and regulations in practice. The initial aim was to look at projects in three cities in three different countries: Belgrade in Serbia, Banja Luka in Bosnia and Herzegovina, and Budva in Montenegro. By comparing the three cities, the aim was to gain rich empirical insight into the multifaceted nature of environmental transformation processes in the region. The countries were 'close enough' in terms of transition status to be comparable, but a focus on different cities with different development objectives (post-war reconstruction, tourism development, and becoming a metropolis) would also allow for explorative findings and diversity of perspectives.

Once in Trondheim, this design changed in a few ways. First, the thematic focus changed from urban planning in general, to transport planning more specifically. There were several reasons for this: the widespread public controversy over current development projects, difficult entry into the field, and the current relevancy of sustainable transport all made transport planning a good choice. Moreover, urban transport, an underexplored field within STS (although themes relative to STS and urban space are growing, see Farias and Blok, 2017) provided a good entry point. Transport is a central target area in sustainability efforts, yet social science approaches are marginal in a field dominated by professionalized studies (Buchmann et al., 2017). Second, the research scope changed from three cities to one. The benefits of focusing on a single city – Belgrade – in both the practical sense (time, money and my familiarity with the city) and empirical/theoretical ambition, outweighed the possible benefits of comparative results. Moreover, choosing different cases within the same transport sector – metro, cycling and parking – provided a broad yet concrete delimitation of the field. The expectation was, that all three cases opened up for the investigation of everyday accountability systems and practices of a wide range of actors (planners, scientists, experts, policy and decision makers, private investors, civil society activists, and local community representatives) and shed light on scientific, technological and political controversies in Belgrade. I thus expected to gain in-depth knowledge of how these systems were constructed and managed, as well as of the agencies aimed at transforming them.

Although the research design clearly changed over the course of my research, some important features remained the same. It is a qualitative case study research design. Case study design is well suited for the in-depth, complex and contextual analysis required of a study of sustainable transformations in the urban transport sector in Belgrade. This is an exploratory methodology, aimed at generating new insights about sustainable transformation. The objective was thus to generate new insights rather than 'settle' predefined conflict. Moreover, this project was an emergent research design, open to adaptability at all stages of the research inquiry (Hesse-Biber and Leavy, 2010). Bearing this in mind, it also relies on constructivist and grounded research methods (Charmaz, 2006). In this way, the research design focused on the enactment of sustainable transport systems and planning but was flexible and open to change.

The main research question is as follows: How may sustainability transitions be enacted in urban transportation? This framing erected some boundaries in relation to the field and topic of research, yet allowed for later analysis to remain close to situations and events that emerged during the fieldwork, and for the more concrete questions to change. At the outset, the guiding questions were:

1) How has transportation planning related to parking, bicycling, and the metro changed over time, and what are the consequences of these changes?
2) How do actors involved in planning and building transportation systems account for and enact environmental knowledge through their practices? How is this knowledge negotiated and translated?
3) Are there differences in terms of how environmental knowledge is acquired and negotiated in the three cases and why?

With a bottom-up approach, I approached the research site without a predefined notion of sustainability. Instead I embarked on a more open-ended inquiry into transformation processes. The three articles and previously presented cross-analysis thus grew out of a broad research agenda and thick qualitative data. Instead of bicycling in general, an elevator for cyclists turned out to be an interesting technology on which to focus. Conversations about parking were not as potent as originally thought, but the respondents' account of the field and their struggles to make professional knowledge authoritative proved to be interesting. The metro study was the only one conducted as originally planned. I eventually had three distinct case studies, which are exemplified in the three papers of this thesis:

1. Epistemic living spaces of the transport planning sector
2. The Belgrade metro
3. An elevator for cyclists

In the course of the research these three cases crystalized as extreme case-studies (Seawright and Gerring, 2008). I describe these cases as extreme due to the heterogeneity of actors involved in technological development and use, the presence of conflicts and antagonisms between these actors, and overall the instability of the transformations. These extreme characteristics help explicate relations between technology and politics that are usually depicted as 'early' stages of technological development, but here help to highlight more pertinent and ongoing conflicts around technology. However, as I have argued throughout this thesis, these findings highlight important mechanisms that might also be relevant to technological development in general.

7.2. Entry to the field, sample, and recruitment

From the start, I had some advantages for entering the field. First, although I grew up abroad, I am originally from Belgrade, speak the language and spent a few years working in the country prior to this research project. This gave me some important advantages in terms of familiarity with the context, both in terms of institutional work and cultural dynamics. The concrete field of urban transport planning was however completely new. My background in political (urban) anthropology and previous research on local governance sensitized me to a certain extent to this field, yet, it was still a road of discovery. An important strategy at the start of my research was therefore to read up on strategic documents and previous research. I also conducted an in-depth background interview (more below). This lack of intimate knowledge of the field also had some advantages because I continually had to be curious and attentive to the mundane and often taken for granted practices of planning work. In this sense, I had limited predefined ideas about respondents' perceptions or practices.

An important advantage was that I had two contacts with connections to the work of the transport sector. They helped me to get in touch with some initial informants who helped orient me, given that information available online to the public (e.g., projects, employees), at least in comparison to Norway, was rather meager and unreliable. It was therefore very difficult to map the responsibilities of institutions and organizations, and subsequently to make an informant sample. Surprisingly, not even interviewees working in the sector had a clear idea

of the division of responsibilities and tasks (which was partly the onset for paper 1). Moreover, the transport community spans across several institutions and organizations, which made it difficult to rely on one gatekeeper or key informant (O'Reilly, 2008) that could provide access to the field.

In grounded research, sampling often moves from convenience to more purposive sampling (Morse, 2007). The convenience sample could in this case be connoted to snowball sampling where I had quite open categories in terms of what interviewees I was looking for e.g. work with transport development, or people working with one of the three transport cases selected. Once I had a better overview of the field and made some connections, the strategy adapted. One objective was to avoid the trap of overlooked and excluded voices (Lee and Brown, 1994) by only 'following the actors' (Latour, 1987). So, the sample strategy was than to find several entrance points to the field. In the second round of fieldwork, with more pronounced cases studies, interviewees were selected more specifically. For instance, including specific people responsible for environmental aspects of plans, actors involved in the metro project and respondents relevant for the design and use of the elevator for cyclists.

The final sample consists of interviewees from several institutions central to transport planning – the Secretariat for Transport, Secretariat for Environmental Protection, Institute for Urban Planning, Mayor's office, consultation agencies, Faculty of Transport, and National Ministry of Transport. Appendix 1 provides a full overview. Initially, the expectation was that individual groups were responsible for selected priority areas, but this was not the case. Interviewees often had overlapping responsibilities and worked with a diverse portfolio of plans and projects. The most selective aspect of this sample was to include informants that were concretely working on environmental consideration in planning, a few informants that were only relevant to the metro project development, and a separate set of interviewees relevant for the elevator for cyclists' case. In this way, papers 1 and 2 analyze a partly overlapping set of interviews, while paper 3 has a separate sample.

A few ethical considerations were important during the recruitment of interviewees. One of the main questions was whether to approach interviewees through official or unofficial channels. I decided on the latter. Rather than direct official requests to the different

institutional bodies, I relied on informal referrals or contacted the informants directly. I decided on this approach based on my previous research experience with local government institutions in Belgrade, as well as on direct advice from actors with intimate knowledge of the field, who alerted me of several risks in formally approaching the institutions. First, if I chose to go through formal channels, I would run the risk of being declined based on one person potentially not having the time to hear out the research objective. Once declined, obtaining another opportunity to argue for my case would be meager. Second, if I managed to contact employees who agreed to participate in interviews, I would expose them to greater risk if their participation was revealed. The ethical consideration in the latter scenario was significant. Third, I wanted to avoid management oversight of the interviews and interviewees. My previous experience suggested that the interviewees would feel extra pressure to tell the 'official' story, and I would likely not obtain access to the interviewees of my choice, but rather to deemed by the management to be most fitting according to their own criteria. Retrospectively, the informal contact did not appear to surprise or cause the interviewees any discomfort.

Kristensen and Ravn (2015) have argued that recruitment processes influence research results. They also claim that theoretical, methodological and practical aspects of recruitment are often not described or given due attention. In this research project, I take a constructivist approach to the construction of empirical data and analysis. The interview situation is thus understood as a site for the co-construction of knowledge (Rapley, 2004). However, entry to the field, initial contact and relation building influence the data collected, much in the same way as sample design or other methodological choices. In this case, I usually contacted potential interviewees by phone using contact information that had been passed on from my initial contacts. During the initial contact, I almost always introduced myself in reference to the person from whom I received the phone number. Their pre-existing relationship, I believe, gave me some reliability. They would usually hear out my proposition and we would make an appointment. In cases where respondents did not answer the call, I would send an email or text message before calling again. On a number of occasions, interviewees were unsure about what their contribution would be since they were not in a decision-making role and considered

themselves unimportant in setting the planning agenda. I had to convince them that their reflections and experience were precisely what I wanted to hear. In retrospect, I think that an official route would have put more pressure on informants to give a formal account of the work they did, whereas I wanted access to the more mundane and messy practices of these workers. The recruitment strategy chosen, I believe, allowed for more open and talkative interview situations that contributed to generating thick descriptions to work with during analysis.

Gaining access to informants through friends or 'people who know people' also held certain risks. First, only getting access to certain 'types' of informants. I tried to counter this effect by using different interlocuters. Moreover, I would also seek out those respondents that interviewees described as having alternative viewpoints and approaches, sometimes in conflict with their own. These accounts would be overlooked if the snowball sample only relied on referral. Lines of division along political affiliation would also be a danger. A second possible problem likely to arise is that informants might adjust their story or feel forced to collaborate due to the connection I foregrounded during the initial contact. In some cases, these could be actors with higher positions within the institutional/organizational hierarchy. I therefore tried to make sure that all conversations were conducted in separate and private rooms and make sure that anonymity was respected. Only in one case was a superior present in the room during the interview. It clearly seemed to have an impact on the length of the answers (they were shorter) and in-depth descriptions, but no conclusions can be made on the basis of one interview. In the end, time constraints and the breadth of my contacts also limited the field in question. I was declined interviews with certain senior-level officials of particular interest, either by phone or email (some went unanswered). In addition, I was not able to gain access to an important institution due to lack of suitable connections and contacts' refusal to participate.

Entering the field of the elevator for cyclists was somewhat easier. One of the operators agreed to the first interview and served as a key gatekeeper in this small ethnographic study. He introduced me to the other operators who agreed to talk to me. The recruitment of lift users was done in and around the elevator by asking if users would care to participate and

answer a few questions. The bigger dilemma regarding the recruitment strategy here was ethical considerations regarding how well operators understood my role. Although, I tried to be as descriptive as possible I could not be sure that their consent was fully informed. Moreover, since there are only a few operators at the site, I could not promise full anonymity, even though I always used pseudonyms. By now, the management company of the elevator along with the operators have been changed out, making this ethical dilemma less pertinent.

7.3. Data collection

Data production consisted of three main modes - written sources, interviews and participant observation. I began the investigation with an overview of relevant strategies and plans for Belgrade's urban development. The most important documents included the national transport planning guidelines and laws (e.g. Social Impact Assessment, Law on Land Use), General Plan from 2003 and adaptations to the plan, Smartplan 2008, Sustainable Urban Transport Plan, Belgrade development strategy, and various EU documents on Serbia's accession proceedings and EU urban strategies Belgrade might be required to follow. The main aim here was to collect all documents and strategies that serve to frame Belgrade's transport planning and its trajectory. It was through these various documents that parking, the metro and cycling appeared as relevant case studies. With this interest, I collected plans and studies that pertained to the individual cases such as previous plans to develop the cycling infrastructure in Belgrade, studies on cycling behavior, as well as previous metro studies and plans. There seemed to be a very limited number of online resources, with missing links and many plans not available digitally or restricted from public access.

Over the course of the research project, media articles served as important sources of data. A problem was that major newspaper outlets did not offer effective databases, making it difficult to do a systemic overview of all media reports pertaining to an individual case study. Newspaper articles served more as background information than as primary data sources. In the metro paper (paper 2), specific articles were collected 'manually' and used to examine how the metro controversies played out in media. However, this method was used generatively and does not claim to be an exhaustive, systematic analysis of all media reports. I also used a

documentary on the metro construction as a similar type of background material. Because the elevator for cyclists was such a specific case study, the articles could be collected systematically through manual searches.

I collected data during two month-long field visits to Belgrade in February and September 2016. Two visits provided the opportunity to analyze parts of the data material before reassessing the data collection strategy prior to the second visit. Different data sets had varied importance for the individual papers. Since this research was rooted in grounded methods (Charmaz, 2006) and the research field unclear, primary data collection did not make a clear distinction as to which interviews would be used for which case study. The elevator case (paper 3) was a separate process, but this case only crystalized as a distinct case study after the first field visit.

Interviews constituted the main source of data. I conducted most interviews on a one-on-one basis and a few group interviews with two participants. Some of the interviewees were interviewed more than once. The interviews were conducted at various sites: respondents' offices, homes or public cafes. When deciding on a location, privacy and preference of the interviewee were the main concerns. Most interviews were recorded and transcribed verbatim. The exceptions included two interviews with planners, and several interviews in the elevator case. Prior to each interview, a verbal informal consent agreement was made. This included consent to participate, use the data, but preserve the anonymity of the interviewees.

Depending on the case in question, the interviews follow a semi-structured interview guide (see Generic interview guide in Appendix 2). My aim was to have a generic interview guide with me, but to adapt this to each interview in question. I also had an in-depth background interview divided in two three-hour interview meetings with a key informant. This provided a historical account of planning in Belgrade and introduced me to possible controversies I needed to take into account in other interviews. As for the rest of the interviews, questions varied from thematic expertise questions regarding urban transport problems to specific account of interviewees' everyday activities, organization of work, barriers in their daily work, and their views on their professional practice. The objective was to understand the mundane and routinized aspects of their practices and to tease out possible

controversies. Or, if respondents did not discuss the specific issues that I found surprising or wanted to know more about, I would ask the at the end of the interview (for example, environmental considerations in planning). As in most qualitative interviews, the objective was to elicit thick descriptions of daily work, meaning that I needed to probe into many different areas. For this, the interview guide was highly adapted, depending on the interviewer in question, topic and themes that came up. For those interviewees that have been or are part of the metro project, I also had an additional set of case-specific questions (see Appendix 3).

Interviews were an area for co-construction, or as Rapley (2004) calls it, interview-data-as-topic. Rapley notes: "Interviews are, by their very nature, social encounters where speakers collaborate in producing retrospective (and prospective) accounts or versions of their past (or future) actions, experiences, feelings and thoughts" (Rapley, 2004:16). Holstein and Gubrium (1995) have also named this type of interview as an 'active interview'. Meaning and knowledge is in this way actively co-assembled by both the interviewer and respondent. The intention was thereby not only to extract information from the informant, but also to co-construct an understanding and reflection on their work.

A shortcoming of the interview format was that the interviewees had difficulty in describing their everyday experience. That is, they could describe how they go into the field or use certain programs, but it was difficult to understand the meanings and interpretations attached to such practices through interviews. This is partly also why and my co-author and I in paper 1 chose to focus on narratives. Participant observation within one of the planning offices would have allowed for more insight into the everyday practices of planning, but at the time of this research, I did not have access. For this reason, the papers do not explicitly engage with the details of daily practices, but as for instance in paper 1, present the main narratives on epistemic practices.

The interviews were mostly successful. By this I mean that respondents were open and shared their experience, most often talking for a bit over an hour. However, several interviews proved surprisingly difficult, at least in comparison to my previous research experience. In probably about a fourth of the interviews, interviewees would not answer the questions. They would either redirect the conversation to an unrelated topic, or their answers would be short,

and the interview terminated quickly. In some case, I experienced this as an overt strategy to overpower and steer the interview or as an expression of the interviewee's disinclination to share or participate in the research. Rather than dismiss these interviews as irrelevant, I think they pointed to some of the topics respondents found controversial or risky to discuss.

In terms of my personal position, my Norwegian background was raised in a few interviews. Often interviewees referenced how things are very different in Serbia – quite different in fact from the more 'civilized' setting I was used to in Norway. My background then served as a cultural boundary object in the interview setting (Lagesen, 2010), used by interviewees to differentiate their local experiences. I would in turn make efforts to say that perhaps everything is not always as ordered as it might seem in 'the West' to try to bring more nuance to the account in question. In other cases, I would make an effort to let interviewees know that I am also very familiar with the Serbian context.

Another significant dimension was the interviewees' gesticulations. They would often lower their voice, keep a hand over the mouth, or observe prolonged silences to physically show how some of their accounts were part of informal practices or commonly known 'secrets'. Similarly, they would look up to signal when they were talking about 'the man at the top', the director, the mayor or the president, instead of mentioning them by name. I would always have to ask for clarification, but in some cases, interviewees clearly did not want to go on record with a name or concrete situation. One topic that for instance remained elusive throughout the fieldwork was how the city administration selected its Commission for Planning. Although interviewees talked about how it had become a political body, no one wanted to give an account of how members were selected. Some said they did not know, others gesticulated that these processes were conducted 'under the table', but they did not give a concrete account either way. Since I conducted all the interviews personally, I used interview notes to keep track of some of this data that would otherwise be lost in the transcription process.

In the case of papers one and two, working with documents and interviews with stakeholders from very different institutions catered to the triangulation of the data. I see the strength and reliability of the data collected as an outcome of more contextual and evaluative

considerations. Continual questioning and exploring controversies was the main strategy to assess what additional data I needed to collect. Separating the two fieldwork periods and writing reports on all interviews prior to the second visit thereby helped guide the robustness of the sample and the type of questions asked during the second visit.

During my second field visit to Belgrade, I also gathered data that was focused on a particular case study – the elevator for cyclists (Paper 3). I conducted interviews directly with the designer and initiator of the elevator, the private management company of the elevator and the Directorate for Roads, which has jurisdiction over the elevator. The main method for data gathering was participant observation (see frequency of field visits in Appendix 4) with aims to understand how the elevator worked on a day-to-day basis. I wanted to understand both the ways in which it is used and users' meanings and interpretations. I therefore combined observation with informal interviews. These interviews were not recorded but were documented through detailed field notes. With each operator I conducted a preliminary individual interview about when they started working and what they think about their work, but I also talked to them and asked questions throughout the field visits. I would ask all kinds of questions about technical aspects of the elevator, their everyday routines and their engagement with users. Interviews with users passing by lasted between two and longer conversations of about 10-15 minutes. At the outset, I tried to speak with as many users as possible that used or were denied use of the elevator. After a few days, I focused more on users who did something outside of the realm of the ordinary or in situations when something unexpected happened. An overview of the guiding questions for different user groups can be found in Appendix 5.

Participant observation allowed me to observe how operators, users and the elevator engaged with one another, as well as to ask specific questions regarding the elevator's construction, its use, what they thought about it, and opened up for other emerging curiosities. At the end of the fieldwork I structured the field notes in a fieldwork report.

7.4. Analysis

As previously noted, this research adheres to a grounded approach to research design and data collection (Charmaz, 2006). The analysis of the material was however in principle approached abductively (Reichertz 2007). Both the empirical data and theory work in tandem, with neither having authority over the analysis process. This distribution helped avoid a priori assumptions about the research material, whilst also not falling into a structured framework of analysis. In many respects, this approach demands constant flexibility, perhaps even playfulness, from the researcher, as he or she attempts to explore the varied ways in which the validity of previous research engages with new empirical material.

Taking an abductive approach (Reichertz, 2007) means that the analyst, or as in paper 1 and 3, analysts) continually go back and forth between the empirical material and existing research and theories, and in this process refine the research objectives, analytical focus and analytical categories. The reason why I still describe this as a 'bottom-up' approach is that the analytical categories applied to the material were always done in a loose sense, and in discussion with the empirical material. Moreover, this meant that the theoretical framings of the case could shift along the way. I could explore, for example, technological frames (Bijker, 1995), before turning to scripts (Akrich, 1992). Analysis shapes the 'reality' (Law, 2004; Knorr Cetina 1995), and this type of process allowed me to explore different storylines.

An instrumental aspect of the analytical work was cooperation with my three supervisors. Even through the analysis is presented as a final step of this methodological section, analysis was a continuous activity throughout the project. With that said, one of the main spaces for analysis were supervision meetings. The frequency was somewhat dependent on the stage of the project, but in general we organized one to two meetings a month. Prior to these meetings, I would send texts (e.g. reports, empirical summaries, drafts of papers, drafts of abstracts etc.) that served as the basis for discussion. These discussions could take many forms. For instance, discussions at the meetings were collective boundary work (Gieryn, 1983) where we would determine what empirical material or further research questions were relevant for STS. In other cases, we would discuss and situate empirical data within a relevant strand of theoretical or thematic discussion. Or, we would discuss the paper drafts and the

relationship between empirical material and arguments made in the papers. These collective discussions were thus instrumental in driving and directing further analysis.

In the practical sense, the first line of analysis was content analysis of documents. Here, the first focus was to understand the main priority areas for urban development, main normative underpinnings for these priorities, and the type of data used to underpin them. The second specific focus was on sustainability and environmental concerns in planning. These documents were partly used as grounds for the selection of cases and preparation of interview material.

The most important data sources where interviews, and interview analysis was based on thematic coding. Memoing was an important tool used to converse with the data, and I did this throughout the research process, through fieldwork reports, as well as in individual interview analysis. Memos are a grounded theory method used at the core stage of research to develop theoretical codes (Holton, 2007; Clarke, 2005). I used them as means to be in conversation with the data, but also to link up certain features to existing theoretical positions. In addition to these memos, I also wrote summaries of the interviews. This initial report writing, which was based on a restructuring of the interviews was a means to regain familiarity with the interviews and to develop some collective understanding across the sample of interviews. This was in line with open coding where many different categories were first made, and then grouped together in line with different themes. Open codes were for instance 'good/bad environmental plan', 'example from other city', 'politicians back and forth'. Once the first open round was done, these codes were grouped together in categories such as knowledge practices, transition, actors, controversies. Atlas.ti facilitated this analysis and made it possible to easily rename and regroup different codes. In the end, this thematic coding distilled the main controversies, main topics, and other defined elements present in the empirical material.

Coding was used to discuss the focus of different papers and to pose new questions to the data material. This type of dialogue was exchanged throughout the analysis, as well as during the conceptualizing of draft papers and writing of final papers. It was also often conducted in dialogue with co-author and supervisors. An important venue for the discussion

of interview material and connections to theory was also the Ph.D. writing groups as well as various paper presentations at workshops and conferences. The aim was thus not only to answer predefined questions, but to also find out how the empirical material spoke to relevant topics in STS and the overall objective of the research.

Once more defined topics crystalized in the papers, this analysis shifted from open to more selective coding. Here, I was more specifically looking at what material spoke to a given topic and then did new rounds of open coding but with a more narrow thematic interest (e.g., knowledge practice-participation, research and analysis, usefulness, transfer, template, experience, etc.). Each paper however, takes a slightly different approach.

Paper 1 looks at the politics of epistemic livings spaces and the epistemic practices of actors involved in urban planning. In this paper, Knut H. Sørensen and I used narrative analysis to capture the breath of the field and interviewees' own perceptions of the field. We understood narratives as meaning-making devices (Holstein and Gubrium, 2011). Since we were interested in interviewees' perspectives and not necessarily the way they conveyed these perspectives, we analyzed thematic narratives across the interviews sample. We thus looked at the content rather than the structure of narratives.

In the first round of analysis in paper 2, the focus was on reconstructing the trajectory and identifying the main controversies of the metro development. The empirical data opened for an interesting connection between the metro development and theoretical discussions on liminality. Based on this initial analysis, I designed a liminal technology framework based on literature deemed relevant to technology development. I then re-read and discussed the empirical findings in a more deductive manner. The agenda of the analysis, however, remained explorative. Meaning, that the aim was to both understand the metro case and to explore the strength of the liminal technology framework as an analytical tool.

Paper 3 was from the outset highly distinctive. The interviews focused on the development and management of the elevator and were used as means to reconstruct the practice of planning based on the interview (Latour 1996) and to elucidate the reasons behind several technical choices. Here, we also used observational material and short interviews that were collected in my field notes. The first analytical strategy was to structure field notes into a

report. This part of the report summarized data focused on the promotion and design of the elevator – how the idea came about, how the activist event was organized, how the elevators were designed and redesigned, why and how operators were designated, and so on. The second part focused on the use of the elevator and the main controversies around its use. The analysis built a grounded analysis of the field notes, followed by a more abductive analytical discussion with theoretical literature on the politics of infrastructures.

In the crosscutting analysis of this chapter, I compared the previous case studies to different questions. To repeat: What is the contribution of the three papers to understanding the politics of urban transformations? How might this contribute to understanding the politics of urban *sustainability* transformations? In practical terms, how might these insights improve current models for governing sustainability transformations regarding urban technologies? The re-reading of the papers is then more of a discussion than a strategically built up methodology. Its aim was a comparative examination of the three cases where my objective was to tease out interesting new insights for understanding the politics of technology. Nevertheless, the focus on multi-politics appears as an interesting theme that can be relevant across the cases. The material analyzed then was not the 'raw' material, but the already formulated arguments in the three papers.

I want to make a final remark on writing. Writing was an important analytical aspect of my research. Most notably, it was also in the writing process that more refined analytical understandings of the data emerged. Hence, through writing, the arguments were continually adapted and re-formed.

7.5. Final reflections

As the above description makes clear, this dissertation mobilized different types of data material and analysis. Keeping close to the empirical data and allowing it to guide the research inquiry also paved the way for new conceptual development and somewhat unexpected case studies. This research design thereby provided rich empirical insights and new perspectives on urban development and sustainability transformation in Belgrade. An STS approach to the study of urban technologies and transformation in Belgrade provides new insight into the

transition dynamics previously explored predominantly through political science perspectives or technical (transport) planning lenses.

One of the biggest challenges during this research project was to continually try to negotiate the balance required of an abductive approach. By this I mean to work bottom up with the empirical material and let it drive the theoretical choices and concepts, yet simultaneously to become knowledgeable within a research field. The topics and questions related to this research, as is often the case in the interdisciplinary field of STS, spans across several disciplinary boundaries – STS, sociology, urban studies, geography, sustainability transitions studies, and political science. Such openness caused continual uncertainty throughout my research. 'Working from the middle' (Latour, 2005) of the material, instead of from any predefined questions and theoretical framework meant that there was always a sense of uncertainly as to which direction the analytical work was going take. In spite of this grievance, a great deal of the growth in this research was connected to trust in the processes. Instead of having a given path, in many ways my personal process runs parallel to the recommendations of this research field – to continually engage with the processes in a caring way. To continue to go back to the material, re-read, let go of set ideas, and be playful yet conscientious. From writing the first reports to re-writing paper drafts, this research was a continual process. This thesis is then only one benchmark of ideas and positions that will continue to develop and transform beyond this research. As a general note, however, the main boundary work (Gieryn, 1983) was to return to STS and determine what type of argument would be most interesting for an STS audience. Thus, in the end, instead of using elements of STS to contribute to another field, the work was often to come back to some core literature and core positions in STS, and work from there.

While reflecting back on some of the limitations of the research, there is a contradiction in talking about time. In a way, there is always too little time, and more time might have opened up for more reading, more discussion and more analysis. I do have to admit that coming from a service-contract and applied research background, I was expecting to write papers relatively quickly, which was not the case. Maturing academic arguments and the abudctive work

presented above required a lot of time. At the same time, I think the methods used in the thesis and the papers, give an in-depth situational picture of urban transformations in Belgrade.

Inevitably, several objects were 'othered' (Law 2004: 83-85) or excluded from the analysis. Thinking reflexively and retrospectively, there are both important groups of actors who could have been included in the interview sample and additional research methods could have been used. As previously mentioned, additional understanding of the day to day settings might have been enriched by an ethnographic study. I think it would have been particularly interesting to be at the sector for transport planning or to follow the development of a specific project. This would have allowed for more detailed reflection on epistemic practices and how these were enacted. Moreover, politicians could be included in further research. The sample includes actors who were politically appointed in the transport sector, but accounts come predominantly from the perspective of professional actors in the planning community.

There is also a great deal of empirical data that remains unused in this thesis. I hope to return to some of this material and develop it further. For instance, topics like standardizations of new laws and regulations only feature as an effect in paper 3 but could be explored in more detail. Especially interesting is the relationship between what interviewees consider good existing environmental practices and how these become changed and obscured in the processes of bureaucratic planning and sustainability concerns. Another interesting topic in this regard is interdisciplinarity and how this work spans both across disciplines and generations. Also, due to clientialism many state employees appeared to lack relevant qualifications for the work in question, which points to interesting dynamics of transdiscplinarity, not from the perspective of citizens' participation, but from that of unskilled workers. A third topic to which this research might contribute further is methodological. Little scholarly work has addressed requirement and sampling methods in a state setting where informality plays an important role.

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Appendixes

Appendix 1: List of interviewees

Table 1: Urban and transport planning sector in Belgrade

Institution	**Nr. of interviewes**
Mayor's office	3
Secretariat for transport	6 (7 interviewees)
Secretariat for Environmental Protection	2
Institute for urban planning	6 (7 interviewees)
Consultancy Firms	4
Ministry of transport, National government	1
Faculty of transport, University of Belgrade	1

Table 2: The case of the elevator for cyclists

Respondents	**Nr. of interviewes**
Management Company	1
Oversight	1
Design of elevator	2
Operators	4
Site around or in the elevator for cyclists	Approximetly 200

Appendix 2: Generic interview guide

Background and current tasks and responsibilities:

- Can you say something about what you do, what you work with?
- What are your main tasks and responsibilities?

- What do you think is particularly interesting and exciting? Why?
- Is there something you are particularly proud of in your career? Something you are particularly disappointed with? Why?

Daily organization of work:

- Who do you cooperate with?
- How is work delegated in the organization/institution? Who does what?
- Can you describe a normal day at work? What did you do yesterday?
- How is the work managed? Can you develop your own ideas? How are decisions made? Is there room for discussion?
- How does this type of work arrangement work? Could you imagine another type of organization? Why? How could this be achieved?

Transport development, general:

- In your opinion, what are some of the main controversies and disagreements in transport planning about? Can you describe them? Why do they occur do you think? Between whom? How are such situations handled? What do you do?
- What are currently the main transport problems? Could you give some concrete examples? How will these be solved? What are the most important considerations, in your view?
- Can you describe coopearation in urban planning in general? How are synergies between transport systems, city strategies, general plans accounted for? What works well and what does not work so well? Why? Do you see any controversies, between whom?
- How do you think different 'level' work? Are there some differences or problems?
- What do you think about your work? Why?

Planning:

- Who are you planning for? Who is you have in mind?

- What do you think about the end users? What do you think they want?
- Are there possibilities to involve them? Why, why not? How?
- Who are the most important actors involved in planning?
- What type of competences are important in your type of work?
- What type of tools do you use in your work? Programs, maps…Has this changed?
- What do you think a person involved in planning need to know? Experience, education…
- In terms of different competences in teams you worked in, what worked well and what worked less well? Is something missing? What do you do to compensate?
- Are there some forms of competences that are especially important? Why?
- Who decides what type of concern/attention is important?

Changes:

- Do you think a lot of things have changed in the area you are working in? What? How?
- Why do you think this is changed? What do you think about it?
- Why and how does this change come about? New partners, new regulations, knowledge development…
- How do you see these changes? How are they met by the community you work in?
- Are some changes especially important? Why?
- What is necessary to realize them? Why? Are there any particular barriers?
- Where do new ideas come from? Are some ideas more 'welcomed' then others?
- Do you think the way people use transport has changed? Why? How?

Visions:

- What do you think about urban development in Belgrade? What type of vision do you have for Belgrade in the future?
- What do you think about you transport areas in particular? What are the biggest problems? What are the biggest opportunities? Why?

- Do you think its possible to achieve this?

Sustainability (if are not mentioned):

- How about the focus on sustainability and other environmental problems? What role do they play in urban development?
- How about your work? What do you think about it?

Other:

- Is there something you think is important to your work that we haven't talked about? What? Why?

Appendix 3: Additional interview questions for metro project

- What are currently happening with the metro? Can you describe the situation with the metro, from your point of view?
- What do you think of the metro? Does it have a future? How so? Why/why not? What do you think should happen with the metro? Why?
- In your view, who are the supporters of the metro? Who is against?
- What type of considerations are most important while working with the metro as a transport system? Why?
- Is the metro an obstacle (or in opposition) to other systems? If, so how?
- What are the alternatives to building a metro and how do you consider them?
- What would be the overall best and sustainable transport system in your view? How important is the sustainability aspect in comparison with other aspects?
- What is the role of the metro in wider city development?
- What are the barriers for building a metro? What will Belgrade gain by building a metro?

- What do you hope (or not hope) to achieve with the metro?
- What are your visions of the future in Belgrade? And in terms of transportation, how would it look like?

Appendix 4: Frequency and time of field visits

Date	Time (ca.)
14.09	16.00 – 17.00
15.09	19.00 – 21.00
16.09	10.00 – 11.30
17.09	13.00 – 14.30
22.09	14.00 – 15.00
23.09	15.00 – 18.00
26.09	15.30 – 17.00
29.09	19.40 – 21.00
30.10	15.00 – 15.30 & 17.45 – 18.15
02.10	17.00 – 19.30

Appendix 5: Interview guide – elevator for cyclists case

Users:

- When do you use the lift, how often?
- Why do you use it?
- How? Have you had any problems etc.?
- What do you think about it? The lift at this place, the operator, the lift in itself?
- How did you learn about/get to know about the lift?
- Other thoughts on the lift?

Technician(s):

- How did you get this job?

- What does you day look like? Can you describe in detail a typical day?
- What are your most important responsibilities?
- What do you think about your job? Do you like it? What do you like most? What do you like least?
- What do you think about the lift? (Is the lift important, in your view, and if so, why/how?)
- Are there any difficulties, hinders, problems in your work? How?
- Who are the users? Is there a typical user?
- What is your relationship with the users?
- Is there anything you find enjoyable?
- Has anything surprised you in your job?
- What do you think about the lift in relation to other similar lifts or technologies?
- Other thoughts

Activists:

- What do you think about the elevator?
- How did you decide to promote the lift as a technical solution?
- What did the action look like?
- What where the outcomes?
- What do you think about the lift in retrospect?

Designer/architect:

- How come you wanted to design a lift?
- How did you design the lift? Who was involved, why did you chose a lift as a solution, why this type of lift…?
- Did you envision the operator as part of the lift? Was this part of the conversation while developing the lift? How did it end up with an operator?
- How did you envision or account for users while designing?

- What do you think about the lift? Do you have any reflections on the lift in relation to cycling infrastructure/transport more generally? Is it important? How? Why?

Management company:

- Why does the lift have an operator?
- Are there any plans for redesign of the lift? E.g. cameras etc…
- Who are you communicating with or how are you making decisions in the regard to lift operation.

Part B is not included in NTNU Open