DISSERTATION

WEIGHING THE TRANSFORMATIVE POTENTIAL OF AUTOMATED MOBILITY

A Study on Patterns of Change in Planning Practice

ausgeführt zum Zwecke der Erlangung des akademischen Grades
einer Doktorin der technischen Wissenschaften Raumplanung
unter der Leitung von

Univ.-Prof. Dipl.-Ing.
Rudolf Scheuvens

E280/4 Forschungsbereich Örtliche Raumplanung
Fakultät für Architektur und Raumplanung
Technische Universität Wien

Begutachtung durch

Assoc. Prof. DI Dr. Habil. Angelika Psenner, Technische Universität Wien
Prof. PhD Matthias Sweet, Toronto Metropolitan University

eingereicht an der Technischen Universität Wien
Fakultät für Architektur und Raumplanung

von

Emilia M. Bruck, MSc

00726633

Wien, am 27.03.2023

ABSTRACT

Since the early 2010s, claims of an automated revolution that would not only disrupt transportation systems but also transform the urban fabric and life in cities have been mounting. Amidst the reignited euphoria for self-driving vehicles, sparked by scientists and technology companies at the turn of the millennium, planning authorities and public agencies are called upon to prepare and manage the complex and likely messy transition to a future with automated mobility. However, the resources and capacities of planning professionals to be proactive, or better yet, to translate identified policies into action, vary significantly among municipalities and regions eager to have a stake in how pathways to automated vehicles unfold at the local level. To analyse how, by what means and to what ends planning professionals are preparing for the potential introduction of automated mobility in one of North America's fastest-growing metropolitan regions, planning initiatives in the Greater Toronto Area serve as case study for in-depth analysis.

Drawing on neo-institutionalist and social science theories, transformative change is understood to evolve gradually through many instances of exploratory deviation and realignment. To challenge common claims of external disruption brought on by automation, the analysis centres on the transformative potential of endogenous change processes, promoted by creative agency and social learning. The case study reveals the capacity of planning actors in the GTA to create and recreate their environment by altering existing forms of practice. Changing the means of planning may be pivotal to ensuring that local and regional pathways to automated mobility are aligned with broader collective interests. Within the institutional, political, cultural and spatial conditions that both enable and constrain emerging forms of practice, a new generation of transportation planners is forging novel relationships, processes and tactics to translate alternative mobility visions into action.

The study provides a more balanced understanding of transformation in the context of vehicle automation by deconstructing its meaning for mobility systems, urban environments and planning practice. In a telling moment of asynchronicity, it highlights the multiplicity of societal, technological and spatial change unfolding at different rates. While ventures by IT companies initially appeared to outpace governmental response, technological setbacks have since altered timelines for commercialization of automated vehicles, to the extent that policy-making has taken over the pace of technological innovation in some places. The merit of this time lag needs to be recognized as an opportunity to expand the narrow focus on technical performance and open up space for social innovation. Whether the advent of automated vehicles reinforces the status quo in transportation and exacerbates existing challenges, or instead fosters alternative visions of mobility, also hinges on the capacity of planners to redirect social practices that stand in the way of implementing transformative visions, policies and concepts.

KURZFASSUNG

Seit Anfang der 2010er Jahre häufen sich die Behauptungen einer Revolution der Automatisierung, die nicht nur Verkehrssysteme transformieren, sondern auch das räumliche Gefüge und das Leben in Städten grundlegend verändern würde. Inmitten der neu entfachten Euphorie für selbstfahrende Fahrzeuge, die um die Jahrtausendwende von Forschenden und Technologieunternehmen ausgelöst wurde, sind Planungsämter und die öffentliche Hand aufgerufen, sich vorzubereiten und den komplexen und wahrscheinlich chaotischen Übergang in eine Zukunft mit automatisierter Mobilität in geordnete Bahnen zu lenken. Die Ressourcen und Kapazitäten von Planungsakteur:innen, um proaktiv zu handeln oder, besser noch, identifizierte Steuerungsansätze umzusetzen, variieren jedoch erheblich zwischen Gemeinden und Regionen, die daran beteiligt sein wollen, wie sich Entwicklungspfade automatisierter Fahrzeuge auf lokaler Ebene manifestieren. Um zu analysieren, wie, mit welchen Mitteln und zu welchem Zweck sich Planungsakteur:innen auf die potenzielle Einführung der automatisierten Mobilität in einer der am schnellsten wachsenden Metropolregionen Nordamerikas vorbereiten, dienen Planungsinitiativen im Großraum Toronto als Fallbeispiel für eine eingehende Analyse.

Auf der Grundlage neo-institutionalistischer und sozialwissenschaftlicher Theorien wird Transformation als ein gradueller Wandel verstanden, der sich durch viele Instanzen explorativer Abweichung und Neuausrichtung vollzieht. Die Analyse stellt das transformative Potenzial endogener Veränderungsprozesse in den Mittelpunkt, die durch kreatives Handeln und soziales Lernen vorangetrieben werden, und widerlegt damit die weit verbreitete Behauptung, dass Automatisierung eine externe Disruption darstellt. Die Fallstudie zeigt die Handlungsfähigkeit von Planungsakteur:innen im Großraum Toronto auf, ihr Umfeld zu gestalten und neu zu erschaffen, indem sie bestehende Formen der Planungspraxis verändern. Die Veränderung bestehender Planungsmethoden kann entscheidend sein, um sicherzustellen, dass lokale und regionale Entwicklungspfade einer automatisierten Mobilität mit gesellschaftlichen Interessen in Einklang stehen. Innerhalb der institutionellen, politischen, kulturellen und räumlichen Rahmenbedingungen, die neue Formen der Praxis ermöglichen und gleichzeitig einschränken, schmiedet eine neue Generation von Verkehrsplaner:innen neue Beziehungen, Prozesse und Taktiken, um alternative Mobilitätsvisionen zu realisieren.

Die Studie bietet ein ausgewogeneres Verständnis von Transformation im Kontext automatisierter Fahrzeuge, indem sie deren Bedeutung für Mobilitätssysteme, städtischen Raum und Planungspraxis dekonstruiert. In einem aufschlussreichen Moment der Ungleichzeitigkeit hebt sie die Vielfalt des gesellschaftlichen, technologischen und räumlichen Wandels hervor, der sich in unterschiedlichem Tempo vollzieht. Während die anfänglichen Vorstöße von IT-Unternehmen

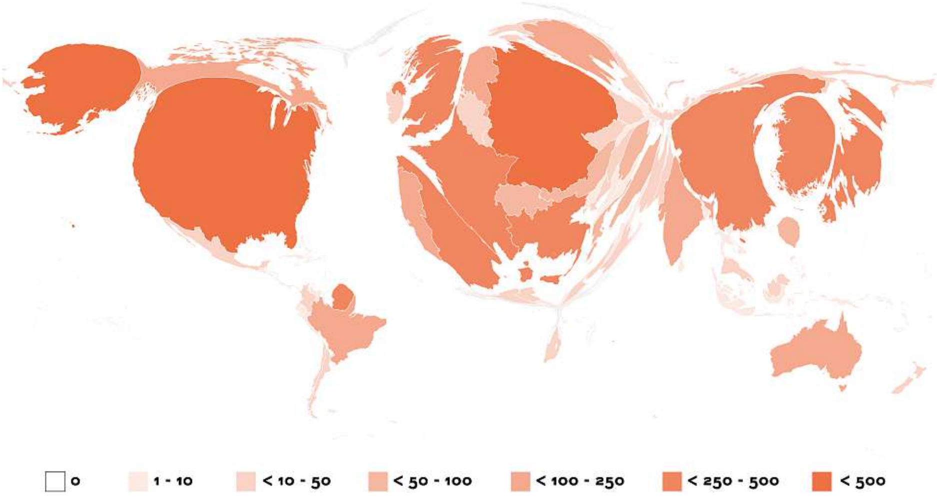
schneller erschienen, als Regierungen imstande waren zu reagieren, haben technologische Rückschläge inzwischen die Zeitachse der Kommerzialisierung von automatisierten Fahrzeugen verändert, mancherorts in einem Ausmaß, dass die Planungspolitik das Tempo der technologischen Innovation überholen ließ. Diese Zeitverzögerung muss als Chance erkannt werden, um den engen Fokus auf die technische Leistung zu erweitern und Raum für soziale Innovationen zu schaffen. Ob das Aufkommen automatisierter Fahrzeuge den Status quo im Verkehrswesen festigt und bestehende Herausforderungen verschärft oder stattdessen alternative Mobilitätsvisionen fördert, hängt auch von der Fähigkeit der Planer:innen ab, die sozialen Praktiken, die der Umsetzung von transformativen Visionen, Politiken und Konzepten im Wege stehen, neu auszurichten.

"Transformative change rarely occurs in instant revolutions. Changes evolve in many small ways, building a ground of understanding and experiences which, over time, eventually come together in what history may then describe as a 'transformative moment'." (Healey, 2006: 541)

PREFACE

In 2017, the year I embarked on this research journey, the trend analysis captured in the Gartner Hype Cycle indicated that automated vehicles (AVs) had just about reached the “peak of inflated expectations” (Panetta, 2017). Our interdisciplinary research team, formed at the Vienna University of Technology and supported by a generous grant from the Daimler and Benz Foundation, had just taken up its work to study the urban, societal and transport implications of this emerging technology through the lens of planning, asking the most fundamental question with which planners are concerned – how will AVs affect cities? Will the technology disrupt urban processes and life in cities to a comparable degree as the introduction of the automobile in the 20th century? Stumbling across our own biases, we later expanded our inquiries to encompass the impact of regional and rural applications. And while research endeavours on the subject were picking up, predominantly across the global North – colleagues produced an impressive geographical representation of all peer-reviewed articles related to AVs published in English between 2007 and 2017 (Fig. 1) – not many had yet found answers to these questions.

Figure 1 Peer-Reviewed articles published in English between 2007 and 2017 aggregated by country of origin



Source: From *AVENUE21 Review Meeting Proceedings*, by AVENUE21, 2017.

What initially felt like uncharted territory would soon emerge as a multifaceted and rapidly densifying field of research largely covered by computer scientists and transport systems engineers, but increasingly complemented by the perspectives of urbanists and urban planning professionals, social scientists and architects. In the four years that we worked as an AVENUE21 team, I benefited enormously from collaborative research, from the struggle to find a common language and agreement on fundamental terminology across disciplines and from the academic network that rapidly expanded across Europe to Germany, Switzerland, France, Denmark and England, to the United States and Canada as well as Singapore and Japan. Without the intense intellectual exchange with colleagues and like-minded international peers, this work would not be what it is today, all these debates, workshops, conferences and papers later.

By 2019, the year that I had the unique opportunity to conduct my personal research as a visiting scholar at Ryerson University (now Toronto Metropolitan University) in Toronto, Canada, the little dot indicating the trend analysis of AVs had slid down into the "trough of disillusionment" in the Gartner Hype Cycle (Panetta, 2019). Being utterly immersed in my research, I had not realized it until one of my Torontonian interviewees brought it up in our conversation. The repositioning on the graph mirrored the fact that in numerous pilot projects, which were increasingly conducted on public streets, it became evident that the technological performance of AVs was not yet up to the spatial complexity of many streetscapes – in their structural functional makeup as well as their lived reality. Although mainly based on market assessments, the disillusionment indicated in the Gartner Hype Cycle also reflected a growing sentiment among planning experts. The potential introduction of AVs would not simply alleviate existing road traffic challenges such as congestion, traffic fatalities and environmental pollution. Instead, its uncontrolled application – particularly during its initial phase of introduction – could exacerbate present conditions and create new conflicts. Early enthusiasm and positivist curiosity gave way to more cautious and weighed assessments that raised self-reflective questions among interviewees regarding the institutional capacity of municipal planning departments and the leverage of planning practitioners to proactively regulate a still evolving technology. This shift in perspective, away from what should be done normatively to what individual stakeholders are able to do given the institutional circumstances, has fundamentally influenced my thinking about planning for a potential future with AVs and thus my writing of this thesis.

Now, as I write my final chapters in 2022, little has changed in the assessment of the AV market. On a global political, societal and economic level, however, our world has been turned upside down by multiple crises. So much so that it would be inappropriate to speak of continuity in my writing and disregard the change occurring in contextual conditions, both personal and pertaining to the subject matter. While still immersed in books and academic thought, much of the writing has been displaced from university campuses into my private home – partly enforced by health policies, partly voluntarily by a new appreciation for isolated focus – with interruptions not merely caused by the mundane but by care work for war refugees, accommodated in an impromptu shelter set up by my housing association. An example of self-organized social infrastructure that complements and at times fills the gap of sluggish governmentally funded services. Given the historic events that have transpired since 2019, it has become nearly impossible to disentangle the complexity and ambiguity of their lasting impacts – an acute climate crisis, a global pandemic and a war in Central Europe with detrimental global social, economic and environmental effects.

Are AVs really what will disrupt and fundamentally transform urban systems in the early decades of the 21st century? Can AVs still be (part of) an answer to the challenges at hand? Against the backdrop of recent events, these questions appear naïve.

Yet, for an academic endeavour driven by an interest in transformational change, occurring not disruptively, but gradually throughout a long phase of incremental institutional realignments as introduced by Kathleen Thelen and others (Thelen, 2003; Streeck & Thelen, 2005; Dolata, 2011), the compounding global events have been instructive, if not critical, to the potential scientific relevance of this work. Circumstances in the Greater Toronto Area have changed radically since my research stay in 2019: an unprecedented emptying of Toronto's downtown core, a drop in transit ridership and car-induced traffic congestion, a historic expansion of the city's cycling network, a roll-out of numerous temporary streetscape alterations and a looming housing crisis. Planned initiatives for AV testing, meanwhile, were postponed and had to be terminated prematurely due to an unexpected technical fall-out. Although AV-related planning efforts in the Toronto region did not cease, the prioritization of planning actions had to be reconsidered. What is more, adjustments in planning practice took place that, while potentially unrelated to the advent of AVs, provided significant precedents for future actions that might shape the potential introduction of AVs.

Studying planning preparations for a still emerging mobility technology before a time of severe upheaval and concluding the research in the midst of that upheaval thus introduces an intriguing temporal multiplicity (Adam, 2003). The impact of normative planning decisions, as inscribed into developed strategies and policy documents, is constrained not only by institutional circumstances as mentioned above, but by the complexity of the temporal dynamics of a "reality in flight" (Van de Ven & Sminia 2012, in Hutter & Wiechmann, 2022: 2). As Barbara Adam elaborates with regard to an understanding of reflexive modernization, openings for change may arise from the paradoxical and unintended consequences of institutional decisions rather than from rationalized conduct (2003). I therefore study emerging patterns of change in planning practice by acknowledging the "irreducible 'otherness' of the future" (Beck et al., 2003: 11).

In this spirit, I would like to express my gratitude to

- the Daimler and Benz Foundation for funding the AVENUE21 research project as a Ladenburger Kolleg between 2016 and 2020, enabling three early career academics including myself to complete their PhD theses under exceptional conditions;
- the future.lab Research Centre at the Faculty for Architecture and Planning at the Vienna University of Technology for providing a platform to conduct truly interdisciplinary research;

- the Transform Lab at Toronto Metropolitan University for their openness to receive me as a visiting researcher and their willingness to generously support my endeavour;
- the Centre for Urban Research and Land Development at Toronto Metropolitan University for welcoming me into their friendly working environment and generously sharing their infrastructure;
- and particularly all interviewees in the Toronto region for their openness, interest and trust in engaging in comprehensive conversation as part of my research.

I want to personally thank

- my promoter and advisor Prof. Rudolf Scheuvens for entrusting me with great freedom throughout this journey and challenging me to grow through teaching opportunities and further research;
- my AVENUE21 colleagues and intellectual peers Andrea Stickler, Aggelos Soteropoulos, Matthias Mitteregger and Ian Banerjee for countless debates and enriching collaborations;
- Prof. Matthias Sweet for his generous support in establishing numerous contacts with interviewees during my research visit at Toronto Metropolitan University;
- Prof. Andreas Voigt and my colleagues at the Research Unit of Local Planning, Vienna University of Technology, for their supportive flexibility and encouragement;
- Dipl. Ing. (FH) Julia Sobota for her diligent revisions and editing;
- my mother for placing the image of a woman writing at her desk into a young girl's mind;
- my late uncle for sharing his fascination with the possibilities of technological advancements and the history of the future;
- my entire family for their tireless belief and reassurance, and for being the early sounding board that formed my ambitions;
- and my partner for his nurturing care and patience.

TABLE OF CONTENTS

PART I. SETTING THE SCENE

1. Planning for automated mobility

1.1. Object of research

This thesis examines the forces of change at work in the technologically, socially and spatially explorative phase scientifically referred to as the transition period towards automated mobility. It is a theoretical and empirical endeavour guided by the questions of *whether*, *in what form* and *to what end* novel forms of planning practice emerge in the midst of ongoing technological system change. To approach this inquiry, transformative change is understood to evolve gradually (Streeck & Thelen, 2005), through many instances of exploratory deviation and realignment. Novelties in planning practice are discerned as locally and historically contingent patterns of change (Healey, 2007; Christmann et al., 2020) that are shaped by the interplay of past dynamics, new driving forces and the creative agency of actors.

In the early 2010s, much of the public debate on automated vehicles (AVs) heralded their near-term market introduction. The industry's attention centred on computational feasibility, business opportunities or legal debates, but failed to look beyond the euphoria of technological innovation to recognize what software developer and data journalist Meredith Broussard describes as the "bleeding edge, where human achievement intersects with human nature" (2018: 7). Translated into urban planning jargon, the bleeding edge concerns the complex reality of urban traffic dynamics and socio-spatial diversity. Less than a decade later, setbacks in navigating what technologists consider "the corner cases" (Wevolver, 2020: 67), e.g. bad weather, poor infrastructure, or interaction with pedestrians and cyclists, have thus challenged claims of imminent disruption. Resolving these corner cases of automated mobility proved far more complex than originally anticipated and their occurrence was acknowledged as far too common to justify their neglect. But despite the tempered technological developments, many experts are undeterred: "For better or worse, one thing is now clear. The self-driving genie has escaped from its bottle. And it will not easily go back in." (Townsend, 2020: 20).

What we are currently witnessing may be the common time lag between the euphoria of early technological successes and the long period in which automated mobility matures and becomes societally diffused. In the early 20th century, American sociologist William F. Ogburn developed the concept of "cultural lag" (Godin, 2010: 286) to describe how the rate of cultural change differs between the societal domains of technological development, behavioural change and policy adjustments. Echoing the sentiment, many transport engineers and policy experts oppose the industry-led enthusiasm and expect that widespread adoption of AVs and their deployment under relatively unconstrained conditions are still years of testing and regulatory approval away

(Martinez-Diaz & Soriguera, 2018; Shladover, 2018; Litman, 2021). Further clarification is required with regard to basic safety and liability issues, privacy concerns, traffic effects and urban development implications (Fagnant & Kockelman, 2015). Above all, it is not yet resolved under what circumstances a technological system change towards automation can pose a desirable alternative for the liveability of cities and the built environment.

Proponents of vehicle automation technology assert that it bears societal benefits in the form of increased safety, more equitable mobility access, improved traffic efficiency, lower costs and more liveable neighbourhoods (Fagnant & Kockelman, 2015; Appleyard & Riggs, 2018). In particular, AVs are perceived to generate a public value when complementing public transit networks, for instance through first- and last-mile feeder shuttles (Fraedrich et al., 2019). Some even go so far as to claim that "If used wisely in the years ahead, AVs could be one of the most powerful tools we have for reducing carbon emissions and halting global warming." (Townsend, 2020: 19). More cautious assessments, meanwhile, emphasize that AVs will lead to short-term traffic inefficiencies (Chaudhry et al., 2022) and induce travel demand in the long run (Taiebat et al., 2019). Efficiency gains and time cost savings, which initially increase passenger convenience, may incentivize additional travel and energy use over time, while new user groups and empty vehicles further add to the overall growth in vehicle travel (Fagnant & Kockelman, 2015). In spatial terms, the benefits of reduced parking demand (Zhang & Wang, 2020) are equally contrasted by the possibility of greater urban sprawl due to the lower cost of long-distance travel (González-González et al., 2020). The most critical voices on this issue argue that widespread adoption of AVs could not only erode transit systems and jeopardize public health (Stead, 2019), but also negatively affect shared experiences and social cohesion in public spaces (Docherty et al., 2022).

> *"Providing public-sector agencies with the necessary tools to plan for this disruption will play an important role in facilitating the smooth integration of CAV with transportation systems."* (Ontario, 2020a: 5)

The discrepancies between the assessments show that vehicle automation is not neutral, nor is its impact inevitably aligned with existing policy goals. Instead, the future of transportation systems potentially dominated by AVs will be shaped by a complex dynamic of multiple factors: governance and political leadership, market forces, levels of public acceptance, legacy transit systems and spatial environments. Within this interplay of forces, local and regional planning authorities can assume an important role in "pushing, organizing, and implementing AV related planning actions" (Fraedrich et al., 2019: 8). Whether they do so is not only a matter of proactive action, as is often emphasized, but above all a question of development objectives, underlying value sets and the modes and tools that support their implementation. Are AVs viewed primarily in the context of improving traffic network issues and optimizing infrastructural capacity for the sake of traveling more? Or is their introduction embedded in a broader understanding of an environmentally sustainable and socially just mobility system (Manderscheid & Cass, 2022) that supports equal access to opportunities, public health and "civitas" (Docherty et al., 2022)? Thus, what is at stake as AV pilots seep into urban and rural transportation systems is *whether*, *how* and *to what ends* planning authorities prepare to manage the complex and likely messy transition to AVs (Freemark et al., 2019; Chaudhry et al., 2022).

In the literature on AVs, policy recommendations emphasize the need to align the introduction of AVs with existing development goals (Lyons, 2018; Fraedrich et al., 2019). In addition, policymakers and planning professionals are called to shape the long-term transition to AVs in support of broader societal values and to discourage commercial trajectories that run counter to public interests (González-González et al., 2019; Docherty et al., 2022). Yet many of the policy levers and regulations recommended to mitigate the adverse effects of AVs are not necessarily new, e.g. congestion charges and mixed-use development policies. Instead, they resemble tools and measures that call into question the prevailing system of automobility and require that a critical mass of system components is changed in a coherent direction in order to unfold their transformative potential (Bertolini, 2017: 130). The present study therefore focuses on the micro level of municipal and regional planning to investigate whether the advent of AVs leads public-sector actors to reassess policy priorities and introduce novel means in planning practice. Is the technological system change of the early 21st century contributing to planning transformations? If so, at what pace is the change occurring and what direction is it taking?

> *"AVs have the potential to impact the way that City staff plan for, prepare, and deliver services to the public."* (Toronto, 2019a: iv)

The extent to which planning professionals prepare for the potential introduction of AVs, e.g. by adapting planning documents and participating in pilot initiatives (Fraedrich et al., 2019), depends heavily on the local characteristics of cities and regions (Freemark et al., 2019). Even though municipal planners may be open and willing to develop regulations, they may simply lack the necessary resources to do so (ibid.). The contextual differences in how cities and regions manage the transition to AVs are even more significant when it comes to translating identified policy interventions and concepts into practice. Whether it concerns new governance arrangements to ensure consistent standards and integration of services, or the introduction of potentially controversial measures such as the enforcement of parking restrictions and pricing policies. The institutional capacity of planning professionals significantly influences their ability to act proactively. Transport scholars have therefore argued that a deeper understanding of the planning and policy context of stakeholders is required to assess how local and regional pathways to future mobility systems with AVs may evolve (Legacy et al., 2019; Docherty et al., 2022).

In this vein, the present research endeavour draws attention to two distinct themes. On the one hand, it focuses on the specificity of contextual forces, that is, the institutional, political, economic, cultural and spatial circumstances that shape policy and strategic planning processes (Booth, 2011; Reimer et al., 2014; Legacy et al., 2019). Particular attention is paid to the resources that planning professionals have available to engage in planning initiatives (Freemark et al., 2019) and to embed new policy fields into their day-to-day organizational procedures (Evans et al., 2021). It is the intricacies of local planning contexts that essentially determine which hurdles need to be overcome in order to effectively manage the transition period in favour of greater societal benefits. On the other hand, particular attention is given to change processes in planning practice that may occur as public authorities engage in planning preparations, adopt strategic positions and implement policies related to the advent of AVs. The focus here lies on change initiated by planning and policy actors themselves (Ibert et al., 2015), fostering novel practices in relation to the specific circumstances of a time and place (Albrechts, 2011; Cajaiba-Santana, 2014).

In order to analyse pattens of change in a situated and contextualized manner, a qualitative case study analysis is conducted on the planning initiatives for AVs, initiated in the Greater Toronto Area (GTA) in Canada. As in many other urban regions that have been considered pioneers in governing the transition to AVs (Mitteregger et al., 2022: 84), planning authorities are engaged in monitoring efforts and research partnerships, pilot programs and policy development. More importantly for this study, however, planning authorities in the GTA have been involved in AV-related initiatives for nearly a decade, providing a case for a continued effort that has been relatively well embedded into organizational structures. This makes it possible to analyse both the temporal progression of activities on AV-related activities and the emergence of novel practices in the context of locally and historically contingent forces. By drawing on the notion of transformation as a gradually unfolding and long-lasting process (Streeck & Thelen, 2005; Dolata, 2011), the case study research takes stock of different velocities of change addressed at the beginning of this chapter with reference to a cultural lag. Moreover, it acknowledges not only that the transition towards AVs unfolds "at different paces in different cities and regions" (Dochorty et al., 2022: 7), but also that it draws its characteristics from a temporal multiplicity of change (Adam, 2003).

1.2. State of the art

Few studies to date have examined the institutional, economic and spatial circumstances that influence whether and how municipalities have begun to prepare for a future mobility system with AVs. As a basis for the empirical research in this thesis, three U.S. and one German study conducted between 2014 and 2019 are reviewed. Importantly, all studies represent empirical research, conducted through quantitative surveys and/or qualitative interviews with representatives from different levels of government, public planning departments and industry.

The "Automated Vehicles: Policy Implications Scoping Study" conducted by Wagner et al. (2014), represents a systematic review of the state of technology and policy development in the United States at that time. One of the study's aims was to facilitate a knowledge transfer between the private sector (automated vehicle industry) and representatives of the public sector (state officials and members of local transportation authorities). To this end, the interview results from the discussions with industry representatives were used as a basis for the later discussion with public transport experts (Wagner et al., 2014). The findings show that there was a high degree of uncertainty in the public sector at the time. On the one hand, regarding the technological development paths of AVs and the potential to realize their societal benefits, e.g. relieving congestion (Wagner et al., 2014). On the other hand, concerning the regulatory response of governmental entities, which was discussed at the state level but not yet at the regional or municipal level. However, there was clarity on the need to coordinate regulations and standardization agreements in the early phase of transition, which is characterized by AV testing (Wagner et al., 2014: 36). With infrastructure considerations largely focused on digital connectivity, the study highlighted the disconnect between hampered AV deployment due to slow infrastructure development and the lack of public funding and empirical evidence to do so resourcefully (Wagner et al., 2014).

In 2016, Guerra (2016) published an early study of how planners at large metropolitan planning organizations (MPOs) in the United States were preparing for what he describes as potentially the "most transformative transportation technology since the internal combustion engine and the mass-produced automobile." (211). The study aimed to clarify the reasons why regional transportation plans (RTP) did not consider AVs at this time and what planning measures were being proposed by MPOs. To this end, the RTPs of the 25 most populous metropolitan areas in the United States were analysed and followed by fifteen interviews with transportation planning experts. Consistent with the study by Wagner et al. (2014), interviewees stressed technological, regulatory and behavioural uncertainties related to AVs. In addition, officials cited uncertainty as the primary reason why local RTPs contained limited references to automated vehicles and why related planning actions were withheld. Planning efforts considered included the development of planning scenarios and travel behaviour models, the commissioning of AV testing and the adaptation of regional investment priorities (Guerra, 2016: 218).

To gain a better understanding of how German municipalities planned for AVs, Fraedrich et al. (2019) conducted a two-phase empirical study in cooperation with the Association of German Cities (Deutscher Städtetag) and its expert commission on transport. The results of the study include a thorough review of the impact of AVs on the built environment, insights into the perceived compatibility between AVs and existing policy goals as well as possible implications for urban policy and planning. The results of a survey conducted in 2016 show that only one-third of German cities whose officials participated in the survey had addressed or planned to address automated mobility (Fraedrich et al., 2019: 166). Remarkably, the sample shows no difference in the level of preparedness between large and medium-sized cities. With regard to the most frequently prioritized transport objectives, e.g. "strengthening non-motorized transportation", "strengthening and complementing public transit" and "reducing energy consumption, CO^2 and air pollution" (Fraedrich et al., 2019: 166), the results indicate that transport experts largely associated the introduction of AVs with negative impacts on their realization. Positive impacts were in turn associated with lower priority policy goals, such as increasing road safety and improving traffic flow and infrastructure capacity (Fraedrich et al., 2019: 167).

A preliminary conclusion of the study was therefore that low level of preparedness of municipalities correlates with a lack of knowledge and familiarity with the potentials of AVs (Fraedrich et al., 2019: 169). The results of the subsequent expert interviews substantiated this hypothesis. Transport planners representing cities that had commenced planning preparations for AVs displayed largely positive attitudes regarding the potentials of the technology, e.g. concerning safety and efficiency gains, but did not deny concerns about potential risks, e.g. increase in VMT and decrease in public transit use (Fraedrich et al., 2019: 169). Municipal planning activities mainly involved the adaptation of planning documents and the preparation of pilot projects. The interviewed transport planners largely shared the objective that AVs should enhance public transit, but disagreed on the issue of infrastructure investment (ibid.). Viewpoints ranged from concerns about funding, confirming the findings of Wagner et al. (2014), to scepticism, to a clear rejection of infrastructure adaptation in order to accommodate AVs and the demand that the industry compensate the respective needs. Overall, the compiled study findings revealed four topics that German municipalities share in terms of preparing for AVs (Fraedrich et al., 2019: 169–170):

1. *Municipalities as driving and steering forces:* Planning authorities play a major role in pushing, organizing and implementing AV-related planning measures. Their focus centres on adapting technology to what serves the city through regulatory activities.
2. *Strengthening, supporting and (re)developing public transport as a major goal*: Instead of creating competing service offers, transport planners call for flexible AV services to complement existing transit networks, increase their attractiveness and make use of existing infrastructure.

3. *Fighting potential increase in car use and its negative effects:* Due to concerns about a potential increase in individual motorized traffic, officials call for systemic approaches, such as enforcing electrification and parking restrictions.
4. *Municipalities' objectives versus federal policy and industry interests:* In Germany, municipal goals (e.g. welfare system, liveable cities) contrast those at the federal level (e.g. economic competition, safety, efficiency). Officials perceive the pressing need for a joint strategic position of municipalities to influence federal policy on research and development priorities (ibid.).

All three studies by Wagner et al. (2014), Guerra (2016) and Fraedrich et al. (2019) emphasize the perception, shared by public officials and planning experts, that existing research has not provided sufficient, actionable, short-term guidance on direct investment and planning priorities concerning AVs. A lack of knowledge on how AVs could positively contribute to urban development challenges and goals stood out. The three studies therefore inform the present research with regard to the following subjects: a.) knowledge level and familiarity of municipal planners with AVs, b.) planning activities to prepare for AVs, c.) the role of transit and active modes, d.) the division of regulatory responsibility for AVs between levels of government, e.) the perceived influence and power of municipalities to shape and manage the transition to AVs, and f.) the institutional relations between government agencies.

Finally, Freemark et al. (2019) analysed the level of preparedness for AVs among U.S. local governments. The study sets itself apart from previous research by examining the correlation between local governments' AV policy adoption and place-specific characteristics, such as demographics (level and change), employment, density, budgets, wealth and political affiliation (Freemark et al., 2019: 136). Importantly, the study showed that U.S. cities respond to AVs with contrasting approaches and show different levels of willingness to engage in policy-making and regulations, depending on local characteristics. To this end, the study examined the comprehensive transportation plans of the 25 largest cities in the U.S. and sent a quantitative survey to 120 U.S. cities with more than 100,000 inhabitants. In addition to surveying developed policies, the authors explored the determining factors, e.g. governments' motivations, obstacles and resources for adopting policies (Mohr, 1969), and whether the advent of AVs encouraged the adoption of well-known, yet politically contested measures, such as congestion pricing (Kingdon, 1986, in Freemark et al., 2019).

The study confirmed the findings of Guerra (2016) and showed that planning initiatives for AVs among U.S. municipalities remain limited. However, officials did have a clear understanding that the technology could significantly alter urban transportation systems and environments in the years to come. In line with the findings for German municipalities (Fraedrich et al., 2019), a large number of respondents displayed optimism about the features of automated mobility (e.g. increased safety and reduced pollution, decreased energy use and lower transportation costs), but was also concerned about increased VMT and urban sprawl, as well as a decline in transit ridership and employment. Notably, the results show that a large proportion of officials would be willing to develop regulations, but that they lack the resources to engage in policy preparations (Freemark et al., 2019: 148).

In terms of the correlation between municipal preparedness and local characteristics, the study identified a strong link between policy engagement and larger municipal budgets, population size and recent municipal population growth (Freemark et al., 2019). Concerns about the negative impact of AVs were particularly shared by cities with more liberal political ideologies, extensive municipal budgets and larger populations. Public officials from such cities would also indicate a higher willingness to regulate through restrictive measures. By contrast, results for municipalities with limited financial resources showed a tendency to perceive AV policies as less of a priority, while results for smaller cities showed greater reliance on legislation from higher-level governments. Moreover, a correlation was found between prioritization of AV policies and municipalities with political officials less opposed to the potential introduction of AVs. Cities that experienced recent population growth were outliers in the study, as they showed high levels of preparedness and policy prioritization, yet paired with an unwillingness to regulate. According to the authors, many fast-growing cities are pursuing a governance approach in which public interference is intentionally withheld “in the face of private investment driving change” (Freemark et al., 2019: 145).

In terms of perceptions of different experts, e.g. directors of planning or transportation departments, the study revealed partially diverging expectations towards AVs (Freemark et al., 2019). No significant difference was found in representatives’ understanding of how AVs may impact land use (e.g. street space segregation and urban sprawl) and transport development (e.g. VMT and congestion). Opposing views instead concerned whether “AVs will improve the city”, “reduce pollution”, and whether “responsibility over AV policy had been clearly defined” (Freemark et al., 2019: 148). In comparison to transportation officials, urban planners were sceptical of the positive impact of AVs on these issues. With regard to the latter, it is noteworthy that 40 % of cities assigned responsibility for AVs to multiple departments, 32 % to transportation departments and roughly 10 % to planning departments. In this light, Freemark et al. (2019) argue that “a clearer division of responsibilities between different levels of government, combined with state authorization to use municipal powers to help shape the arrival of AVs” (148) are necessary steps to reduce municipal governments’ hesitation to adopt policies.

Given that American cities respond to AVs with varying approaches, the study by Freemark et al. (2019) points out that policy recommendations assuming a "one-size-fits-all approach" (Freemark et al., 2019: 149) overlook contextual dependencies, such as resource levels and political leanings. Moreover, while the research was able to show that transport and planning officials play an important role in the early stages of a policy cycle, it did not reveal the extent to which their actions influence the final decision-making of elected officials. Freemark et al. (2019) therefore emphasize the need for further research on this topic. Inspired by these two aspects, the present research on the Greater Toronto Area pays particular attention to the resources and institutional capacity that municipal planners have to influence the adoption of AVs and to translate developed policies into practice. In addition, the present analysis examines how responsibilities over planning for AVs are divided between transportation and urban planning departments, and how they differ in their ability to shape the transition to AVs. Finally, the present research expands on the analysis of local characteristics by Freemark et al. (2019) by taking a historical perspective and considering the broader planning cultural context of the analysed city region.

1.3. Research questions

In addressing one of the most advocated technological trends of the early twenty-first century, this work is guided by an interest in whether effectively managing the transition to automated mobility in urban and rural contexts requires a change in planning practice. The research is therefore not normative, i.e. debating why planning practice *should change* in the face of AVs, but rather interpretive, scrutinizing *whether, in what form* and *to what end* novel forms of planning emerge as cities prepare for the potential introduction of AVs. The main research question is therefore as follows:

> To what extent do novel modes of planning practice emerge in the midst of the societal, spatial and technological transition to automated mobility (AM)?

To operationalize the empirical study, the main research question is divided into three sub-questions, which are theoretically addressed in Part I of the thesis, Setting the Scene, and empirically examined in parts II to IV (Fig. 1.1). Based on findings from qualitative expert interviews and an extensive literature review, Part II explores current planning initiatives and ties into previous research on how cities and city regions prepare for automated mobility by providing answers to the question below:

I. By what means (objectives, processes and instruments) and to what end are the various planning actors in a metropolitan region such as the Greater Toronto Area (GTA) preparing for the advent of AVs?

To this end, planning initiatives for automated mobility are examined with regard to regional actor constellations, the institutional setting for collaboration (e.g. networks and committees), initiated planning modes and tools (e.g. legal amendments, adopted policies, strategic planning documents and pilot projects) and underlying objectives. To contextualize AV-related planning initiatives and gain a better understanding of the planning cultural context that may both motivate and constrain efforts to adopt novel planning practices, the research further addresses the question:

II. How do planning initiatives for AM relate to their planning cultural context, e.g. urban structures and transportation system, planning framework, institutional relations and societal perceptions of technology?

The challenges and expectations raised by the interviewed experts in relation to a possible introduction of AVs serve as an entry point to examine the local specificities of mobility and urban development planning as well as regulatory capacities and institutional arrangements in the GTA. Building on neo-institutionalist and social science theories, potentially transformative change in planning is understood as a gradually unfolding process that emerges from endogenous potential and is fostered by actors' agency and social learning. In an effort to identify patterns of emerging novelties in planning (Christmann et al., 2020), planning initiatives for AVs are reconsidered against the backdrop of recent developments and perceived challenges. To this end, actors and actor networks, the planning and policy elements conceived, as well as institutional arrangements of AV-related planning initiatives are examined. Acknowledging that novel modes of planning may occur in response to the advent of AVs, but may equally well have emerged prior to AV-related preparation and are now merely being reconfigured, the research concludes by examining the question:

III. To what extent can patterns of change and realignment in planning practice be traced in relation to planning initiatives for AM? In what form do they take place?

1.4. Research aims & thesis structure

This work seeks to bring greater attention to the role of experts and their ability to influence planning initiatives for AVs by investigating whether planning professionals take up novel practices as they prepare for a potential introduction of automated mobility. The interest is rooted in the notion that planners have the capacity to proactively change established practices, rather than merely reacting to external pressures or "when things go wrong" (Healey, 2006; Christmann et al., 2021; Docherty et al., 2022: 6). At the same time, the endeavour rests on the notion that cultural contexts shape technological advancements just as much as they influence planning processes, societal dynamics and politics (Graham & Marvin, 1996). By combining these lines of thought, the research aims to promote a more differentiated understanding of the transformative potential of automated mobility – a common claim in the transport and urban planning literature on the subject (Alessandrini et al., 2015; Beiker, 2016; Duarte & Ratti, 2018).

In this effort, research points to the context-dependence of such claims, which pertains to the plausible scale of change in urban transportation systems, as well as planning and policy practices (Marsden & Docherty, 2013). Moreover, by focusing on endogenous changes taking place within the planning profession, it challenges the common perception in the existing literature on automated driving that urban processes are disrupted or transformed solely by an external force such as automated vehicle technologies. Instead, it explores the agency of planners to influence local and regional pathways to AVs by shaping policy and planning processes in line with the values, ideals and agendas they hold as professional planners (Füg & Ibert, 2020: 557). Processes of change in planning are therefore understood not only as locally and historically contingent (Christmann et al., 2020), but as social processes that unfold through the interaction of planners and their planning cultural contexts (Cajaiba-Santana, 2014: 49).

In tracing deviations in local planning practice against the backdrop of planning cultural specificities, this thesis generates both theoretical and methodological knowledge. It offers theoretical insights into the correlation between emerging mobility technologies and processes of change in planning practice. In this context, it deepens the understanding of how institutional, political and cultural forces may inspire or hinder planning practitioners to forge novel strategies, and the means they adopt to overcome resistance. Resistance may refer not only to institutional gridlock, but also to public opposition towards novel schemes in transport planning. Meanwhile, methodological insights are gained about the possibilities and limitations of tracing patterns of currently unfolding change processes, rather than doing so in retrospect. The generated insights may be of relevance to scholars and planning practitioners interested in the subject of AVs and their potential impacts as well as professionals studying processes of change in planning practice. The following section therefore refers to the relevant chapters by area of interest.

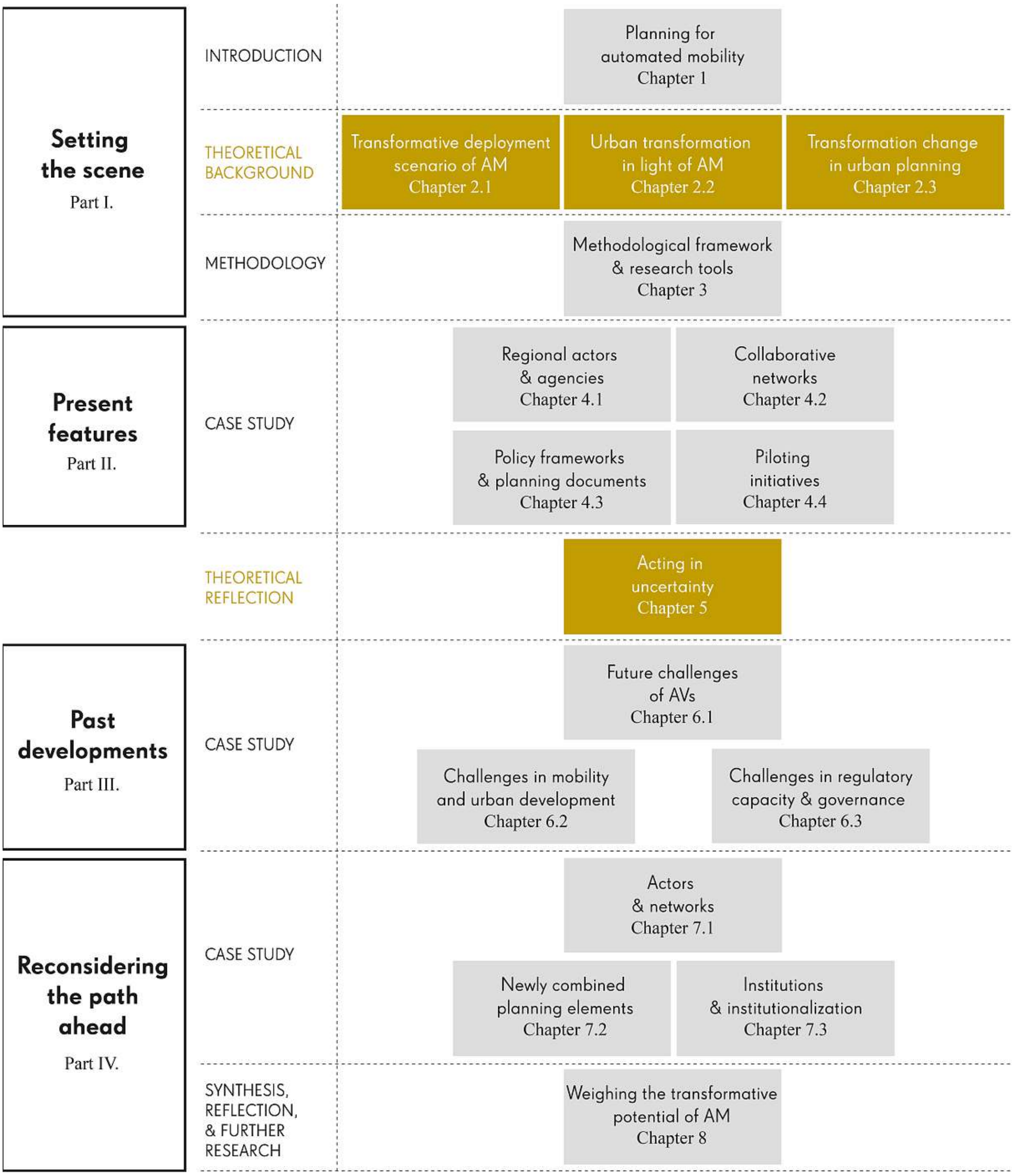
Thesis structure & reading guide

The present work is structured into four parts, comprising eight chapters (Fig. 1.1). Part I sets the framework for the research by introducing its aim and research questions, the theoretical background and the methodological approach. Within the theoretical background (Chapter 2), the meaning of automated mobility's "transformative potential" is differentiated for transportation systems, urban development and planning practice. Academics and planning professionals interested in the potential impact of AVs on urban development and in particular on the design of streetscapes will find a comprehensive research synthesis in Chapter 2.2. Readers interested in theoretical concepts of transformative change in planning practice may advance to Chapter 2.3. The case study approach of this thesis, which translates theoretical concepts of change in planning into an analytical framework, is elaborated on in Chapter 3.

Parts II, III and IV comprise the empirical part of this work. Chapter 4 centres on planning and policy preparations on AV technologies that were commenced between 2014 and 2022 in the GTA, Canada. Municipal planners and academics seeking a comprehensive synthesis of local and regional activities will find information on the involved "Actors & agencies", "Institutional settings for collaboration, "Policy frameworks & planning documents" and "Pilot initiatives". In Chapter 6, the challenges that the interviewed experts associate with the potential introduction of AVs are taken as an entry point to elaborate on the specificities of the GTA's planning cultural context. Following a general review of the "Future challenges with AVs", the thesis focuses on contextual challenges concerning the mobility and urban development of the region, as well as the institutional capacity of planning actors and transport-related governance arrangements.

In conclusion, municipal planners and scholars interested in identified patterns of change and the capacity of planning practitioners to proactively shape the means of planning may gain relevant insights from the interpretive findings presented in Part IV of this thesis. Chapter 7 illustrates traceable "patterns of change", some occurring in response to the anticipated introduction of AV and some emerging as new assemblages of multiple concurrent change dynamics. The synthesis of the case study findings and concluding remarks on velocities of change shaping the local and regional pathways to automated mobility are presented in Chapter 8. The work concludes with reflections on the methodological approach and the potential for future research.

Figure 1.1 Thesis structure



Source: illustration by the author.

2. The transformative potential of automated mobility

Since the early 2010s, much of the public discourse around vehicle automation has focused on the technology's disruptive power. Public attention was drawn to the rush within the tech and automobile sectors to follow suit with Google's efforts to develop a self-driving vehicle under the lead of former Stanford scientist Sebastian Thrun[1]. In contrast to the market introduction of electric vehicles, which was largely pushed by policymakers, Sperling (2018: 47) argues that driverless technology has instead been pulled into the market by consumer demand and industry competition. Amidst the reignited euphoria – research endeavours to launch self-driving robots date back to the mid-1960s – many asserted the onset of a driverless revolution that would not only fundamentally transform transportation systems, but significantly alter the urban fabric and life in cities, regions, and rural environments (Alessandrini et al., 2015; Sperling, 2018).

> *"With the emergence of AVs, we have another opportunity to rethink urban life and city design. Instead of thinking reactively, we argue that urban designers should embrace AVs as a catalyst of urban transformation."* (Duarte & Ratti, 2018:12)

In the meantime, the technological setbacks of recent years have shown that the transition towards vehicle automation is unfolding in a more unsteady and geographically fragmented way than initially expected (Markoff, 2010; Beiker, 2016). Despite numerous demonstration projects, conducted on highways, inner-city roads, or in rural downtowns, the technological performance of highly automated vehicles (e.g. AV shuttle buses) has by and large remained faulty and capital-intensive, resembling "hopeful monstrosities" (Geels, 2002: 1261), as radically new technologies have been described. Emerging in niche-like environments which allow for learning processes, technological innovations are expected to cumulate over a long period of time. Mitteregger et al. (2022) correspondingly characterized the transition towards automated mobility as "long level 4". This implies that the transport integration of highly automated vehicles (SAE Level 4 according to SAE International, 2018) will progress gradually and selectively within urban environments, alongside conventional, motorized vehicles (Beiker, 2019; Shladover, 2018).

The recent plunge into the "troth of disillusionment" (Panetta, 2019) begs the question – how will the transition period evolve? Optimistic voices sustain the view that in the long run, technological advancement will prevail: "So while the driverless revolution starts with a trickle, before long that slow drip will become a torrent. By 2050 or thereabouts, most human-driven cars will be gone." (Townsend, 2020: 11). But even if highly automated vehicles were to meet the required safety

[1] A pioneer in automated vehicle technology (Sperling, 2018), Sebastian Thrun led Stanford's winning team at the 2005 DARPA challenge and founded Google's self-driving vehicle program (Townsend, 2020).

standards and become commercially available by 2030 (Litman, 2022), they will likely be limited to high-priced consumer segments and continue to be technologically constrained, e.g. operating only along predefined corridors. A more moderate assessment that acknowledges a spatially selective introduction and the unpredictability of consumer preferences is that fully automated vehicles are unlikely to navigate all parts of the road network before 2075 (Shladover, 2016).

As a result, critics have scrutinized the linear thinking underlying the widely adopted terminology of SAE levels, that suggests successive technological advancement. Stayton & Stilgoe (2020) argue, for instance, that the SAE levels disregard the possibilities of human-machine cooperation, the variation of operational feasibility within systems, and the significance of environment, infrastructure, and context. A state where fully automated vehicles navigate all parts of a road network under any condition (SAE Level 5) is not only utopian to Stayton & Stilgoe (2020), but also constitutes an "unattainable end state" (6). Arguing in favour of more nuanced technological notions of AVs, the authors essentially call for greater variation and contextual specificity in place of linear technological progress. A sentiment that resonates with Geels' (2002) understanding of technological transitions, which he conceptualizes as evolutionary processes encompassing variation, selection, and retention mechanisms. According to his line of thought, radical technologies are not simply adopted by design, but undergo a selection process, which requires their integration into the routines and everyday practice of users, adequate response by policymakers and institutions, and inclusion in cultural debates. In order to be permanently integrated into a socio-technical regime, technological innovation needs to coincide with socio-political, institutional, and spatial changes – all of which are essentially context-dependent processes (Geels, 2002: 1272).

The review of policy and legal amendments commenced by different levels of government is perhaps more revealing of how and where the transition towards AVs is unfolding. During the past decade in the United States, for instance, the absence of an AV-specific regulatory framework at the federal level has prompted state governments to determine whether companies are allowed to test AVs on private circuits or public roads, and whether they are permitted to offer commercial services while still testing the technology (Fanelli & Stoddard, 2022). The result is a heterogenous landscape of R&D activity, largely concentrated in states that are home to tech companies (e.g. California), the automobile and manufacturing sectors (e.g. Michigan), as well as renowned research institutes and universities (e.g. Massachusetts). The policy role assumed by individual states greatly varies. On the one hand, there are states such as California or Pennsylvania that issued state-wide testing permit systems (Steckler et al., 2021). The former stands out, as it is the only U.S. state that requires companies participating in the Californian Autonomous Vehicle Tester Program to share the testing data compiled on public roads, particularly disengagement and collision reports (Boggs et al., 2020).

States with the least restrictive regulations, on the other hand, include Arizona and Texas (Bellon, 2022). Stable weather conditions and vast suburban infrastructure add to the appeal of testing under less complex environmental conditions. As a result, both states have been early sites of commercial service offers by companies developing AV technologies. While passenger trips and food delivery services are operational since 2020, commercial freight delivery may be commenced as early as 2023 (Bellon, 2022). Interestingly, both states have pre-empted local governments from regulating AVs or imposing additional requirements, e.g. concerning areal coverage, data sharing, or service operation (Steckler et al., 2021). Although the scope of commercial services with highly automated vehicles remains limited to date, the legal amendments and policy actions demonstrate how vehicle automation is gradually seeping into the transportation system, above all in states and regions with accommodating and industry-friendly regulatory frameworks.

> *"Just as the automobile did, AVs provide an opportunity to rethink our world."*
> (Townsend, 2020: 19)

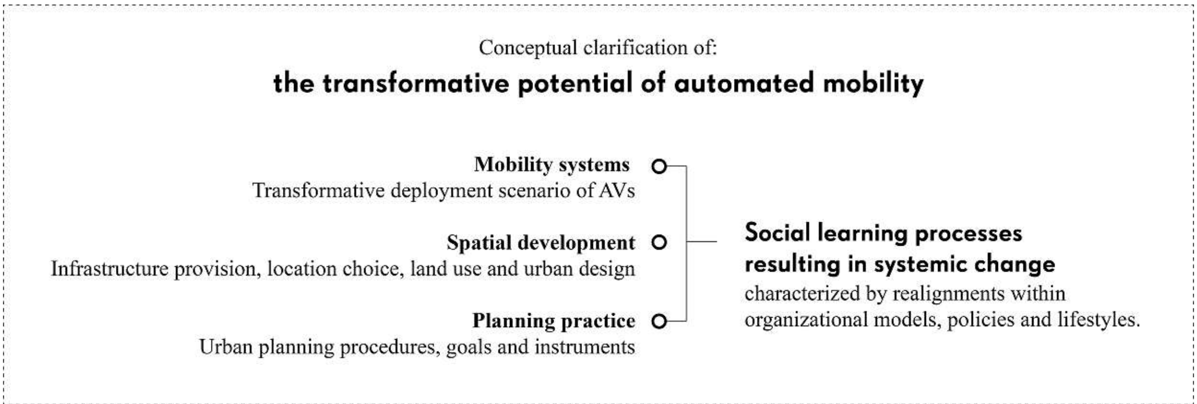
Against the backdrop of unsteady technological development, uncertainty with regard to public acceptance, and inconsistencies across regulatory frameworks, the introductory claim to this chapter that AVs will have a transformational impact on urban and rural environments may appear far-fetched. Yet it is precisely this claim, which prompted the inquiry into the transformational potential of AVs, that lies at the core of this work. To approach this question with an emphasis on transformation as incremental change, the endeavour distinguishes itself from claims that draw on historical analogies between vehicle automation and the vast impact of the introduction of the automobile on urban development throughout much of the 20th century. As political scientists and historians have argued, drawing parallels between contemporary historical moments and past periods is not only bold, but may also be dangerous (Confino, 1994; Shulmann, 2018). An overemphasis of correlations with the past falls short of recognizing the influence of contemporary socio-economic, political, as well as urban preconditions. Importantly for this work on changes in planning practice, drawing parallels to the introduction of the automobile omits the extent to which planning principles, and the thinking on and planning for the complexity of urban dynamics have evolved throughout the past century. Thus, projecting past trajectories or contemporary planning standards into the future would not only disguise subtle, yet unfolding, change, but stand in the way of recognizing its mechanisms and direction.

To delineate how the transformative potential of AVs may be understood apart from historical analogies and the assumption of imminent disruptive change, this chapter introduces study results on mobility system configurations with AVs and their expected spatial implications, as well as theoretical concepts about incremental change. Etymologically, *transformation* is a noun of action that stems from the Latin verb *transformare*, literally meaning "to change in shape, metamorphose"

(Online Etymology Dictionary, n.d.). As such, it describes an activity – to "undergo a change of form" (ibid.). In the fields of planning, social sciences, and policy making, *urban transformation* has become a widely used phrase. While it largely addresses processes and results of change in urban areas, definitions vary. Much of the literature and research emerging from Science and Technology Studies, for instance, is concerned with systemic processes of change for sustainability (Wolfram et al., 2016). Research angles on urban transformation may thus range from concerns about system change (i.e. new system configurations), to urban change (i.e. new spatial structures, processes, or paradigms), and urban system relations.

Setting the scene for the subsequent parts of the thesis, this chapter introduces different dimensions affected by transformative change processes in the context of vehicle automation: a.) urban mobility systems; b.) urban design and spatial development; and c.) local planning practice (Fig. 2.1). The main body of work focuses on the third dimension, that of planning practice, in order to determine whether responses to automated mobility entail changes in planning, and if so, towards which goals. In this context, transformation is understood as change, which is essentially rooted in social learning processes and may be characterized as realignments towards new trajectories and goals, as well as new organizational structures, policies and lifestyles (Zapf, 1989: 177).

Figure 2.1 Three types of transformative potential



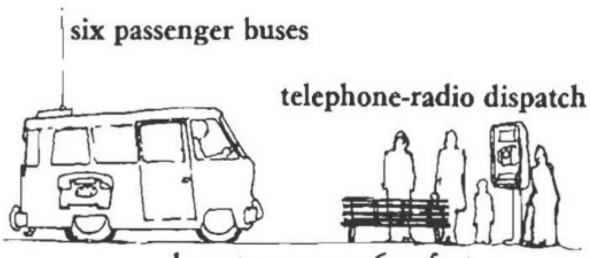
Source: illustration by the author.

2.1. Transformative deployment scenario of AM

The advent of automated vehicles and their decelerated, yet ongoing market introduction, rests on a number of promises. These range from security enhancements curbing road fatalities, efficiency gains in traffic flow and reduced congestion, to improved accessibility for those who physically cannot drive, or the expansion of mobility options for children, the elderly and those who cannot afford to drive (Gavanas, 2019). Beyond these notions commonly associated with AVs, not all forms of application and operational models resemble a substantial transformation of the mobility system as we know it. Beiker (2016) describes the transformative deployment scenario of automated vehicles as that which merges personal mobility with public transport, largely pursued by high-tech start-ups eager to deploy high or fully automated vehicles (SAE Level 5). The vision rests on automated mobility on-demand systems (AMOD), which combine the convenience of private vehicles – that is, door-to-door travel and flexible routing and scheduling – with the space-efficient sharing of trips similar to traditional transit options.

Remarkably, the vision of demand-responsive point-to-point services with flexible routing is not as novel as one might think. In fact, MIT scholars were already studying the advantages of *dial-a-ride systems* in the 1970s. Based on radio-connectivity and a computer program to manage real-time routing and scheduling, the intention was to develop a personalized system that was better attuned to customer needs (Roos, 1971). At the time, Christopher Alexander and other architects (1977) asserted that transit networks should integrate such feeder systems in order to bridge the access gap between transit stations and meet the needs of those who cannot drive (Fig. 2.2). While the vision of on-demand feeder buses was never as widely institutionalized as it is currently debated, the dial-a-ride concept did lay the foundation for door-to-door paratransit services, which have played an important role in North American cities and peripheral areas (Roos & Alschuler, 1975; Ceder & Yim, 2003).

Figure 2.2 Small taxi-like buses provide a point-to-point service



Source: From *A Pattern Language: Towns – Buildings – Construction*, by C. Alexander et al., 1977: 112.

Half a century later and with more sophisticated computational resources at hand, efforts to launch automated shuttles, yet again, propel the hybrid vision of a half-taxi, half-bus vehicle running on demand (Alexander et al., 1977). The concept of demand-responsive transit shuttles or microtransit services has meanwhile evolved to represent a transit solution for areas with low population density and limited cost-efficiency for traditional public transit (Ronald et al., 2016; Calderón & Miller, 2020). Compared to conventional line-based transit options, its advantage lies in geographic flexibility and demand-based operation, as well as in the deployment of minibuses. The reignited interest in the concept amongst transportation planners (see Ceder & Yim, 2003; Shaheen et al., 2015; Ronald et al., 2016) coincides with the ongoing shift towards mobility services, propelled by the Internet of Things (IoT), digital platforms, and electric mobility.

Mobility services may range from shared bicycles and scooters, to demand-responsive transit (DRT), and ride-hailing. The latter two differ in that DRT – or microtransit – is a public service offering shared rides, while ride-hailing is a private service based on real-time transactions between users and drivers facilitated by a digital platform, with sharing being an optional feature (Calderón & Miller, 2020). Much as the Dial-A-Ride concept of the 1970s relied on radio-connectivity and a control centre answering requests, today's services are accessed through smartphones with mobile internet, and ordered or booked by tapping an app, methods considered more cost-saving than the traditional call centres (Shaheen et al., 2015). Beyond that, mobility services use automatically retrieved locational data to support matching processes, route optimization, and navigation. The performance of demand-responsive transit and ride-hailing services, specifically, also relies on computational tasks such as matching, rebalancing, and pooling (Calderón & Miller, 2020).

The vision of automated mobility on-demand systems providing shared and space-efficient services thus builds on these mobility services which are often considered bridge technologies for AVs. The expected advantages of vehicle automation pertain to labour cost savings (Calderón & Miller, 2020) and, if combined with electrified vehicles, a reduced environmental impact (Alessandrini & Filippi, 2004). Moreover, researchers assuming complete traffic saturation with shared AVs, assert that such scenarios would significantly reduce the number of vehicles on streets and decrease required parking (Alessandrini et al., 2015). From a users' perspective, former car-owners would have the advantage of consistent flexibility at a significantly lower cost (ibid.). The following section highlights the current state of testing automated shuttle services, potential forms of service integration, and infrastructural considerations, before examining several key factors on which the transformative potential of automated on-demand mobility hinges.

Current state of piloting AV Shuttles

Parts of this section are contributions to a previously published paper:

Soteropoulos, A., Bruck, E. M., Berger, M., Holst, A., Egoldt, A. & László, Z. 2021. Automatisierung, öffentlicher Verkehr und Mobility as a Service: Erfahrungen aus Tests mit automatisierten Shuttlebussen. In Mitteregger, M.; Bruck, E. M.; Soteropoulos, A.; Stickler, A.; Berger, M.; Dangschat, J. S.; Scheuvens, R. & Banerjee, I. AVENUE21. Politische und planerische Aspekte der automatisierten Mobilität. Heidelberg: Springer Vieweg.

Since the early 2000s, a growing number of cities and rural communities across the globe host pilots and demonstrations of self-driving shuttles – smaller-sized vessels that fit 5 to 20 passengers and run along designated routes. According to the pilot inventory by Hagenzieker et al. (2021) *Automated Buses in Europe*, research interest in automated bus systems specifically began to grow in 2016 and peaked just before the Covid-19 pandemic in 2018 and 2019. Next to highway pilots, automated shuttles came to represent the most commonly tested use case for automated passenger mobility and represent a "transit first" approach to automation (Heinrichs et al., 2019: 248). Particularly in the United States, the uptake of AV shuttle testing resembles a shift in technology development away from a sole focus on single occupancy automated vehicles (Perkins et al., 2018). Of the 36 automated passenger vehicle pilots Kaplowitz et al. (2021) locate across North America in 2019, more than half use low-capacity shuttles. A best practice study conducted for the City of Toronto (CAVCOE, 2019) identifies as many as 53 past, present, and future AV shuttle pilots.

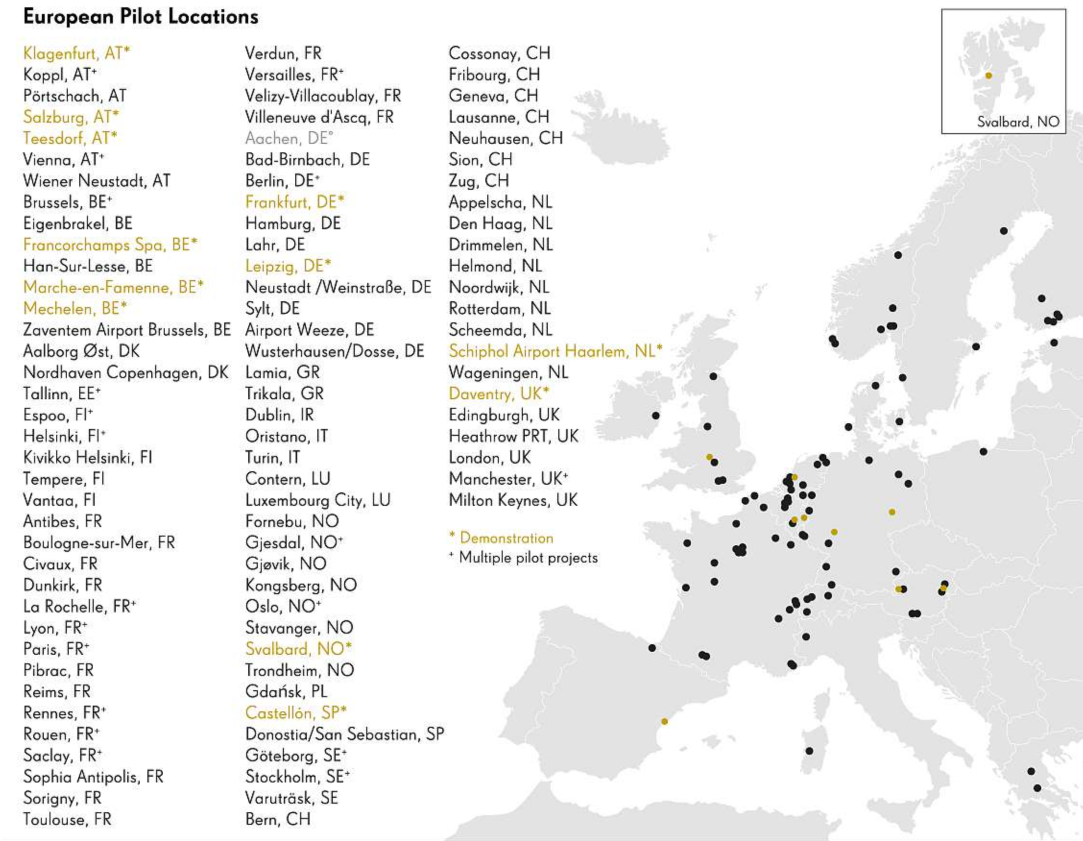
The earliest efforts to showcase shared automated transit systems on segregated road infrastructure in Europe include the Rivium Parkshuttle (NL) and the Heathrow PRT (UK), operational since 2005 and 2011, respectively. The first deployment of automated shuttles on open roads took place within the scope of the *CityMobil2* demonstration projects between 2012 and 2016[2]. Numerous research entities and public-private consortia have since followed suit, as national governments passed legislation and allocated considerable amounts of research subsidies. Large-scale funding programs include, for instance, the European Union's program *Horizon 2020: Smart, Green and Integrated Transport* – to name just one of many European funding programs, which made it feasible for a growing number of municipalities and research entities to pursue local pilot projects with the aim to advance and gain knowledge on automated shuttle systems (well-known funded projects include, e.g. *CityMobil 1* and *2*, or *CoExist*). By 2021, more than 120 AV shuttle pilots have been conducted across 18 European countries (Hagenzieker et al., 2021; Martijnse-Hartikka, 2020). More than 90 municipalities hosted at least one trial or demonstration, with the highest number of locations in France, Germany, and Norway (Fig. 2.3). While levels of municipal engagement and capacity to mobilize resources vary greatly, identifying pilot zones and test locations has been a widely shared priority among municipalities (Soteropoulos et al., 2021).

Beyond aspects of technological development, operation and liability, economic viability, and social acceptance, pilot projects increasingly address transit system integration of shuttle services and expansion of mobility options (Jürgens, 2020). As such, the vast majority of automated shuttles are applied as first- and last-mile services, closing existing gaps in transit systems (Hagenzieker et al., 2021). According to Bloomberg Philanthropies' (2017) *Global Atlas of Cities and Autonomous Vehicles*, testing last-mile connectivity at the fringes of transit networks represents low-hanging fruit for municipalities and transit agencies. Particularly in suburban and rural-peripheral areas, where land use and activities are dispersed, travel distances increase, and mobility needs diverge (Baniewicz & Neff, 2020), transit provision is costly due to low user demand. Assuming that driver costs will be saved, and operational models will be more competitive (Bösch et al., 2018),

[2] CityMobil2 was a European project addressing the integration of automated road transport systems with real-life demonstrations hosted in seven different cities (CityMobil2, 2016).

automated shuttles are considered to provide an economically more viable option that would make it possible to increase service frequency.

Figure 2.3 European pilot projects and demonstrations of automated shuttles since 2008

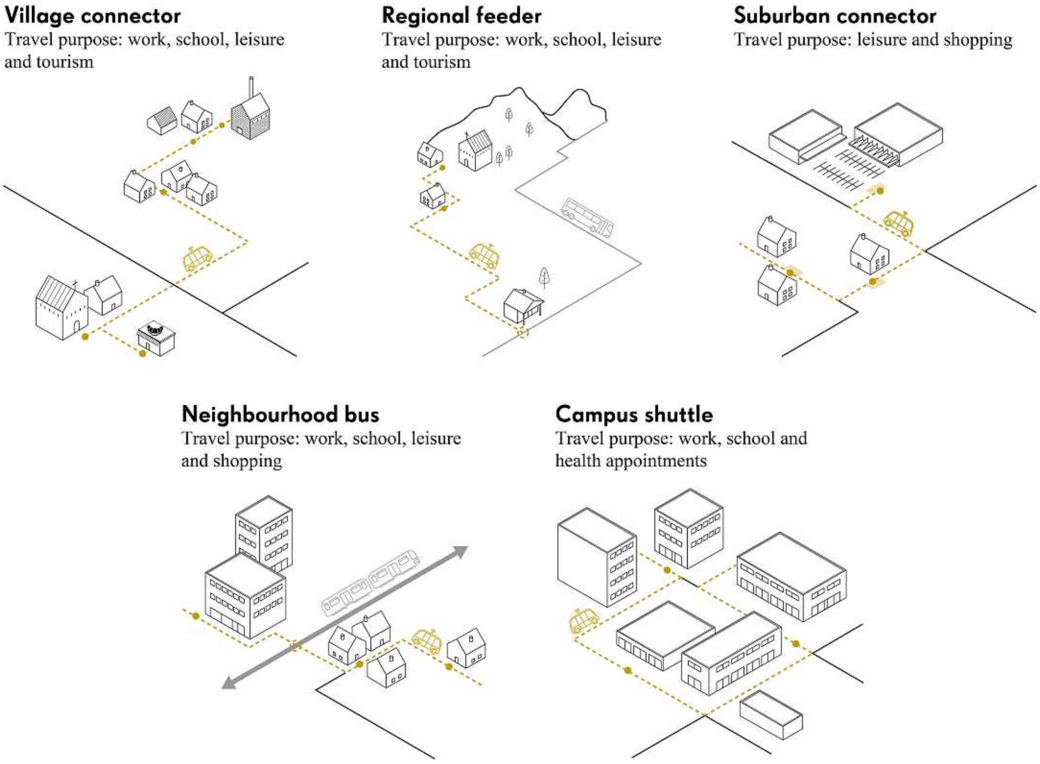


Source: illustration by the author, based on *Automated buses in Europe: An inventory of pilots,* by M. P. Hagenzieker et al., 2021; *Ambitious goals for robot bus piloting in the FABULOS project,* by R. Martijnse-Hartikka, 2020; and *Testberichte. Tests auf Straßen mit öffentlichem Verkehr in Österreich gemäß der Automatisiertes Fahren Verordnung. Zeitraum: 2016–2021*, by BMK, 2022.

Network integration

The service integration of last-mile applications may range from connectors between rail stations and employment centres or residential neighbourhoods, to shuttles roaming different kinds of campuses. Beyond feeder services of this kind, transit applications may also comprise local buses or connectors that may operate in various settlement structures and vary in geographic service coverage (Fig. 2.4; Alessandrini et al., 2015; Jürgens, 2020: 40). Depending on the spatial context, service challenges may significantly vary and require locally specific operational models. While the previously described vision of automated on-demand mobility services or microtransit holds the promise of improving the accessibility of remote areas by extending existing transit networks, the current generation of shuttles resembles little more than a precursor. To date, trials show technological limitations, operational challenges, and limited integration (Soteropoulos et al., 2021: 101).

Figure 2.4 Different options for transit network integration



Source: illustration by the author, based on an older version from *Automatisierung, öffentlicher Verkehr und Mobility as a Service: Erfahrungen aus Tests mit automatisierten Shuttlebussen*, by A. Soteropoulos et al., 2021: 83.

A comparison of European pilot projects (Soteropoulos et al., 2021) shows that none of the applications tested to date constitute an on-demand service in terms of flexible booking and routing (Földes & Csistar, 2018). Instead, automated shuttles run along predetermined routes with fixed stops, which may range from 500 metres to more than 20 km. Of those pilot projects conducted in Europe before 2021, 50 % reported a route length of less than 1,500 metres (Hagenzieker et al., 2021: 14). Often these are located in areas of limited urban complexity. In the majority of the projects, the vehicles have an operator on board, who can take control or navigate the shuttle in case of an emergency or system failure. While on board operators represent a legal prerequisite for testing on public roads in a number of European countries (e.g. Austria, Germany and Denmark), this circumstance also points to a technological lag in the driving performance of automated shuttle buses. Testing at an assumed SAE Level 4 is, in fact, happening at an SAE Level 3 (Stayton & Stilgoe, 2020).

Real-life experience of deploying automated shuttles in a mixed-traffic scenario has shown that smooth and secure operations at this point require infrastructural adaptations, e.g. artificial landmarks that demarcate the edges of the streetscape. Moreover, certain vehicle types were unable to perform more complex driving behaviour, such as, taking a left turn, anticipating the behaviour of other vehicles and cyclists, or passing an obstacle without the aid of an operator (Zankl & Rehrl, 2018). Failing the expectations placed on highly automated vehicles, the trialled shuttles rather resemble prototypes that require ongoing and systematic research regarding technical, operational, as well as social questions, before reaching the maturity necessary for deployment as part of a transit service. In this regard, Stayton and Stilgoe (2020) argue that there is a distinct need for public clarification of the factual possibilities and limits of specific automated driving systems – rectifying the often-postulated claim of "autonomy" and the end goal of replacing "human beings with machines" (18). Moreover, policymakers are challenged to find a clearer language for the infrastructural, spatial, and regulatory requirements, in order for automated vehicle technologies to be safely, effectively, and equitably tested and used (ibid.).

Infrastructural and spatial conditions

A number of infrastructural and spatial measures need consideration in order to successfully integrate automated shuttle services into transit systems, enhance the likelihood of providing a viable mobility alternative to private automobiles and increase access for people without one. Aside from the numerous technological hurdles (e.g. spatial, material, and topographic complexity), uncertain user preferences, and the challenge of shifting mobility habits, the following aspects call for local assessment planning professionals:

1. Comprehensive infrastructure enhancements should not pose a prerequisite for automated microtransit operation, unless under circumstances in which other traffic modes (e.g. cyclists, pedestrians) benefit from the adaptation (Soteropoulos et al., 2021: 102). It is advisable to limit the enhancement of digital infrastructure that is currently set up for pilot projects, such as, satellite communications systems (Zankl & Rehrl, 2018). Firstly, due to high infrastructure costs, secondly, due to the fast pace of changing infrastructure requirements by AVs, and thirdly, due to the increasing demand for scarce public space (Soteropoulos et al., 2021; Bruck et al., 2021).

2. Area-specific studies on the integration of pick-up and drop-off locations for AVs are necessary to assess their traffic and land use impact (Bruck & Soteropoulos, 2022). Pilot projects have highlighted the importance of smooth interchanges between feeder systems and other transportation modes (Zankl & Rehrl, 2018), as fast and convenient transfers reduce overall trip duration and may significantly add to the attractiveness of automated mobility on-demand systems. Moreover, research has shown that the provision of designated collection points can ease trip bundling by simplifying the routing of ride-sharing services, while also increasing network performance and traffic cost savings (Stiglic et al., 2015).

3. Beyond physical design, mode integration needs to encompass operational service alignment, i.e. demand-based feeder systems need to be synchronized with the timetables

of higher-order transit in order to minimize transfer and waiting times (Soteropoulos et al., 2021). Moreover, digital platform integration is necessary, which might require new systems and API standards. Data harmonization between various providers and agencies thus proves to be a critical issue.

4. Operational models need to reflect settlement structures, densities, and local transport demand, and thereby contribute to an intermodal mobility shift. This concerns operating hours, frequencies, routes and service areas, as well as station integration (Soteropoulos et al., 2021). Moreover, the evolution of existing land use and land densities needs to be considered as new service models are deployed (Higgins et al., 2021). Transit-oriented developments may be of particular interest in suburban communities, where a greater mix of functions can increase the frequency and urban centrality of stations and collection points.

Conclusions on a transformative deployment scenario with AM

> *"The focus of automation discussions needs to turn outward, away from the narrow technical capabilities of a system measured against a known human task, and toward the environments and conditions that can make safer, fairer, more accessible mobility achievable."* (Stayton & Stilgoe, 2020: 19)

The recent growth of mobility services, electric vehicles, and the reignited interest in on-demand point-to-point mobility services has not only diversified mobility options, but also service providers, who are increasingly challenged to coordinate efforts. Automated vehicles add to the diversity of interests involved in the mobility market by introducing further players from the IT sector. There is a long-term expectation that the boundary between public and private service provision of demand-responsive mobility will eventually dissolve once automated systems are commercially introduced and service goals begin to blend (Lenz & Fraedrich, 2016). Leading up to such a scenario, a key challenge for local governments and transit providers remains the aforementioned system integration of flexible services into existing transit networks. Studies on demand-responsive transit and, more recently, on mobility hubs emphasize a number of factors that need to be taken into account for a successful integration of systems and shared transport options: a. digital integration of information, booking, payment and services; b. service stability; c. network integration (including smooth transfers and place making); d. integrated fare structures; and e. maximal service synchronization (Ceder & Yim, 2003; Geurs et al., 2022).

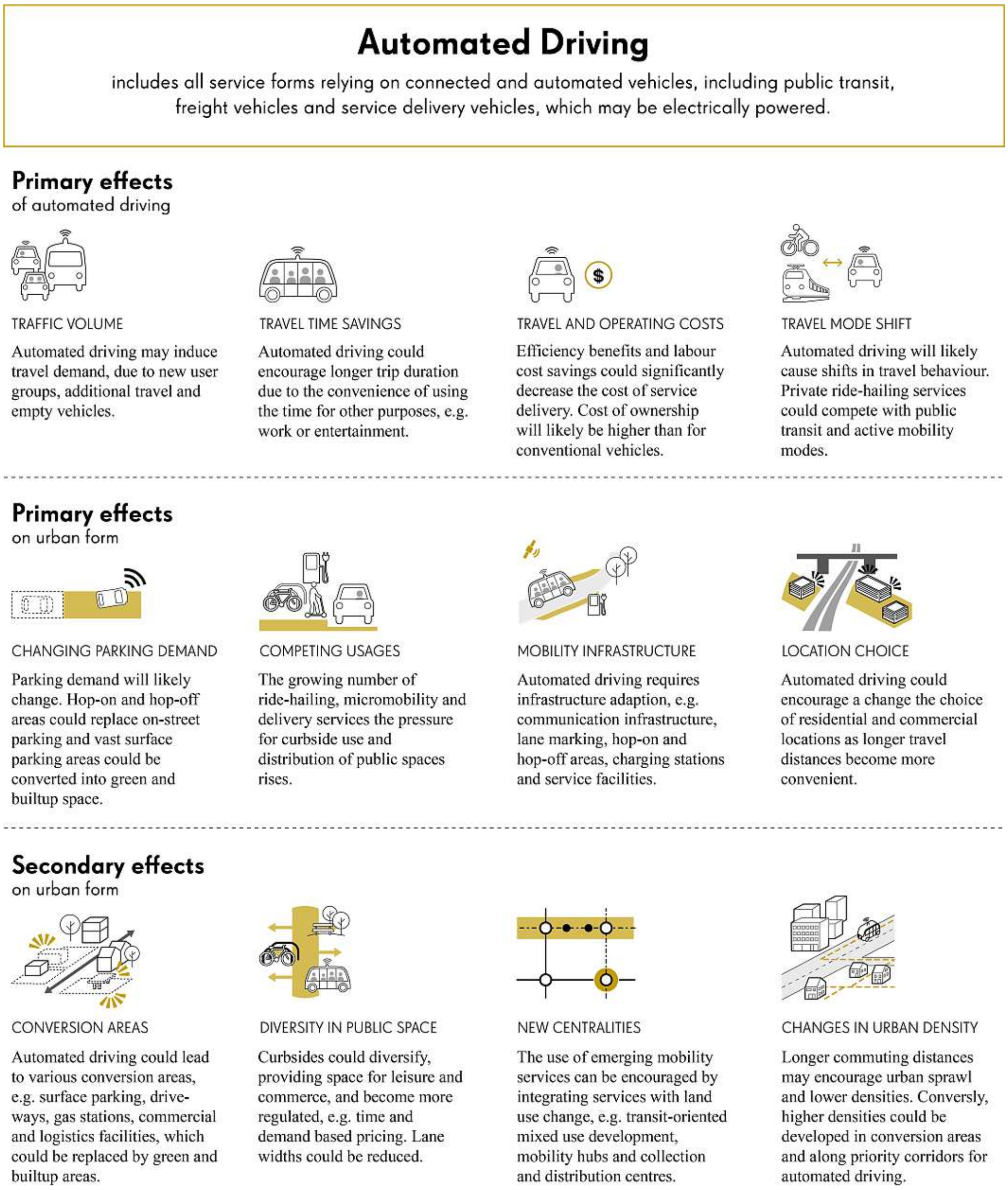
Beyond the question of integrating diversifying services and modes, regulatory levers and policy interventions are necessary to ensure both equitable and environmentally sustainable outcomes of a mobility future including AVs. On the one hand, recent assessments of ride-hailing companies have shown that the hoped-for effect of reduced vehicle ownership has not been met in North American cities, but that the service cannibalizes public transit instead (Jin et al., 2018; Eliot & Fagan, 2021). On the other hand, new mobility services are predominantly deployed in profitable areas with high customer densities rather than increasing accessibility for low-income neighbourhoods (Steckler et al., 2021). These precedents illustrate what can be equally expected of automated mobility services: radical technologies on their own will fail to bring about a socio-ecological transformation in the mobility sector. Government intervention will be required in order for AV service providers to cover less affluent and more dispersed neighbourhoods (Steckler et al., 2021), as well as for transit to remain competitive as convenience, affordability and value of time are expected to spur demand for AMOD systems.

Modelling studies on AVs have also shown that in order to reap the benefits of automated on-demand systems (e.g. the decline of circulating vehicles, on-street parking demand, and vehicle ownership) high occupancy-rates and policies minimizing empty cruising are key (Zhang & Guhathakurta, 2018). However, for a widescale shift towards ride-sharing to occur – particularly in traditionally automobile-oriented regions – established mobility habits and lifestyles need to fundamentally shift, including understandings of social status and safety needs (Cyganski, 2016; Lenz & Friedrich, 2016). This is all to show that while the vision of automated on-demand mobility services does hold a transformative potential, its effective implementation rests on operational, institutional and cultural dimensions of change.

2.2. Urban transformation in light of automated mobility

Another dimension of transformational change concerns processes of urban transformation. The present work frames such processes as change processes in the built environment, concerning both morphological and functional configurations of urban landscapes. With automated mobility on the rise, the question is to what extent related mobility changes may contribute to a transformation of urban structures, land use, and functional relations. Transportation and planning studies on urban implications of AVs have shown that these may comprise morphological change concerning, i.a. transport infrastructure, public spaces, and urban form (Stead & Vaddadi, 2019; Larco & Tierney, 2020), or functional configurations addressing, i.a. changing land use, location choice, real estate, and forms of use (Cavoli et al., 2017; Milakis et al., 2017; González-González et al., 2019). To grasp the mechanism of change, vehicle automation needs to be understood as part of the larger transition towards service oriented urban mobility described above. New mobility services not only affect traffic patterns, but also spatial relations, infrastructural affordance, and demands for urban development. In that context, vehicle automation may accelerate processes of change which were set in motion prior to the introduction of AVs. An early example of this change is found in the growing demand for curb access, which is fuelled by the introduction of transport network companies (TNCs)[3] and the rise in goods delivery, as well as courier network services (Howell & Tan, 2020).

Figure 2.5 First- and second-order effects of automated driving on urban form



Source: translated by the author, from *Automatisiertes und vernetztes Fahren (avF): Berücksichtigung des lokalen, räumlichen Kontextes und räumliche Differenzierung*, by E. M. Bruck, and A. Soteropoulos, 2021: 11.

When considering early indicators of spatial change, as well as possible future consequences, the implications of automated mobility on urban form may be differentiated between primary and secondary effects (Fig. 2.5). Primary effects on urban form range from declining parking demand,

[3] Transport Network Companies (TNCs) are private firms such as Uber or Lyft that offer personal transportation services based on a digital platform economy model (Brail, 2018). In the literature on emerging mobility technologies, TNCs are commonly referred to as ride-hailing companies. In the Canadian context, the term Private Transportation Companies (PTCs) is most commonly used (Toronto, 2019b).

competition for right-of-way and curb access, to new infrastructural requirements and changing location choice of residents and businesses. Secondary effects are of a hypothetical nature and concern shifting spatial relations due to a changed mobility system. These may comprise the conversion and redevelopment of former industrial zones, the diversification of public spaces due to an increasing variety of mobility modes that need to be catered to, new urban centres, as well as changing dynamics of densification and dispersion.

The effects are cascading, in that they comprise short-term and long-term urban transformation. But rather than unfolding conditionally and successively, transformations of this kind are expected to unfold in a temporally and geographically asynchronous manner, depending on factors such as urban form and land use. In effect, spatial implications may not only vary between urban and rural areas, but also between urban districts of the same municipality. The argument here is that both functional demands of AVs and spatial affordance vary across urban neighbourhoods, causing automated mobility to affect some neighbourhoods more than others (Kondor et al., 2020; Zhang & Wang, 2020). Critical economic geography provides another lens through which to view uneven development. Clark (2020) argues, for instance, that technological innovations, such as AVs, are likely to reproduce contemporary uneven development since “places within cities and between cities have different resources, access, opportunities, and outcomes” (5).

2.2.1 Primary effects

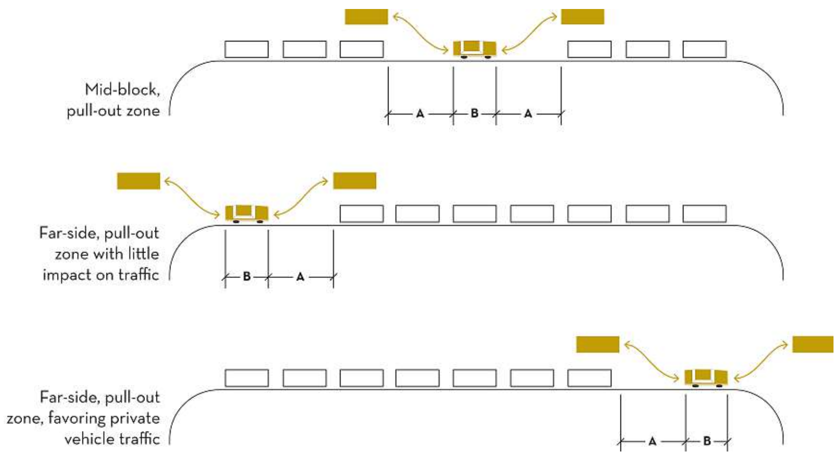
Declining (on-street) parking demand is considered one of the positive effects that vehicle automation could have on urban form. Using modelling studies, scientists have examined to what extent AV-related traffic changes may impact short-term as well as long-term parking demand in cities (Zhang & Wang, 2020; Kondor et al., 2020). But whether parking needs will in fact decline, geographically relocate, or rather exacerbate due to increased short-term parking, correlates with factors such as occupancy rates, adoption of car- and ride-sharing services, as well as the operational range of fleets, and public policy. While some studies could show that high levels of shared automated vehicles (SAVs) may considerably reduce urban parking demand (Soteropoulos et al., 2019), more recent studies emphasize the trade-off between parking reduction, fleet sizes, and increased vehicle travel (Kondor et al., 2020). The latter may particularly occur, if deadheading (zero-passenger vehicle travel) increases, be it due to empty vehicles cruising between passenger trips or as AVs return to their depots. Yet the transformation of urban infrastructure such as parking represents a long-term process, which will occur over the course of decades. Preceding any large-scale changes, however, the demand for designated pick-up and drop-off areas will grow.

The rise of AMOD systems will likely add to the intensification of use in public spaces and at curbsides, set in motion by recent changes to the mobility system. Marsden et al. (2020) assert that the growing demand for ride-hailing companies, delivery and courier services, as well as micromobility options, not only diversifies spatial demands, e.g. in terms of pick-up and drop-off areas or charging stations, but also encodes the interests of private actors venturing into the mobility market. The development entails a competition for access and use of public space, while also having an impact on the future distribution of spaces to move, spaces to (temporarily) park, and spaces to linger. As mobility modes evolve, the competition for right-of-way equally increases. In this regard, studies on North American cities have shown that the rising demand for ride-hailing has led to conflicts with cyclists and public transit, as vehicles stop in designated bike lanes and bus stops to pick-up and drop-off passengers at the curb (Schaller, 2017; Erhardt et al., 2019; Toronto, 2019b). In light of possible AV introduction, Larco & Tierney (2020) have further argued that the prospect of induced demand could increase the pressure to redesign streets in favour of facilitating higher numbers of vehicles per hour. But continuous traffic flows will likely have a separating effect on streetscapes, making it more difficult for pedestrians and cyclists to cross, and decreasing the walkability of neighbourhoods (Ghielmetti et al., 2017).

Even more so than today, the design and policy challenge will rest in finding an adequate balance in catering to demands for traffic efficiency, as well as to demands for a sense of place, comprising a balance between traffic safety and walkability, as well as between public and private interests (Docherty et al., 2022). In this context, infrastructural changes are a frequent subject of dispute between public and private entities. High investment costs and the likelihood that infrastructural requirements will quickly change as technologies evolve make the financing of comprehensive developments appear unattractive (Fraedrich et al., 2019). Infrastructural adaptation may range from improving the visibility of existing road markings and street signs to upgrading them as digital systems, e.g. radar reflection, street sensors, connected street lights, etc. As public agencies are reluctant to prematurely invest, an evolutionary adaption of functionality and standards appears more likely (Ambrosius, 2018). Frequently addressed changes to the built environment further include the designation of pick-up and drop-off areas and depots for parking, charging, and maintenance. Loading and transfer points need to be planned at different urban design levels. On the one hand, they may be integrated into existing train and bus stations, mobility hubs, as well as park and ride facilities. On the other hand, designated pick-up and drop-off areas may be required on a comprehensive scale across the entire street network to which new mobility services are introduced or provided access.

As demand for pick-up and drop-off areas was expected to grow even prior to the introduction of AVs due to ride-hailing companies, an increasing number of studies and pilot projects are concerned with the effective repurposing of on-street parking as loading zones. Micro simulation results illustrated that providing dedicated stopping bays rather than permitting lane-based halting, could positively impact waiting times, safe interactions, and customer satisfaction, while decreasing travel times (Wang et al., 2018). The spatial drop-off model developed for Seattle's New Mobility Playbook (Sam Schwartz, 2017: 39), for instance, centres its focus on determining the curb space demand depending on land use categories (e.g. residential, commercial, office, public facility). Asserting that demand for pick-up and drop-off areas depends on the number of trips generated by different activities and urban functions, trip generation rates for each land use category are used as the key input variable. The underlying assumption for determining the necessary number of pick-up and drop-off areas is that every pick-up or drop-off activity takes 45 seconds, amounting to 80 interactions per hour within a single parking space (1h/45s=80). The total amount of necessary pick-up and drop-off areas within a given street segment is then calculated by estimating activity levels (peak trips per hour) for each land use along a given street segment.

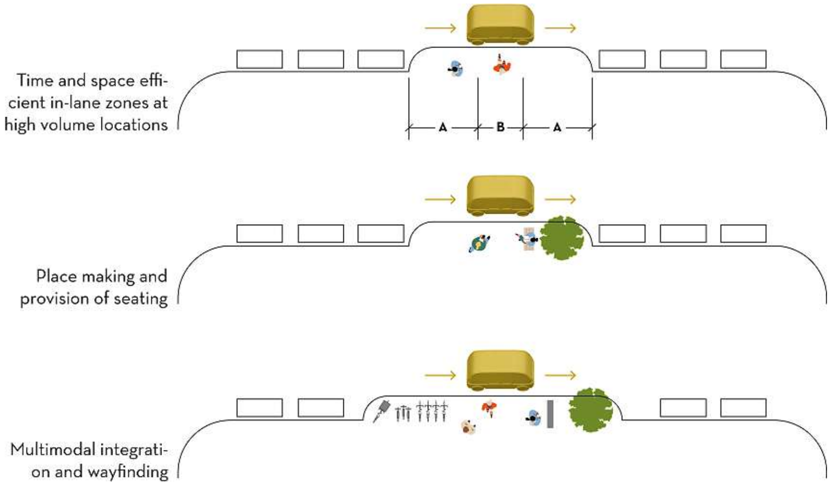
Figure 2.6 Placement of pick-up and drop-off zones for on-demand ride-sharing



Source: illustration by the author, based on *Cincinnati Curb Study*, by Fehr & Peers, 2019.

A different approach is adopted in the modelling study by the International Transport Forum that examines the urban implications of shared mobility services in Lisbon (ITF, 2018: 66). Pick-up and drop-off areas are assigned an average of 15 metres, while locations with high demand, such as schools or shopping centres, are assigned larger areas that comprise a standard of four parking spaces. Beyond taking note of local trip generation rates, studies of San Francisco (Fehr & Peers, 2018) and Cincinnati (Fehr & Peers, 2019) show that pick-up and drop-off area dimensions require fine-tuning, depending on their exact location along a block, which may have varying effects on the overall traffic (Fig. 2.6). Considering that some use cases will blend with transit service options, such as on-demand automated shuttles running as feeder services, in-lane pick-up and drop-off zones may be a design strategy to reduce travel times and increase user convenience, particularly when combined with place-making elements and multimodal infrastructure enhancing smooth transfers (Fig. 2.7).

Figure 2.7 Midblock in-lane hop-on/hop-off zones for on-demand transit shuttles



Source: illustration by the author, based on *Cincinnati Curb Study*, by Fehr & Peers, 2019.

Finally, convenience, cost, and accessibility advantages of using AVs are expected to encourage longer travel distances and thus the location choice of households and businesses. In the short run, this may particularly relevant to businesses and industries that are considering a relocation to more affordable, yet accessible locations within metropolitan regions (Milakis et al., 2017; Lewis & Anderson, 2020; Mitteregger et al., 2022). As automated driving is likely to be approved on highways earlier on, areas adjacent to high-capacity routes may gain in value. Cargo transport or corporate fleets could be among the first highly automated use cases introduced, since these may equally navigate connected industrial areas, business parks, or campuses. While suburban logistics centres would be among those facilities that are relocated further away, the development of small-scale urban distribution centres is likely to gain relevance in urban centres. Due to the rapid growth of online commerce and parcel deliveries, delivery companies and courier services are challenged to develop more effective distribution strategies. Among the presently considered concepts are small-scale distribution hubs, automated delivery services, and electric cargo bikes.

2.2.2 Secondary effects

In the long run, the greater shift towards automated mobility could entail a number of different structural changes to urban form. Based on the assumption that automation will propel the demand for mobility services and the decline of private vehicle ownership, car-related facilities could go out of use. Gas stations, repair shops and workshops, rental stations, car dealerships, and driving schools are all facilities which frequently border suburban arterials and characterize the urban fringe. With shared automated mobility services on the rise, a significant amount of land that is presently occupied by such businesses could be freed and repurposed for other functions (Mitteregger & Soteropoulos, 2021). If industrial areas and retail parks are adequately rezoned, shuttered car-facilities and vast parking lots may be converted into new mixed-use urban development areas.

Moreover, an emphasis on mobility integration and transit-oriented development could provide an impulse for a more sustainable suburban transformation (Bruck, 2019).

On a smaller scale, the prospect of automated mobility systems could encourage means of redistributing space in roadways and the introduction of more flexible forms of use. Prioritizing safety and comfort for pedestrians, cyclists, and transit users, former on-street parking and surplus travel lanes may be repurposed for additional green areas, public use, or slow speed zones. Additionally, areas for pick-up and drop-off may be provided only at specific peak hours, allowing for more active mobility space during the rest of the day. Functional differentiation, e.g. for the mobility impaired or para-transit, street vendors, and delivery services, may likewise enable a temporary provision of vehicle infrastructure, while otherwise prioritizing public use. Urban sensors, beacons, and vehicle connectivity may provide a technology-based way forward, but do not present the only means for cities to regulate flexibly used streetscapes. Spatial design solutions such as level surfaces with continuous paving, for instance, reduce spatial barriers, promote accessibility, and significantly contribute to a sense of place (Karndacharuk et al., 2014).

Building on the notion that, for decades to come, AVs will only be introduced to select parts of the street network, it may be assumed that local urbanization processes will be affected. Accessibility via AVs may cause spatial concentration to occur in proximity to new transfer points and mobility hubs, or result in new development corridors within the operational range of automated mobility services (Larco & Tierney, 2020: 123). The former effect would, however, require cities to enforce transit-oriented development policies and proximity principles. The previously mentioned conversion of monofunctional suburban structures may give way to more polycentric development, relieving monocentric mobility patterns frequently causing congested arterials and metropolitan highways to reach capacity limits.

Aside from new nodes and centralities, changes in location choice bear the risk of enhancing long-term metropolitan sprawl (Milakis et al., 2017; Litman, 2020). Particularly, if privately owned automated vehicles come to dominate future mobility markets, dense urban centres may be left behind by those seeking more affordable residences and proximity to nature. If municipal governments fail to counteract this development, regional peripheries will likely gain traction, while densities in central districts may in turn decline (Larco & Tierney, 2020: 122).

2.2.3 Contextual differentiation of effects and compatibility

To what extent and in what form automated mobility may contribute to processes of urban transformation, requires a differentiated understanding of local preconditions and circumstances. These may concern the specificity of existing urban form and infrastructural features, transport availability and mobility behaviour (modal split, degree of motorization, CO^2 emissions), as well as local development challenges and policy objectives. Contextual factors such as these not only create different starting points for the local implementation and regulation of automated mobility, but also influence whether and how effects on urban form materialize. Following the argument of Stayton and Stilgoe (2020) that automated mobility systems will evolve conditionally, one may make a case that their urban implications too will manifest in locally specific forms. A contributing aspect, which has not received enough attention in studies on urban implications to date, but may significantly influence which areas will be affected by spatial transformations, concerns the authorization of automated mobility services' operational range.

Thus far, the debate on the potential operating conditions of AVs has mainly centred on determining operating design domains (ODD) from the view point of technological feasibility and traffic efficiency. As studies on pilot projects show that AV safety performance significantly decreases on streets and roads with more complex environmental conditions in comparison to highways and freeways (Boggs et al., 2020), various approaches to extending ODDs and optimizing traffic networks for AVs have been suggested. Infrastructure-based measures range from digital supporting elements such as dynamic maps, real-time information for vehicle guidance and vehicle-to-infrastructure communication technology (Carreras et al., 2018), to road classification systems based on technological feasibility (Soteropoulos et al., 2020) and modelling AV-ready subnetworks, dedicated AV links, as well as dedicated AV lanes (Madadi et al., 2021).

All of these studies acknowledge that at the current level of technological maturity, AVs may only be selectively introduced onto urban street networks. Particularly as changing road features, traffic interactions and weather conditions add to the complexity of traffic environments and increase sensing, as well as processing requirements for driving automation systems (Mitteregger et al., 2022). In essence, such recommendations point towards the strategic balance that planners need to strike between selecting routes and networks that are attuned to AV safety performance and the enhancement of road network infrastructure at manageable investment costs. Most of these studies, however, do not consider the urban implications which may occur as a result of traffic demand changes, new accessibilities and functional demands of AVs. The following section thus introduces an integrated methodology to assess automated mobility's compatibility with adjacent land use and possible street design impacts. Integrated assessments of this kind may further inform strategies to determine adequate operational conditions for automated mobility systems by revealing the urban and social trade-offs that a system change towards automated mobility may entail.

A comprehensive version of this section was previously published in the following paper:

Bruck, E. M. & Soteropoulos, A., (2022). Traffic-Land Use Compatibility and Street Design Impacts of Automated Driving in Vienna, Austria. *Journal of Transport and Land Use,* 15(1), 137-163. https://doi.org/10.5198/jtlu.2022.2089

To gain a better understanding of how changing traffic demand due to AVs could affect street life, infrastructural requirements, and urban form, a street design study was conducted for the City of Vienna, Austria. The study was based on a previous scenario analysis which was carried out under the lead of Wiener Linien GmbH as part of the research endeavour "auto.WAVES. Autonomes Fahren – Wirkungsanalyse Verkehr, Energie und Stadt für den Raum Wien" between 2017 and 2020. The study was developed as a research collaboration between the future.lab Research Centre, TU Wien, and the MA 18 – Department for Urban Development and Planning of the Vienna City Administration.

In order to investigate urban effects at the neighbourhood and street level, the research approach comprises three methodological steps:

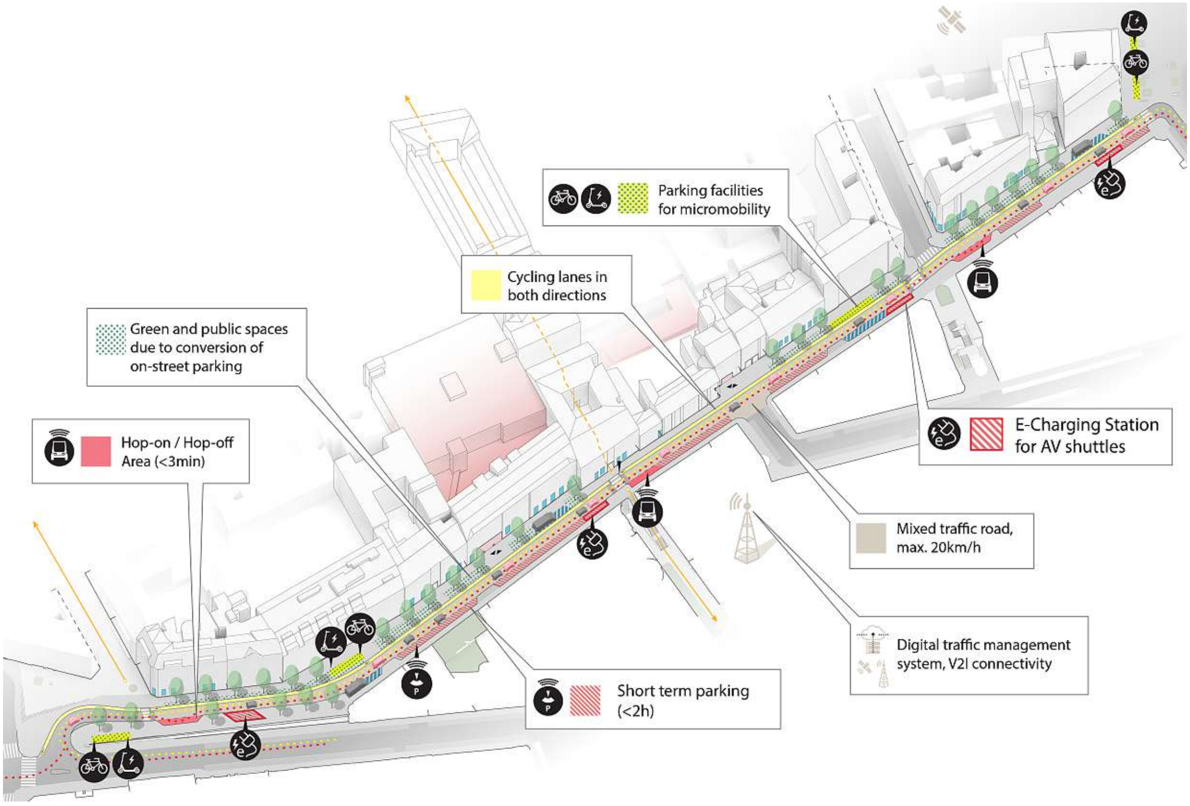
1. Compatibility changes between traffic demand and land use depending on AV scenarios;
2. functional street space demands of AVs;
3. design strategies illustrating alternative paths of transformation based on functional demands, literature findings, and local urban development goals.

The spatial assessments and design strategies built on three scenarios with AVs, which were modelled using MATSim, an agent-based transport simulation package. The first scenario assumed a shared automated shuttle service providing door-to-door travel on demand. The second scenario differed from the first in that shared automated shuttles provided stop-based travel, using existing bus stops as collection points. The third scenario assumed that the existing number of private vehicles was automated and therefore provided higher levels of comfort. While the simulation model did not generate fine-grained data on a street level, it was possible to delineate variables, which are significant for the assessment of functional demand and street-based activity changes. With regard to automated mobility, these encompass the density distribution of pick-up and drop-off interactions, need for passenger loading zones, and demand for short-term parking of waiting vehicles.

Building on earlier studies, which indicated that urban implications of automated mobility are likely to occur unevenly across cities (Kondor et al., 2020; Zhang & Wang, 2020), three study areas were selected with varying land use and street typologies: 1) an inner-city commercial street, 2) a suburban arterial with a tramway, and 3) an industrial access street. Functional requirements that mobility modes pose on streets differ according to traffic-related criteria, such as, a street segment's location within a network, diversity of travel modes, and speed limits, but also according to urban form. Both land uses (e.g. housing, commerce, public institutions, or industry) and urban density influence the number of multimodal interactions in public space. Moreover, adjacent functions create a demand for public space, accessibility, and walkability. Depending on the traffic effects and functional requirements that various types of automated mobility services entail, they may be more or less compatible with different street typologies and neighbourhoods.

The analysis was able to demonstrate that traffic compatibility, spatial demands and conceivable street design changes differ significantly across urban areas:

Figure 2.8 Spatial requirements of automated shuttles along inner-city residential street

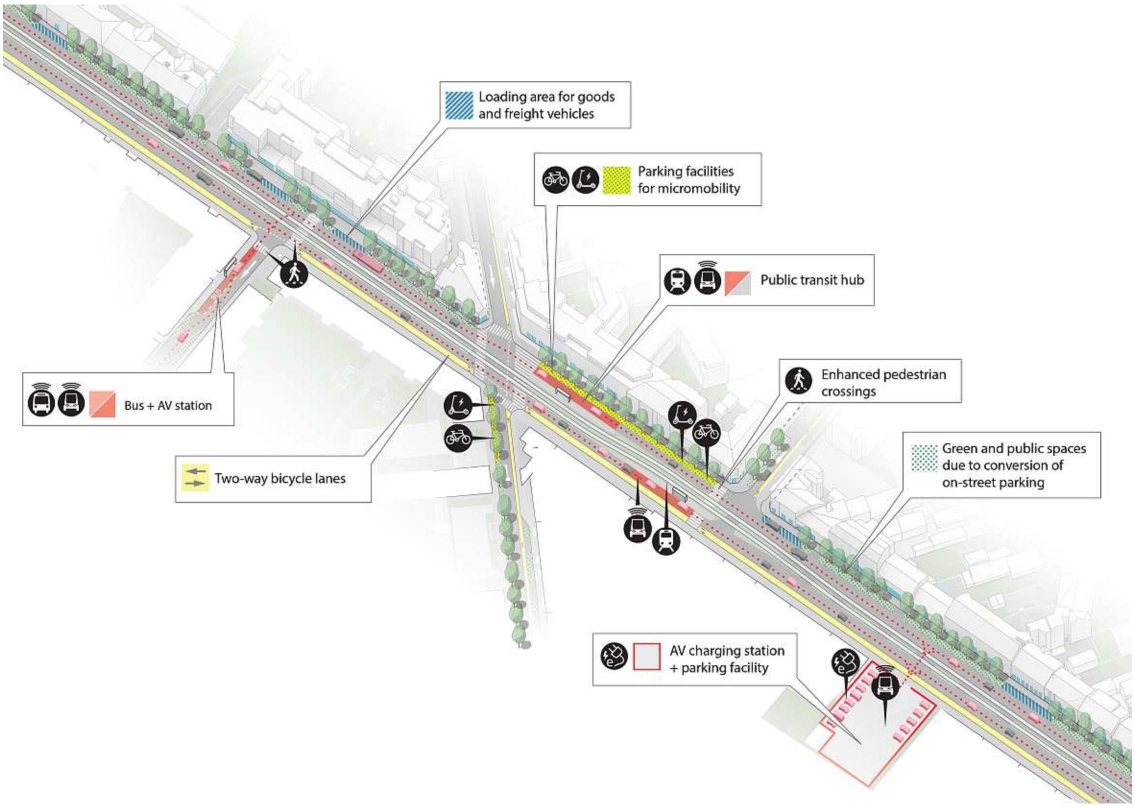


Source: translated by the author, from *Straßenräumliche Wirkungen und Verträglichkeit des autonomen Fahrens im Raum Wien*, by E. M. Bruck et al., 2020: 18-19.

1. **Inner-city street with intensive commercial use (Fig. 2.8)**: The simulation results showed that automated shuttles providing door-to-door travel (scenario 1) would cause traffic to increase on local roads and neighbourhood streets. When analysing the traffic-land use compatibility, more vehicles passing through streets with intensive commercial use have a negative effect on adjacent functions and forms of use, e.g. pedestrian and bicycle traffic, gastronomic uses, and leisure. Even today, options to spatially integrate different demands for street space are constrained by high building densities and narrow street widths. An unregulated introduction of shared automated shuttles could not only conflict with other

modes and forms of activity in public space, but increase the pressure on the spatial distribution of streets. Proactive planning would require targeted measures: 1) reducing the spatial demand of motorized vehicles, such as, less parking and narrower roadways, promoting interaction safety between different mobility modes, and dedicating sufficient space to green areas, lingering, and commercial uses, 2) providing dedicated pick-up and drop-off zones, 3) reducing traffic speeds, and 4) extending pedestrian and cycling infrastructure.

Figure 2.9 Modal integration at transit hub along suburban arterial

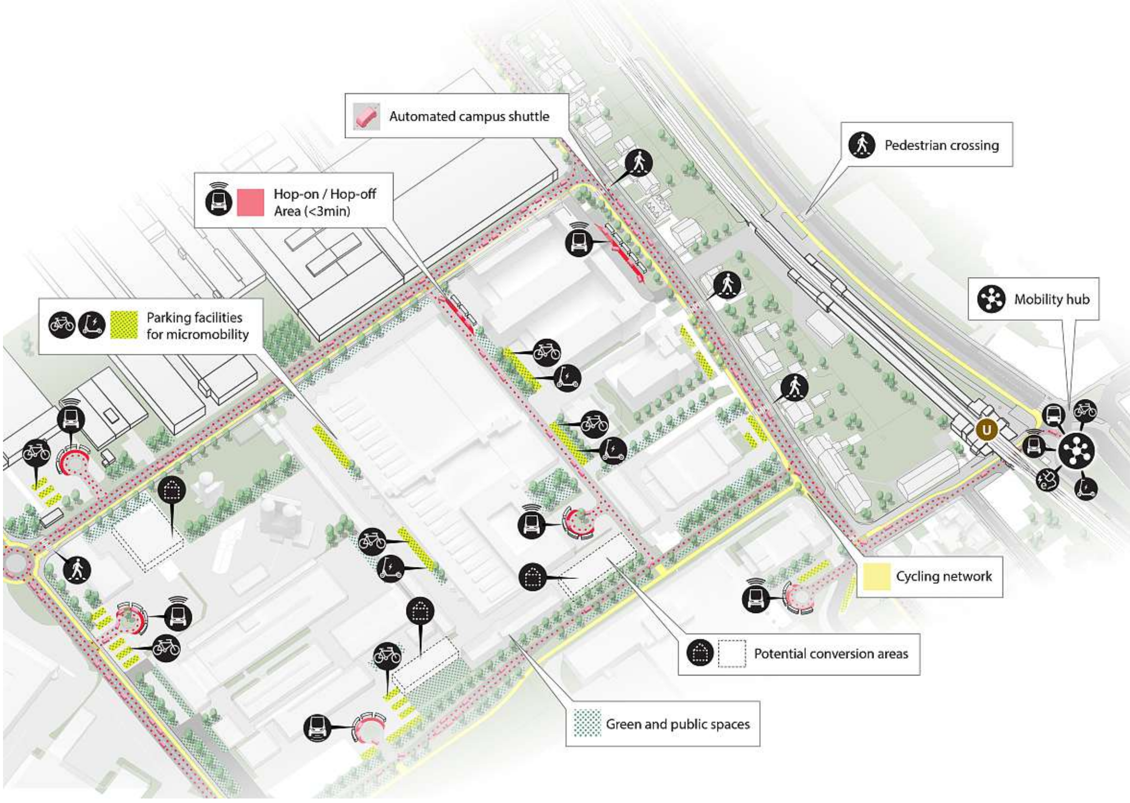


Source: translated by the author, from *Straßenräumliche Wirkungen und Verträglichkeit des autonomen Fahrens im Raum Wien*, by E. M. Bruck et al., 2020: 34-35.

2. **Suburban arterial with tramway (Fig. 2.9)**: In the case of a suburban arterial, which are often characterized by high traffic volumes, the simulation showed that a stop-based automated shuttle service (scenario 2) could decrease traffic congestion and positively affect traffic compatibility with surrounding land use. Such results could represent a development opportunity to implement measures that counteract the separating effect of main roads and contribute to street liveability. These could include: 1) enhancing mobility hubs such as tramway stations through furniture and design accents, 2) improving pedestrian accessibility and attractiveness of spatial connections into surrounding neighbourhoods, 3) converting parking in favour of wider sidewalks and green infrastructure to improve the attractiveness of the public realm and the frequency of adjacent

store fronts, restaurants, or services, and 4) integrating stopping areas for automated shuttles at existing transit stops in such a way that walking distances are kept short and seamless transfer is possible.

Figure 2.10 Feeder system in suburban industrial area



Source: translated by the author, from *Straßenräumliche Wirkungen und Verträglichkeit des autonomen Fahrens im Raum Wien*, by E. M. Bruck et al., 2020: 50-51.

3. **Industrial access street (Fig. 2.10):** The simulation results showed no significant changes to the traffic-land use compatibility in largely uninhabited industrial locations for both the use of automated shuttles providing door-to-door (scenario 1) or stop-based services (scenario 2). Quite conversely, positive spatial effects may occur when automated shuttles provide door-to-door travel and thereby offer an alternative means of organizing mobility within a confined area, e.g. a business park. In doing so, automated shuttle services could close the gap between a company's location and subway stations, train stations, or park and ride facilities. In effect, a significant share of commuter traffic could be shifted and the spatial demand of motorized vehicles reduced. Actualizing spatial development potentials in industrial areas and business parks would require targeted planning approaches, which 1) increase the attractiveness of shared and active mobility on the last mile by redistributing street space in favour of pick-up and drop-off facilities, continuous bicycle and green infrastructure, 2) encourage the transformation of existing train stations, and park and ride facilities into mobility hubs that may accommodate future shuttle fleets, and 3) promote

densification and greater diversity of land use when developing freed-up land on company premises. However, the potential increase in deadheading caused by a door-to-door service must be taken seriously and mitigated by respective transport policies, e.g. pricing models.

The contextual differentiation of traffic demand changes, its compatibility with adjacent land uses, and implications for street designs provide indicators for planners and legislators regarding the potential trade-offs of system change with automated mobility. The convenience of door-to-door travel, in particular, bears the risk of fundamentally altering mobility patterns and negatively affecting neighbourhoods by inducing through traffic. But whether automated driving will alleviate or rather exacerbate existing traffic volumes, demands for curb access, and parking will depend on the specific use case, form of organization and business model, as well as the urban form and street typology of a given context.

Integrated assessments can support planners in anticipating local consequences and thus inform adequate operational conditions for automated mobility systems. The potential outlook of inner-city neighbourhood streets being clogged with automated robotaxis and competing with active modes begs the critical question whether AVs should be generally denied access to certain street typologies. The study for the City of Vienna illustrates quite strikingly that cities will be compelled to develop regulatory measures and design strategies during the transition period in response to such questions. Moreover, the simulation results confirm that without adequate policies in place, automated mobility systems will not lead to a more sustainable and equitable urban transformation. Instead, actualizing the oft-cited spatial and environmental advantages of automated mobility, e.g. the decline of vehicle ownership and increased demand for pooled rides, the reduction of environmental pollution and conversion of street space in favour of diverse modes and a sense of place, fundamentally relies on public policy levers being put in place. There are a number of policies and strategies that cities can implement in order to be prepared for a gradual transition, even as some aspects of automated mobility remain uncertain:

- Incentivizing measures for higher vehicle occupancy rates, shared journeys, and carpooling in order to reduce the amount of vehicle miles travelled and of cars on the street;
- prioritization of active mobility and micromobility in traffic and street designs by granting slower modes more street space, ensuring priority at traffic lights, and providing corresponding infrastructure;
- management of diversifying demands in streets and public spaces through curbside inventories and pricing strategies, as well as designated pick-up and drop-off locations for ride-hailing companies;

- carrying out parking studies and strategic parking infrastructure plans in order to dynamically manage parking demands and determine most effective locations for automated fleet depots;
- implementation of pricing policies addressing deadheading, occurring due to empty cruising cabs, in order to curb its environmental impact;
- and a citywide classification of the road network according to traffic speed, mode division, land use, and automated use cases.

Whether such policies also lead to more accessible, liveable, and environmentally sustainable public spaces will depend on public officials prioritizing the utility that infrastructure connectivity and automated mobility may have for their city. Rather than extending ODDs and optimizing traffic networks for the sake of safe technology performance at the cost of environmental impacts, cities are compelled to determine the actual urban problems that need to be addressed with new technologies.

2.3. Understanding transformative change in urban planning

As scholars such as Venturi (2006) have argued, times of change invariably cause the realignment of professions. Just as “politics, institutions, economies, technologies and social values are all subject to continuous, often radical, change” (Friedmann, 2005: 29), the planning sector too is asked to reinvent itself as new challenges arise. This may lead to a shift in competences or inspire new disciplinary fields and responsibilities (Venturi, 2006).

In Europe, the second half of the 19th century serves as a well-known precedent for understanding how forces of change are formative for the responsibilities and instruments of the planning practice. Amidst rapid industrialization, military de-fortification, urban growth, and the introduction of new transport modes, urbanism became formally institutionalized as a discipline (Calabrese, 2004). Institutional changes that affected European planning practice include the strengthening of urban authorities, the establishment of town planning departments, the production of urban design handbooks, as well as the proliferation of planning associations and international networks (Calabrese, 2004). Throughout the 19th century, town planning concerns shifted from matters of sanitation and public health to those of housing provision, rental issues, and towards the end of the century, quality of accommodation (Hall, 1997). Thus, a variety of disciplines such as hygiene, urban statistics, cartography, national economy, housing and social reform, as well as urban design theory contributed to urban planning practice before architects and engineers assumed dominance over the disciplinary field (Kamleithner, 2020).

The introduction of railways and trams as new modes of transport had a particular impact on planning thought and practice. The introduction of new velocities and organizational principles gave rise to planning notions based on expectations of population distribution and even of relieving the wider challenges of urbanization such as inflation, hunger, and unemployment (Kamleithner, 2020: 167). As such, railway and tramway expansion not only contributed to urban growth and changes in daily travel patterns (McKay, 1976, in Calabrese, 2004; Vogt, 2005), but affected the social and functional configuration of European cities. The mobility networks of the 19th century laid the foundation of urban extension plans, functional zoning, and growth patterns.

Studies on planning history have concerned themselves with one of two questions (Wiechmann, 2018; Christmann et al., 2018). Either, what is/was being planned? In which case the focus centres on changes, realignments or resistance to the substance of planning, e.g. urban visions, ideas, and goals. Or, how is/was the subject being planned? In which case emphasis is put on the means with which planning tasks are approached, e.g. instruments, procedures, legal status, stakeholder participation, etc. In a similar fashion, literature on novelties and change in planning largely addresses one of the following two dimensions:

a. The ideas and principles behind new planning models, e.g. the modernist city, the compact city, and the smart city (e.g. Burton et al., 1996; Hall, 2014; Hajer & Dassen, 2014), or

b. new planning procedures and instruments, e.g. (integrated) development plans or strategies, official plans, sustainable urban mobility plans, (transportation) master plans, neighbourhood management.

While such studies may provide explanatory theories and significant analyses of novel approaches in urban planning, they tend to underemphasize two aspects relevant to this work on *transformation*. First, few studies have systematically dealt with the process of how new ideas and procedures are being put into planning practice (Zupan, 2018; Christmann et al., 2020). Although novelties in planning may result from a passive adaptation to changing circumstances or an individual's generative creativity, changing planning ideas may also be understood as a process of proactive and collective realignment within the professional community (Zupan, 2018; Healey, 2013). In this sense, the genesis of novel ideas and procedures is not an entirely new field of investigation. It has been addressed, for instance, by research on innovation processes in urban and spatial planning.

Among the various notions of "innovation" applied and studied in planning theory and practice[4], those studies are of particular interest that retrace the process of how new planning approaches emerge and become institutionalized (Ibert et al., 2015; Christmann et al., 2020). Scholars engaged in this research theme emphasize the agency of different actors (networks) and conceptualize change accordingly as "social innovation" (ibid.). While the understanding that processes of change in urban planning are not only historically and locally contingent, but are also pushed by agents is significant to this work, the concept of innovation is not entirely applicable. Innovation implies that a certain practice or form of action has been put into practice and become institutionalized (Christmann et al., 2020). Consequently, it can only be identified as such *ex-post* and not while still unfolding.

Relatedly, the second aspect important to this work are the contextual circumstances in which planning novelties emerge. Few studies have thoroughly explored "in which situations change [in planning practice] occurs and how it changes the cultural bias of a group or society (Othengrafen & Reimer, 2013: 1278). This has to do with recognizing the institutional, cultural, and spatial preconditions which may influence the development and application of technologies, as much as the institutionalization of new ideas and approaches in urban planning (Rammert, 1999; Reimer et al., 2014). Even though many scholars will recognize that planning substance, processes, and context need to be studied as interdependent entities to gain a comprehensive picture (Wiechmann, 2018), contextual factors continue to be underemphasized, particularly when it comes to transferring policies or planning ideas to different contexts (Booth, 2011). To this effect, the concept of planning culture may provide a useful model in order to gain insight on how planning practice is rooted in culture (Gullestrup, 2009). Applying planning culture as an analytical concept allows one to examine the correlation between planning responses to recurring challenges and factors such as local planning styles, organizational backgrounds and institutional relations, spatial structures, and cultural norms (see Chapter 3.2). Common cultural features of this kind provide planning practice with guidance, while also being subject to continuous change. Moreover, Gullestrup (2009: 19) argues that cultural embeddedness may also have a limiting effect on what solutions are sought, or perhaps dismissed, through political agendas and in effect mandated as part of planning efforts.

In order to substantiate the understanding of transformation in urban planning practice as an actively

---

[4] The debate on and study of planning innovation takes on various facets. Some scholars are concerned with the organization and stimulation of urban innovations as a new task of urban and spatial planning (e.g. Ibert, 2003). That is, the planning of settings and conditions for innovative approaches to emerge. Others invoke the term innovation to analyse processes of change within the profession of urban planning itself. By adopting a social scientific understanding of "social" innovations as learning processes, scholars explore means to facilitate learning and reflection in order to propel new approaches within planning practice (e.g. Jessen & Walther, 2010). To this end, real-world laboratories in particular have been explored as a learning infrastructure within the German planning context (see Chapter 2.1).

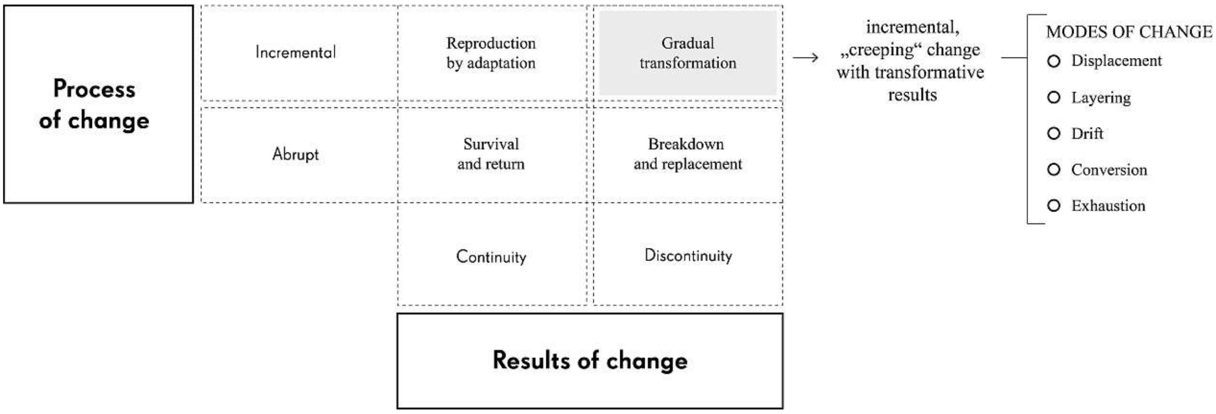
pursued and locally contingent process, three theoretical and methodological studies are reviewed in more detail. The first two comprise selected institutionalist and planning theories that provide theoretical tools to identify and characterize change processes that take place incrementally and within a given institutional setting or regime. These studies are helpful to distinguish mechanisms of gradual change and their temporal progression throughout different phases. The third study introduces a methodological framework to analyse changes in planning systems and practices by taking a comparative perspective. It gives an example of how to apply the concept of planning culture in order to distinguish diverse logics of practice that may lead to transformations within planning systems. The theoretical notions and analytical elements of these studies provide a backdrop for the methodological framework of this thesis introduced in Chapter 3.

2.3.1 Learning from institutional change processes

At the outset, it is important to elaborate on different understandings of how change may unfold. Building on literature from political economy and the social sciences, Streeck & Thelen (2005) put forward a compelling conceptual tool to distinguish and analytically compare various modes of institutional change. The authors' premise is to argue in favour of local variations in institutional arrangements rather than transnational convergence. In this effort, they go on to emphasize a mode of change that tends to be overlooked, which is the transformational impact of creeping, evolutionary processes. By doing so, they provide an empirical and theoretical basis for a broader typology of change and move beyond traditional models such as the "punctuated equilibrium model" that much of the institutional literature, e.g. historical institutionalism, builds upon (Krasner, 1988). The scheme distinguishes between long periods of institutional stability that are periodically interrupted by sudden, exogenously generated shocks, which result in a more or less radical reorganization of the system (Pempel, 1998, as cited in Streeck & Thelen, 2005). Such notions are inherent to the work on path dependence, which according to Streeck and Thelen (2005: 6) tends to encourage the differentiation between two kinds of change processes: minor, adaptive and ultimately reproductive change, and major abruptly occurring change resulting in discontinuity. Varying interpretations have been put forward for this kind of institutional change. Scholars such as Mahoney (2000) or Krasner (1988) define "path-dependence" sequentially, arguing that the relative contingency at historic choice points, during which institutions are formed, is followed by periods of relative determinism and institutional stasis. Another argument is that institutional legacies of the past constrain the possibilities for institutional change and innovation in the present, thereby inherently influencing whichever comes afterwards. In this light, institutional continuity is understood to be sustained by mechanisms of increasing returns and positive feedback, which reinforce established arrangements throughout time (Streeck & Thelen, 2005).

But theoretical models emphasizing transformative change processes taking place due to exogenous shocks underestimate the transformative impact of endogenous change. They also present themselves less useful when intending to examine ongoing processes without interpreting the new as a variation of the old (Streeck & Thelen, 2005), an aspect that appears particularly pertinent when analysing change in the context of a transition towards automated mobility. On the one hand, because it is an ongoing process, and on the other hand, because no single exogenous factor can sufficiently explain the specific forms in which institutional change is currently taking place (Blyth 2002). While exogenous factors may destabilize institutional arrangements, there are limitations to understanding realignments and new trajectories as a mere function of exogenous developments, as rational-choice theories tend to do (Blyth, 2002; Streeck & Thelen, 2005). Scholars who support the assertion that institutional rearrangements "must be seen as an endogenous process" (Blyth 2002: 8), instead characterize institutional change as a dynamic process in which diverse actors perpetually create and recreate institutional arrangements (Streeck & Thelen, 2005). Challenging notions of disruptive moments, they emphasize that "the biases inherent in existing conceptual frameworks are particularly limiting in a time, like ours, when incremental processes of change appear to cause gradual institutional transformations that add up to major historical discontinuities." (Streeck & Thelen, 2005: 8). To conceptualize varying typologies of change, Streeck & Thelen distinguish between *processes of change* and *results of change* (Fig. 2.11).

Figure 2.11 Processes of change



Source: illustration by the author, based on *Introduction: Institutional Change in Advanced Political Economies*, by W. Streeck, and K. Thelen, 2005: 9.

While processes of change may be incremental or abrupt, both may amount to either continuity or discontinuity. The scheme expands the punctuated equilibrium model, which reduces radical change to abrupt shifts of institutional "breakdown and replacement", and incremental change to the reproduction of a given system. Instead, Streeck and Thelen (2005) argue that institutions may also prevail despite critical junctures or historical shocks, and maintain continuity through so-called "survival and return" (8). Far reaching institutional transformation may thus also occur in the absence of disruptive events. If incremental change accumulates over long periods of time, institutional arrangements can be radically altered through so-called "gradual transformation" that equally results in discontinuity (Streeck & Thelen, 2005). Such processes often unfold endogenously, beneath the surface of stability, which is why it is easy to obscure change that proceeds, e.g. in the form of reinterpreting or redirecting traditional rules in the service of new goals.

To present an alternative to the adopted approach and point out its advantages and shortcomings, an example is given on how path dependency may be used as part of an analytical framework. Moulaert et al. (2007) build on the notion of path dependency as part of a case-study-based research conducted in a number of European contexts. The premise was to examine how urban change movements – described as social innovation practices – affect urban political regimes and governance dynamics, which are largely characterized by neo-liberal New Urban Policy agendas. By integrating elements from a spatialized Regulation Theory (i.e. accumulation and regulation dynamics) and Cultural Political Economy (i.e. discourse analysis, hegemonic and counter-hegemonic construction), the authors emphasize discourse production as instrumental in the formation of hegemonic systems. The local scene is identified as a key arena for reproducing discourses or generating criticism. Accordingly, the analysed case studies centre on discursive and material strategies of change agents and the extent to which they are successful in challenging established governance mechanisms and institutional structures.

The study shows that despite failing to fundamentally alter dominating arrangements, all initiatives adapt to the specificity of urban political regimes. The adopted strategies by change agents either lie radically outside of a governing regime, exploit opportunities of regime change, or valorize institutional inertia to the benefit of added values on a neighbourhood scale. The analysis reveals valuable conclusions concerning gaps between discourse and practice, which arise as new discourses collide with existing institutions (Moulaert et al., 2007). While values and principles may be changing on a discursive level, policies need to comply with existing structures and procedures, which often leads to "institutional compromises and hybrid policy frameworks." (Moulaert et al., 2007: 206). The authors thus argue that institutional change is path dependent. However, by emphasizing institutional inertia and continuity, the analysis falls short of uncovering the endogenous change processes that might have been triggered within an institutional regime in response to social countermovements. Moulaert et al. (2007) do conclude that social innovation initiatives bear the potential to "trickle up", as institutional structures are never entirely impermeable, and may in effect "contribute to the creation, strengthening or perfecting of macro governance dynamics" (207). But the study does elaborate on these institutional consequences, or the form that these, perhaps subtle, changes take in spite of persisting institutional arrangements.

As the present work on automated mobility examines planning responses to a still evolving mobility technology, models of gradual transformation may be insightful on how change unfolds during a phase of preparation and anticipated radical change. Acknowledging that divergent institutional preferences may be constrained by or even operate to maintain traditional structures, this work is interested in tracing incremental adjustments within the field of planning practice that may accumulate over time and bear the potential to result in a "major recasting of the system" (Streeck & Thelen, 2005: 5). Yet an analysis of structural parameters alone would fall short of reasoning what mode change occurs in, and how new arrangements take shape. Thus, it is worth elaborating more closely how patterns of gradual or "creeping change" may be identified and characterized (Streeck & Thelen, 2005: 9).

In line with what Moulaert et al. (2007) describe as a gap between discourse and practice, which becomes more apparent the closer one gets to local levels of implementation and development, Hacker (2005) points out that the enactment of institutions or rules requires particular attention when analysing institutional change. Relatedly, Streeck & Thelen (2005: 11) understand the "enforcement" of institutions as a social process realized through the behaviour of agents. Agents interpret and apply rules according to given circumstances, inevitably enacting social institutions or rule sets in an imperfect manner, which are thereby modified (Streeck, 2009: 9). In effect, gaps occur between an institutional design or a set of rules and an agents' behaviour. Such gaps may exist by design, due to the ambiguity inherent to rules and institutions, or emerge over time, and essentially provide space for political contestation (Streeck & Thelen, 2005). But rather than viewing contestation as rare occasions for agency, limited to "periods of social transformation" (Swidler, 1986, as cited in Streeck & Thelen, 2005: 7), institutions can be viewed to be perpetually contested through the everyday reinterpretation and redirection of actors. It is precisely the leeway of actors to alter their enactment and implementation that may be explored as source of change, when analysing incrementally unfolding gradual change. Sources of change may thus be found in, e.g. changing meanings and functions (Jackson, 2005), alterations of pursued goals (Vogel, 2005) or new logics of action that comprise strategies, routines, and shared decision rules (Deeg, 2005: 196). In regard to the latter, Streeck & Thelen (2005) point out that fundamental change occurs when alternative practices that are initially explored by individual, so-called "enterprising" actors are adopted by a multitude of others. Shifts of this sort may be set in motion, if changing external conditions pose new demands that can't be sufficiently met through established means of action. But rather than concluding that agency is only sequentially effective, Deeg (2005: 195) asserts that transformation is more likely when endogenous and exogenous pressures for change are combined. Acknowledging various characters and mechanisms by which gradual transformation can unfold, Streeck & Thelen (2005: 18-30) differentiate five modes of incremental change: *displacement*, *layering*, *drift*, *conversion*, and *exhaustion*.

1. *Displacement* – dominant institutional arrangements coexist with other arrangements that may embody conflicting logic; space for action within dominant institutions; in critical moments/phases, traditional arrangements are discredited or pushed aside in favour of new institutions and associated behavioural logic. **Mechanisms:** rediscovery/activation of alternative institutional forms that were previously dormant, or (metaphorical) invasion through importation and cultivation of "foreign" institutions and practices. Change requires active cultivation by enterprising actors or agents who are willing to pay a price for their incongruent behaviour (e.g. exercise of power, or expenditure of resources) and whose interests are better served by new arrangements. Exogenous change is advanced by endogenous forces: endogenous evolution of a social system may provide the foundation for a new logic of action, when activated by interested parties in response to changing external conditions.

2. *Layering* – institutional reform set in motion by path-altering dynamics. **Mechanisms:** differential growth between established institutions and initially minor alternatives that experience explosive growth as they siphon off support by key constituencies. As established institutions stagnate or lose grip, the dynamics amount to an alternative arrangement or development trajectory. Such dynamics may be set in motion by active sponsorship or political actors working on the fringes, who introduce amendments that are initially sold as refinements of or corrections to existing institutions. As new layers do not directly undermine existing institutions, they typically do not provoke countermobilization by defenders of the status quo. The key questions concern the extent to which the fringe can coexist with the core, and whether the fringe attracts enough defectors from the core to eventually displace it.

3. *Drift* – in the absence of resets responding to changes in the political and economic environment, institutions can be subject to erosion or atrophy through drift. **Mechanisms:** deliberate neglect that may be masked by stability on the surface. Disjuncture may result from "natural trends" without explicit political manoeuvring: the world surrounding an institution evolves in ways that alter its scope, meaning, and function. Disjuncture may also be caused by gaps in rules allowing actors to dismiss previous responsibility or it may be promoted by political cultivation, that is, as a result of non-decisions in the event of exogenous developments causing existing institutions to lose their grip. In effect, the failure to actively maintain an institution may amount to allowing it to decay.

4. *Conversion* – institutions are redirected to new goals, functions, or purposes. **Mechanisms**: redirection or reinterpretation. In response to new challenges in a social, economic, and

political environment, policymakers deploy existing resources to new ends. Policymakers may use institutional capacities to intentionally make fundamental change proceed gradually. Alternatively, new actors turn an institution to new ends more aligned with their interests through a change in power relations. Redirection may also occur through political contestation, which is possible due to gaps between institutionalized rules and their enactment. Four sources of gaps comprise a.) unintended consequences (due to cognitive limits of the institutions' builders) that may offer opportunity for political contestation, b.) political negotiation that leads to compromises and results in ambiguities regarding how institutionalized rules should be interpreted and applied, c.) actors that circumvent or subvert rules by interpreting them in their own interest or mobilize political resources to influence decisions by rule-makers/enforcers, and d.) time, modifying the nature of challenges or balance of power. Institutions may not only impede change, however, but also condition it by redeploying traditional institutions to new ends.

5. *Exhaustion* – processes which lead to institutional breakdown in form of a gradual collapse. **Mechanisms:** depletion through behaviours that are invoked or allowed under existing rules and operate to undermine these. Institutions give rise to dynamics that make them increasingly vulnerable over time. They might age, e.g. by meeting limits to growth (further expansion destroys resources required for their continued operation), or by becoming ever more complex (increasing exceptions/special provisions are added, depriving the institution of its legitimacy, practicability, or both). Alternatively, their resources may be systemically incompatible or eroding.

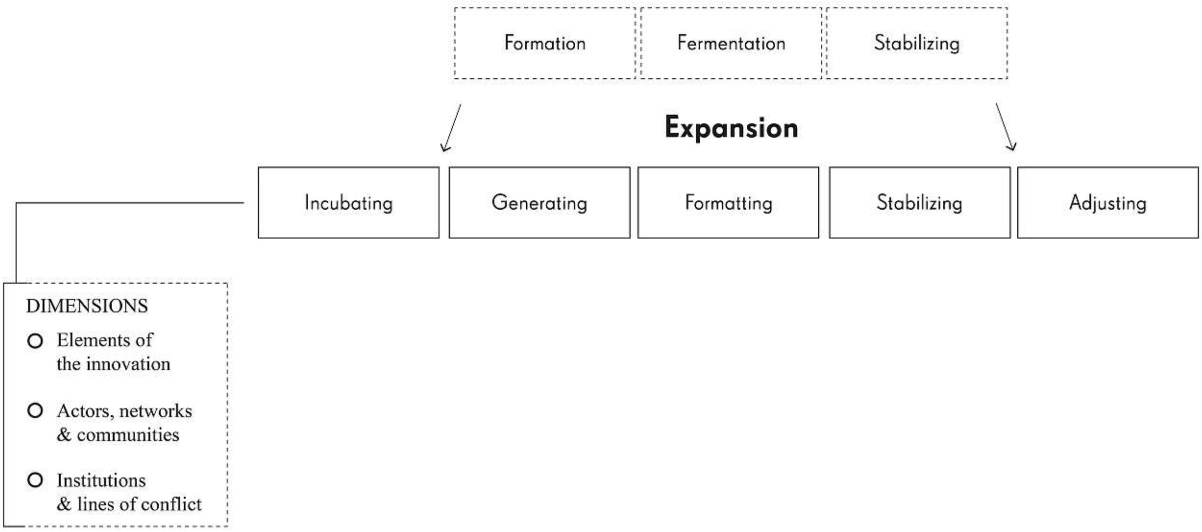
Of the described modes of change, *displacement*, *layering*, and *conversion* are those which bear characteristics most relevant to the research on unfolding processes of change in urban planning. While the first two are characterized by entrepreneurial actors who seize the opportunity to cultivate novel practices which ultimately displace or outgrow existing arrangements, the latter differs in that persisting institutional arrangements are redirected towards novel ends or interests. Two significant elements are derived from this analytical framework on gradual transformation. First, the widening of gaps between institutional arrangements and practice. Second, the enactment of diverging practices, ideas, and goals by enterprising actors.

2.3.2 Phases of incremental change in planning

To illustrate an approach that translates the notion of incremental and continuously proceeding change into planning, the research endeavour "Innovations in Planning: How do new approaches emerge in spatial planning?" (InnoPlan) is briefly elaborated. The research contrasts planning literature, which characterizes new planning approaches as a mere response to changing societal circumstances or, as elaborated above, as initiated by exogenous forces alone (Ibert et al., 2015). By contrast, the present work concerns itself with change that is initiated from within the profession itself in a proactive and intentional manner. Emphasizing the significance of agency, Ibert et al. (2015: 172) suggest to conceptualize change processes in spatial planning as "social innovations". Understood as a "complex and multi-layered social process" (Christmann et al., 2020: 501), innovations in planning may concern both product innovations, which aim for material urban design goals, as well as process innovations concerning procedures and instruments (Ibert et al., 2015). Social innovations are also considered to unfold over long periods of time, perpetuated by numerous steps that amount to profound realignments.

To be recognized as innovations, novel practices need to be perceived as an improvement by the actors involved (Zupan, 2018). Once new practices are legitimized and validated, they are more likely to be successfully diffused, enforced, and established as a new routine (Cajaiba-Santana, 2014). Christmann et al. (2018) point out that novel ideas may turn into a new mainstream, if they are imitated by others and transferred into contexts different from the one in which they were originally conceived. In contrast to the three-phased model commonly applied in innovation research (Braun-Thürmann, 2005: 45), the analytical framework of the InnoPlan project identifies five phases that characterize innovation processes: incubating, generating, formatting, stabilizing, and adjusting (Fig. 2.8; Ibert et al., 2015: 175-178).

Figure 2.12 Analytical Framework InnoPlan: Phases and dimensions



Source: illustration by the author, based on *Leitbildwechsel - Dynamiken und Charakteristika städtebaulicher Innovationsprozesse,* by D. Zupan, 2018: 36.

As part of the InnoPlan project, empirical research was conducted in different fields of spatial and urban planning to identify core characteristics of innovation processes. Based on the findings, Christmann et al. (2020) differentiate three dimensions that feature common themes: a.) "patterns of recombining elements", which essentially comprise the ideas and content of planning novelties;

b.) “key roles and types of actors”, which include networks and individual as well as collective agency; and c.) “eroding and emerging shared expectations as well as conflicts”, which concern institutions and means of institutionalizing new ideas or practices (Christmann et al., 2020: 501). To demonstrate an immanent logic of innovation in urban planning, Christmann et al. (2020) go on to abstract recurring patterns from the particularities of the examined case studies. In each of the five phases, patterns are characterized that may be observed within the three analytical layers (Fig. 2.9). For the purpose of this work, particular attention is given to the first three phases of innovation:

1. *Elements of innovation* – previously existing elements that could not be accessed or effectively connected, perhaps due to hampering institutionalized perceptions, e.g. temporary use. **Incubating:** Elements in the air. **Generating:** Overcoming of siloed administrative separation and establishment of joined strategies, commonly in local niches and supportive conditions. **Formatting:** Linkages are made robust through supportive formats.

2. *Actors, networks, communities* – individual or collective agents that push and promote innovations. Actors enrol in strategic networks (temporary collaboration on a voluntary basis to achieve common goals) and become enculturated in professional communities (shared practice, training, interest, and pool of knowledge). **Incubating:** Networks of founders/pioneering practitioners are formed by “elitists” and “outsiders” from the planning community. The latter share external viewpoints, but also critique of the establishment, which causes both irritation and inspiration. **Generating:** Networks are strategically extended and joined by “patrons” and “local allies” who support initial implementations in practice. **Formatting:** “Early adopters” try to repeat the success of the prototype elsewhere, while patrons step back and local allies may act as consultants or get promoted to higher positions in another region. Networks gradually grow into multi-local professional communities.

3. *Institutions, institutionalization and lines of conflict* – institutions are understood as “stabilizations of mutual expectations”, while social innovations are new ideas or practices that deviate from existing shared expectations. As such, they can become drivers of institutional change, while also causing lines of conflict to emerge due to challenging established institutions. **Incubating:** Growing discomfort with existing institutions. Shared expectations loose legitimacy as a group of avant-gardists sympathizes with critique by outsiders. Novel approaches require extraordinary efforts – institutional voids. **Generating:** Conflict lines change in nature due to investment of institutional resources into prototypical novel practices. Identification of situations in which the establishment is underrepresented.

Formatting: Desire to learn about the successful innovation. Conflicts flare up in the context of poorly protected local coalitions. New conflict lines emerge in response to institutionalization efforts (terminology, research designs, etc.), as well as concerning opinion leadership and reputation amongst members of the avant-garde.

Figure 2.13 Patterns of social innovation in spatial planning identified in the InnoPlan project

Phases

DIMENSIONS		Incubating	Generating	Formatting	Stabilizing	Adjusting
Elements of the innovation	ASSEMBLAGE	Unconnected elements	First links btw. elements	Consolidation of elements	Variation and adaptation	Mundane routine
Actors, networks & communities	NETWORKING	Founders' network + critique	Enrollment of patrons & local allies	Enrollment of early adopters	Enrollment of late adopters	Network closure
	PROFESSIONAL COMMUNITIES	Overlapping practices	Local blend	Multi-local boundary practice	Multi-local boundary practice	Wide-spread common practice
Institutions & lines of conflict	INSTITUTIONS	Deviant idea	Institutional void	Reducing inertia	Creating new rules and laws	Common sense
	INSTITUTIO-NALISATION	Anti-institutions + growing discomfort	Extraordinary conditions	Establishing concepts and frames	Establishing rules and laws	Differentiation of rules and laws
	CONFLICTS	Avant-garde vs. establishment	Avant-garde vs. establishment	Dominant vs. average avant-garde	Pragmatists vs. idealists	Fatigue

Patterns of unfolding innovations

Source: illustration by the author, based on *Innovations in spatial planning as a social process – phases, actors, conflicts,* by G. B. Christmann et al., 2020: 514.

The findings of the InnoPlan project correspond with the previously introduced framework on gradual institutional transformation insofar as both emphasize the ability of agents to shape and (re)configure the institutional or social conditions that might simultaneously constrain them. The shared notion of change being a social process is refined within the InnoPlan project by highlighting the reflexive feature of agency. Reflexivity stands for the capacity of actors to monitor and reflect upon the outcome of their actions, and shape their conduct accordingly (Cajaiba-Santana, 2014). As such, reflexivity may be viewed as a transformative element of social systems (ibid.). Christmann et al. (2020) find that agency and proactive learning not only empower planners to influence their working conditions, but may be "distributed across several institutional roles, locations, societal spheres and spatial scales." (513). The multidimensional analysis proved that substantial change is more likely to succeed when pursued by evolving networks of actors that are extended according to the demands of a situation. Besides shifting actor constellations, emerging lines of conflict may likewise change. The perception of what is socially desirable varies depending on the phase and the stakeholders involved, from subverting the establishment in a phase of incubation to ideological fractures between pioneering agents and more pragmatic followers in later stages of stabilization.

Given that social innovation in planning is understood as successfully established and relatively widespread modes of planning, the concept of innovation appears to be less applicable to the study of yet unfolding change. Relatedly, the normative framing of social innovation as a contribution to social wellbeing and the public good (Zupan, 2018; Christmann et al., 2020) is subordinate to interest of this work. Instead, the ambition is descriptive, explanatory and interpretive (Getimis, 2012). While Christmann et al. (2020) conclude by recommending means to stimulate change in a deliberate fashion, the work at hand examines potentially transformative patterns of change regardless of their orientation or goal. Nonetheless, the illustrated framework provides useful features and inspiration. Firstly, it provides a procedural model for change in planning, which makes it possible to temporally delineate occurring patterns. Secondly, it differentiates analytical layers that encompass the interrelatedness of social or institutional structures, agency and new ideas (Cajaiba-Santana, 2014). They allow for a more refined analysis of the previously mentioned elements that may induce change; i.e. widening gaps, agents' enactment and guiding ideas.

2.3.3 Context-based analysis of change processes in planning

Contrasting the abstraction of the procedural model described above, the final section introduces an approach that acknowledges processes of change as historically and culturally situated. In reference to the larger debate on a Europeanization in spatial planning, Reimer et al. (2014) stress the need for a contextualized or context-based analysis of change in spatial planning. Based on the premise that planning must constantly adapt and reposition itself due to ever-changing social and spatial challenges, the authors' aim is to examine national and local specificities therein. An integrated analytical and methodological framework is developed to compare processes of adaptation across European planning systems. The approach contrasts endeavours that attempt to construct typologies of planning systems by emphasizing a sensitivity for differences between and within planning systems. While the authors confirm that tendencies to convergence may be found across European planning systems, they stress a lack of comparative research on the manner in which specific adaptation mechanisms and practices manifest and unfold at a local level. The ambition is thus to shed light onto the dynamic relationship between change and continuity, while illuminating the diversity of planning systems and practices (Stead & Cotella, 2011).

> *"[T]endencies to convergence will not eliminate the diversity of local planning practices, as these will evolve as local institutional capacity confronts wider opportunities and pressures. The significant change, however, is in the point of reference through which these opportunities and pressures are perceived and ways of responding to them articulated."* (Healey & Williams, 1993: 717)

In order to compare processes of change in various countries, Reimer et al. (2014) adopt a multi-scalar and relational approach (Getimis, 2012). To this end, they too argue that the institutional settings and concrete practices enacted by various actors require equal consideration, if tendencies of change are to be critically examined. Institutions that frame planning practice are understood as both formal (i.e. legal and administrative foundation), and informal (i.e. actors' cognitively anchored patterns of perception, beliefs, shared values, and behaviour). Concerning the actor constellations, "actors of change" (Getimis et al., 2014: 292) are understood as driving forces of transformation. Their interaction dynamics with and within institutions, as well as with political or economic forces influence how processes of change unfold and which results they achieve. In addition, the authors highlight that the specific preconditions for change require attention. Reimer et al. (2014) emphasize that spatial and institutional challenges – which, again, may be considered as external or internal forces – may set in motion adaptations of a planning system's characteristics. Based on Getimis (2012), the authors propose three interrelated spatial tiers in which change may be observed:

1. *Spatial and institutional challenges (macro level)* – These may comprise social, economic, ecological or technological developments (e.g. economic restructuring, demographic trends, or climate change) that equally affect various contexts, but are dealt with and thus materialize in a different manner. Institutional challenges of spatial planning on the other hand concern the (in-)ability of institutional structures to adjust in accordance with changing circumstances.

2. *Structural nature and adaptive capacity of a planning system (meso level)* – Spatial and institutional challenges exercise pressure on a planning system to evolve. The pressure is particularly high, when established institutional frameworks and/or the goals of spatial development are no longer sufficient to adequately respond to existing or newly emerging challenges. In response, informal approaches may supplement formal planning procedures, or new approaches, concepts, or tools become trialled. The manner in which a given challenge is dealt with may vary between contexts as planners ascribe different understandings and priorities to a given theme, and may be influenced by social traditions or cultural values (Othengrafen, 2010). Processes of adaptation unfold gradually, as dynamic processes that are shaped by the interaction of various stakeholder groups (Getimis et al., 2014). The (in-)ability of institutional alignments or means of practice to adjust to changing circumstances may depend on the maturity and functionality of a planning system (Reimer et al., 2014: 5).

3. *Planning practices (micro level)* – Within a given planning system, multiple practices may be found at a local or regional scale. These comprise forms of planning action that differ in their respective policy or steering styles, as well as actor constellations. Drawing on a cultural planning perspective, planning practice may be locally or thematically differentiated, and analysed as "intrinsic logic" (Getimis, 2012: 31), that is, the specificity of a region or city.

For the purpose of comparing European planning systems, Reimer et al. (2014) emphasize the national level of planning systems, but acknowledge the relevance of local planning practice by stressing actor constellations and policy styles. The interplay of a planning system's dimensions – discourse, structure, and tools – is understood as a corridor of action for planning practice (Janin Rivolin, 2012). To identify contextual specificities in planning adaptations, the authors propose a methodological framework that comprises five "dimensions of change" (Reimer et al., 2014: 13):

1. Scope and objectives of spatial planning;
2. modes and tools of spatial planning;
3. scale(s) of spatial planning;
4. actors and networks in spatial planning;
5. policy and planning styles.

Two elements of this approach are critical for the work at hand. Firstly, the notion of a relational dynamic between institutional settings and actor constellations, and secondly, the consideration of specific preconditions for change. Both aspects are touched upon as part of the literature on institutional change processes by Streeck & Thelen (2005), but are substantiated here for planning research. As argued by Getimis (2012: 32), actor constellations are shaped by space-specific constellations of interests and influence, amongst others. An analysis of transformational dynamics thus needs to consider the power relations between involved actors as well as their constellation. The described multi-level approach resembles in part the framework proposed by Christmann et al. (2020), however on a larger, national scale. With regard to processes of transformation across European countries, Getimis et al. (2014: 303) conclude that there is no uniform direction of spatial planning transformation, but rather multiple trends of continuity and change driven by path-dependent as well as path-shaping factors. However, what the authors describe as coexistence between mainstream planning approaches and more innovative practices, may well be a transformational trajectory of *layering* or *displacement* without having resulted in such as yet (Streek & Thelen, 2005). Thus, while Getimis et al. (2014) focus on the results of change within the five dimensions mentioned, the study falls short of specifying in what form transformational processes unfold, and what direction they point towards.

Notwithstanding the above, the study is constitutive to the understanding of transformation in urban planning that is adopted in the subsequent parts of this thesis. That is, transformation in planning practice is viewed as an unfolding process that proceeds incrementally across long stretches of time and is set in motion by the agency of actors (networks), who reflexively interact with their institutional environments and social systems. Institutional, cultural, as well as spatial preconditions affect the speed, intensity and mode with which shifts occur. In effect, external pressures may exceed reinforcing influence, if they coincide with widening institutional gaps, discomfort, and inadequacy to meet emerging challenges. Lines of conflict of this kind, along with newly formed actor networks, deviant ideas, and informal planning efforts are considered entry points to analyse patterns of transformation before the backdrop of established planning practices. In this effort, the present work distinguishes itself from the studies presented above. Rather than analysing processes of change *ex-post*, it endeavours to examine currently unfolding change. In an effort to translate and consolidate the three approaches, the following chapter will introduce the methodological framework and premise of the case study analysis.

3. Methodological framework & research tools

This work is inspired by an interest in whether the advent of automated mobility is contributing to transformative change in planning practice. Do novel modes of planning emerge as municipalities take up planning preparations for a technological transition? Assuming an incremental understanding of transformative change processes arising from endogenous potential (see Chapter 2.3), patterns of change in a particular planning context are explored. An in-depth case study analysis is adopted as the primary research tool to first gain an understanding of how the process of planning preparation is characterized, which policies are being developed to which ends and which actors and actor networks are involved. The preparation of plans and policies for automated mobility is understood as a multidimensional process that is inductively explored.

Building on Appadurai's notion (1996) that cultural contexts influence societal processes, politics and ideoscapes, Graham and Marvin (1996) argued that technological developments too need to be distinguished according to the cultural contexts in which they are embedded. The question, then, is how perceptions and means of preparing for the introduction of AVs differ across cultural contexts and traditions. And how planning cultural contexts affect the capacity of planning professionals to introduce novel modes of planning. A second objective of the case study is thus to explore the correlation between planning initiatives for AVs and the broader cultural and social context in which they take place, adding another dimension to the characteristics previously identified as correlating with municipal preparation for AVs (Freemark et al., 2019). To this end, the contextual research is structured into cultural planning dimensions, adapted from Othengrafen's (2010) culturalized planning model. Following Levin-Keitel & Othengrafen (2016: 79), planning can be understood as a cultural action characterized by social norms and values, individual and institutional perceptions and interpretations, as well as planning routines. Understanding the cultural planning context therefore makes it possible to scrutinize the extent to which planning initiatives for AVs represent deviations from the established planning environment and the mainstream planning system.

The third objective of the study is a theoretical evaluation. As part of the quest to determine patterns of incremental and deliberate change in planning practice, the theoretical model for innovation in spatial planning by Christmann et al. (2020) is applied (see Chapter 2.3.2). The case study thus serves to test its applicability to contemporary rather than historical phenomena in planning. The aim is not to form a representative sample of changes in planning practice coinciding with the advent of automated mobility, which would run counter to the validity of a case study, as argued by Thomas (2011). Instead, the aim is to explore "the complexity and uniqueness" (Simons, 2009: 21) of emerging modes of planning that may coincide with the emergence of new mobility technologies. Originating from an interest in change initiated from within the profession (Ibert et al., 2015), the agency of planning actors in promoting novel practices and their means of doing so are explored.

The following chapter first introduces the rationale for the selection of the urban case study and then elaborates on the dimensions of a culturalized planning model before introducing the analytical framework and research methods used.

3.1. Selection of the urban case study

In previous studies analyzing so-called "pioneer regions" (Mitteregger et al., 2022: 84), the selection of case studies was based on the distinctiveness of their visions, strategic and programmatic transition initiatives (R&D, policy, and planning), as well as their internationally recognized contribution to the global discourse on automated mobility. The Greater Toronto Area (GTA), the subject of this thesis, has thus far not been considered a particular outlier. Even though the scope of public investment in CAV technologies and related transition initiatives since 2014 in the GTA, the Province of Ontario, and the Canadian federal government have been remarkable (see Chapter 4), and while the author would argue that it has been a particular omission of academics and policy analysts to examine the structural conditions that have given rise to this sheer breadth of activities, this is secondary to the suitability of the GTA for the research at hand.

As the selection of cases is essentially linked to answering the research questions (Baur & Christmann, 2021), it was crucial to choose a city or city region where public officials, policymakers and municipal planners have been actively engaged in AV-related initiatives over several years in order to examine the development of activities over time. In order to trace coinciding processes of change and deviation from the established planning system, planning preparations had to go beyond externally funded projects, such as the implementation of pilot projects that wane when funding ends and therefore liable to be unsustainable (Evans et al., 2021). The Greater Toronto Region, with the City of Toronto at its centre, is an example not only of proactive planning initiatives, but also of ongoing efforts that are organizationally embedded. Toronto's 2016 Divisional Workplan, the appointment of an AV team and the initiative to form an Interdivisional AV Working Group are examples of one municipal administration being invested significantly more than others in a subject of uncertain future relevance (see Freemark et al., 2019, for an overview of the state of preparedness across U.S. cities).

To apply the theoretical model of social innovation in planning and trace patterns of change (Christmann et al., 2020), it is important to note that the present case study consists of two dimensions. Firstly, the planning preparations initiated by the municipality of Toronto, including the various divisions and agencies involved in these efforts. Emerging patterns of change in planning practice are traced with particular attention to this dimension, as the City of Toronto's planning activities far outnumber those of neighbouring municipalities. Secondly, AV-related activities in the Greater Toronto Region, a metropolitan area without a governing institution but heavily affected by provincial policy overlays (Taylor, 2020). The second dimension is important to understand the multiplicity of initiatives, actors and drivers in the region that local activities closely relate to. Finally, it is important to note that the case selection was highly dependent on the openness of stakeholders to collaborate and support the present research effort through their time, expertise and trust.

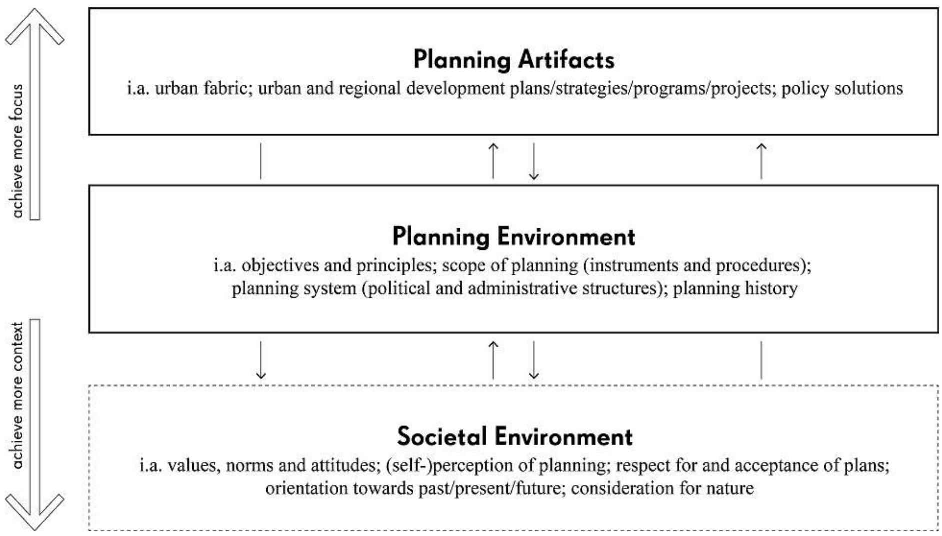
Uniqueness

The case of Toronto is unique among cities preparing for AVs. Looking specifically at the adopted plans and policy documents, a variety of approaches are taken. In some cases, overarching strategy papers are developed, for instance, Seattle's *Preliminary Automated Mobility Policy Framework* (Seattle, 2017), which is part of its *New Mobility Playbook,* and Toronto's *Automated Vehicles Tactical Plan* (Toronto, 2019a). More frequently, however, existing planning documents are updated and expanded to include policy recommendations for new mobility technologies. These may comprise comprehensive land use and transportation plans or strategic development frameworks. North American examples include San Francisco's *Guiding Principles for Emerging Mobility Services and Technologies* (SFMTA, 2017), Portland's *Transportation System Plan* (Portland, 2018), and Detroit's *Strategic Plan for Transportation* (Detroit, 2018). In such policy documents, the language on AVs ranges from referencing them as part of broad, outcome-based policies, e.g. in Portland, to specifying measurable objectives and actionable items with concrete projects, e.g. in Toronto. Although more and more cities are formulating positions on automated mobility as they update their comprehensive municipal and mobility plans, Toronto's AV Tactical Plan represents a distinct exception rather than the rule. On the one hand, due to its extensive development process, which was realized as a collaborative effort between 30 municipal divisions. And on the other hand, due to its thematic scope and actionable details.

3.2. Planning cultural framework

Despite the widespread recognition of cultural diversity in planning, there is no uniform understanding or definition of planning culture as a concept (Fürst, 2007). Much less when it comes to applying a culturalized planning model for empirical purposes and developing a systematic analytical framework (Getimis, 2012). Scepticism prevails concerning its scientific adequacy and methodological complexity (Casprig, 2009; Levin-Keitel & Othengrafen, 2016). As a comprehensive analysis of the theoretical construction of planning cultures exceeds the scope of this thesis (Casprig, 2009), an existing conceptual framework of planning culture is applied to structure the contextual and historical backdrop of ongoing planning initiatives for AVs.

Figure 3.1 Dimensions of a culturized planning model



Source: illustration by the author, based on *Spatial Planning as Expression of Culturised Planning Practices: The Examples of Helsinki, Finland and Athens, Greece,* by F. Othengrafen, 2010.

In doing so, this study employs Othengrafen's *culturized planning model* (2010; Fig. 3.1) as a starting point, but goes beyond it by also considering aspects highlighted by Getimis (2012) as typically neglected, e.g. actor constellations and institutional relations. By using culture as an organizing category, the model integrates concepts from cultural theories, organizational studies and intercultural studies (Othengrafen, 2010). In contrast to theoretical concepts of planning culture that tie into governance studies, institutional theories or practice-based approaches, it also considers the built environment. Visible urban structures, architecture and planning documents are understood as expressions of underlying value sets, attitudes and traditions (Knieling & Othengrafen, 2009).

As much as political or planning decisions determine urban development and other visible artefacts, the built environment equally impacts the expectations of various actors concerning specific development goals or applied planning instruments (ibid.). In this vein, the first dimension of the culturalized planning model comprises the so-called *planning artefacts*, or "visible planning products, structures and processes" of a planning system (Othengrafen & Reimer, 2013: 1275). In relation to automated mobility, these may include published position papers and strategy documents as well as legal acts and decrees. Moreover, Othengrafen & Reimer (2013) assign the role and responsibilities of the different planning actor groups to this category.

The *planning environment* further includes the shared assumptions, values and cognitive frameworks held by the planning actors, which relate to the objectives and principles that urban and spatial planning strives to achieve (Othengrafen, 2010). It also refers to the culturally conditioned instruments and procedures applied by actors in their planning practices (Levin-Keitel & Othengrafen, 2016), as well as the structural arrangements (political, administrative and organizational structures) that shape them (Friedmann, 1967). Drawing on Getimis (2012), the institutional context is characterized by an interactive process. While institutional arrangements influence actors and their means of interaction, they are likewise shaped by the capacity of actors to foster new discourses and practices (Getimits, 2012). As argued earlier, the enactment of institutions or sets of rules may be viewed as an essentially social process (Streeck & Thelen, 2005). Emphasizing the "intrinsic logic" (Getimis, 2012: 31) of a place, Getimis et al. (2014) point out that different planning styles may exist within one country, depending on the region and locality. Based on the degree of local and/or regional autonomy, local actors have broader options to exercise their planning power and thereby shape place-specific planning practices and styles (ibid.). This issue is particularly relevant to the planning regime in the metropolitan region of Toronto (Taylor, 2020).

Finally, a temporal dimension to understanding a planning environment is gained by reviewing local planning history and planning tradition (Booth, 2011). Past realignments of planning and administrative traditions, e.g. towards decentralization or multi-actor participation and consensus features, shed light on the historical background of a local planning style and its principles e.g. sustainability, provision of equal living conditions, etc. (Knieling & Othengrafen, 2009: 56). Reimer & Blotevogel (2012: 18) further argue that specific planning traditions result from an interplay between planning routines (i.e. functional logics of institutional environments) and spatial structure. The development of urban structures and mobility systems can thus be understood as a result of and influencing factor for entrenched traditions of planning practice, creating a feedback cycle that

Sorensen & Hess (2015) emphasize in relation to the land use planning system in the Greater Toronto Area (see Chapter 6).

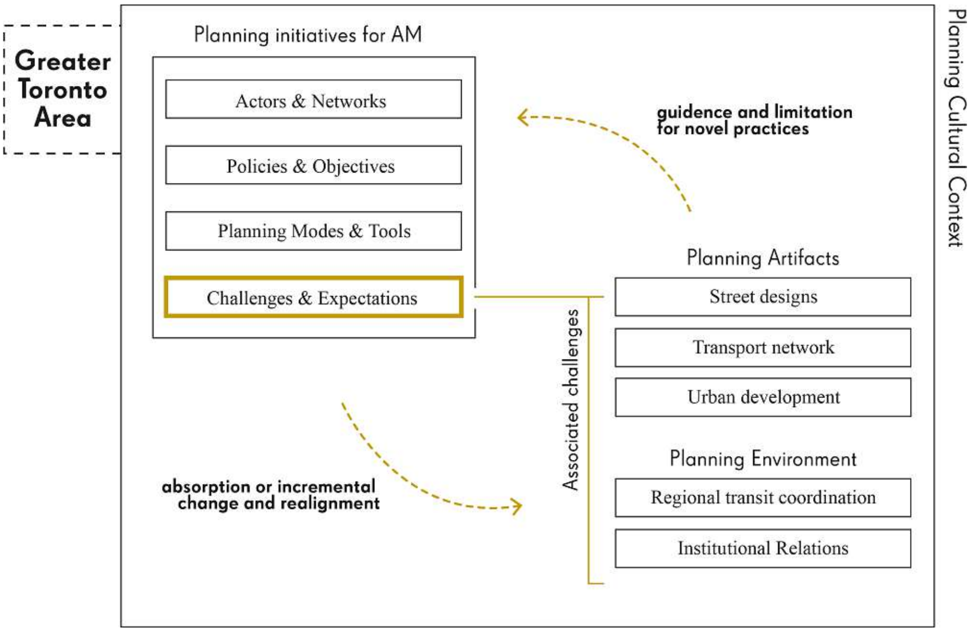
The third dimension of the culturalized planning model is the *societal environment,* which comprises unconscious societal norms and attitudes adopted by planners, but also the societal perceptions of planning actions and policies. For instance, public considerations and attitudes towards new mobility technologies and urban development, including the need for climate adaptation, may be relevant for planning initiatives for automated mobility. According to Knieling & Othengrafen (2009: 56), public support for such issues affects planning culture in terms of planning principles (e.g. urbanism vs. suburbanism) and priorities (e.g. economic competitiveness vs. environmental protection).

In light of the desire to use the concept of planning culture for analytical purposes, it is important to recognize the challenge involved. Scholars have pointed out that the correlation between variables can be highly complex and difficult to substantiate, unless a large number of case studies provides a higher level of control (Booth, 2011; Zupan, 2018). Hence, the ambition is not to draw conclusions about causal mechanisms between planning culture elements and planning initiatives for AVs or patterns of change that occur. This would likely prove to be an idle effort as planning culture is not a static concept but is understood to be in constant state of change (Getimis, 2012). An empirical study that examines the manifestations of planning culture is therefore limited in its observations to the time frame of its implementation. This is particularly the case for the perceptions and interpretations of the interviewed experts, which according to Levin-Keitel & Othengrafen (2016), are likely to be anchored in the zeitgeist of a given place of action. Instead, the goal is to understand planning initiatives for AVs as embedded in planning culture and to trace patterns of change through a historical perspective structured by the specificity of planning culture dimensions.

3.3. Stages of analysis & dimensions of change

In order to operationalize the three objectives of the case study, an analytical framework was designed (Fig. 3.2). Based on the neo-institutionalist and social science theories introduced in Chapter 2.3, the analytical framework combines the processual understanding of social innovation in planning (Cajaiba-Santana, 2014) with contextual dimensions of the culturalized planning model (Othengrafen, 2010). The first phase of the empirical enquiry focuses on planning initiatives for automated mobility. In reference to the "dimensions of change" by Reimer et al. (2014: 12), the analytical scope is structured into the following dimensions: 1. actors & networks, 2. policies & objectives, 3. planning modes & tools, and 4. challenges & expectation.

Figure 3.2 Analytical Framework, Phase 1 and 2



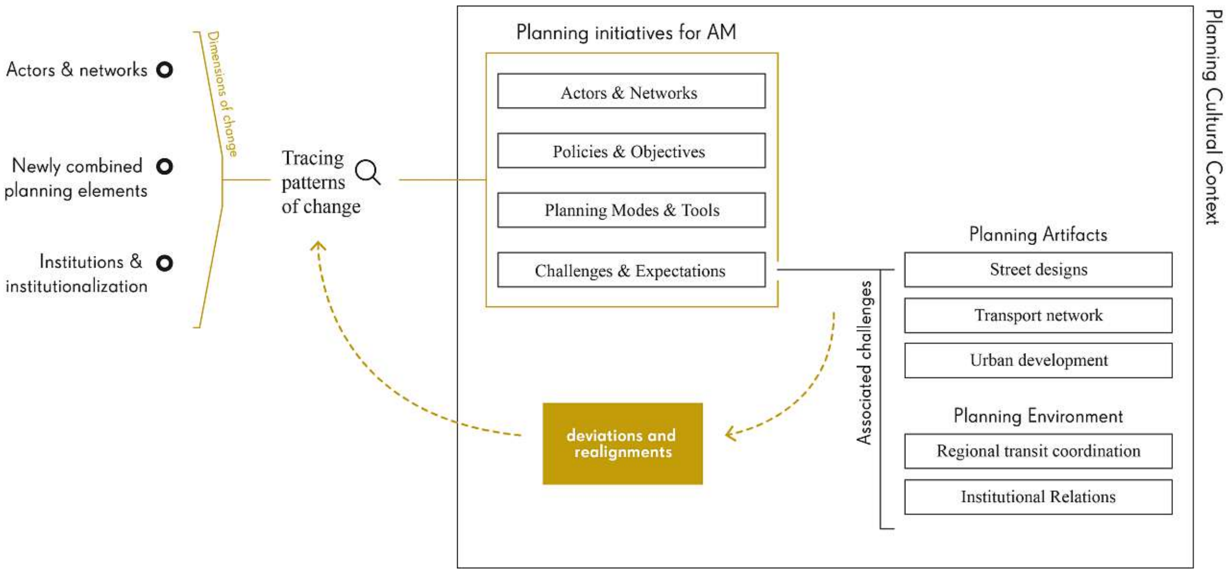
Source: illustration by the author, based on *Spatial Planning as Expression of Culturised Planning Practices: The Examples of Helsinki, Finland and Athens, Greece,* by F. Othengrafen, 2010; and *Spatial planning systems and practices in Europe: a comparative perspective,* by M. Reimer et al., 2014.

Following an "inductive investigative strategy" (Merriam & Tisdell, 2015: 37), the first phase is initially concerned with identifying the main actors (groups) involved in the field of automated mobility policy and planning. Their institutional backgrounds, constellations and interactions (Getimis, 2012), as well as engagements in strategic networks. Secondly, the most relevant policy documents are analysed in terms of their vision, thematic goals and actionable objectives. On which understanding of planning (strategic, adaptive, integrated, etc.) are the visions for an uncertain future with automated mobility based? What kind of regulatory approaches do they allude to? Thirdly, local piloting initiatives are examined as a key planning tool in preparing for AVs. Here, the analytical focus is particularly on urban integration, research objectives and expected learnings, as well as process design. Fourthly, the perceived challenges and expectations related to AVs are derived from expert interviews. Other primary sources of analysed data include policy documents and grey literature.

The identified challenges related to AVs serve as entry points to explore the planning cultural context in the second phase of analysis. Based on the previously described culturalized planning model (Othengrafen, 2010), the perceived challenges are differentiated into those related to planning artefacts, e.g. the transport system and the built environment, and those related to the planning environment, e.g. organizational structures and institutional relations. To understand the historical embeddedness of present-day challenges, each is framed by a revision of its planning and institutional context, including significant developments in the past. Contextual dimensions for AV-related planning initiatives include: 1. street design, 2. transportation network, 3. urban development, 4. regional transit coordination, 5. institutional relations.

Embedding the analysis of planning initiatives for AVs into their planning cultural context opens up a historical perspective that allows to historically situate the preparation for AVs and to link past developments with current planning approaches (Streeck, 2009). The institutional, social, cultural and spatial conditions of a place give rise to and enable social action (Cajaiba-Santana, 2014). Yet the same conditions can also constrain and dismiss novel practices or cause emerging concepts to be absorbed by established ways of doing things (Albrechts, 2011). In this sense, emerging practices and proactive agency have a reciprocal relationship with their structural environment, which is equally subject to change due to them. Planning novelties are thus locally and historically contingent (Christmann et al., 2020) and unfold in an organic, rarely linear manner (Cajaiba-Santana, 2014). A historical and multidimensional perspective facilitates the tracing of temporal variations of ideas and concepts and the identification of widening institutional gaps as well as lines of conflict that may bring about new ways of thinking (Streeck & Thelen, 2005; Albrechts, 2011).

Figure 3.3 Analytical Framework, Phase 3



Source: illustration by the author, based on *Spatial Planning as Expression of Culturised Planning Practices: The Examples of Helsinki, Finland and Athens, Greece,* by F. Othengrafen, 2010; *Spatial planning systems and practices in Europe: a comparative perspective,* by M. Reimer et al., 2014; and *Innovations in spatial planning as a social process – phases, actors, conflicts,* by G. B. Christmann et al., 2020.

Against this backdrop, local planning initiatives for AVs are reconsidered in relation to their planning cultural context and analysed with regard to possible implications for divergence and realignment (Fig. 3.3). Borrowing from the model of social innovation in spatial planning by Christmann et al. (2020), the third phase of analysis is structured into three dimensions of change: 1. actors & networks, 2. newly combined planning elements, 3. institutions & institutionalization. Initially, actors of change and strategic networks are analysed in terms of their role in cultivating institutional and organizational change. Secondly, AV-related policy goals and action items are examined for their capacity to respond to existing challenges in the transportation system. Moreover, the reconfiguration of goals and procedures in recent practical examples is analysed. Thirdly, material and organizational novelties are analysed in their institutional context and in terms of their level of institutionalization.

To qualify the extent to which planning initiatives for automated mobility resemble or deviate from established planning practice, typical patterns of early change processes in planning serve as the lens of investigation (Christmann et al., 2020). In contrast to other theoretical notions that frame change in planning practice as a response to exogenous forces (Ibert et al., 2015), the focus of the present study centres on change emerging from within the planning profession, intentionally fostered by the agency of planning actors. Deviations in planning practice may thus involve ideas that challenge established planning assumptions or instruments, the involvement of actors beyond the planning domain, as well as a growing discomfort with established planning processes, means and principles (Christmann et al., 2020). New rationales for action may not yet have emerged, but changing circumstances or unprecedented challenges may inspire and reinforce the exploration of alternative pathways. In analysing the dimensions of change described above, following Christmann et al. (2020), an attempt is made to identify some of the following patterns:

- **Unconnected elements/first links:** pre-existing elements are recombined in unprecedented ways or in new settings. Such "assemblages" (Christmann et al., 2020: 506), may consist of both procedural and organizational elements as well as physical structures that are reconfigured, often drawing on traditional practices and concepts that were previously unrelated or difficult to access.

- **Actors of change, networks of founders, patrons & allies:** Individual or collective actors who drive and promote alternative practices and may thereby trigger processes of change. They can form so-called "founders' networks" (Lelong, 2014: 221) that bring together pioneering stakeholders. These typically comprise planning professionals that consider themselves avant-gardists and so-called "outsiders" – professionals from outside the planning sphere who are concerned with planning related topics. Together, the founders' networks express or engage in practical criticism of established planning practices. To realize initial experiments and examples of novel approaches, it is crucial to have the support of so-called patrons and local allies, who ensure political backing or adapt ideas to contextual needs and traditions (Christmann et al., 2020).

- **Overlapping practices:** Perceived challenges may require circumventing, amending or supplementing existing planning practices. While negative references within the planning sphere and critical viewpoints stimulate an openness to alternatives (Ibert & Müller, 2015), other approaches or solutions are not established from the onset, but remain unfamiliar at first. Alternative approaches are only gradually adapted to local contexts and made accessible to different stakeholders in order to find a common solution.

- **Deviant ideas & expectations, institutional voids:** New ideas and practices emerge in relation to, in response to or against existing institutional expectations and interaction practices (Bathelt & Glückler, 2014). This depends on whether actors of change or networks of founders perceive existing planning practice as capable of adequately responding to changing circumstances (Streeck & Thelen, 2005). Initial patterns of change may emerge in the form of shifting expectations and new means of interaction, even if the formal rules remain unchanged (Bathelt & Glückler, 2014). Initial instances and provisional implementations of deviant ideas, concepts or practices typically take place outside or at the margins of established institutions, benefiting from so-called "institutional voids" (Hajer, 2003: 175).

- **Institutional discomfort:** As part of newly established networks, practitioners "cultivate a growing discomfort" (Christmann et al., 2020: 511) towards mainstream planning. Due to external criticism and the perception that existing (cognitive) frameworks, principles or planning tools are no longer adequate to address the urban challenges at hand, their legitimacy erodes. Reasons for the increase in practical constraints or institutional incoherence may include a lack of foresight by the establishment, alternative interests or changing circumstances (Streeck & Thelen, 2005). Founding networks collaborating with patrons and local allies need to exert extraordinary efforts to realize alternative approaches or ideas. Exceptional events, as well as planned pilot projects, can provide a temporary setting in which existing rules do not apply, and testing of unconventional ideas and joint learning is possible.

- **Lines of conflict:** The (growing) group of avant-gardists or pioneers stands in conflict with representatives of the establishment, who defend existing expectations, principles or means of practice. New ideas and practices are expressed in political contestation. This can change as resources, patron support and local allies grow. To test and implement alternative practices, situations are sought where the establishment has less influence or suffers from de-legitimization.

In the context of this work, planning practice is understood as a dynamic and continuously evolving process. Accordingly, the patterns of change that can be determined are not considered to be finite or consequential, but as tendencies that may set in motion wider currents of change if successfully consolidated and organizationally embedded. Here, the link between learning and the institutionalization of novel practices is critical (Evans et al., 2011). Conversely, if actors fail to mobilize the necessary resources for new practices to become routine, they may equally well subside and be absorbed by established arenas (Albrechts, 2011). But even if this is the case, the interplay of unconventional ideas and practices can lead to incremental adjustments in the institutional and cultural contexts in which they occur, which can only be qualified as contributing forces in retrospect (see Section 2.3.1).

3.4. Research methods

Following Yin's (2014) definition of case studies, the empirical inquiry is designed to explore processes of change in planning related to the advent of AVs as a contemporary phenomenon in its real-life context (18). To this end, qualitative research methods are applied, including semi-directed expert interviews and a comprehensive content analysis of policy documents and grey literature. This combination of tools allowed for cross-verification and triangulation of the empirical findings (Gläser & Laudel, 2009: 105). The case study is framed by research conducted simultaneously as part of the project *AVENUE21 – Connected and Automated Driving: Prospects for Urban Europe* (Mitteregger et al., 2022) and as part of the study on *Street Design Impacts and Traffic-Land Use Compatibility of Automated Driving in Vienna* (Bruck et al., 2020). As part of the first study, a qualitative meta-synthesis of studies on automated shuttle buses was conducted. Parts of the findings are presented in Chapter 2.1. The latter study involved a secondary analysis of primary data retrieved from a MATSim simulation, in an effort to investigate the urban impact of automated vehicles at street level. The urban implications for traffic compatibility and urban street designs are presented in Chapter 2.2.3. The following sections introduce the primary analytical methods applied in the case study research on the Greater Toronto Area.

3.4.1 Qualitative expert interviews

Selection of interviewees

As part of the empirical research, a total of 16 qualitative interviews were conducted with selected experts in the field: Representatives from public administrations at different levels of government (7 interviews), public agencies (2 interviews), academia (5 interviews) and the private sector (2 interviews). The interviewees were selected for their expertise in transport policy and planning, urban development and urban studies. Moreover, their professional involvement in automated driving and emerging mobility technologies in the Greater Toronto Area was crucial. The conducted interviews were therefore experience-focused and non-random (Brinkmann, 2014). The initial interviewees were selected based on local academic research; the selection was later on expanded according to the interviewees' recommendations (Gläser & Laudel, 2009).

Thirteen interviews, consisting of twelve individual in-person conversations and one group interview, were conducted between August and September 2019. Two interviews were conducted via video conference, one in October 2019 and one in January 2023. The interviews lasted between 30 minutes and one and a half hours. With the interviewees' consent, 11 interviews were recorded for transcription, and in five cases detailed notes were taken and later digitized.

Aim

Qualitative expert interviews were conducted in order to gain insights into the perceptions and opinions of experts (Dandekar, 1986) on the questions of *what* (e.g. current policies and planning actions on AVs, future trajectories and the broader planning context) and *how* (e.g. necessary process designs, actor involvement, modes and tools). The aim was to gain an in-depth understanding of planning initiatives on AVs, their characteristics, temporal progression and stakeholder involvement. Moreover, the interviews also sought to obtain a differentiated picture of the perceived potentials and challenges of introducing AVs in the GTA. This also encompassed the ability to manage the transition, future actions by institutional actors and the perceived need for changes in policy and planning.

Interview Design and Strategy

The interviews were conducted as semi-structured knowledge-producing conversations (Brinkmann, 2014) and following the same interview guide (Appendix A). They were hermeneutically oriented, i.e. focused on understanding phenomena in context. The approach was methodologically flexible and open to a qualitative nexus of meaning unfolding throughout a variety of accounts. In order to gain a more comprehensive picture of local planning initiatives for AVs, the interviews followed an inductive strategy. The conversations were set up as informal exchanges, treating interviewees as active participants rather than "speaking questionnaires" (Potter & Wetherell, 1987, as cited in Brinkmann, 2014: 292). For such a situational practice, the interview guide had to enable an iterative conversational development that allowed respondents to question the proposed concepts. The course of the conversation could thus involve the negotiation of meaning and clarification of interpretations by the interviewer (Brinkmann, 2014). In this sense, the interviewees were not viewed as mere informants of particular stories, processes or relations (Peattie, 1983), but as active participants in the construction of knowledge. The findings are contingent, reinforced not only by the conversational design of the interviews, which acknowledges the historical horizon of perceptions and interpretations (Brinkmann, 2013), but specifically by the unforeseen outbreak of the Covid-19 pandemic in early 2020.

Coding and analysis

The transcribed and anonymized interviews were coded using MAXQDA software. In an initial iteration, an open coding methodology was applied to inductively capture themes and patterns (Merriam & Tisdell, 2015). Thereafter, the codes were thematically grouped into theory-oriented categories, which were iteratively revised as new themes emerged (Gläser & Laudel, 2009). Finally, the categories were sorted according to the dimensions of the analytical framework. The generated material was analysed and substantiated by findings from the policy and literature analysis.

3.4.2 Literature analysis

Policy document analysis

In order to understand the extent to which planning documents and policy frameworks have been either adapted or newly developed with regard to AVs in the Greater Toronto Area, a review of so-called planning artefacts was conducted, which examined position papers, strategy documents, legal acts as well as decrees published between 2014 and 2022 on the topic of AVs. Government websites were used to retrieve policy documents at local, regional, provincial and national levels. Following Prior (2003), policy documents may be understood as "situated products" that are "produced in social settings" and thus "consumed and used in organized settings" (26).

Based on recurring references made during conversations with interviewees, selection criteria were established for the most relevant policy documents, including the guiding influence of policy on municipalities in the GTA, explicit development for the preparation of AVs, or explicit amendments in light of AVs, and their official publication by 2020. On this basis, four documents were selected for in-depth analysis (see Chapter 4.3): a.) the *Automated Vehicles Tactical Plan* (Toronto, 2019a), b.) the *Amendment 456 to the Official Plan* (Toronto, 2020a), c.) the *2041 Regional Transportation Plan* (Metrolinx, 2018), and d.) the *CAV Readiness Plan* (Ontario, 2020a). The selected policy documents were analysed by means of an interpretive synthesis (Weed, 2005) focusing on the following dimensions: a.) format; b.) development process; c.) directions, goals, and tactics; and d.) action items.

In terms of the documents' "format", the analysis determined the underlying planning approaches, the applied instruments and the perceived priority of a potential introduction of AVs on planning practice. The social setting of its development was analysed as part of the "development process". Political and administrative decision-making processes leading up to the publication of the documents were traced to the extent that public records, e.g. reports to City Council, minutes of City Council meetings and expert interviews, could grant insights into the "inner workings" (Caulley, 1983, as cited in Owen, 2014: 11). "Directions, goals, and tactics" were analysed for their reference to spatial and mobility-related transformations, or their lack thereof. Lastly, "action items" were reviewed to gain insight into the planning activities prioritized for the coming transition period.

Grey literature analysis

In order to gain a chronological overview of the planning initiatives that have been launched in the GTA since 2014, the analysis of policy documents was complemented by a comprehensive review of grey literature. Grey literature can be characterized as literature which "is produced on all levels of government, academics, business and industry in print and electronic formats, but which is not controlled by commercial publishers" (GreyNet, 2013, as cited in Mahood et al., 2013). It is perhaps best described by the types of documents it refers to, which comprise dissertations, conference abstracts and proceedings, government reports, research and committee reports, book chapters, magazine articles, newsletters, blogs, wikis, and preprints (Mahood et al., 2013; Paez, 2017). Reviewing grey literature is essential for a systematic and chronological review of recent planning initiatives, as much of the required data is either not disseminated through peer-reviewed commercial media (Paez, 2017) or is published only after a significant time lag. In addition, complex government approval processes may equally prolong policies from being officially released.

Grey literature on planning initiatives in the Greater Toronto Region was accessed through the official websites by governmental agencies, research institutes and university repositories, as well as web searches for local press reports and blog entries by advocacy groups. The data collected on AV-related planning and policy action covers the period between 2013 and 2022. Identified AV planning initiatives focused on the Greater Toronto Region were chronicled along a timeline and differentiated by municipal, provincial and federal levels of activity (see Fig. 4.1). Initiatives include provincial regulations, governmental plans, strategies and policy frameworks, AV shuttle trials on public roads, networks, governmental initiatives and programs, and third-party studies.

Toronto's open data platform and its legislative website, including the database of City Council meetings, agendas and staff reports, provided critical sources of data. So-called *Reports on Action* by municipal divisions, and City Council decisions were particularly informative in relation to the progress of planning procedures and Council approvals. For instance, concerning policy amendments that had not yet appeared in overarching policy documents, such as the Official Plan, indicating ongoing government revision. The inclusion of a grey literature review may therefore "help ensure the most current picture of what is happening within a body of evidence or area of practice at the time of the review" (Paez, 2017: 237). For the research at hand, obtaining data from grey literature was critical to extend the analysed timeframe beyond the point of conducting the interviews in 2019, as the onset of the Covid-19 pandemic significantly affected planning actions in Toronto and the GTA.

3.5. Reflection

The expert interviews conducted were critical to the in-depth analysis of the case study, which would have not been feasible based on policy and literature analyses alone. The publication of the Automated Vehicles Tactical Plan (Toronto, 2019a) shortly before the interviews were conducted enabled in-depth discussions on its development, content and implementation in the form of individual studies and pilots. Moreover, interviewees were able to speak to the quality of its development process and its impact on organizational change. And perhaps most importantly for the research question at hand, interviewees referred to ongoing changes in Toronto's planning environment. Qualitative dimensions that a document analysis alone would have not revealed. The initial challenges in conducting the interviews related to the length and wording of the questions, as well as cultural differences in the use of terminology. Therefore, the interview guide, including the wording, was revised and the interview style was adapted to be somewhat less directive. In addition, the interview guide was iteratively adapted to the institutional background of the interviewees to facilitate entry into the conversation.

The triangulation of the qualitative instruments proved nonetheless crucial in answering the research questions related to the topic at hand. Firstly, to substantiate insights into planning cultural dimensions that were referenced in the interviews without being their primary focus. Secondly, to extend the analysed timeframe beyond the interviews conducted in 2019, which would otherwise certainly have led to different conclusions. The onset of the Covid-19 pandemic not only delayed the implementation of several key projects in the AV Tactical Plan, such as the West Rouge Shuttle Trial, but also prompted Toronto City Council to adopt a Pandemic Mobility Recovery Strategy. Although it remains to be seen whether the programs accelerated in recent years and analysed in Chapter 7 will succeed in being institutionalized and scaled, or whether they will eventually fade. They have certainly contributed to novel policy assemblages that incorporate AV-related elements, to organizational learning about temporary improvements to the transportation system, and to positive real-life experiences for many Torontonians. Without attempting to draw conclusions about their future prospects, the program examples are informative on how a municipality that has prepared extensively for the potential introduction of AVs integrates related policy elements into its ongoing planning practices.

PART II. FEATURES OF THE PRESENT

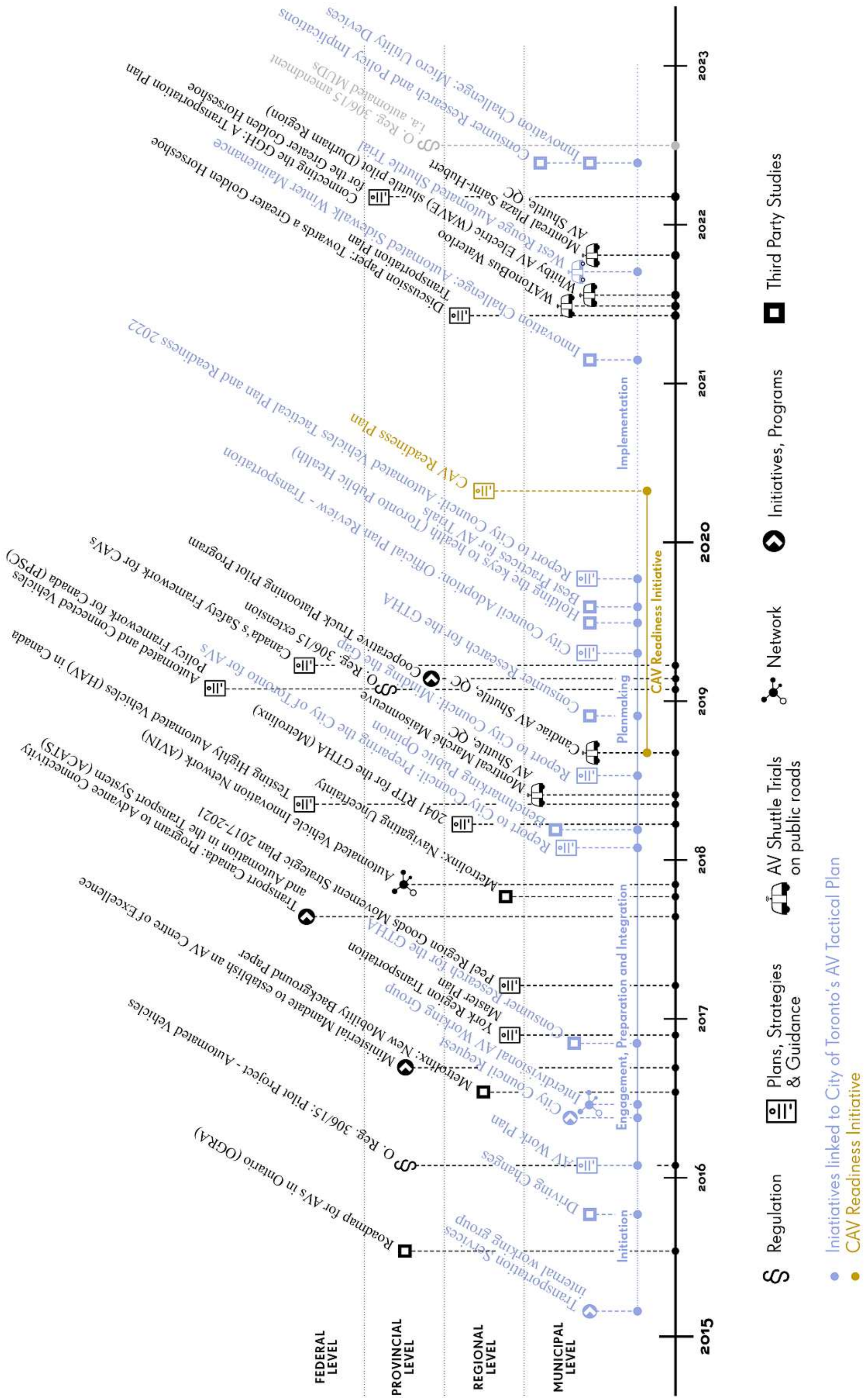
4. Planning initiatives for AVs in the Greater Toronto Area

An effort to understand whether and in what form transformative change in urban planning may coincide with the advent of AVs must begin with the identification of the actors and processes driving the project of automated mobility forward (Clark, 2020). What started as an industry push has challenged governments and planning authorities alike to respond and take a role in managing the transition. Yet the public sector's capabilities and opportunities to prepare for, respond to and adopt new technologies vary significantly. Governmental resources, population size and growth as well as political ideologies have been shown to produce variations amongst municipal levels of preparation for AVs (Freemark et al., 2019).

In this chapter, the Greater Toronto Area (GTA) serves as an example of how the automated mobility project is being pursued in one of the fastest-growing metropolitan regions in North America. Since 2014, public agencies in the GTA, the province of Ontario and the Canadian federal government have launched numerous planning initiatives on AVs (Fig. 4.1). These range from governmental programs, policy frameworks and jurisdictional guidelines, to municipal transportation strategies, demonstrations and pilot projects. Most importantly, regulatory changes were implemented at the federal and provincial levels that challenged municipalities to respond with adequate planning steps. As the legal way for CAVs is being paved, it is undeniable that the scope of investments in CAV technology and related activities is remarkable across the GTA, perhaps to the extent of providing "a welcoming environment for CAV technology" (Ontario, 2020a: 5).

Drawing on previous research, which has shown that transport and planning officials can play an important role in pushing, organizing and implementing AV-related planning action (Fraedrich et al., 2019; Freemark et al., 2019), the present chapter first elaborates on how regulatory oversight of automated mobility is divided across levels of government in Canada. In the following section on regional actors and agencies (4.1), attention is drawn to actors from all sectors of society in order gain better insight into the various forces at play in a specific planning context. The following sections then address specific modes and tools that public agencies adopt as a means to prepare for, learn about and shape a possible transition towards AVs. Three specific modes are distinguished and analysed in detail: a.) newly commenced networks as institutional settings for municipal and regional preparation (4.2); b.) newly developed planning strategies and adapted policy documents (4.3); and c.) piloting initiatives as a form of real-life experimentation (4.4). The aim is to identify noteworthy facets of policy and planning preparation in the GTA that may characterize locally specific pathways to AVs and provide indications of related shifts in planning practice.

Figure 4.1 Selected CAV initiatives at different levels of government in Canada



Source: illustration by the author.

Regulatory authority over automated vehicles in the GTA

Before delving into the details of planning initiatives, Table 4.1 summarizes how the regulatory oversight of automated mobility is divided between different levels of government. As in other Canadian provinces, municipalities in Ontario have limited legislative authority over automated mobility. Thus far, regulations for AV testing and deployment are determined by higher levels of government, with legal enforcement being constitutionally divided between federal and provincial governments. Safety issues, for instance, are defined as national standards, while testing and deployment matters fall under provincial jurisdiction. Moreover, the provinces, not the federal government, largely have authority over the use of roads, including the management of highways, driver licensing and vehicle registration.[5] Responsibility over road infrastructure maintenance is divided between all levels of government, however, with municipal governments maintaining roughly 80 percent of public roadways in Canada (CNC, 2015).

Although municipalities lack legislative power, they do have the mandate to enact bylaws and policies, which may very well shape how automated mobility systems manifest at a local level. These include municipal road classification systems that determine service types, modal mix and speed limits according to street category. Furthermore, municipalities also determine the spatial design and infrastructural provision of street categories, set parking standards and enact ride hailing bylaws. While their leverage to generally permit or deny the operation of AVs may be constrained, they do determine which areas are granted access to new mobility services. Relatedly, municipalities may influence the operational conditions and targets of infrastructural investments.

In order to grasp the scope of the transformative potential of AVs, it is pertinent to also consider regional spatial dynamics and governance. Being Canada's most populous city-region, the Greater Toronto Area exemplifies how metropolitan regions grow ever more intertwined – be it socially, economically, spatially or ecologically. In light of the outlined division of regulatory oversight of AVs, it is relevant to note that the GTA lacks an overarching governing authority for regional growth management and infrastructure investments. As cross-jurisdictional issues, such as technology standards, data sharing and service integration, largely exceed the scope of the GTA's regional transportation authority, they may be critical to the transformative potential of AVs. Precisely because municipal collaboration on these issues is not a challenge specific to the GTA (I-14), it is worth examining how municipal collaboration and regional planning efforts pan out in a

[5] Unlike Europe, where highway systems are largely administered and planned on a national scale, the federal government in Canada is rarely involved in financing or building highways. One exception is the historical construction of the Trans-Canada Highway between 1950 and 1971. In effect, 95 % of Canada's National Highway System is, in fact, owned and operated by provincial or territorial governments, falling under their respective jurisdictions (Council of Ministers, 2017).

city-region with highly invested stakeholders in the field of automated vehicles.

Table 4.1 Comparison of regulatory oversight

Municipal	Provincial	Federal
Regulatory oversight • Enacting and enforcing bylaws • Enforcing traffic laws and regulations • Adapting infrastructure to support CAV deployment • Managing passenger transportation (including public transit, taxis, and ride-hailing services) • Managing and creating new logistics for traffic control and parking enforcement • Public education on motor vehicle safety	Regulatory oversight • Testing and licensing human drivers and registering motor vehicles in their jurisdiction • Enacting and enforcing traffic laws and regulations (including trials) • Conducting safety inspections • Regulating motor vehicle insurance and liability • Public education on motor vehicle safety • Adapting provincially-owned infrastructure for CAVs • Planning for future transportation projects (e.g. highway, management, transit)	Regulatory oversight • Setting and enforcing motor vehicle safety standards • Investigating and managing the recall and remedy of non-compliances and safety-related motor vehicle defects nationwide • Public education on motor vehicle safety issues • Monitoring and developing rules on privacy and cybersecurity • Setting and enforcing compliance with technical standards related to wireless technologies integrated into vehicles and roadside infrastructure
Relevant legislation • Municipal Code	Relevant legislation • Highway Traffic Act • Ontario Planning Act • Greenbelt Act • Places to Grow Act	Relevant legislation • Vehicle Safety Act

Source: table by the author, based on *AV Tactical Plan,* by City of Toronto, 2019a: 26.

4.1. Regional actors & agencies

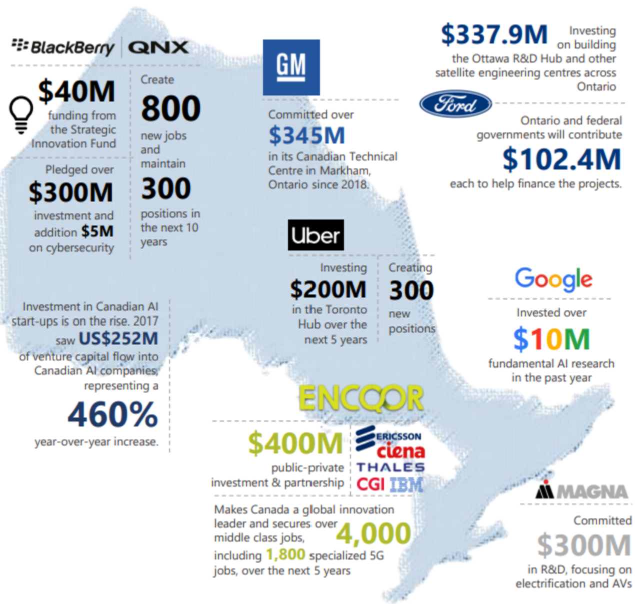
An entire range of actors from different sectors and at different levels of government are directly and indirectly involved in planning initiatives for automated mobility in the metropolitan region around Toronto, Canada. In order to gain insight into the decision-making dynamics and power relations that shape spatial and infrastructural development, an understanding of the municipality's relations with the region is pertinent. It is only in the regional perspective that the wide range of AV-related actor networks, the plethora of interests and the diversity of perspectives from which the topic is approached in the area becomes apparent.

Economic Actors

While the Province of Ontario has historically been home to a strong automotive and mobility sector, it is the growing tech industry and the shift towards knowledge-intensive work that is radically changing its technological and economic landscape (Wolfe & Goracinova, 2017). The GTA, in particular, is part of the so-called "innovation corridor" (WSP & OCE, 2019: 25) that stretches from the City of Toronto to Waterloo and even Stratford to its West. Notably one of several growing tech clusters in Canada, it has repeatedly been recognized as the second largest IT region in North America (Deloitte & OCE, 2020). As one interviewed expert observed: “there is great work being done in other places in Ontario, and Canada, as well. But I think that this is a unique hub, and it just needs to be capitalized on a bit more.” (I-08). The economic challenge lying ahead concerns a strategic shift from traditional manufacturing that has characterized the region since the 1920s, to a research and development hub for emerging technologies. As the manufacturing sector wanes, the provincial government has been seeking alternative opportunities for industrial investment and job creation (I-12).

Vehicle connectivity and automation bear an obvious promise in this regard: to diversify the mobility sector by fusing the old economy with the new (Wolfe & Goracinova, 2017). In place of traditional manufacturing, the market is increasingly centred on software development and services. As a result of the ongoing shift, the landscape of economic actors is diversifying. Traditional large-scale OEMs (Original Equipment Manufacturers) are now competing with new entrants and non-OEMs pursuing fleet-based mobility models (e.g. Uber or Lyft), as well as technology and logistics companies (e.g. Apple and Amazon). By 2020, more than 250 companies and organizations were producing automated vehicle technology in Ontario (Ontario, 2020b), with some investing heavily into the region (Fig. 4.2). International companies are drawn to Ontario due to its talent pool and academic institutions, while their presence places the province on the world map of automotive and mobility development (I-12; I-15; Deloitte & OCE, 2020). Uber, for instance, invested in a local talent hub for autonomous research in Toronto and is among the few multinational corporations permitted to test AVs on public roads (I-05; Deloitte & OCE, 2020).

Figure 4.2 Examples of technology investment in Ontario related to the automated vehicle industry



Source: From *ONTARIO CAV ECOSYSTEM ANALYSIS 2019*,
by WSP Canada Group Limited, and Ontario Centres of Excellence, 2019: 22.

Adding to the ongoing economic restructuring, OEMs in the region recently announced plans to greatly expand electric vehicle production (OVIN, 2021). While this is primarily a response to the national government's objective of ensuring that 100 % of newly sold light-duty vehicles are electric by 2035 (Canada, 2022: 8), it also reflects the provincial government's interest in further diversifying the industry and strengthening "Ontario's role as a leading vehicle manufacturing hub" (OVIN, 2021: 29). One of the key actors driving the economic shift towards electric, connected and autonomous vehicle and mobility technologies in the region has been the *Autonomous Vehicle Innovation Network* (AVIN), initiated by Ontario's Ministry of Economic Development, Job Creation and Trade (MEDJCT) and Ministry of Transportation (MTO). Since its inception in 2018, AVIN's funding streams stimulated the growth of Ontario's AV sector by investing into R&D activities across industry and academia (WSP, 2019). Although the Ontario government broadened the initiative's thematic focus in 2021 by renaming it *Ontario Vehicle Innovation Network* (OVIN), its objective remained unchanged: to accelerate the commercialization of new products and services by fostering regional knowledge linkages between academia, industry and public agencies (Wolfe & Goracinova, 2017; OVIN, 2021).

Several interviewed experts mentioned AVIN as a leading voice for automated vehicles in the region (I-08; I-09-A). By collaborating with municipalities and public agencies, launching and funding initiatives to promote local talent development, the network has functioned as an intermediary between the private and public sectors. Despite not having immediate policy influence, the AVIN network has affected public and political discourse on automated vehicles and, more recently, on electric, connected and automated vehicles. Moreover, it serves as a visible example of the provincial government's interest in reaping the economic development benefits of the technological transition in the mobility industry (I-15, I-16).

Policy and Planning Actors

It is in this context that urban and regional planning initiatives for automated mobility have been commenced. An expert describes an evolution from CAVs being a largely industry-driven topic dominated by the automotive sector, to the public sector catching up and finding its role in recent years (I-08). Looking at the public sector actors concerned with urban planning and transport issues in particular, the scene is characterized by a diversity of stakeholders. Across the three levels of government that influence urban and infrastructural developments in the region, familiarity with the subject and interests differ. The following section focuses on municipal and regional stakeholders, while federal policies, programs and organizations are only referred to for contextual purposes.

Transportation Services, City of Toronto

At the municipal level, the City of Toronto stands out as a pioneer due to its AV planning efforts (I-01), which have a distinct focus on mobility. To a large extent, the municipality's initiatives stem from its Transportation Services division, which picked up AVs as a subject of concern in 2014 and subsequently developed a three-year work plan to focus internal efforts (Toronto, 2018a). Although it would not have been the division's responsibility to take action, its motivation to proactively prepare for a potential introduction of AVs was significantly shaped by the disruption that ride-hailing companies caused in the early 2010s (I-01; I-16). Rather than having private companies determine the conditions for future deployment, as was the case with Uber, the intention was to get ahead of technological developments and determine early on what the municipality's goals and objectives would be for a future with AVs (I-16).

The initial efforts of the transportation division centred on education and awareness initiatives (I-16), research on potential implications for the Municipal Code and the monitoring of technological development (Toronto, 2018a). Over the years, the division increasingly assumed a strategic role within the City of Toronto and the region (I-02). Transportation Services not only established partnerships with local universities, industry, peer cities and other levels of government (I-01). The division also pushed for the provincial and federal governments to recognize municipal concerns over the effects AVs could have on traffic, transit networks and public spaces (I-16). Within the municipality of Toronto, the division's AV team took on the responsibility of coordinating an *Interdivisional Working Group (IDWG)* and became the driving force behind the development of the *AV Tactical Plan*, a cross-divisional policy position framing municipal action (Toronto, 2018a). It mobilized, coordinated and assisted affected divisions and agencies in preparing for AVs (I-01; I-16), engaged various stakeholder groups for consultation and defined a set of corresponding actions and projects to be developed between 2020 and 2022 (Toronto, 2019a). Following the document's approval by City Council in the fall of 2019, the AV teams' ongoing responsibilities concern the implementation of selected projects and the administrative support of the IDWG that monitors and evaluates progress (I-02).

City Planning, City of Toronto

Toronto's City Planning division began to formally address the subject of AVs as part of its efforts to prepare for new mobility services in 2015 and through its engagement in the IDWG since 2016. Within the division, the main responsibility for the topic was assigned to Transportation Planning, a section whose focus centres on long-term, strategic planning. When joining the IDWG, one intention was to contribute a long-term urban development perspective to the debate on AVs and to emphasize a stronger connection between operational issues and the City's existing development objectives (I-06). Beyond that, various sections of the City Planning division, e.g. Urban Design and Built Form, contributed to the process of preparing the cross-divisional policy framework. Initial engagement in the topic remained nonetheless reserved. One interviewed expert explained the reluctance of City Planning to take a more proactive role by referring to the technological setbacks of recent years: "… there was an initial wave of hype that suggested we might be seeing massive AV penetration in the 2020s. I don't think that's the case, I think those expectations have been tempered quite a bit." (I-04).

A staff report from 2018 includes comparable argumentation. While the evolutionary introduction of partially automated vehicles is expected to cause low-level disruption confined to the road network, higher levels of disruption might occur in the long term, affecting more far-reaching issues, e.g. land use, built form, and the use of public space (Toronto, 2018a: 6). Another expert interview revealed that the reluctant stance on the topic concerns the language used in debates on automated mobility (I-06). Rather than assuming a positive development and adopting strategic changes to planning documents early on, the cautiousness involves being aware of potential challenges or even risks that need further assessment (I-06). A paragraph on new technologies from the City's Downtown Mobility Strategy reads accordingly: "While new technologies such as automated or electric vehicles are appealing, they won't solve the city's transportation challenges and may even cause congestion to increase, if not properly regulated." (Toronto, 2018b: 23). Further planning efforts by City Planning concern the modelling of travel demand changes, the examination of implications for parking demand forecasts, and policy considerations on HOV priority for AVs (Toronto, 2019a).

TTC – Toronto Transit Commission

In Toronto, mass transit is operated by the TTC – Toronto Transit Commission. The agency became involved in interdivisional efforts on AVs in 2015 and is a project partner for the city's automated shuttle trial. With innovation and future technologies representing a relatively new field of concern for the transit agency, its attention for AVs was largely triggered by City Council motions requesting to commence research and planning steps (I-05). Although initial thinking on AVs was limited by a lack of time and resources, internal developments are being aligned, and the initiatives are reflected in its 5-year "Service Plan & 10-year Outlook", e.g. the AV shuttle trial and microtransit integration (TTC, 2019). In 2018, the TTC established a New Technology and Innovation (NTI) team, whose responsibility it is to oversee technological trends and evaluate their relevance in terms of potential safety or efficiency benefits. Recent fields of interest include electric buses and charging infrastructure, automatic train control for subways and bus platooning (TTC, 2020). The latter is representative of two issues specific to the transit agencies perspective on AVs, whose central concern is financial and operational pragmatism (I-05). Firstly, the use case fits the TTC's core business interest, being mass transit. While a microtransit application, as currently trialled with the AV shuttle, is a known transit option, the most recent strategy has been to move away from providing door-to-door services with fleets of small vessels, i.a. as part of its paratransit service (I-05). Instead, the agency is interested in high-capacity applications such as automation for 40-foot buses or streetcars. Secondly, bus platoons bear the potential of increasing capacity on the existing network, while remaining cost-effective. A platoon of two or three bus lines compares to the capacity of a light rail, without requiring additional infrastructure and lower operating costs (TTC, 2020: 32). The potential benefits are significant for TTC network operations, which held the second-highest public transit ridership levels among U.S. and Canadian cities prior to the pandemic, but are characterized by a chronic lack of subsidies and revenue streams (CodeRedTO, 2018; Spieler, 2021).

Metrolinx, Ontario Ministry of Transportation

At a metropolitan level, the regional transportation agency Metrolinx is one of the key actors involved in shaping AV policies in the region. It represents a regional special purpose body established in 2006 by the Province of Ontario as a Crown agency (Ontario, 2006) – a distinct institutional composition that grants it unique powers due to its size, provincial support and policy focus (Krawchenko, 2011). As a public agency, Metrolinx is accountable to the Ontario Minister of Transportation, yet it has a corporate board and pursues "business-like" operations (Krawchenko, 2011: 4). Its founding purpose was to coordinate the regional development of integrated, multimodal transportation in the Greater Toronto and Hamilton Area (Ontario, 2006). Since its inception, its operational focus has largely centred on rapid transit provision, complemented by strategies on goods movement, integrated land use development as well as emerging mobility technologies and services that may enhance or complement transit operation (Metrolinx, 2018).

AVs first surfaced as a subject for the agency in 2016, during the 10-year review of its regional transportation plan, *The Big Move*. As part of that process, emerging new mobility options were reviewed regarding their impact on regional transportation, both in terms of potential benefits and looming complexity (Metrolinx, 2016). A background paper accompanying the review process includes a trend analysis of ride and car-sharing, electric vehicles and vehicle automation developments in the region (Metrolinx, 2016). The corporation's interest in emerging mobility is described as exploring "possible models for the delivery of new mobility options" (Metrolinx, 2016: 44). Many of the models involve partnerships with the private sector and are intended to "fill gaps in the conventional services provided by the public sector" (45). Relatedly, an interviewed expert stressed that vehicle automation represents "an overlay on existing service" (I-09-A) that might enhance their performance and cost-efficiency. In this sense, the added benefit of automated vehicles for a transit agency lies in their potential of cost reduction; resources that may in turn support service expansions (I-09-A).

Next to the City of Toronto's transportation division and the Ontario Ministry of Transportation, interviewed experts described Metrolinx as the driving force behind planning initiatives for AVs. While one mentioned the significance of internal champions that understand the relevance of the subject, another expected its facilitatory role to gain significance in the coming years (I-04; I-07). Particularly since Metrolinx, as the Regional Transit Authority, provides the institutional structure responsible for regional coordination in the area of transportation (Krawchenko, 2011). In the context of preparing for AVs, coordination pertains to local municipalities and transit agencies as well as the provincial and federal governments, the private sector and stakeholders from academia and research. An interviewee expanded on the particular need for coordination across municipal boundaries and all levels of government in the GTA: "Autonomous vehicles are not a City of Toronto-only topic or a Region of Peal or City of Mississauga-only topic. It's for everyone in the region to work together." (I-09-A).

Ontario Ministry of Transport

The Ontario Ministry of Transport (MTO) represents the driving force behind many of the policy initiatives, including pilot programs and economic funding streams in the GTA. Being the responsible agency for the subject within the provincial government, it has substantially shaped the legislative environment on AVs, which may be considered "supportive" in character (Metrolinx, 2016: 45). Three occasions stand out as path-defining moments for the role of the MTO in shaping the transition towards AVs in the metropolitan region, above all, the 2014 mandate letter released by former Ontario Premier, Kathleen Wynne. Outlining the ministry's priorities for the year, the Premier requested the Minister of Transportation at the time to "prepare a regulatory framework for automated vehicles" (Ontario, 2014). In response, the Ministry's Road User Safety Division developed the *Ontario Regulation 306/15: PILOT PROJECT – AUTOMATED VEHICLES*, which allows testing AVs on Ontario roads and went into effect for a duration of ten years on January 1st, 2016. As the technology continues to evolve, the regulation has since been amended. As of January 1st, 2019, the legislation also allows for the testing of cooperative truck platooning on public roads, the testing of driverless AVs as part of pilots and the use of conditionally automated vehicles (SAE Level 3 AVs) by the public (Ontario, 2021a).

In 2016, Ontario's Premier issued another mandate letter, which defined the development of a Centre of Excellence for autonomous vehicles a key priority for the Minister of Transportation. The motion gave way to the previously introduced *AVIN – Automated Vehicles Innovation Network,* a multi-million-dollar fund with the objective to foster economic growth and research in the sector (I-14). Within the MTO, the main responsibility for the development of the program was assumed by its Transportation Policy branch. Having the overall policy lead, the branch coordinates various divisions (e.g. the Highway Management Division, the Road User Safety Division and the Fleet Management Group), it develops adequate policy levers and leads cross-governmental efforts, such as AVIN. In addition to conducting provincial policy actions for AVs, the various divisions collaborate with their federal and municipal counterparts on projects and programs. For instance, the Highway Management Division co-initiated the regional *CAV Readiness Initiative* (Chapter 4.2.2), the Road User Safety Division authorized and ultimately suspended the City of Toronto's *AV Shuttle Pilot* (Chapter 4.4.1) and the Transport Policy Branch reviewed the City of Toronto's *AV Tactical Plan* (Chapter 4.3.1). Throughout these initiatives, the subject of AV technologies shifted from largely being a traffic management issue requiring standardization guidelines, to being a recognized subject across ministries (I-14).

> *"[Automated Driving] is going to fundamentally change the way we operate and get around."* (I-14)

The third occasion that stands out as cause to engage with the issue of AVs concerns the *GTA West Transportation Corridor*, a much-disputed highway project planned northwest of Toronto. Since the 1990s, various plans have included a highway corridor that would connect the regions of York, Peel and Halton and relieve future travel demand caused by anticipated growth in the area (Beggs et al., 2017). In 2015, the provincial government at the time temporarily suspended the GTA West Corridor Environmental Assessment[6], reasoning that it was necessary to re-evaluate the project's alignment with changed governmental policies, particularly with respect to emissions and climate change, but also in light of emerging mobility trends including ride-sharing and AVs (I-15; Beggs et al., 2017). As part of a commissioned review, the ministry's Transportation Planning branch conducted initial research on the subject of AVs, on which subsequent planning efforts have partly built (I-15). The most important planning document the ministry has since published is its long-range transportation plan *Connecting the GGH: A Transportation Plan for the Greater Golden Horseshoe* (Ontario, 2022). Building on scenario planning techniques, various policy approaches to AVs were tested with regard to their impact on reaching the goals and objectives of the long-

[6] The GTA West Corridor Environmental Assessment (GTAW EA) was a multi-phased study that is legally required under Ontario's Environmental Assessment Act to determine an infrastructure project's environmental (positive or negative) effects. Following its suspension in 2015, a project review was commissioned to assess alternative approaches to building a highway and their potential impacts on future transportation demand, including AVs. The GTAW EA review panel concluded that AVs were not a viable alternative to building the highway corridor and recommended that the MTO stop the GTAW EA (Beggs et al., 2017). In 2017, provincial elections led to a change in government that set aside the review panel's recommendations and continued the environmental assessment (I-15).

range transportation plan (I-14; I-15).

Across the various areas of responsibility of the Ontario Ministry of Transportation, its key concern lies in ensuring the safety and efficiency of the road network (I-14; I-15). Given that the provincial government also has a strong interest in the economic development of the mobility industry, the ministry's policy approach is one that ensures safety without constraining innovation (I-15). According to one expert, the government's early economic interests had distinct priority over the potential long-term implications of AVs on transportation (I-16). Although work had commenced internally on the long-range implications and necessary policy levers, it has been overshadowed by the government's activities to promote research and development by facilitating pilot projects and testing.

Greater Toronto Region

Other municipalities engaged in AV planning efforts in the region comprise the Region of Peel, Durham Region and the City of Hamilton. The Regions of Peel and Durham have both integrated language on automated vehicles in their most recent Transportation Master Plans. The master plan for the Peel Region, having a particular interest in freight transport, mentions a CAV corridor pilot project as an explicit key action item (Region of Peel, 2019: 85). The master plan for the Durham Region includes the general claim of positioning itself at the forefront of technologies such as AVs, due to its history in auto manufacturing and recent expansion of post-secondary institutions (Durham Region, 2017: 153). Hamilton's efforts, in turn, have centred on managing a testing and demonstration site within the municipality. As to why so few of the regional municipalities have adopted AV planning strategies, the interviewed experts pointed to the availability of resources as a key factor and the lack of a political mandate to mobilize them (I-07; I-15). In effect, leaving them to rely on higher levels of government to provide planning orientation.

Scientific Actors

Scientific actors include academic institutions (universities and colleges), research entities and non-for-profit organizations. They take on a significant role in the actor landscape related to automated vehicles, as they closely collaborate with all levels of government as well as industry and economic actors. While virtually all planning initiatives on automated vehicles in the GTA have academic institutions involved, collaboration can take many forms. Direct commissions, for instance, may concern the provision of guidance through foundational studies, consumer research or modelling studies (See. Fig. 4.2). Larger research endeavours with municipal actors and transit agencies, in turn, may comprise a supporting role in monitoring and evaluation. Participation in stakeholder networks, such as the CAV Readiness Initiatives, but also informal relations between academic and public actors contribute to a continuous knowledge transfer between the sectors.

The *Canadian Urban Transit Research & Innovation Consortium* (CUTRIC) is a non-profit organization that supports research and development of mobility and transportation technologies with a focus on low-emission, electric and automated vehicles. Its *National Smart Vehicle Joint Procurement Initiative* was a research effort in support of deploying first- and last-mile electric low-speed automated shuttles (e-LSA). The project received federal funding through Transport Canada's Program to *Advance Connectivity and Automation in the Transportation System* (ACATS). Within the framework of the initiative, working groups with manufacturers were held, an overview of communication software and hardware system standards was developed and a modelling study on transit ridership impacts was conducted. A case study research on transit ridership found that deploying AV shuttles as feeder systems in areas that lack first and last-mile connections to transit hubs may positively affect transit ridership and reduce the number of car ownership within its catchment area (Nesheli et al., 2021: 43). Most recently, CUTRIC issued a report for Metro Vancouver assessing the impact AVs and MaaS may have on the region's transportation sector and providing strategies to ensure that new mobility services contribute to a reduction of carbon emissions (Abotalebi et al., 2021).

Civil-Society Actors

Despite being a heavily industry-led subject with governments and public agencies largely grappling to establish regulatory systems, automated vehicles are also "a subject in which the public has a substantial interest" (CAVCOE, 2019: 5). In 2018, a quarter of respondents to a public opinion survey on AVs in the Greater Toronto and Hamilton Area (GTHA) indicated they were aware of provincial and municipal AV planning initiatives (Shi et al., 2019). As part of the planning and policymaking actions conducted in the GTA since 2015, residents and neighbourhood groups have been involved in individual instances. Most recently, in preparation for the *West Rouge Automated Shuttle Trial* conducted as a joint venture between the City of Toronto, the Toronto Transit Commission and Metrolinx. In surveys and public consultations, which took place between 2019 and 2021, residents and the general public were asked to provide feedback on the intended trial, share their thoughts on the pilot design and voice their concerns (Toronto, 2019c). Consultations with TTC's *Advisory Committee on Accessible Transit* (*ACAT*) and Metrolinx's *Accessibility Advisory Committee* (AAC) were held in order to ensure that the automated shuttle met the needs of people with disabilities. Specific concerns and requirements by committee members include, for instance, the shuttle's technical features, such as the availability of a ramp or visual and audible stop announcements, the training of the on-board steward and the shuttle's usability when boarding with a wheelchair or service dog (TTC, 2021).

Beyond that, several studies were conducted examining the public's opinion on AVs in the Greater Toronto and Hamilton Area (Birnbaum et al., 2018; Olsen et al., 2018; Shi et al., 2019; Robertson et al., 2022). The first consumer survey for the GTHA was conducted in 2016 by Toronto Metropolitan University's TransformLab, asking residents to assess their future use of AVs in order to then estimate the potential implications of AVs on travel behaviour in the region. The subsequent survey conducted in 2018 built on the initial study in order to understand whether and how consumer attitudes change as residents learn about AV technology and the impact these changes potentially have on policymaking. Survey findings on the government's role deduced, for instance, that in 2016 more than half of the respondents indicated support for governmental regulation, whereas in 2018, nearly half preferred governmental involvement to be limited to monitoring the introduction of AVs (Shi et al., 2019: 5). The general sentiment appeared to be "that too much intervention may lead to over-regulation of the AV industry, resulting in the unreasonable restriction and delay of AV technology, and its expected benefits." (TransForm Lab, 2018: 2).

However, results from focus groups conducted with residents from the GTHA in 2017 and 2018 also show that participants' assessments may significantly change, if they have the opportunity to learn about the technology and work with experts on the subject directly (Birnbaum et al., 2018). The results of the most recent consumer survey, based on data collected in the fall of 2021, show increased support for the government's monitoring and response to AVs, while approval of the public sector's active encouragement of AVs declined (Robertson et al., 2022). Moreover, respondents in 2021showed less interest in using fully automated vehicles than in 2016 or 2018. Two aspects stand out, which would significantly affect the uptake of AVs and subsequent travel behaviour. Firstly, consumers unwillingness to spend additional money for potentially automated vehicles, and secondly, a reduced interest in shared use cases including transit (ibid.).

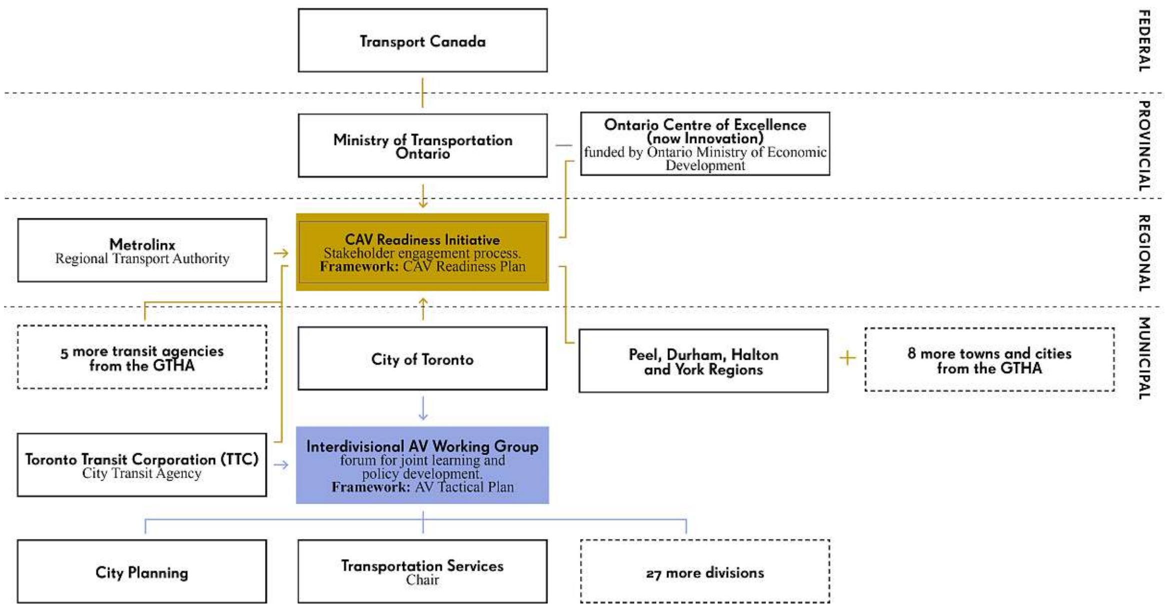
4.2. Collaborative networks

Since 2016, several networking efforts on automated mobility involving both public and private actors have been initiated in the region.[7] They differ with regard to the initiating party, their interests

[7] Other municipal networks addressing issues related to AVs include: 1) The Municipal Alliance of Connected and Automated Vehicles in Ontario (MACAVO) initiated by the Ontario Good Roads Association in 2016. It functions as a forum for municipal and regional staff to collaborate and partner with the private sector, e.g. in establishing an AV Testing Corridor that stretches from Windsor to Ottawa and may assist early integration of AVs in the City of Toronto (OGRA, 2019; Toronto, 2019a: 81). Its objectives being to facilitate testing

and activities. The two networks considered here stand out due to their role in facilitating knowledge exchange and capacity building amongst public administrations and transit agencies (Fig. 4.3). Firstly, the Interdivisional AV Working Group, an intra-municipal network set up at the City of Toronto in 2016 that has since grown to include thirty municipal departments and agencies. Secondly, the CAV Readiness Initiative, launched in 2018 by a regional consortium that successfully acquired federal funding to facilitate capacity building and knowledge exchange. More than 70 agencies from all levels of government took part in the year-long stakeholder collaboration process. While both endeavours centre on the development of a joint strategy framework, they differ with regard to who initiated and participated in the process, the extent of collaboration and what aspects of automated mobility the policy frameworks centre on. The first two dimensions are highlighted in the section below, while the content of the policy frameworks is analysed separately in section 4.3.

Figure 4.3 Public agencies involved in AV networking initiatives based in the GTA



Source: illustration by the author.

4.2.1 Interdivisional AV Working Group (IDWG)

Established in 2016, the *Interdivisional AV Working Group* at the City of Toronto grew out of a staff initiative in an effort to create a forum for knowledge exchange and learning on the subject (I-02; I-03; I-16). Given that automated vehicles are not only a transportation issue, but may entail a variety of second and third order effects (I-01; Milakis et al., 2017), the key motivation for engaging the majority of municipal divisions was to bring together multiple perspectives and learn about the

opportunities for private corporations, collaboration between stakeholders in finding solutions, and synchronize communication.

wide variety of possible implications (I-16). In this vein, topics of concern greatly varied across municipal divisions: from operational impacts (Transportation Services) and privacy aspects (Information and Technology), to long-term strategic alignment with urban development goals (City Planning). From potential cost reductions (Fleet Services) to the concern about safety impacts and the hope for reduced environmental pollution (Public Health). The intention to take on a leadership position on AVs by being proactive and forging a comprehensive approach is perhaps best described in the early *Divisional Workplan 2016–2018*:

> *"This Group will move the City of Toronto forward in assessing opportunities to lead, prepare, and integrate automated and autonomous vehicles with the services and operations of all divisions."* (Toronto, 2016a: 6)

As noted by interviewees, the group successfully grew, as it received "a lot of buy-in from different divisions of the city very quickly" (I-06; I-02). Toronto's transportation division, leading the effort, based its early assessment of which divisions and agencies may be affected on a discussion paper by David Ticoll (2015) describing the potential implications of AVs (I-16). Corresponding with direct and indirect effects, a distinction was made between whether agencies would be affected early on or in the mid-term, or whether they should simply be sufficiently informed to raise concerns (I-16). By 2018, 30 divisions had joined the IDWG, taking part in the capacity-building process and contributing policy considerations to the city's *AV Tactical Plan 2019-2021*. The latter policy framework was developed to ensure that municipal divisions and agencies follow a consistent approach in preparing for AVs (Toronto, 2018a). The more involved divisions, such as City Planning, Information and Technology, or Environment and Energy, went on to commence independent projects on the subject, e.g. studies on potential health impacts of AVs (Dean et al., 2019). Less involved divisions would primarily focus on how their division could be affected.

Despite varying degrees of involvement, the scope encompassed by the IDWG appears unique to the City of Toronto and beyond. An interviewee and senior staff member involved in the network described it to have "ended up being an almost completely citywide exercise. I haven't been involved in other things at the city that have gotten that much buy-in." (I-06). The IDWG format breaks up functional silos and provides the necessary institutional framework for municipal divisions to "jointly monitor technological and policy development, share information, and collaborate on cross-divisional initiatives." (Toronto, 2018a: 5). And since its launch, the IDWG has also become a best practice example for municipalities across the globe preparing for AVs (Toronto, 2018a; Steckler, 2019). When asked about the IDWG's prospects, an interviewee foresaw that the collaborative culture would continue as divisions moved on to implement identified actions, e.g. the AV shuttle trial (I-02).

4.2.2 CAV Readiness Initiative

On a regional level, the *CAV Readiness Initiative* stands out due to its aim to foster collaborative planning for AVs on a regional scale. It was launched by a Steering Committee composed of representatives of Ontario's Ministry of Transportation (MTO), Metrolinx, the City of Toronto, the Region of Peel, and a private planning consultancy. In 2018, the committee successfully applied for partial funding through Transport Canada's Program to *Advance Connectivity and Automation in the Transportation System* (ACATS). Making it one of two regional initiatives that received funding through the federal call. By tapping into one of the program's foci, capacity-building and knowledge-sharing activities, an inter-governmental effort was launched for the Greater Toronto and Hamilton Area (GTHA) and the Kitchener-Waterloo corridor. The one and a half year-long project combined research, scenario planning, and a comprehensive stakeholder engagement process, providing the main components of a regional CAV Readiness Plan published in 2020.

> *"Both public agencies and private companies will need to collaborate to integrate CAV on the transportation network."* (Ontario, 2020a: 11)

Several policy and planning initiatives by the provincial government preceded the CAV Readiness Initiative, prompting an understanding that AVs will become more prevalent in the market and on Ontario roads over time (Ontario, 2020a: 2, Appendix A). Most importantly, the 2019 extension of the Ontario Regulation 306/15 emphasized that public agencies must prepare themselves. Amongst others, the legal amendment gave way to the provincial pilot program for truck platooning. Within this framework, more than 200 km of the highway network have been provincially authorized as designated pilot areas in Ontario. At the time of writing, an almost 100 km long corridor is located in the Greater Golden Horseshoe (Ontario, 2021b). The implications of a changing policy environment in Ontario are unmistakable in the CAV Readiness Plan: "The presence of this AV Pilot Regulation indicates that it is time for the region to begin preparing and rolling out the necessary infrastructure, as well as operational, institutional and public lever changes to accommodate highly automated vehicles on roads." (Ontario, 2020a: 3, Appendix A). An interviewee specified that municipalities may not be able to influence the direction of technological development, but they can choose and limit the areas and corridors on which they permit AVs to operate within city limits (I-09-A). An inter-municipal effort should thus focus on how AVs are to be applied in the region and build a strong voice, able to represent municipal interests to higher levels of government as well as industry players (I-09-A; I-16).

In total, more than seventy experts from over thirty organizations participated in the CAV Readiness Initiative, representing federal and provincial government agencies, local and regional municipalities, transit agencies, academia, and non-profit organizations. A common issue was to understand how public agencies could adequately respond to the prospect of AVs being successively introduced into the market and onto public roads (I-08). According to an interviewed expert, a critical insight at the beginning of the process was that levels of preparation and knowledge on the subject greatly varied between participating agencies (I-08). The Ministry of Transportation and the City of Toronto, for instance, stood out regarding their levels of preparation, while smaller municipalities in particular lagged behind due to a lack of resources. In this light, one of the purposes for holding collaborative workshops was to "Educate Stakeholders on potential CAV technology impacts and the considerations that will need to be taken to prepare for them." (Ontario, 2020a: 5, Appendix B). Beyond that, knowledge sharing constituted an integral part during the Initiative's stakeholder workshops. Presentations by public and private agencies, e.g. on Toronto's automated shuttle pilot, provided insight into ongoing work and CAV involvement in the region.

Another reason for holding stakeholder workshops was to gain input and feedback on the CAV Readiness Plan's components (I-15). Stakeholders were involved in reviewing the proposed scenarios, personas and guidelines, in developing the CAV Programs, and clarifying the objectives of a potential CAV Liaison Committee (Ontario, 2020a: 5, Appendix B). While the level of preparedness did not particularly improve by the end of the project phase, participants did note that their knowledge of CAVs, and the technology's potential impact on the transportation system significantly increased due to their involvement (Ontario, 2020a: 10, Appendix B). One expert viewed it as particularly beneficial to bring the municipalities and agencies across the region to the same level of understanding on AVs (I-15). In this this sense, the CAV Readiness Initiative is also viewed as a successful networking platform. According to a survey conducted by the Steering Committee, stakeholders benefited from the Initiative by gaining insights on shared goals and opportunities, breaking down silos, and raising awareness for CAV related studies by other agencies (Ontario, 2020a: 10, Appendix B). Finally, identifying action items as part of the Readiness Plan helped to create momentum on preparing for CAVs. When asked whether stakeholders intended to participate in future collaborations, e.g. in the form of a *CAV Liaison Committee*, more than 90 % indicated interest in an active role and participation (Ontario, 2020a: 8, Appendix B).

> *"From what I understand, there is quite a desire to continue the work and the collaboration and the momentum that was set up."* (I-14)

The aforementioned Connected and Automated Liaison Committee was conceptualized in an attempt to continue regional collaboration and networking beyond the publication of the CAV Readiness Plan in 2020. Its intended mandate lay in implementing the guidelines and programs defined in the CAV Readiness Report. Local and regional municipalities, public transit agencies and industry stakeholders were invited to become Committee members and have the option to take up coordinating responsibilities on subcommittees or provide project funding depending on their level of participation (Ontario, 2020a: 51). An interviewee pointed out the likelihood of it being co-chaired by the MTO, Metrolinx and AVIN, while another asserted that maintaining momentum will require coordination and political leadership (I-08; I-15). At the time of writing in 2022, the Liaison Committee as such has not come into being, but the CAV Readiness Initiative found continuation in a format called *Smart Mobility Readiness Forum*. Set up within the framework of the renamed OVIN – Ontario Vehicle Innovation Network and supported by MTO and Metrolinx, it functions as a platform that connects municipalities, transit agencies and other stakeholders in the region. Its main pillars are networking and knowledge sharing events, e.g. on conducting an automated shuttle pilot or rolling out an electric bus fleet and charging infrastructure as a municipal transit agency (OVIN, n.d.).

Notably, the two introduced networks differ with regard to the initiating party, level of engagement by participants, and the initiative's duration. The effect these networks have on participating members thus varies. Given the continuous mandate by Toronto's City Council, the IDWG is an ongoing initiative that is carried by the commitment of Transportation Services' AV working group, its permanent staff position, and the in-kind contributions of other divisions. The CAV Readiness Initiative, in contrast, was a temporary and project-based endeavour initiated by the provincial government and outsourced to a private consultancy. Partly funded through the federal government's ACATS program, it was strongly motivated by provincial policy action. Thus, the impetus for establishing these networks and levels of engagement differs, yet both were driven by voluntary participation and member commitment.

As such, the established networks both function as institutional intermediaries that promote knowledge transfer and capacity building and also facilitate the diffusion of CAV-related programs and policy action (Clark, 2020). In working horizontally rather than vertically, they resemble a novel process of intra-urban or city-to-city information exchange and collaboration. In place of top-down processes and large-scale policy design, e.g. by the provincial government, these distributed networks function as potential equalizers of information and knowledge between public agencies and entities. The two examples mentioned here differ in the extent to which the developed policy frameworks are tailored to local development conditions. While the first network focused on integrating every division's perspective in order to utilize AVs to the benefit of existing development visions, the second network is less concerned with varying local perspectives on how to utilize CAVs. Instead, its focus lies on establishing an overarching framework that supports a smooth technological transition across administrative boundaries and may be transferred to other regions within and outside of Canada. Contextual contingency thus is less relevant to the CAV Readiness Initiative.

4.3. Policy frameworks & planning documents

At the time of writing, the strategic planning documents that were developed or adapted in reference to AVs in the GTA include at least the following, listed in chronological order: the *Downtown Mobility Strategy*, which is part of the *TOcore: Planning Downtown* (Toronto, 2018b), the *2041 Regional Transportation Plan* (Metrolinx, 2018), the *Automated Vehicles Tactical Plan* (Toronto, 2019a), the *Amendment 456 To The Official Plan* (Toronto, 2020a), the *CAV Readiness Plan* (Ontario, 2020a) and the *Connecting the GGH: A Transportation Plan for the Greater Golden Horseshoe* (Ontario, 2022*)*. In this sense, it is evident that the metropolitan region around Toronto resembles an outlier with regard to policy and planning preparation for AVs in comparison to U.S. and German cities (see Guerra, 2016; Fraedrich et al., 2019).

Naturally, the various plans and policy frameworks, which have been updated to include the topic of AVs, differ in terms of their planning horizons and their policy guiding influence. While all were reviewed as part of the research, four documents are introduced in more detail. First, the *AV Tactical Plan and Readiness 2022* and the *CAV Readiness Plan*, two documents that include the most explicit language on planning actions and stem from the stakeholder networks introduced in the previous section, the *Official Plan* amendment, due to its legally binding nature on a municipal level of Toronto and the *2041 Regional Transportation Plan*, as the common transportation vision for the region.

4.3.1 AV Tactical Plan and Readiness 2022

With the *AV Tactical Plan and Readiness 2022* (henceforth "Tactical Plan"), the City of Toronto adopted a strategic policy framework specific to the operation of automated vehicles on public roads and streets. Comparable to Seattle's preceding *New Mobility Playbook* (Seattle, 2017), the document was developed to proactively guide the changing landscape of transportation technologies by providing detailed actions for the City to move forward.

> *"The overall goal is to be proactive, ensuring that Toronto is well-placed to both maximize opportunities and mitigate impacts arising from the arrival of AVs in Toronto."* (Toronto, 2019a: xi)

Format

The policy framework provides a comprehensive strategic vision for how the City of Toronto can shape the early introduction of AVs and successfully harness their potential by 2050 (Toronto, 2019a). Given the volatile context of emerging mobility technologies, the framework assumes a flexible format. Seven directions and associated goals paint a long-term outcome that can be achieved at any time within the plan's 30-year timeframe (ibid.). The directions range from improved social equity and health, environmental and economic sustainability, protection of privacy, to integrated transportation options that centre on public transit, increased efficiency and progress toward achieving Vision Zero[8] (Toronto, 2019a: viii). The broad range of strategic directions reflects the diversity of municipal departments involved.

The interviewed experts involved in the development process described the Tactical Plan as a flexible document meant to be reviewed at regular intervals (I-01; I-02). In the face of an uncertain future with AVs, maintaining strategic flexibility acknowledges that planning processes and regulation need to be equally dynamic and open to unforeseen change (I-12). To monitor and assess the effectiveness of identified short-term actions as the AV technology evolves, an impact-oriented evaluation approach has been conceptualized as part of Toronto's Tactical Plan. Rather than evaluating the completion of so called "tactics", the progress in reaching the identified Key Performance Indicators (KPIs) is measured, e.g. percentage changes of mode share for active transportation, transit, 2+ occupant vehicles and combined-purpose vehicles (Toronto, 2019a: 90).

Figure 4.4 Components of the AV Tactical Plan and Readiness 2022

Source: illustration by the author, based on *Automated Vehicles Tactical Plan*, by City of Toronto, 2019a.

Next to its flexible and adaptive format, the 78 action items listed in the framework are among its unique features (I-02). These range from short-term efforts to prepare, e.g. through research and development, a public education project or an Automated Shuttle Trial, to more nuanced policy actions which anticipate a mid to long-term transformation of the transportation system. To this effect, the framework provides operational guidelines for concrete policy and planning actions, while also maintaining the flexibility of future reconsiderations (Rauws et al., 2014). It includes

[8] Vision Zero is Toronto's Road Safety Plan for the period of 2017 to 2021. Modelled after the Swedish example, the overarching aim of the policy document is to "eliminate fatalities and serious injuries" (Toronto, 2017a: 17) in Toronto's transportation system by adopting a KSI approach ("killed and seriously injured" collisions). As such, it emphasizes the protection of vulnerable road users, such as pedestrians, cyclists, and motorcyclists.

four components: a.) an introductory section with background information on the state of technological development and expected timelines; b.) the Tactical Plan which outlines Toronto's strategic vision; c.) a separate part focusing on the city's internal operation of AVs; and d.) a near-term strategy that outlines five implementation projects until 2022 (Fig. 4.4).

When addressing the uncertainty inherent in all planning and thus also AV-related action, one interviewed expert acknowledged that the notion challenged the process as much as it structured the Tactical Plan (I-02). In planning theory, different notions of uncertainty exist. For instance, Christensen (1985) differentiates between uncertainty that pertains to "technology" – the knowledge of how to do something, which may be known or unknown – and uncertainty pertaining to "goals", which may or may not be agreed upon (63). Abbott (2012) identifies five slightly different dimensions that affect planning: a.) causal uncertainty, b.) organizational uncertainty, c.) value uncertainty, d.) external uncertainty and e.) chance events (573). While theoretically, planning for future transportation systems with AVs may be viewed as a "technological" challenge in Christensen's (1985) terms – not knowing how to plan in a highly volatile context – the reference to uncertainty in the Tactical Plan is better described by Abbott's dimensions (2012).

The document outlines technological, policy-related, economic and human factors, which shape the uncertainty concerning how and when AVs might permanently enter urban mobility landscapes (Toronto, 2019a: 9). The factors described most broadly pertain to external uncertainty, which describes unknowns that are not within direct influence of planning, but affect both planning and the environment being planned, e.g. vehicle performance or changes in material and energy costs (Abbott, 2012: 573). Other factors relate to causal uncertainty, i.e. the lack of knowledge about how future policies may affect a still developing technology. And some factors concern value uncertainty, that is, "unknown social views and values" (Abbott, 2012: 573) of individuals and communities that will affect the potential uptake and travel behaviour with AVs.

Given the complex interplay of these factors, the policy framework draws on a scenario planning exercise that studied the implications of diverse pathways with AVs: from a future shaped by shared automated vehicle (SAV) fleets, to one dominated by private AVs, a mixed traffic scenario and a scenario with no AVs at all (I-02). The Tactical Plan elaborates only the first two scenarios. The scenario based on SAVs is assumed to bear a significant transformative potential for urban economies and environments: "In this scenario, AVs contribute to the creation of new business and service delivery models, shifting job markets, transforming industries, altering energy consumption, and reshaping the urban form." (Toronto, 2019a: 15). As mobility services diversify, driveway und curbside designs could drastically change (I-01). Meanwhile, in a scenario in which private AVs dominate the transportation system, the status quo is assumed to be prolonged, leading to further urban sprawl and congestion, as "the positive transformative potential of AVs has not yet been fully realized" (Toronto, 2019a: 12).

Development process and Authorship

Toronto's Tactical Plan differs from other policy documents on AVs and New Mobility by North American cities in that it was preceded by an extensive knowledge-building process within the interdivisional AV working group (Steckler, 2019: 17). Under the leadership of the transportation division, various formats such as webinars, conferences and workshops were held to engage divisional staff and create momentum in the conversation on AVs (I-02; I-16). Yet, as an institutional framework, the IDWG not only enabled the exchange of knowledge and expertise, but also provided the necessary governance structure for collective decision-making (Reimer et al., 2014). After all, the underlying achievement of having published the Tactical Plan in 2019 lies in the fact that each of the IDWG's 30 participating divisions was involved in its development. Given the complexity of the task, subject-specific subcommittees were formed to enable in-depth collaboration, e.g. on data analysis and management policies or strategic KPIs (I-01; I-02).

A report for action to the Public Works and Infrastructure Committee (Toronto, 2018a) describes the function of the policy framework as to ensure that "all divisions and agencies are following a consistent direction with respect to automated vehicles and the City's policies, plans, and strategies." (5). In part, administrative coordination is facilitated through the institutional framework of the IDWG, in part it is ensured by building on existing policy documents, strategies and plans of the divisions and agencies involved. In this regard, the development of the Tactical Plan shifted from the formulation of a municipal position on AVs (I-16) to the recognition that the City of Toronto already has a development vision that AVs must in turn align with (I-01; I-02). By building on what exists, the intention is to leverage automation as:

> *"a tool toward a future that has already been envisioned, rather than act as a force that pushes Toronto away from its existing goals."* (Toronto, 2019a: viii)

One of 20 documents that informs some of the strategic directions rendered in the Tactical Plan is the *Official Plan* by Toronto's city planning division. Policy language adopted from the Official Plan addresses accessibility and socioeconomic equity, e.g. by stating the aim of "a more socially cohesive and equitable city through the integration and coordination of transportation planning and land use planning" (Toronto, 2022a: 2-5) or inclusive, multimodal and space-efficient transportation. Moreover, streets are acknowledged as "significant public open spaces which connect people and places and support the development of sustainable, economically vibrant and complete communities" (Toronto, 2022a: 3-3). Other policies, which guide the underlying vision and refer to urban development and mobility issues, include the 2017 *TransformTO Climate Action*

Strategy, the City Clerk's *Protection of Privacy Policy*, the 2017 *Vision Zero Road Safety Plan*, the *Toronto Complete Streets Guidelines*, the Toronto Transit Commission's *5-Year Corporate Plan & 10-Year Outlook* and the *Congestion Management Plan*. Beyond those, the Tactical Plan also refers to strategies that involve economic and cultural development, circular economy, public health, poverty reduction and inclusive development.

An independent expert review panel, engaged to review a draft version of the Tactical Plan in 2019, concluded "There is consensus that the City's draft Tactical Plan is comprehensive, well written and that its direction is sound and well detailed. … It was further noted that this is only one of a few plans like this in the world" (Toronto, 2019c: 22). Due to their participation in the IDWG and the development process of the Tactical Plan, some municipal divisions launched independent efforts to investigate the impact on AVs within their policy fields. The Public Health department, for instance, conducted a research study on the public health impact of AVs (Dean et al., 2019), the Environment and Energy department aligned the City of Toronto Electric Vehicle Strategy (Toronto, 2019d) and City Planning integrated language on AVs as part of its Official Plan revision. Efforts such as these are continued through the implementation of strategic projects (see Chapter 4.3.2), specified as part of the *AV Readiness Plan 2022* that constitutes the final section of the Tactical Plan.

Directions, Goals and Tactics

The seven overarching directions that constitute the Tactical Plan's vision (Table 4.2) are substantiated by goals and objectives that align with existing policy documents and serve as guiding principles. To gain a better understanding of how the IDWG envisioned to shape the transition to AVs, the following section reviews the extent to which goals and tactics address urban and spatial implications, refer to different AV use cases and policy levers to regulate AVs are specified.

Table 4.2 Directions and Goals constituting the Tactical Plan

Directions	Goals	KPI – Key Performance Indicators
1. Social Equity & Health		
The City of Toronto will encourage the adoption of driving automation systems in a manner that improves social equity and health.		
	1.1 Ensure Barrier-Free Access	Percentage of AV services that are barrier-free for each group
	1.2 Increase Mobility Equity	Median wait time for barrier-free AVs versus standard AVs by geographic area (neighbourhood)
	1.3 Promote Health	The City of Toronto will be determining the required key performance indicators from 2019-2022
2. Environmental Sustainability		
The City of Toronto will encourage the adoption of driving automation systems in a manner that increases environmental sustainability across a vehicle's entire lifecycle.		

2.1	Reduce Vehicle Emissions	City-wide GHG emissions Percentage of vehicles licensed through the City that use low- or zero-carbon energy sources Percentage of City fleet that use low- or zero-carbon energy sources
2.2	Reduce Vehicle Waste	Average fleet lifecycle Waste diversion rate

3. Economic Sustainability

The City of Toronto will support and enhance sectors related to automated vehicles, with a particular focus on attracting industries, investment, and employment, as well as on exporting products and services.

3.1	Expand Sectors	Total economic output of sectors related to AVs
3.2	Expand Employment Opportunities	Number of jobs created in AV-related sectors per 1000 jobs Percentage of workers who have transitioned into a new role
3.3	Demonstrate Sector Leadership	Number of times Toronto achieves top 50 in global AV rankings

4. Privacy

The City of Toronto will support and enhance data privacy as it relates to the generation, collection, and use of information by automated vehicles.

4.1	Protect Public Privacy	Month-over-month percentage +/- (increase/decrease) of privacy breaches that result in unauthorized data discovery, and leakage, of personal information.

5. Road Safety & Security

The City of Toronto will encourage the adoption of driving automation systems that are proven to create a net benefit to road safety and security.

5.1	Prevent Collisions	Number of persons killed/ seriously injured involving AVs per VKT (vs. non-automated vehicles) Number of non-KSI collisions involving AVs per VKT (vs. non-automated vehicles)
5.2	Update Infrastructure	Number of infrastructural barriers to AV use eliminated
5.3	Update Emergency Response	Average response speed (specifically driving time)
5.4	Protect Data Confidentiality, Integrity & Availability	Month-over-month percentage +/- (increase/decrease) of security breaches that result in unauthorized data discovery, and leakage, of personally identifiable information.

6. Integrated Mobility

The City of Toronto will encourage the adoption of driving automation systems that further integrate space-efficient and active modes of travel, and better manage all traffic impacts from the movement of goods.

6.1	Increase Space Efficiency	Throughput in persons per hour per unit area of public right-of-way Percentage change in mode share for: • Active transportation • Transit • 2+ occupant vehicles • Combined-purpose vehicles Urban Goods Movement KPI TBD based on completion of Goods Movement Strategy
6.2	Design Smart Streets	Number of flexible curbside hours per 100 m
6.3	Increase System Seamlessness	Percentage of ridership satisfied with system seamlessness

7. Transportation System Efficiency		
The City of Toronto will enhance its ability to manage traffic in real-time through driving automation systems for the purpose of increasing the efficiency of moving people and goods.		
	7.1 Increase System Capacity	Annual average daily curbside access events per 100 m Number of open datasets on City of Toronto Open Data portal Throughput in persons per hour per unit area of public right-of-way
	7.2 Manage System Demand	Proportion of daily traffic outside AM/ PM peaks

Source: table by the author, based on *Automated Vehicles Tactical Plan*, by City of Toronto, 2019a.

Urban and spatial implications

Four of the seven directions and corresponding goals address spatial effects and changes due to AVs: "1. Social Equity & Health", "5. Road Safety & Security", "6. Integrated Mobility", and "7. Transportation System Efficiency". Referring to the Official Plan's policies on a cohesive and equitable urban development, the first direction includes the goal *1.2 Increase Mobility Equity,* which emphasizes the assessment of mobility service coverage across Toronto's neighbourhoods, amongst others. Acknowledging that certain areas of the City have been disadvantaged by lower levels of transit and mobility service availability, it is assumed that AVs may play a role in providing more equitable service, if frequencies, hours of service and proximity to mobility services were improved across all neighbourhoods (Toronto, 2019a: 47). The corresponding short-term action is thus to identify affected areas within Toronto and specify potential benefits that AV use cases may provide. Moreover, one of the more unique tactics of the document concerns the long-term transformation of the transportation system towards so-called "mobility neutrality" (Toronto, 2019a: 48). In a scenario where AV-based mobility services proliferate, the tactic's intention is to prevent that specific user classes, e.g. affluent non-drivers, receive unregulated priority due to their ability to pay for premium services (ibid.). The tactic particularly stands out when considering that expanding equity has thus far received little emphasis in planning documents on AVs by U.S. municipalities (Freemark et al., 2019: 139).

As part of the second direction, goal *5.2 Update Infrastructure* points to infrastructure decisions relevant to future urban development. On the one hand, the need to identify specific corridors and areas within the City is highlighted, which may serve as early deployment zones during the transition to AVs (I-01). On the other hand, it emphasizes the assessment of possible new products, be it transit vehicles with ADAS or CV infrastructure. The underlying arguments being a focused investment into potentially necessary infrastructure upgrades and a secure integration of private AVs, transit AVs and CVs. While some cities dispute whether infrastructural upgrades are necessary in order to ensure safe interactions between driverless vehicles and pedestrians or cyclists, arguing instead that public authorities should be cautious of accepting additional financial burdens

(Telepak & Augustin, 2018), the Tactical Plan frames focused investments as a "way to support early integration of AVs" (Toronto, 2019a: 81).

In this vein, installing dedicated lanes for AVs serves a double purpose: firstly, they add a layer of safety, and secondly, they may serve as a testing ground for technological advancements in transport and infrastructure provision. Specifying the implementation of such a corridor as a short-term action until 2022, demonstrates the city's resolution to take a regional lead in promoting "innovation in transportation and standardization across municipalities" (Toronto, 2019a: 81). It also has immediate relevance to actions for vehicle and infrastructure connectivity, as the latest iteration of Toronto's *Congestion Management Plan*, the *MoveTO 2021-25* interim action plan, includes the roll-out of smart signals and intelligent intersections (Toronto, 2020b).

More explicit language on urban design issues can be found in the two goals, 6*.1 Increase Space Efficiency* and *6.2 Design Smart Streets*, of the sixth direction. The first addresses urban development by pointing out the need to specify corridors for transit priority that ADS may play a supporting role in, as well as corridors and zones that will prioritize walking and cycling "alongside AV infrastructure upgrades" (Toronto, 2019a: 91). While related short-term tactics include some of the most concrete planning actions – both refer to a 2022 white paper on either transit priority or walking and cycling related to AVs – the overall language regarding mobility prioritization remains vague. Resource efficient mode requiring less space or energy are not to be prioritized in general, but merely along specific corridors or within certain areas, where a reduction of motor vehicles may be beneficial to residents and businesses (Toronto, 2019a: 90-91).

The second goal focuses on and addresses possible implications for urban street designs. Corresponding tactics emphasize the development of design standards specific to the benefits (automated speed limits, reduced lane widths and dynamic street use) and challenges of AVs, the need for a road classification system and policy options for flexible curb management with AVs (Toronto, 2019a: 92-93). The latter refers to managing availability by coding the curb, that is, essentially using sensor-based information to communicate occupancy levels and the location of vacant spaces. As part of digital parking management strategies, the dynamic retrieval of such information can be used to support enforcement and reduction of environmental pressures (Rye et al., 2022). The tactic on road classification, meanwhile, does not involve an assessment of the entire street network, but focuses instead on using local streets as AV facilitators (Toronto, 2019a: 93). The underlying assumption being that upgrading local roads may relieve areas, such as the downtown core, where a growing demand for curb access along major arterials could cause congestion.

Finally, goal *7.1 Increase System Capacity*, contained in the seventh direction, is concerned with urban development by stressing the capacity increase in existing transportation infrastructure, rather than expanding the city's road network. Relatedly, different forms of vehicle connectivity (v2v, v2i, v2n, v2x) are mentioned as technologies that could enhance in-vehicle traffic services, active traffic management and vehicle throughput. The related tactic specifies that a mechanism for increasing throughput via ADS and connectivity shall be drafted in accordance with the 2021–2025 Congestion Management Plan (Toronto, 2019a: 98). There is no mention, however, of who would provide the communicational technology, e.g. sensors, that would be required along affected arterials and expressways. A significant issue, as responsibility over the road network is not only divided between the transportation and city planning divisions (Hess, 2009), but is further complicated due to the Province's veto right, previously preventing the City from installing Transportation Demand Management (TDM) measures along its urban expressways (see Chapter 6.3.2). The tactic on designated loading areas for AVs confirms previous studies in recognizing that the introduction of AVs will likely boost the demand for designated pick-up and drop-off areas and time- or location-specific regulation (NACTO, 2019a). In line with Toronto's Curbside Management Strategy (2017), which encourages off-street pick-up and drop-off, the related tactic involves the short-term development of a potential design standard (Toronto, 2019a: 99).

AV Use Cases with implications for urban development

Beyond statements on spatial issues per se, the reference of specific use cases and regulatory conditions is most telling concerning the potential impact of AVs on urban and spatial development. After all, whether or not automated driving systems will support or rather contradict strategic development goals depends on their application. While privately owned AVs are likely to increase total vehicle travel and sprawl, public transit innovations could in turn reduce car dependency, whereas pooling-services with AVs would require TDM measures and anti-sprawl policies to have a beneficial effect (Litman, 2021: 95).

In a similar manner to other major cities in the U.S. that have emphasized AVs support of the transit system (Freemark et al., 2019), the Tactical Plan is based on "taking a transit-centric approach to automation" (Toronto, 2019a: 122). Planning measures are mentioned, which stress "improving transit priority through technology" (Toronto, 2019a: 90), integrating "small commuter shuttles or shared fleet vehicles" (Toronto, 2019a: 94) and achieving a "seamless mobility centred specifically on public transit" (Toronto, 2019a: 94). Next to such transit applications, high-occupant vehicles are mentioned as another priority in planning and for AV-related infrastructure (Toronto, 2019a: 91). After all, if implemented alongside transit improvements, MaaS and incentives for vehicle sharing, HOV lanes bear the potential of encouraging a shift from individual to shared trips, potentially supporting the stated aim of “moving more people in fewer vehicles on less-congested streets” (Toronto, 2019a: 91).

Yet the specific tactics assume the prioritization of these “space-efficient and active modes” (Toronto, 2019a: 90) within geographic limits. Suggesting that although the stated intention is to increase the overall proportion of sustainable mobility modes, the dominance of private vehicles will likely remain the general default. In the end, language on reducing automobile dependency and vehicle travel is scarce and there is no mention of supporting space-efficient modes through more compact development, e.g. in the vicinity of transit hubs or by repurposing parking areas. Even a tactic addressing traffic-calming mechanisms does not explicitly mention the reduction of vehicle travel. Instead, the particular approach refers to an additional vehicle representing an automated “pace car”, which could enhance traffic flow by adjusting its speed and position to achieve a system equilibrium (Toronto, 2019a: 98). In this vein, many tactics refer to more or less unique (technological) enhancements and mechanisms with the aim to positively influence a more environmentally sustainable mobility system, but do not allude to reducing current levels of automobile dependence at a larger scale.

Policy Levers

Beyond that, regulatory measures that may guide the implementation of AVs are mentioned as part of goal *7.2 Manage System Demand*. For instance, pricing or permit systems are addressed as an addition to designated loading zones in order to effectively manage the growing curbside demand due to ride-hailing services and goods transport. Without making the existing safety threads for active modes explicit, the ongoing “fight for the curb” (Toronto, 2019a: 100) is generally mentioned. The corresponding short-term action involves research on variable pricing options for AVs, which could motivate a much-needed update to Toronto’s Curbside Management Strategy, which lacks restrictive measures.

Another, potentially significant, tactic addresses pricing mechanisms and value propositions that would ensure that transit remains more affordable, hence more attractive, than AV alternatives. While the tactic addresses a critical issue, since low AV operating costs could induce private vehicle travel and compete with transit services, the corresponding short-term tactic broadly refers to necessary research on value propositions of automated transit, rather than more comprehensively specifying possible pricing schemes and the effects of financial advantages on consumer choice (for more information on consumer willingness to pay for various AV use cases, see Laidlaw et al., 2018). Other tactics that could potentially contribute to travel changes in favour of transit, e.g. *7.1.2 Active Traffic Management & Coordination* and *7.1.3 Designated Loading Areas,* remain equally vague. Both tactics address technological applications that could facilitate mobility and parking prioritization, but neither of them specify which forms of use (e.g. higher-value trips and activities, more efficient modes, etc.) shall receive priority within the system or to what extent on-street parking may be repurposed (Toronto, 2019a: 98-99).

Finally, pricing policies are also addressed regarding the management of on- and off-street parking and the management of travel demand. However, the associated tactics are not explicit as to when corresponding regulation or strategies could be developed. Instead, technological and policy development relevant for the management of on-street parking is to be *monitored*, externalized costs of off-street parking are to be *studied* and options for road tolls are to be *researched* with regard to zero-occupant vehicles (Toronto, 2019a: 98-99, emphasis added by the author).

Action Items

The final section of the Tactical Plan introduces a 3-year agenda, building on five projects that were financially approved by the City Council in 2019 and planned to be implemented by, 2022. These short-term measures are meant to provide a comprehensive foundation to prepare the City of Toronto for an AV future (I-02) and "ensure that any significant changes related to [AVs], will not come as a surprise to City government, or Torontonians" (Toronto, 2019a: 122). Referring to the previously described tactics, the five projects include: a.) Automated Shuttle Trial; b.) Transportation Innovation Zones; c.) Testing Response & Incident Preparedness (TRIP); d.) Information Hub; and e.) Research & Development program. At the core of these projects lies the intention of further knowledge creation, be it through collaborative learning across public entities, public-private synergies, cross-municipal knowledge transfer, or in-depth research within certain divisions. In this vein, the efforts largely reflect those of MPOs in the United States (Guerra, 2016), with the exception of adapting investment priorities, although the potential to do so is referenced, for instance, in relation to parking demand studies (Toronto, 2019a: 130).

Resembling earlier pilot projects conducted in jurisdictions worldwide (see Chapter 2.1), Toronto's *Automated Shuttle Trial* serves the purpose of testing the technological maturity of self-driving shuttle buses and evaluating their adequacy, if deployed as a feeder system to existing trunk lines. Running short-term pilot projects of this sort allows public entities to build capacity – in this case the City of Toronto, TTC, and Metrolinx – and the public to familiarize itself with a novel technology (I-01). In a similar vein, but directed towards different use cases and private-sector actors, Toronto plans to install *Transportation Innovation Zones* on city ground. Aside from providing a dedicated area for technological trials and public demonstrations, the project centres on developing a framework allowing the City to systematically assess piloting requests and streamline approvals (Toronto, 2019a: 124). Both projects are comprehensively examined in Chapter 4.4.

The project *Testing Response & Incident Preparedness* (TRIP) comes as a reaction to the provincial government's 2019 regulation that permits the general public to drive commercial vehicles with SAE Level 3 automation, the testing of driverless AVs (SAE Level 4 and 5) and the testing of cooperative truck platoons on Ontario roads. For municipalities, the policy entails the administration of trial notifications as well as a so-called *Work Zone and Law Enforcement Interaction Plan* and managing the consequences for its public services, e.g. law enforcement personnel and first responders (Toronto, 2020f). As part of TRIP, which has been implemented, Toronto provides public service entities with interaction protocols, while also publishing guidelines for participants in Ontario's AV pilot program intending to set up a trial in Toronto. While answering to the guidelines is optional, gathering participant information can benefit the city's knowledge on technological maturity and level of preparation for AVs.

Finally, the projects *Human Learning* and *Research and Development Program* centre on knowledge creation amongst the general public and internally within municipal divisions. As part of the former, the aim is to initiate a third-party group, responsible for funding and communication, that develops formats where the public can learn to interact with AVs being tested on public roads (Toronto, 2019a: 124). The latter project is more encompassing, as it includes a series of studies that continue the engagement started by various divisions while part of the IDWG. Topics range from a study on new performance measures for a multimodal level of service, research on AV implications for land use and land use planning regulations, research on parking demand and capacity requirements, strategic forecast based on macro-level societal trends that could shape a future with AVs, research on mobile production units, as well as research on the effects of an evolving mobility marketplace dominated by global service providers for local businesses and Toronto's ability to ensure competition. Conducting the various studies, it is argued, serves the purpose of exploring long-term implications and preparing the municipality for sudden changes by proactively developing necessary policy options (Toronto, 2019a: 129).

The five projects constituting the *AV Readiness 2022* thus range from immediately necessary actions, e.g. streamlining trial applications, to long-term investigations and learning about future implications. According to an interviewed expert, the various learning processes, taking place within divisions and creating opportunities to understand the implications and relevance of AVs, lie at the very core of the municipal initiative on automated mobility (I-02).

4.3.2 Official Plan Amendment

Toronto's *Official Plan* (OP) represents a municipal planning document that is mandated by the provincial *Planning Act* and holds a legally binding status. It governs the city's planning actions by providing the basis for any land use and infrastructure development, zoning bylaws, and subdivision plans (Hess & Sorensen, 2015). For any municipal bylaw, neighbourhood-related secondary plan, or public works project, consistency with the plan needs to be ensured.

Format

Encompassing a 30-year planning horizon, the current OP was first published in 2006 and has since been reviewed on several occasions, as Official Plans are subject to review every four years. Amongst others, the review before the Ontario Municipal Board ensures that secondary plans are aligned with changed circumstances and the city's overarching development objectives. While Toronto lacks an overarching transportation vision incorporating the foci of various affected divisions, the OP includes City Planning's transportation strategy. Based on an integrated understanding of managing growth, the OP centres on achieving its overall aim of increased accessibility through "… mutually supportive transportation and land use policies that combine the mechanisms of mobility and proximity…" (Toronto, 2022a: 2-4). Moreover, it aims to use available infrastructure more efficiently and reduce car dependency by making "walking, cycling, and transit increasingly attractive alternatives to using the car" (Toronto, 2022a: 2-34).

Development and Authorship

According to interviewees (I-02; I-04), the impetus to integrate the issue of self-driving vehicles into the OP during its most recent review process, came as a result of the capacity building process within the AV Interdivisional Working Group. Parallel to the development of the AV Tactical Plan, the City Planning department reviewed options to integrate AVs. But in light of the OP's legally binding status, City Planning takes a cautious stand when it comes to integrating AVs into the City's OP early in the transition phase. The cautiousness reflects the concern for potential challenges and negative aspects that need further assessment and understanding, e.g. changes in travel behaviour and implications for transit (I-06). Following the release of the Tactical Plan, amendments to the OP were adopted by the City Council in early 2020 (Toronto, 2020a), but the updates associated with automated vehicles remain non-prescriptive.

Goals and Objectives

The amendments concern the OP's transportation policies, which include the policy statement:

> "*New and emerging mobility-related technologies, practices and designs will be assessed to determine their impacts on urban travel conditions, the environment, public health and safety, the economy and the policies of this Official Plan. Regulations will be put in place, as necessary, to achieve the objectives of this Plan."* (Toronto, 2020a: 15)

The amendment implies a wait-and-see attitude concerning the technological advancement of automated vehicles, and a tentative inclination to regulate the mobility option, if existing development goals were to be undermined in the future. Planned assessments concerning AVs include efforts to conduct modelling of travel demand changes, to examine implications for parking demand forecasts, and to consider policy regarding HOV priority (Toronto, 2019a).

Beyond automated vehicles per se, "curbside management" was adopted as a subpolicy, resembling a practice which may contribute to better travel conditions across all modes. Its adoption also implies the acknowledgment that mobility sharing options as well as ride-pooling services will not only persist, but require adequate regulation in order to fulfil the transportation principle of:

> *"... leveraging advances in technology to develop an integrated multi-modal transportation system that is efficient and sustainable"* (Toronto, 2022a: 2-37)

Further amendments indicating the expectation that sharing services will continue to diversify, and their demand persist, include the substitution of taxis with the term "vehicles-for-hire" when referring to pick-up and drop-off infrastructure and its integration into the transportation system. A separate policy addresses their spatial provision as part of newly built urban development:

> *"Development will be encouraged to make off-street provisions for pick-ups and drop-offs, loading and parking activity."* (Toronto, 2020a: 15)

Aside from these individual action items that address emerging mobility technologies, the bundle of updates to City Planning's transportation policies centre more broadly on the promotion of space-efficient and low-carbon modes of transportation, as well as giving investment priority to enhancements of the existing transportation system. In addition to implementing a comprehensive transit network plan, this particularly concerns the vision for an expanded cycling network with designated cycling and multi-use corridors, improved connections to transportation amenities, and the promotion of public bike sharing (Toronto, 2020a: 10). These policies support the existing transportation vision embedded in the Official Plan as described above.

4.3.3 CAV Readiness Plan

The *CAV Readiness Plan* (henceforth "Readiness Plan") constitutes a regional planning framework on emerging trends in transportation directed towards public agencies in the area serviced by Metrolinx, roughly corresponding to the GTHA. As many municipalities grapple with planning for AVs, the Readiness Plan may be viewed as a roadmap for municipalities on how to prepare for AVs (I-15). In this sense, it is intended to provide regions across Canada with guidance. It differs from the Tactical Plan in focusing solely on transportation and transit issues related to AVs and by considering all levels of government. To this end, it includes guidelines and programs that may be of relevance at the local, regional, provincial or the federal level, and that refer to passenger vehicle, transit as well as goods movement in urban, suburban and rural contexts.

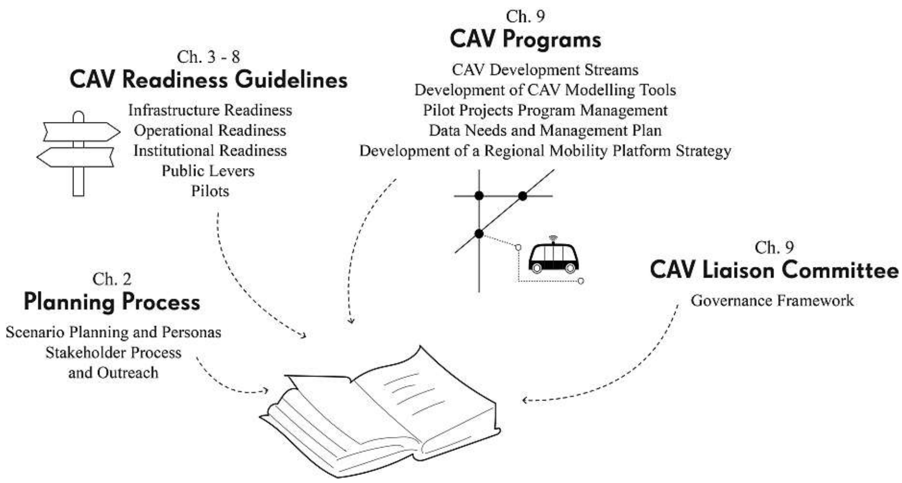
"Providing public-sector agencies with the necessary tools to plan for this disruption will play an important role in facilitating the smooth integration of CAV with transportation systems." (Ontario, 2020a: 5)

Format

Recognizing provincial legislation as a critical step forward in legalizing the introduction of AVs on public roads, the authors emphasize the need for public agencies to prepare in order to ensure "a coordinated approach to a CAV future" (Ontario, 2020a: 49). They again highlight the uncertainty of planning for emerging mobility technologies, which is why the Readiness Plan provides public transportation agencies with a range of considerations. As guidelines may gain or lose relevance over time, a Scenario Planning Approach is introduced as a methodological tool to assess their adequacy. Moreover, persona profiles serve as sounding boards to evaluate whether the guidelines meet the needs and mobility requirements of various user groups (Ontario, 2020a: 13). As such, the Readiness Plan does not build on a single, normative vision on where transportation developments should ideally be headed towards in the GTHA. Instead, the developed guidelines and programs are intended to support various futures and to be transferable to other jurisdictions – granting, however, that provincial and municipal agencies will need to locally adapt the proposed steps for implementation.

The Readiness Plan comprises four main components: a.) a section introducing the Scenario Planning Approach; b.) the *CAV Readiness Guidelines* including general principles and tasks; c.) five *CAV Programs* that provide a common planning framework and potential follow-up projects in the GTHA and d.) a governance framework for a regional *CAV Liaison Committee* (Fig. 4.5). The latter introduces an institutional framework for continued regional collaboration and the implementation of the CAV programs beyond the CAV Readiness Initiative in 2020.

Figure 4.5 Components of the CAV Readiness Plan



Source: illustration by the author, based on *CAV Readiness Plan,* by Government of Ontario, 2020a.

In terms of a technological definition of AVs, the policy framework is built on the notion that vehicle connectivity and vehicle automation will eventually merge and comprise various forms of mobility services, such as ride-pooling, car-sharing or transit services (Ontario, 2020a: 5). Referring to a proposed rulemaking in the United States that all vehicles could be required to use V2V communication technology, the Readiness Plan suggests that "Connectivity will be required to achieve highly to fully automated (driverless) systems connected to the internet for map information updates, and live traffic information." (Ontario, 2020a: 2, Appendix A). The assumed notion of CAVs implies that future vehicles not only rely on sensors and cameras to automate the driving task, but are also connected to a network and exchange information with each other (v2v), with infrastructure (v2i) and with other road users (v2x).

> *"The greatest benefit of this technology is, if they are automated and connected, connected to each other, connected to the infrastructure."* (I-14)

As Ontario legalized the public use of SAE Level 3 vehicles in 2019 (Ontario, 2021a), the Readiness Plan primarily refers to the introduction of SAE Level 4 or 5 vehicles. Given the uncertain time frame of their deployment, the guidelines function as buildings blocks, which apply to different levels of AV saturation: few CAVs, mixed CAVs and primarily CAVs (Ontario, 2020a: 2, Appendix D). Moreover, the scenarios developed for the Readiness Plan differ with regard to levels of passenger occupancy and deliveries per capita, but do not differentiate operational models or service providers. For the base scenario, the authors adopted mode share estimates from the *2016 Transportation Tomorrow Survey* (for the zero-to-single and two-to-three passenger vehicle occupancy share), the *Greater Golden Horseshoe Model* (for the transit mode share) and the MTO provincial passenger and freight model – TRESO (for inner-city truck freight VKT and intra-city truck freight VKT). Table 4.3 gives an overview of the assumed mode shares.

Table 4.3 Five future scenarios with CAVs for the GTHA

		Base Scenario	High Average Occupancy	Low Average Occupancy	High Goods Movement	Low Goods Movement
Passenger Occupancy Share	0 - 1 Passengers	50 %	25 %	75 %	50 %	50 %
	2 - 3 Passengers	25 %	25 %	10 %	25 %	25 %
	4+ Passengers	25 %	50 %	15 %	25 %	25 %
Deliveries per Capita (% of Today)	Inter-City freight	100 %	100 %	100 %	120 %	80 %
	Intra-City freight	100 %	100 %	100 %	200 %	50 %

Source: table by the author, based on *CAV Readiness Plan,* by Government of Ontario, 2020a: 4, Appendix D.

The metrics used to differentiate the scenarios resonate with an interviewee's remark that amidst a changing transportation landscape with an increasingly diverse mobility mix, transport metrics need to be reconsidered (I-08). While congestion levels are traditionally used to evaluate an effectively functioning urban road network, the question arises whether the value of time and the significance of congestion may change, if passengers are able to use their travelling time for work or leisure due to self-driving vehicles (I-08). In light of overcrowded city regions and limited road infrastructure, other metrics have gained importance in transport and land use planning. For instance, studying AVs impacts on Vehicle Kilometres Traveled (VKT) and passenger occupancy, as referred to in the Readiness Plan, has become critical to understand their potential travel-efficiency and environmental sustainability, e.g. carbon intensity. Rather than emphasizing travel flow, such metrics offer insight as to how efficiently different travel modes, or AV use cases, move people.

The identified shift in mode share was based on the transport policies and the direction of consumer trends assumed for each scenario. Both factors were informed by stakeholder consultations and a revision of previous scenario studies that were developed for the City of Toronto, Metrolinx's 2041 Regional Transportation Plan, York Region's 2016 Transportation Masterplan, and Ontario's Greater Golden Horseshoe (GGH) Transportation Plan 2051/2071 (Ontario, 2020a: 3, Appendix D). The scenarios developed as part of the Readiness Plan were characterized as follows (Ontario, 2020a: 11, 2, Appendix D; emphasis added by author):

1. **Base Scenario:** Vehicle occupancy and travel patterns remain similar to the present day. Goods movement and deliveries increase proportionally to population growth.

   CAV Phasing: CAV pilots become more prevalent for personal travel, public transit and goods movement. As the technology matures, it eventually leads to a predominantly CAV-based future. CAVs rely on curbside access for pick-up/drop-off activities.

2. **High Average Occupancy:** *Pricing policies* and other regulations (e.g. bonus/malus incentives) encourage higher occupancy trips. Shared mobility services grow as a transportation mode: private trip-sharing, ride-hailing services, the first-/last-mile services are integrated with transit. Goods movement and deliveries increase proportionally to population growth and truck platooning is introduced for longer-haul freight trips.

   CAV Phasing: Early indication of a growing demand for single-occupant travel leads to the introduction of mobility pricing, HOV incentives and limitations for zero-occupant vehicle trips. Overall parking demand declines as shared CAVs continuously pick-up and drop-off passengers, but related curbside demand compels strong regulation or pricing.

3. **Low Average Occupancy:** *Pricing policies* are *ineffective* in encouraging higher occupancy trips, leading to increased low- and zero-occupancy trips, VKT, and greater

traffic congestion. Goods movement and deliveries increase proportionally to population growth and truck platooning is introduced for longer-haul freight trips.

CAV Phasing: Lack of mobility pricing and a fading gas tax cause public transit funding and ridership to decline. Few incentives exist for ride sharing and HOVs. CAVs increase accessibility and service offerings for all citizens and cause a growth in transport demand.

4. **High Goods Movement/Delivery:** *Economic and consumer trends* (online ordering and shipment) lead to a higher demand for goods movement, causing inter-city deliveries and intra-city deliveries to increase. Passenger travel evolves in a similar manner to the base scenario.

   CAV Phasing: CAV technology enables "free" shipping to become the norm due to the absence of regulation and mobility pricing. Platooning becomes the standard for highway trucking. CAVs attract new user groups, increasing demand for personal vehicle travel.

5. **Low Goods Movement/Delivery:** *Environmental policies* (e.g. mobility pricing and curbside management policies) increase the cost of goods movement: the use of rail reduces the demand for inter-city truck freight; small delivery centres and alternative delivery modes reduce intra-city truck deliveries. Passenger travel evolves in a similar manner to the base scenario.

   CAV Phasing: Curbside management regulations restrict urban truck parking and dwell times, making deliveries costlier and consequentially reducing demand for urban deliveries. CAVs attract new user groups and increase demand for personal vehicle travel.

In the Readiness Plan, scenarios are not targeted towards a specific time horizon, but phased according to CAV traffic saturation levels, which helps to differentiate between short-term, medium-term and long-term changes. The CAV Readiness Guidelines associate respective action items with levels of CAV saturation, allowing public agencies and "road authorities to implement the recommendations based on their expectations of CAV commercialization and adoption." (Ontario, 2020a: 2, Appendix D). An interviewee noted that thinking in saturation levels is tied to the assumption that a scenario with solely AVs roaming the streets will not come to pass: "We don't expect that it will ever actually be 100 % connected automated vehicles. Because if you look at people [that] have historic cars and heritage cars – they're on the roads now and those aren't ever likely expected to change" (I-08).

Development Process and Authorship

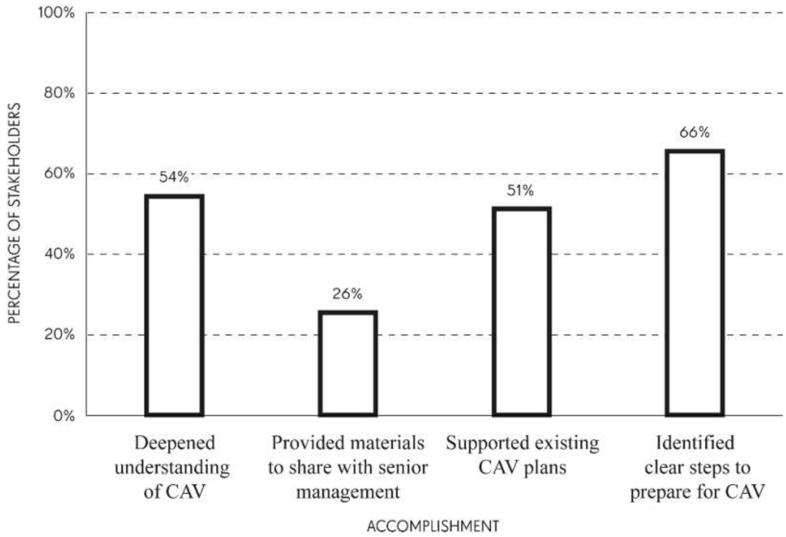
A private agency with years of experience in consulting the public sector on transport innovation was contracted with developing the Readiness Plan and facilitating the corresponding stakeholder engagement process. In three project phases, comprehensive research was combined with a scenario planning approach, followed by the development of the *CAV Readiness Guidelines* and the *CAV Programs* (Ontario, 2020a: 1, Appendix B). As mentioned in Section 4.1, a significant effort was made to engage representatives from a variety of transportation and transit agencies across the region and thus to co-create the policy framework to a certain degree. For instance, collaboration took place during in-person workshops (I-08; I-15), via online surveys and online interactive tools, and by means of document reviews. The participatory formats enabled stakeholders to share inputs, express their needs and expectations as well as learn from one another.

The Readiness Plan is intended to complement earlier policy documents and planning initiatives, issued at different governance levels in the years 2017 to 2021, as shown earlier in Figure 4.1. To this end, the authors drew key insights from documents providing guidance on testing and trial operation, for instance, the 2019 *Automated Vehicle Policy Framework for Canada* issued by the Canadian Policy and Planning Support Committee (PPSC), or from high-level policies on safety, such as the *Safety Framework for Automated and Connected Vehicles* by Transport Canada. The two local planning documents that are referred to are Toronto's *AV Tactical Plan* and the *Goods Movement Strategic Plan* by the Regional Municipality of Peel. The Readiness Plan sets itself apart from earlier policy frameworks, as it provides a regional approach to planning for CAVs and emphasizes multi-actor collaboration across jurisdictions.

In contrast to Toronto's Tactical Plan, which builds on several years of divisional preparation and commissioned studies by municipality, the Readiness Plan provides an actionable roadmap for municipalities, transportation and transit agencies that have not yet invested into planning preparations for CAVs (I-15). While perhaps lacking an integrated urban development vision, it emphasizes regional collaboration and highlights the need for attuned planning in order to ensure a smooth transition to a new mobility paradigm. To this end, guidelines under *Institutional Readiness* introduce planning considerations for all levels of government, ranging from amending municipal official plans to account for CAV adoption to developing regional transportation plans and updating provincial legislation. In the case of the GTHA, the latter include the *Planning Act* or *Environmental Assessment Act*, the *Growth Plan for the Greater Golden Horseshoe* and related policy statements (Ontario, 2020a: 39). Thus far, the province's long-range transportation plan *Connecting the GGH: A Transportation Plan for the Greater Golden Horseshoe* (Ontario, 2022) was updated to include actions on emerging technologies, such as AVs (44).

A survey conducted towards the end of the process shows that participating in the development of the Readiness Plan did not necessarily raise the actual level of preparation by stakeholders, but did clarify how to move forward for the majority of participants (Fig. 4.6). Besides the participatory formats that enabled stakeholders to learn about the state of the technology, participants particularly valued its illustration of action items, clarity on necessary steps and possible initiatives (Ontario, 2020a: 9, Appendix B).

Figure 4.6 Stakeholder feedback on the achievement of the CAV Readiness Plan process



Source: illustration by the author, based on *CAV Readiness Plan,* by Government of Ontario, 2020a: 9, Appendix B.

Readiness Guidelines, Objectives and Action items

To provide public agencies with guidance in preparing for a possible future with CAVs, twenty guideline categories were developed and grouped into five Readiness Types. Each category includes action items that are classified according to CAV saturation levels. The classification implies at what saturation rate – Few CAVs (pilots, testing programs platooning on highways), Mixed (conventional vehicles and CAVs coexist with equal deployment of connectivity) and Primarily CAVs (the majority of vehicles are CAVs with widely used connectivity applications) – a specific action is meant to be completed (Ontario, 2020a: 16). Comparable to the AV Tactical Plan, the underlying planning approach serves adaptive flexibility. The actions facilitate small movements along a dynamic, open trajectory of AV introduction (Hillier, 2017: 302). The principle is perhaps best described using the example of communication infrastructure. In the Readiness Plan, connectivity is considered to be relevant during all stages of CAV adoption – starting in its initial phase, when the needs and capabilities of connectivity are tested in pilot projects (I-15; Ontario, 2020a: 18). As CAV adoption spreads, connectivity technologies are expected to geographically and functionally expand. With an increasing reliance on connectivity, cybersecurity measures are to equally evolve.

Urban and spatial implications

In line with U.S. state officials' prime concern over infrastructure connectivity and ITS (Wagner et al., 2014), Ontario's Readiness initiative was originally focused on infrastructure. Relatedly, none of the Readiness types and corresponding categories summarized in Table 4.4 reference spatial development in their titles. The following three categories, however, implicitly address urban and spatial effects by addressing planning actions related to urban development: "4.2 Physical Infrastructure", "7.1 Bonus/Malus Policy" and "7.3 Infrastructure Policies and Regulations".

Table 4.4 CAV Readiness Guidelines grouped by types

Types	Guidelines
Infrastructure Readiness	
considers the impact of transportation operations, network management, maintenance teams, operations and maintenance fleets, urban commercial delivery, public transportation and transit agencies, as well as relationships between public agencies and mobility services.	
	4.1 Technology (T)
	4.2 Physical Infrastructure (PI)
	4.3 Communications, Privacy, and Cybersecurity (CPC)
Operational Readiness	
considers the impacts to transportation operations, relationships between public agencies and mobility services, network management, and public vehicle fleets.	
	5.1 Data Needs and Data Management (DN)
	5.2 Inter-Regional Goods Movement (IEG)
	5.3 Intra-Regional Goods Movement (IAG)
	5.4 Mobility Services (MS)
	5.5 Network Management and Operations (NMO)
	5.6 Public Fleet Management and Operations (PF)
	5.7 Transit Management and Operations (TMO)
Institutional Readiness	
considers the impact to demand and simulation models, transportation planning (strategic planning, transportation masterplans and capital planning), design standards and relevant safety regulations, as well as strategies for agency collaboration.	
	6.1 Freight Safety and Regulations (FSR)
	6.2 Regional Collaboration (RC)
	6.3 Safety (SY)
	6.4 Standards (STD)
	6.5 Transit Service Planning (TSP)
	6.6 Transportation Planning (TPP)
Public Levers	
considers incentives, policy and legislative changes required to create a CAV future that improves mobility with considerations for urban, suburban and rural contexts.	

	7.1 Bonus/Malus Policy (BMP)
	7.2 Traffic Laws and Regulations (TLR)
	7.3 Infrastructure Policies and Regulations (IPR)
Pilots *describe the testing of a variety of use cases in urban and rural areas, including physical infrastructure arrangements, technology, mobility service arrangements, transit and commercial vehicle operations.*	
	8.1 Pilot Programs (PP)

Source: table by the author, based on *CAV Readiness Plan*, by Government of Ontario, 2020a: 15.

Urban implications of CAVs are most explicitly referred to in guideline *4.2 Physical Infrastructure*, which acknowledges the need for proactive planning due to "long capital planning and funding timeframes and infrastructure life cycles" (Ontario, 2020a: 20). Considerations largely address the assessment of existing infrastructure, for instance, the revision of capital plans and projects to clarify where planning for CAVs may be integrated and evaluating whether existing bridges would bear the load of platooning vehicles. Beyond that, short-term actions address adjustments that benefit frictionless vehicle mobility: improved signage, road markings or temporary lane separations. An interviewed expert commented in this regard that automakers designing to be self-sufficient and not relying on infrastructure is a prudent stance as long as standards have not been put in place (I-14). While another asserted the unanimous stance among participants of the CAV Readiness Initiative that it will be up to both the private and public sectors to invest in the circumstances required for safe operations (I-08). However, in order to meet uniform infrastructure standards across the network, public funding will be required to relieve municipalities of the potential burden (I-15). More comprehensive design changes along highways or urban roads, parking facilities and transit stations, are thus referred to as potential long-term investments in the Readiness Plan.

The possibility that more efficient traffic flows and reduced VKT may relieve existing infrastructure to the extent of repurposing it, e.g. by turning on-street parking into public space (González-González et al., 2020), is not mentioned in the section on *Physical Infrastructure*. Other than in the Tactical Plan, where streets and roads are acknowledged as spaces for living, culture and commerce, they are generally described as spaces for movement in the Readiness Plan. Even if the safe interaction with vulnerable road users is recognized, the primary goal is still "to accommodate new technology and facilitate its safe integration on roads" (Ontario, 2020a: 20). Conversely, the goal to harness CAVs as a means to improve the quality and sustainability of physical infrastructure is subordinate to traffic efficiency gains. However, public levers to incentivize the conversion of underused land, e.g. by repurposing surface parking for added green space or urban development, are recommended as part of the *7.1 Bonus/Malus Policy* and the *7.3 Infrastructure Policies and*

Regulations guidelines. While the former points towards an update of the provincial Planning Act, the latter invokes possible zoning changes, curbside management strategies and bylaws to utilize on-street parking for pick-up and drop-off activity or urban deliveries (Ontario, 2020a: 44).

Meanwhile, the risk of CAVs inducing sprawl, particularly within a low-density urban region highly dependent on private car use, receives little attention in the document. The issue is explicitly mentioned once, as part of the guidelines on *6.6 Transportation Planning,* which includes the recommendation that municipalities evaluate potential impacts on land-use, regional employment and government revenue sources (Ontario, 2020a: 40). According to the Readiness Plan, municipalities should asses changing parking demands as well as potential urban sprawl, "as commuting may become easier and more pleasant with increasing levels of vehicle connectivity and automation" (Ontario, 2020a: 40).

AV Use Cases with implications for urban development

Specifications on how to plan for the adoption of certain AV use cases are more frequently found in the Readiness Plan than statements on spatial implications and urban development. Most notably, the potential role of CAV technologies in commercial vehicles is emphasized. Future freight transport is differentiated as inter-city delivery and truck platooning as well as intra-city urban delivery vehicles. Action items concerning the former highlight areas that are likely to be affected earlier on, such as long-distance freight corridors and connections to local transportation networks. For instance, under Ontario's *Cooperative Truck Platooning Pilot Program*, launched in early 2019, testing of platoon technology is limited to designated highway corridors authorized by the province (Ontario, 2021b). Once CAV adoption spreads, regional highways and local roads surrounding distribution centres, airports and rail yards could be affected (Ontario, 2020a: 25). Identifying dedicated zones for intra-city urban delivery is equally stressed as a necessary planning step. Particularly, as urban delivery robots are considered to potentially interfere with pedestrian movement, be it along curbsides, on parking locations or within urban consolidation centres.

Guideline *5.4 Mobility Services* centres on-demand and sharing services as another AV use case. Associated planning actions are less concerned with their spatial implications as with the strategic planning steps necessary to steer a shift towards mobility services across the region in a coordinated manner. The main emphasis lies on the implementation of a regional framework for mobility provision and its potential to improve operational efficiency, contribute to financial growth and enable seamless connectivity and convenience for users (Ontario, 2020a: 27). Initial planning actions address the need to identify its implications for transportation master plans, mobility and land-use planning. Others introduce the specific idea of a regional mobility platform, similar to Mobility as a Service (MaaS) applications in Europe. In addition to the integration of a variety of public and private mobility services (including CAV microtransit) with public transit, a regional mobility platform could build upon existing trip planners (e.g. Triplinx) and fare cards (e.g. Presto) in the region (Ontario, 2020a: 27). One of the notable policies recommended as part of a common policy framework is equally mentioned in Toronto's Tactical Plan: mobility service pricing schemes should be managed with respect to transit fares in order to prevent them from driving down transit ridership (Ontario, 2020a: 28).

Other uses cases address transit vehicles and the general upgrade of public fleets with CAV technology (*5.6 Public Fleet Management and Operations*). According to the Readiness Plan, more efficient public fleet operation may "allow the delivery of better services at a reduced cost" (Ontario, 2020a: 30). Recommended planning actions include early piloting, development of operating standards and a gradual replacement of maintenance vehicles, snowploughs and transit vehicles. Guidelines addressing public transit, specifically, largely concern the reduction of accessibility barriers by bridging the first-mile/last-mile gap and the expansion of V2V connectivity (*6.6 Transportation Planning*). Unlike Toronto's Tactical Plan, where the potential benefits of automation in transit are described as supporting transit priority, ensuring space-efficiency and reducing overall transport demand (Toronto, 2019a), the Readiness Plan emphasizes new business models. Various sections of the document address the integration of on-demand mobility services into transit networks. Related planning actions include identifying the impact of first-mile/last-mile feeder systems and assessing the need to provide designated pick-up and drop-off areas at rural and urban transit stations (Ontario, 2020a: 38). Correspondingly, an update of transit station demand management strategies is suggested (*5.7 Transit Management and Operations*), e.g. assessing the pick-up and drop-off activity and service demand (Ontario, 2020a: 31). The planning actions resonate with ongoing efforts by the regional transit agency Metrolinx and a similar policy action in the recently published long-range transportation plan *Connecting the GGH*, which highlights the exploration of alternative means to access transit hubs in the region (Ontario, 2022: 44).

Strategic Planning Goals & Policy Levers

Although the overall language on prioritizing use cases is relatively scarce in the Readiness Plan, different sections and guidelines mention the promotion of higher occupancy vehicles (shared use and transit). Guideline *6.6 Transportation Planning*, for instance, suggests prioritizing HOVs in planning and infrastructure development initiatives as a means to promote more sustainable transportation and mitigate additional congestion due to empty vehicles (Ontario, 2020a: 39). Municipalities are also recommended to implement a bonus/malus system as a complementary policy lever. A pricing framework based on congestion charges or dynamic pricing is mentioned as a possible means to discourage single- and zero-occupancy vehicle trips, while travel improvements and convenience benefits for car-pooling, e.g. in the form of HOV lanes or dedicated parking could incentivize high-occupancy travelling (Ontario, 2020a: 41). The hoped-for effects of these levers concern the reduction of trips, a shift of trips to alternate times, increased ride sharing and larger demand for less impactful modes. Yet implementing such measures may require an update of provincial legislation, e.g. the Municipal Act, which would need to permit municipalities to implement respective pricing schemes. One of the recommended short-term actions correspondingly addresses the development of detection technology for vehicle occupancy in order to track zero-occupancy and high-occupancy CAVs, while also enforcing rewards and penalties (Ontario, 2020a: 19).

Recognizing that a system change towards automated mobility is of metropolitan concern and cannot be sufficiently addressed at the local level (I-09-A), guideline *6.2 Regional Collaboration* constitutes a distinct feature of the Readiness Plan. As “personal travel, shared mobility, and goods movement does not recognize boundaries” (Ontario, 2020a: 33), public agencies, including the private sector, are required to join in planning efforts. Most notably, collaboration is necessary in order to ensure safety and communication infrastructure standards. Respective considerations at the regional level concern ITS architecture, data management, system security/back-ups and operational safety layers, e.g. pavement sensors ensuring all-weather navigation or detection technology ensuring the safety of vulnerable road users, pedestrians, and cyclists (Ontario, 2020a: 18-20).

Lack of financial and personal resources may be another concern for municipalities and agencies that collaborative strategies may relieve. Joint planning in the GTA may have significant cost benefits, ensure operational consistency and reduce redundancies in the form of duplicated efforts. The guideline suggests a variety of areas for potential collaboration: a pilot project registry, information on network management, research partnerships with the private sector, information sharing partnerships, shared funding and cooperation in the provision of public transportation services across the region (Ontario, 2020a: 34). Beyond that, the guideline underscores that institutional collaboration and policy coordination are required in order to successfully align provincial legislation with the municipal need for action.

Finally, many of the short-term guidelines refer to pilot programs that could be conducted throughout the transition period and despite uncertainty about the future of CAVs. Special emphasis is placed on developing a common testing approach between all levels of governments and assuming a general openness towards pilot projects (Ontario, 2020a: 45). While an overarching piloting framework including necessary funding streams is recommended at the provincial level, municipal governments are advised to identify necessary regulations or bylaws. Pilot projects are generally understood as a valuable tool for governments and public agencies to generate insights on a new technology without risking large-scale spending of public budgets (I-14). To facilitate the exchange of lessons learned and data between municipalities (I-15), a regional pilot project registry is suggested in the Readiness Plan. Pilot projects are addressed with regard to the following fields of application:

- Pilot programs leveraging private sector initiatives for CAV to infrastructure connectivity (e.g. traffic signal communication, vehicle-to-pedestrian or vehicle-to-cyclist connectivity);
- pilot programs addressing physical infrastructure designs, e.g. pick-up and drop-off zones, the interaction with other traffic participants and CAV performance in extreme weather;
- pilot programs investigating transit service operation, including dedicated corridors and transit rights of ways, automated shuttle buses and mobility service arrangements that explore travel behaviour impacts of first- and last-mile solutions;
- pilot programs investigating commercial vehicle operation for inter-regional and intra-regional freight and goods delivery, e.g. concerning urban stopping locations, delivery strategies, long-distance platooning and dynamic traffic signal timing;
- pilot projects investigating the application of CAV technology for municipal maintenance, e.g. snow clearing, grass cutting, public park maintenance or rubbish collection.

Action Items

A key feature of the proposed regional collaboration is also recommended as a first step to implement the planning framework. It constitutes the establishment of a *CAV Liaison Committee*, which is conceptualized as institutional settings that continue coordinated planning for AVs. Ontario's Ministry of Transportation, Metrolinx and AVIN are stated as potential chairs, while local and regional municipalities, public transit agencies and other stakeholders are suggested to participate as committee members. The stated intention behind the Liaison Committee is to propel an integrated transition towards a transport system with CAVs in the region:

> *"Help prepare public sector agencies, in the GTHA and surrounding areas, to connect and collaborate in their efforts to implement CAV technology to achieve their regional transportation goals and objectives."* (Ontario, 2020a: 49)

Initially, a Liaison Committee would be tasked with increasing the reach of the Readiness Plan, providing support in the implementation of pilot projects, building up its assets and developing its operational components, e.g. its term length, form of coordination or public campaign strategy (Ontario, 2020a: 49). Additional activities listed in the policy framework refer to the phase after its establishment. These include updating the planning framework and identifying CAV Program needs, establishing an advisory group, communicating status updates on active projects to its members, establishing relations with relevant working groups and supporting the development of a *Regional Centre of Excellence* (Ontario, 2020a: 50). The latter represents another key feature of the proposed regional collaboration – a forum for stakeholder outreach. Firstly, through a digital platform that enables knowledge exchange between agencies and hosts a database for ongoing research and pilot projects. Comparable to a European example developed as part of the EU funded research project ARCADE and titled *Knowledge Base on Connected and Automated Driving* (https://www.connectedautomateddriving.eu). Secondly, through a public engagement stream informing on CAV-technology through various formats. The latter initiative was launched in 2020 as part of the *Ontario Smart Mobility Readiness Forum,* initiated by OVIN, MTO and Metrolinx.

Beyond the Liaison Committee, the Readiness Plan also introduces five program areas that provide an actionable framework to the guidelines. In total, these two components address roughly 80 % of the CAV Readiness Guidelines. To this end, each program's mission statement frames a number of concrete research and policy development tasks that are complemented with recommendations on priority, schedule, involved agencies and lead agencies as shown in Table 4.5. While the list of recommended guidelines and action items is remarkable, none of the identified projects have dedicated funding (I-15). Their implementation thus hinges on public sector leadership and coordination.

Table 4.5 CAV Readiness Programs

#	Program	Timing/Priority	Schedule	Involved Agencies
1	CAV Development Streams *Establishes a number of Task Forces to continue to identify impacts that CAVs will introduce to the transportation network and its users.*	Short-term (0-5 years)	Start March 2020	Provincial Government, All Regional Government, All public transit agencies, All municipalities, Others (AVIN, etc.)
2	Development of CAV Modelling Tools *Develops a System Dynamics Model and identifies necessary demand and simulation model updates to existing long-term transportation planning and operational analysis tools to address CAV in the transportation network.*	Short-term (0-5 years)	Start September 2020	Provincial Government, All Regional Government, All public transit agencies, All municipalities, Others (Academia)
3	Pilot Projects Program Management *Manages pilot projects that will gather data, assess and evaluate CAV and connected infrastructure, identify operational needs, test different designs and strategies, and identify needs for legislation, regulations and policies.*	Short-term (0-5 years)	Task 1 completed by 2021, Tasks 1-6 tbd	Provincial Government, All Regional Government, All public transit agencies, All municipalities, Others (Member of Data Needs and Management Plan Project Program, etc.)

4	Data Needs and Management Plan *Defines needs for data standards, data dictionary, message sets, repository, security/privacy needs and creates a Data Management Plan.*	Short-term (0-5 years)	January 2020 – December 2021	Provincial Government, All Regional Government, All public transit agencies, All municipalities, Others (Private sector agencies/companies, e.g. TNC)
5	Development of a Regional Mobility Platform Strategy *Develops a strategy that explores fare integration, trip planning applications, public and private mobility service provider partnerships, mobility platform development regulations and the need for a region-wide approach to offering shared mobility services.*	Short-term (0-5 years)	Tasks 1-7 completed by early 2021, Tasks 8-9 tbd.	Provincial Government, All Regional Government, All public transit agencies, All municipalities, Others

Source: table by the author, based on *CAV Readiness Plan*, by Government of Ontario, 2020a: 1-25, Appendix F.

4.3.4 2041 Regional Transportation Plan (2041 RTP)

At a regional scale, the long-range regional transportation plan, *The Big Move,* provides the strategic direction for planning and expanding an integrated transportation network in the Greater Toronto and Hamilton Area (GTHA). The document was first released in 2008, following the inauguration of Metrolinx as a regional transportation agency. As stipulated in the *Metrolinx Act* (2006), the plan has since undergone a ten-year review with the aim to measure its effectiveness and adapt its goals and strategies to regional shifts and macro trends (Metrolinx, 2013: 4).

> *"The future will be one of rapid and unpredictable change, filled with a range of challenges and opportunities. This plan acknowledges that there will be unpredictables that may either accelerate or stunt progress. The 2041 RTP must build in the ability to remain relevant, effective and efficient under a range of possible futures."*
> (Metrolinx, 2018: 32)

Format

As a long-range strategy document, *The Big Move (2008)* is developed for a 25-year time span. In this vein and to align it with the *Growth Plan (2019)*, the census year of 2041 is assumed as a new planning horizon in the revised document respectively titled "*2041 Regional Transportation Plan*" (henceforth "2041 RTP"). The purpose of the document is to revise the vision and goals set by Metrolinx, the Province, as well as the region's municipalities and transit agencies in order to achieve a more integrated transportation network. To this end, the document is structured in a reflexive manner. In "Chapter 2: Setting the Stage", the legacy of *The Big Move* is outlined, key influences and trends that affect transportation change are introduced, e.g. automated vehicles, and regionally specific challenges are specified. The document's core chapter, "Chapter 3: Vision, Goals, Strategies and Priority Actions", then presents the Vision, Goals and five Strategies, which were designed to address the key influences previously highlighted and were weighed in terms of their traffic implications based on a scenario study. The document closes with "Chapter 4: Next Steps – Making it Happen", in which required actions are briefly introduced. A more elaborate description of how to implement the strategies and actions was published in a separate report titled *Making it Happen* (Metrolinx, 2018).

The key influences introduced as macro trends most importantly concern population and employment growth patterns that correspond with forecasts and policies anchored in the *Growth Plan* and are expected to drive traffic and transit use in the region. For instance, travel patterns may significantly be altered, if office employment continues to grow in downtown Toronto or if it is concentrated in suburban employment centres instead (Metrolinx, 2018). Accompanying challenges may respectively vary, possibly ranging from a growing transit demand and capacity limits in Toronto's downtown, to a lack of suburban transit access due to an insufficient transport land use integration.

Other socio-demographic variables that are determined to be influential for future transportation include demographic and income (poverty) changes due to their impact on household sizes, car-ownership rates and transport needs (Metrolinx, 2018: 34). Furthermore, the GTHA's rising cost of housing, which may significantly affect the choice of where to live and how to travel and changing work patterns are addressed (Metrolinx, 2018: 37). In this sense, too, user-group and location-specific developments can lead to entirely different challenges. While a precarious job market can increase the car dependency of some residents (ibid.), the recent rise of remote and flexible working arrangements may reduce commuter patterns and drive-up recreational travel (de Abreu e Silva & Melo, 2018). Lastly, a potential rise of automated vehicles is discussed as an influential macro trend as part of changes within the transport sector itself, e.g. disruptive business models (demand-responsive and MaaS) and emerging transportation technologies. Acknowledging that its potential impact is largely ambivalent – ranging from societal advantages to substantial traffic risks (e.g. rising congestions and inequity) – stakeholders identified the need "for a coordinated, regional approach to prepare for the changes that new technologies and business models will bring" (Metrolinx, 2018: 28). Rounding off the list of macro trends, climate change is referred to as an increasing concern that may very well affect future transport systems.

Development and Authorship

In parallel to the development of Toronto's AV Tactical Plan and Official Plan review, the 2041 RTP was developed under the lead of Metrolinx and in collaboration with its governmental counterparts on provincial and municipal levels. Despite formal and informal communication between Metrolinx and the City of Toronto on the subject of AVs, the documents were developed independently, addressing different spatial scales and concerns (I-07). Most distinctly shaped by the fact that the 2041 RTP provides the overarching transportation strategy for the region, addressing AVs as one of the variables to be considered in future projects and actions.

Throughout the two-year revision and development process, public consultation and stakeholder feedback was scheduled at two specific moments. The first opportunity to comment on the revisions and process was in response to a *Discussion Paper for the Next Regional Transportation*, which was published by Metrolinx in August 2016. In addition to providing an analysis of *The Big Move's* progress, a review which started with a Baseline Monitoring Report in 2013, the discussion paper also proposed an updated vision and the consolidation of the original goals and objectives (Metrolinx, 2016: 21). A year later, a public review period was arranged upon releasing the *Draft 2041 RTP* in September 2017 (Metrolinx, 2018: 7). Consultations were held with the general public, stakeholders, municipal councils, municipal staff and provincial ministries.

Aside from integrating the Growth Plan's forecasts and policy directions, the document builds on a wide range of technical studies and academic background research addressing various transportation issues (e.g. active transportation, transportation demand management, mobility hubs, goods movement, etc.), as well as emerging mobility technologies such as AVs. With regard to automated vehicles, the *New Mobility Background Paper* stands out due to its undeterred language on the forthcoming introduction of AVs, stating amongst others that "automation is inescapable" (WSP, 2016: 11). At the same time, the document acknowledges that the timeline within which AVs are adopted, the deployment scale of specific use cases and their implications remain largely uncertain. Representing one of the first analyses on AVs developed on behalf of Metrolinx, the strategic directions identified in the background paper are formulated on a high level and towards a long-term planning horizon, pointing out means to prepare for a potential shift towards AVs (I-07).

Finally, three specific planning tools were applied in the process of developing the 2041 RTP (Metrolinx, 2018: 7). Firstly, a scenario planning process corresponding to background reports and academic studies that applied different versions of the tool and informed the 2041 RTP development process (e.g. WSP, 2016; Laidlaw et al., 2018). Its main purpose was to test the effectiveness of strategies and action items against varying degrees of population and employment growth as well as travel patterns. As AVs and other trends may differently affect the scenarios, strategies need to be flexible and adaptive to unforeseen change (Metrolinx, 2018: 141). Secondly, a Residents' Reference Panel was convened in order to "provide guidance during the development of the 2041 RTP" (Metrolinx, n.d.). The format, which Metrolinx used on several occasions in recent years, allows the agency to learn about the transport reality of a randomly selected volunteer group, while giving public participants the opportunity to gain an insight into current policy issues and inform respective policy development and revision processes. Thirdly, to reflect the adequacy of planning actions from a user perspective, Regional Traveller Profiles were developed that were based on surveys and focus groups with residents of the GTHA (Metrolinx, 2016). Aside from the reference panel, the application of tools strongly resonates with the later developed *CAV Readiness Plan*, which sheds light on similar actor constellations as well as the relevance of planning instruments suitable in the context of growing complexity and uncertainty.

Goals and objectives

Prior to the MTO's publication of the long-range transportation plan *Connecting the GGH* in early 2022, the 2041 RTP was the only regional planning document to which municipalities must adhere and which contained specific language on AVs. With a focus on transit provision, goods movement and integrated land use development, it provides policy goals to align potential mobility concepts and AV initiatives in these areas. Outlining a strategic direction for development, its revised vision emphasizes the pursuit of "a sustainable transportation system that is aligned with land use, and supports healthy and complete communities." (Metrolinx, 2018: 48). The described aim of implementing the 2041 RTP provides further guidance by stating:

> *"Full implementation of the 2041 RTP will lead to an integrated and seamless transportation system for the GTHA. It will improve the traveller experience and offer enhanced transportation choices. It will improve access to reliable and frequent rapid transit, and will make travel more affordable by reducing the need to own a car—benefits of particular importance for elderly and low-income residents. The 2041 RTP will help achieve the Province's objectives for land use intensification and the reduction of greenhouse gas (GHG) emissions. It will offer health benefits from a reduction in air pollution and an increase in active transportation, and will improve economic competitiveness and productivity in the GTHA."* (Metrolinx, 2018: 8)

The statement summarizes the key components upon which a future integrated transportation system for the GTHA should be built and prioritizes the desired impact of mobility initiatives. Unlike the CAV Readiness Plan, which emphasizes infrastructural development and the smooth integration of AVs into the transport system, the implementation of an integrated and seamless mobility network is specifically characterized by reducing car dependency and increasing mobility options. To pursue such a vision, three goals are specified in the strategy document: a.) strong connections; b.) complete travel experience; and c.) sustainable and healthy communities (Metrolinx, 2018: 48). With regard to AVs, the key question is, via which application and under what circumstances can the technology contribute to achieving these goals? Against the backdrop of possible negative consequences, identified in various technical studies and background research informing the 2041 RTP, the transportation plan devotes one high-level priority action specifically to AVs (priority action 5.2) and tentatively addresses their prospective introduction as part of two other priority actions (priority actions 3.8 and 4.8). Specific policy levers or means of harnessing the positive effects of AVs are left unanswered.

The following section focuses on two of the five strategic directions outlined in the 2041 RTP (Table 4.6). Firstly, "Strategy 5: Prepare for an uncertain future", in which planning for AVs is specifically addressed. Additionally, strategies 4 and 3 are briefly elaborated upon, since related priority actions refer to spatial development issues frequently addressed in relation to AVs, both in the scientific literature and as part of the conducted expert interviews.

Table 4.6 Strategies and associated Priority Actions

Strategy	Priority Actions
Strategy 1: Complete the delivery of current regional transit	
	1.1 Complete In Delivery projects by 2025 including the GO RER program; the Hurontario, Eglinton, Hamilton B-Line and Finch West LRT lines; and the Highway 7 and Yonge BRT lines.
	1.2 Advance the In Development transit projects through preliminary design, detailed design and construction.
	1.3 Strengthen the Union Stations's capacity as the centre of GO RER.
	1.4 Coordinate planning and implementation of In Delivery and In Development projects with the Province, the federal government and VIA Rail Canada.
Strategy 2: Connect more of the region with frequent rapid transit	
	2.1 Implement comprehensive and integrated Frequent Rapid Transit Network by 2041
	2.2 Strengthen and support the ability of local transit to provide reliable service in urban areas where demand for transit is high, and to connect to the Frequent Rapid Transit Network.
	2.3 Develop and implement a 24-hour transit network composed of strategic regional routes to address growing off-peak markets and destinations.
	2.4 Deliver a Regional Express Bus Network to serve long-distance transit markets not served by GO RER
	2.5 Improve access to airports, and prioritize transit use by airport passengers and workers.
	2.6 Strengthen connections between the GTHA and the Region of Waterloo, to support the economic prosperity of the GGH and the growth of one of North America's largest technology clusters.
Strategy 3: Optimize the transportation system	
	3.1 Advance the integration of transit services and fares.
	3.2 Expand first- and last-mile choices at all transit stations.
	3.3 Set consistent high-quality standards for the traveller experience.
	3.4 Develop and implement a mobility as a service strategy.
	3.5 Place universal access at the centre of all transportation planning and designing activities.
	3.6 Eliminate transportation fatalities and serious injuries as part of a regional Vision Zero program.

	3.7 Make TDM a priority.
	3.8 Expand the current HOV lane network.
	3.9 Further integrate road and transit planning operations.
	3.10 Define and support a regional goods movement system.
	3.11 Promote integrated planning for rail corridors.
Strategy 4: Integrate transportation and land use	
	4.1 Develop an approach and framework for Metrolinx to review and provide input to secondary plans, publicly funded development plans and large-scale planning applications (e.g. at GO stations) to advise on alignment with the 2041 RTP.
	4.2 Make investments in transit projects contingent on transit-supportive planning being in place.
	4.3 Focus development at Mobility Hubs and Major Transit Station Areas along Priority Transit Corridors identified in the Growth Plan.
	4.4 Evaluate financial and policy-based incentives and disincentives to support transit-oriented development. Work collaboratively to build on and develop regional and site-specific measures and tools to encourage development that supports growth management and transportation objectives.
	4.5 Plan and design communities, including development and redevelopment sites and public rights-of-way, to support and promote the greatest possible shift in travel behaviour, consistent with Ontario's passenger transportation hierarchy.
	4.6 Develop and implement a Regional Cycling Network, creating new on- and off-road facilities that connect areas with high cycling potential to rapid transit stations and Urban Growth Centres, helping commuter cyclists traverse boundaries and physical barriers.
	4.7 Embed TDM in land use planning and development.
	4.8 Rethink the future of parking.
Strategy 5: Prepare for an uncertain future	
	5.1 Develop a regional framework for on-demand and shared mobility.
	5.2 Develop a region-wide plan for autonomous mobility.
	5.3 Coordinate across the region to improve climate resiliency of the transportation system.
	5.4 Coordinate across the region to ensure the safety, security and emergency preparedness of the transportation system.
	5.5 Proactively prepare for a future with low-carbon mobility options.
	5.6 Develop a regional transportation big data strategy.
	5.7 Develop a strategy for innovation in mobility to.

Source: table by the author, based on *2041 Regional Transportation Plan,* by Metrolinx, 2018.

In addition to the RTP's general vision for an integrated transportation network, *Strategy 5 Prepare for an uncertain future* introduces the plan's attitude towards transportation innovations and emerging technologies. Based on the literature addressing the roles of government and policy, the role of the public sector may vary between providing public subsidy and encouraging adoption, regulating and constraining, and playing an active role by becoming a service provider through public-private partnerships (see for instance Laidlaw et al., 2018; van Wee et al., 2020). The RTP assumes a stance of enabling and proactively testing innovations in service provision, particularly in areas “where conventional transit and active transportation are not meeting demand” (Metrolinx, 2018: 107). Initial examples of implementing the related priority action include a six-month pilot initiative in 2019 in collaboration with the ride-hailing company Lyft, during which an on-demand and ride sharing system was tested as car-free access to regional GO Stations (Tutunzis, 2019).

Specifically addressing AVs, the RTP includes the priority action *Develop a region-wide plan for autonomous mobility*, which is to contain the necessary policy levers to meet its goals. A highlighted issue concerns the upgrade of very specific standards, namely, regarding parking and pick-up/drop-off areas, which may support a smooth introduction of AVs. It directly relates to strategy 4: Integrate transportation and land use, which offers more detail on infrastructural and spatial adaptions envisaged to support a more integrated future transportation network. With Metrolinx playing a pivotal role in ensuring that transit-oriented development goals of the regional Growth Plan are met, transit station areas receive particular attention (Metrolinx, 2018: 90). With regard to a potential uptake of AVs, the need to renew parking management strategies is emphasized in terms of integrating “loading areas where vehicles can pick up or drop off passengers” (Metrolinx, 2018: 95) – a policy approach equally emphasized in the CAV Readiness Plan – and in terms of coordinating off-street parking supply with transit expansion by adopting new standards in secondary plans and zoning bylaws.

Such infrastructural measures address a key challenge for the regional transit agency, whose parking lots at regional GO stations quickly fill up after the AM rush (I-09-B). *Strategy 3 Optimize the transportation system* addresses this issue by emphasizing the need to expand first- and last-mile choices at transit stations in order to “shift trips to modes that do not require parking, and to allow more people to access new train services” (Metrolinx, 2018: 86). An interviewee described this to be one of the two areas of focus for Metrolinx with regard to AVs (I-09-A). Meaning, exploring AVs’ potential when deployed as feeder shuttle that bundle trips from suburban residential areas to regional transit hubs (see Chapter 4.4.1). The other area of focus, which refers to “segregated transit ways” (I-09-A) that are managed by the transit agency, also addresses an RTP policy action. In the *Strategy 2 Connect more of the region with frequent rapid transit*, priority bus corridors are highlighted as a strategy to provide fast and frequent transit services in lower-density areas by restricting conventional traffic (e.g. HOV lanes) and applying transit priority measures (e.g. queue-jump lanes and signal priority) on designated lanes (Metrolinx, 2018: 62). HOV lanes, priority bus corridors or BRT corridors, are often considered suitable environments to test automated driving systems in buses.

Action items

The planning approaches and projects described in the RTP provide a guiding framework for many of the AV initiatives that have been piloted in collaboration with Metrolinx over the past several years (see Chapter 4.4). Missing in the RTP, however, are concrete approaches describing how to implement the various concepts, whether it be reconfigured parking at transit hubs or the coordinated roll out of priority bus corridors. Which stakeholders are responsible and required to collaborate? What are the sources of the financial investment required for infrastructure development as well as, on the institutional side, the corresponding planning and coordination services? Furthermore, the RTP lacks a serious consideration of concrete policy actions that need to complement infrastructural development in order to achieve an effective shift from private car use to alternative first- and last-mile options, such as shared AV shuttles, or rapid bus lanes. Literature on AV policy and regulatory action mentions, i.a. the integration of CAVs with public transport, the incentivizing of ride-sharing and the implementation of congestion pricing schemes as possible measures "to curb development of additional traffic" (Narayanan et al., 2020: 44). While the latter two issues are addressed as part of transport management strategies and HOV lanes, the issue of proactively curbing excess traffic is not seriously mentioned with regard to automated vehicles.

4.4. Piloting initiatives

In issuing the *Ontario Regulation 306/15: Pilot Project – Automated Vehicles* in January 2016, Ontario became the first Canadian jurisdiction to regulate the testing of AVs on public roads. The ten-year pilot program provides the regulatory framework for private and public entities that apply for testing authorization. According to an interviewed expert, the underlying testing regime is geared towards striking a balance between ensuring safety and staying out of the way of technological development (I-14). In other words, towards promoting associated economic development. In the end, Ontario's testing regime aims to attract the same players as other jurisdictions, e.g. Arizona or California, albeit with a different regulatory environment and climatic conditions. Since automated driving technology continues to dynamically evolve, the regulation is subject to revisions and supplements. Its most recent iteration, amended in 2019, now permits driverless on-road AV testing, that is, without human oversight within the vehicle, the testing of cooperative truck platooning, and the commercial sale of SAE Level 3 vehicles (Ontario, 2020a: 2, Appendix A).

With respective legislation in place, a growing number of urban and rural municipalities on both sides of the Atlantic host piloting initiatives with AVs that range from private sector programs to city-led initiatives (Perkins et al., 2018). Municipal involvement therein varies between acting as (co-)funding partner, (co-)proponent, host, or external stakeholder administering registration or consulting on issues such as adequate test locations (CAVCOE, 2019: 6). In 2019, the City of Toronto commissioned a best practice study on AV pilot initiatives in North American municipalities, according to which at least 9 Canadian and 31 U.S. municipalities had participated in one or more initiatives since 2016 (CAVCOE, 2019: 11). Aside from a few exceptions that involved cars, all of the conducted and planned AV pilots concerned automated shuttle projects. All across North America, 53 such pilot projects could be identified as of 2019 (for extensive pilot inventories see Kaplowitz et al., 2021 and CAVCOE, 2019), not including the AV shuttle trials that have since been launched in Toronto and Whitby, Ontario, Canada.

Testing environments for AVs are frequently viewed as an early opportunity to test and learn about the technology in real-world settings and to familiarize the public with technological advances (I-12). By implementing trials on a small scale and for a limited duration, research entities commonly explore new services or entirely new vehicle concepts (Barillère-Scholz et al., 2020). For public agencies and municipalities, pilot initiatives provide an opportunity to study the environmental effects of technological innovations and generate insights on beneficial applications. Participating in AV trials may thus allow an evaluation of their impact on transit systems, as well as on equity, health and safety, the environment, and the economy (Steckler et al., 2020). As cities across North America host a variety of transportation pilots – from micromobility to partnerships with ride-hailing companies and from microtransit applications to AVs – Steckler et al. (2020) argue for a more deliberate assessment of pilot projects' implications on a local community.

The following section examines the *West Rouge Automated Shuttle Pilot* and the *Transportation Innovation Zones* as two piloting initiatives launched by the City of Toronto since issuing the *AV Tactical Plan* in 2019. Particular attention is given to the local contextualization of AV pilot projects. This concerns the role of public agencies, the participation and user involvement, the alignment with local challenges, the geographic embeddedness, and the nature of data requirements, which determine to what extent information on pilots' impacts and outcomes may be collected or even made public.

4.4.1 West Rouge Automated Shuttle Trial

In 2017, the City of Toronto's Transportation Services partnered with the Toronto Transit Commission (TTC) and Metrolinx to apply for joined research funding through Transport Canada's ACATS program. In line with its early objective to "Establish the City of Toronto as an international leader in municipal/local government AV preparedness." (Toronto, 2016a: 3) and the City Council's request to "explore opportunities to enhance partnerships […] to share strategies and develop best practices." (Toronto, 2018a: 3), City's transportation division led a consortium, which was subsequently selected to receive funding for one of Ontario's first automated shuttle trials.

At the time of conceptualizing the pilot project, the Draft Automated Vehicle Tactical Plan 2019-2021 had been published, which put forward that the City take a transit-centric approach to automation. The stance confirms what Heinrichs et al. (2019: 248) describe as a growing awareness amongst public agencies and transit providers that automation bears the risk of increasing VMT and competing with traditional transit services. In response, municipalities adopt strategies that prioritize the shared use of AVs and transit (I-01; I-04). In this context, electric low-passenger-capacity shuttle buses have come to represent the favoured use case of transit agencies and municipalities involved in North American or European pilot initiatives.

Initially titled *Minding the Gap*, the core intention underlying Toronto's pilot project was defined as testing "the technology's ability to meet an existing unmet need in public transit, such as filling the lower-demand 'last mile' gap" (Toronto, 2018a: 1). Consistent with previously conducted automated shuttle trials, AV shuttle operation was planned to be temporary and take place in a confined geographic area within Toronto's city limits. Its implementation was set to take place between 2018 and 2022, but was significantly delayed due to the volatile public health condition caused by the Covid-19 pandemic and, later, due to continued evaluations of the shuttle's performance. Following a two-month-long testing phase in mixed traffic along local and arterial roads, the project partners ultimately suspended the trial in early 2022 before launching public ridership (Toronto, n.d.).

Influencing factors were the withdrawal of the contracted shuttle vendor, Local Motors, as financial constrains led the company to cease its operations. In addition, Ontario's Ministry of Transportation suspended its approval for the West Rouge trial, following an accident that occurred with the same vehicle type, an Olli 2.0, during the Whitby Autonomous Vehicle Electric (WAVE) shuttle pilot in December 2021. Although the pilot projects were formally unrelated, the regional transit agency Metrolinx was a project partner for both trials. Moreover, the WAVE project, conducted in the town of Whitby 20 km East of West Rouge Hill, was financially supported through AVIN and led by the Ontario Centre of Innovation (Whitby, 2022). Given the Province's interest in promoting innovation and the city's interest in gaining public support for the use of innovation in the public transit system (Toronto, 2018a: 8), it is reasonable to assume that both trials were suspended to avoid further safety risks as well as negative implications on public innovation programs.

Project goals and alignment with local planning framework

As part of the implementation strategy of the *AV Tactical Plan and Readiness 2022,* conducting an *Automated Shuttle Pilot* was defined as one of five projects on which the City of Toronto will focus its preparatory efforts. By exploring the potential of automation in transit, the pilot initiative is seen as a contribution to the Tactical Plan's goals (Toronto, 2019a: 123). Namely, a.) ensuring a more space-efficient mode of travel; b.) a more seamless system for the user; c.) less acute demand across the transportation system; and d.) improved safety. With the renamed *West Rouge Automated Shuttle Trial,* the partnering municipal division and transit agencies set the intent to gain first-hand knowledge and experience of the technology. Table 4.7 summarizes the pilot project's testing framework.

Table 4.7 Testing framework of shuttle trial

West Rouge Automated Shuttle Trial	
Project Title	West Rouge Automated Shuttle Trial
Policy Framework	AV Tactical Plan and Readiness 2022
Themes	• Technical performance • Ability to address the "last mile" gap • User and community acceptance • Future planning and policy requirements
Project goals and objectives	Increase understanding and knowledge of • technical and administrative requirements to operate an automated shuttle; • interaction of an automated shuttle in the transit and transportation system; • human response to an automated shuttle; • value of an automated shuttle service in the transit and transportation system; • Increase public support for the use of innovation in the public transit system; • Develop a plan to increase the attractiveness of Toronto for investment in the development and export of automated transit vehicle technology; • Provide leadership in automated vehicle preparedness at the municipal level through knowledge transfer and exchange.
Municipal role	• Transportation Services Division, City of Toronto – Host, co-funder, and project lead
Stakeholder involvement	• Launched in partnership between the City of Toronto, Toronto Transit Commission (TTC), and Metrolinx; • University of Toronto and Ryerson University – Evaluating partners; • co-funded by the Canadian Minister of Transport through the Program to *Advance Connectivity and Automation in the Transportation System* (ACATS); • Local Motors – Shuttle vendor; • AutoGuardian by SmartCone – Shuttle operator; • Ontario Ministry of Transportation – Authorizing agency through *O. Reg. 306/15: Pilot Project – Automated Vehicles;* • Residents, users and general public – Input through surveys and public events.

Source: table by the author, based on *Minding the Gap – Request for Authority to Receive Federal Funding for an Automated Shuttle Pilot Project* by Toronto, 2018c; and *Automated Vehicles Tactical Plan,* by City of Toronto, 2019a.

The key learning objectives defined as part of the trial are consistent with common research themes identified for European pilot projects[9]. In West Rouge, they concern the technical requirements for operation, the administrative demands for service delivery, the potential contribution of automated shuttles to the existing transit network and transportation system at large and the response of users and affected groups with regard to novel transit services (I-01; Toronto, 2019a). Regarding the latter, an interviewed expert mentioned the particular interest in mixed traffic interactions with conventional vehicles and pedestrians, which has posed a challenge to previous pilot projects conducted in North America and Europe (I-09-A). Beyond that, further objectives concern learning from the technology's public exposure, being able to promote the novelty and showcasing Toronto as an innovation-friendly environment (I-01). The goal "to increase the attractiveness of Toronto for investment in the development and export of automated transit vehicle technology" (Toronto, 2019a: 123) is shared with many pilot initiatives, particularly in the United States (Steckler et al., 2020: 97).

An objective that stands out as specific to the initiative is the City of Toronto's intention to expand its municipal leadership in AV preparation by conducting the pilot project, be it through successive knowledge transfer and communication within municipal divisions, as recommended in the research report *Best Practices for Automated Shuttle Trials in North American Municipalities* (CAVCOE, 2019), or through cross-municipal exchange and collaboration (I-01). The latter aspect is stressed in the *CAV Readiness Plan* (Ontario, 2020a) with regard to the untapped opportunity to share lessons learned and testing results in order to avoid duplication of initiatives and built on existing knowledge (I-15). An effort that a potential "pilot project registry" (Ontario, 2020a: 45) could support in the future and would equally benefit initiatives across the border.

Service type and urban-transit integration

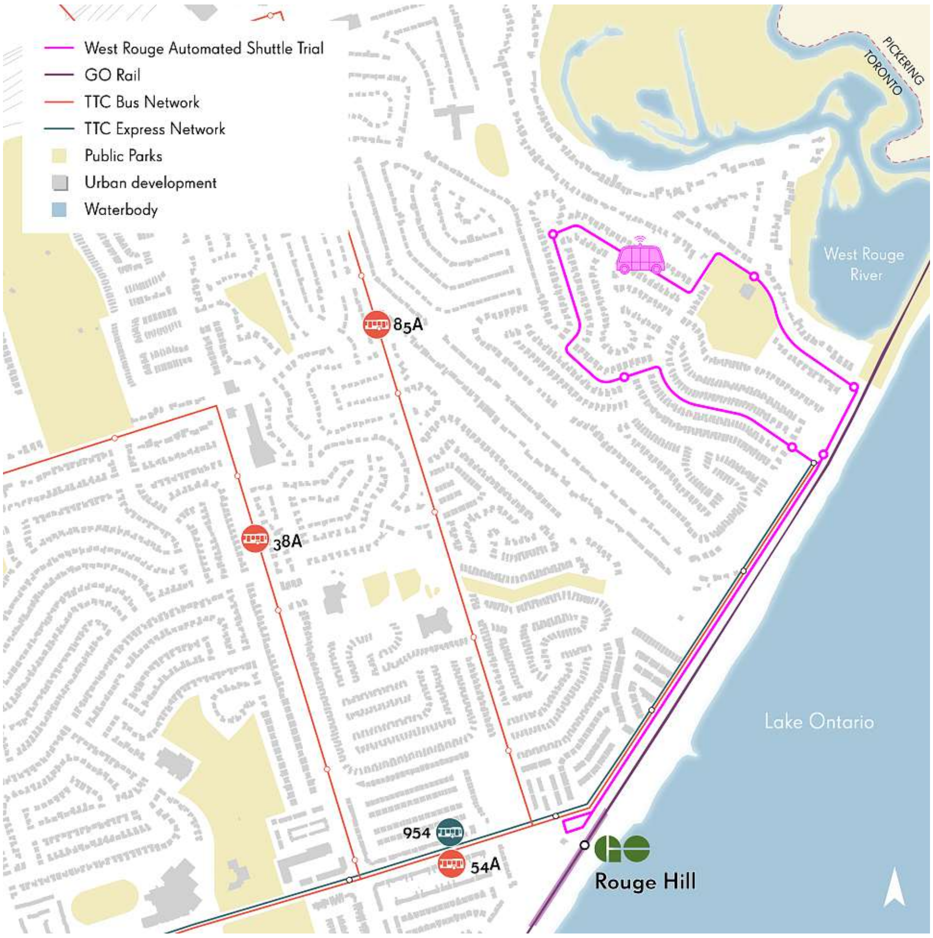
Planned to operate for a limited duration, yet filling a gap in the transit system, the *West Rouge Automated Shuttle Trial* resembles earlier pilot projects conducted in European cities (Soteropoulos et al., 2021). Unlike piloting initiatives with passenger AVs conducted in cities in the United States and analysed by Steckler et al. (2020), the West Rouge trial centres on testing the feasibility of AV shuttles as a first-/last-mile service (I-01). Functioning as a suburban feeder that connects a residential neighbourhood to the nearest rapid transit station (Fig. 4.7), the trial represents a much-debated use case for automated shuttles in transit (Nesheli et al., 2021). To test the potential for this kind of transit integration, the two main selection criteria for the location in Toronto were a.) a

[9] Topics identified as typical research themes amongst automated shuttle pilots in Europe include: a.) technological feasibility; b.) organizational and operational feasibility; c.) economic feasibility (including user acceptance); and d.) social inclusion and equity (Soteropoulos et al., 2021).

location outside the existing TTC 400-metre service areas and b.) close proximity to a major transit hub (I-01; Toronto, n.d.). The partnering agencies successfully crafted a localized approach to piloting AV shuttles by not only addressing a gap in the existing transit network, but also by testing a service model equally relevant to neighbouring municipalities in the region, which lack sufficient connections to rapid transit stations (GO Train). An interviewed expert raised the corresponding research question:

> *"What types of service can you provide that would be attractive for the customer and affordable for the transit agency so that people aren't driving as much?"* (I-09-A)

Figure 4.7 Urban-transit integration of the West Rouge Automated Shuttle Trial



Source: map by the author, based on *Automated Shuttle Trial Public Consultation Report. Phase 1: September 9 to October 31, 2019,* by J. Diceman, 2020.

The suburban neighbourhood of *West Rouge*, situated at the South-Eastern fringe of Toronto (Table 4.8) was ultimately chosen as the location of the trial. To the north, the neighbourhood is bound by the provincial Highway 401. The Rouge River Valley and National Park lie to its east, while the Port Union Road forms its Western boundary. Its urban form is characterized by low density but continuous urban development, typical for suburban residential areas built between the 1960s and early 2000s in the Toronto region (Hess & Sorensen, 2015). Despite being a predominantly residential neighbourhood, public infrastructures such as schools, parks and a community centre are provided. Commercial functions are located along main roads at the neighbourhood's edge, where several public transit routes run. With regard to its mobility condition, however, the neighbourhood includes only a few highly connected streets, impeding pedestrian connectivity and contributing to a relatively high car-dependency. Lacking an interior transit service, the majority of commuters that use the regional train service drive to the station, even for distances of less than 5 km. As a result, parking facilities are quickly filled and service expansions are hampered (I-09-A). The AV shuttle was intended to service a catchment area of roughly 500 to 550 buildings with a neighbourhood-based microtransit system (I-09-B). By providing residents and transit riders an alternative to accessing the train station by car, it reflects the regional transit agency's general intent to shift GO Transit passengers away from private vehicles and to incentivize intermodal trips (I-01; I-09-A).

Table 4.8 Urban characteristics of AV Shuttle Pilot

	West Rouge Automated Shuttle Trial
Service Duration	• 10/2021 – 02/2022 (planned)
Regional context	• Suburban neighbourhood in the South-eastern outskirts of Toronto; • Bordering provincial highway (North), the Rouge River Valley (East) and Lake Ontario (South).
Urban form	• Low density, but contiguous urban form; • Mix of single-detached houses, semi-detached houses, row houses, and apartment buildings; • Residential neighbourhood with interior parks, community centre and school sites, and commercial functions at the neighbourhood's edge; • Relatively well-connected street system, but fairly low level of pedestrian connectivity; • Above average number of residents commuting >1 hour to work; • Below average number of residents use transit to work.
Testing environment and route length	• Mixed-traffic environment on urban public roads with low traffic volume; • 3.5 km, 7 stops (weekdays); 1.5 km, 5 stops (weekends)
Traveling speed	• 20 km/h in automated mode; • 40 km/h in manual mode.
Urban and traffic integration of route	• Connects the GO Station "Rouge Hill", the West Rouge Community Centre, and the beach entrance of Rouge National Urban Park; • Route lies outside the TTC 400-metre service area and fills an existing gap in the transit network

Source: table by the author, based on *About the Trial,* by City of Toronto, n.d.; and *Compact, concurrent, and contiguous: smart growth and 50 years of residential planning in the Toronto region*, by P. Hess, and A. Sorensen, 2015.

Beyond its urban transit integration, the goal of showcasing Toronto as an innovation-friendly environment also influenced the selection of the testing environment. The ambition was formulated early on, so as to "Increase public support for the use of innovation in the public transit system"

(Toronto, 2018c: 8). Unlike pilot initiatives that centre on advancing the technological capabilities of AVs and therefore take place in environmentally challenging conditions, such as on sloping streets, in pedestrian zones or on gravel roads, the Toronto trial was located away from risk-prone school zones or road construction areas. To that effect, reducing the environmental complexity of a shuttle trial may increase the chance of users having a positive experience when driving in an automated shuttle (Edelmann et al., 2021), as the technology's acceptance is likely to be influenced by the manner in which AVs interact with other traffic participants, be it pedestrians or other drivers that must reduce their speed. Such aspects are particularly critical, as the current state of highly automated shuttles continues to show significant technological limitations. To this end, the final selection criteria required that the route not cross rails, include designated pick-up and drop-off areas and be limited to a mixed-traffic environment with low traffic volume (Toronto, n.d.).

The Toronto trial employed an Olli 2.0 produced by Local Motors, a shuttle vehicle especially present in North American cities, whereas the European market is dominated by EasyMile (EasyMile EZ10) and Navya (Navya Arma) vehicles. In terms of deployment, all of these shuttles cater to what Beiker (2016: 199) describes as a transformative mobility scenario with AVs, in which the advantages of a flexible and independent personal mobility option are combined with the space-efficiency of transit services. To date, many of the tested AV shuttles that aim for higher-order automation, in fact perform at SAE Levels 2 or 3. Which means that they are not only limited to a geographical range, but run along predetermined and digitally captured routes comparable to virtual rails. Once they leave the fixed pathway or an emergency occurs, navigation is handled by an on-board steward or, as is the case with more recent trials, by an operator who can remotely intervene from a control centre (Hagenzieker et al., 2021; Zankl & Rehrl, 2018). The case study report on the West Rouge Automated Shuttle Trial correspondingly states that "Automated shuttle technology needs further development to become a feasible alternative for long-term service in truly mixed traffic environments" (Toronto, 2022b: 3).

Interviewed experts voiced their scepticism in that regard. One (I-09-A) finds the imbalance between AV developments in the private sector and developments intended for transit use disappointing, while another suggests that at the current level of operation and speed, AV shuttles are more likely to compete with walking and cycling than provide a transit solution (I-07). Evaluations of trials conducted in Europe confirm the general sentiment that the "technology is in its infancy" (I-09-A). Automated shuttle buses, as currently trialled in urban and rural settings, follow an incremental development path, rather than entering the market disruptively (Derer & Geis, 2020: 8). As AV technology is being tested within individually adjusted system boundaries, taking into account the vehicle's level of automation and environmental complexity, it matures successively (ibid.).

Participation and user involvement

Survey results by neighbourhood residents confirm that the pilot initiative in West Rouge addresses an existing transit need. According to the project's first *Public Consultation Report* (Diceman, 2020), its communication and engagement strategy builds on the intention to gather the community's input early on. In an online survey conducted in 2019, West Rouge residents most commonly stated the potential to provide "a convenient option to avoid driving, and not have to compete for parking at the GO station parking lot" (Diceman, 2020: 3) as a reason for supporting the trial. Other reasons given by both the general public and residents comprised the interest in a technological novelty and the support for an electric-powered vehicle, as well as the extension of transit. On the other hand, concerns were expressed with regard to the safety of the vehicle when interacting with pedestrians, particularly children, and the project's success. Aside from the survey, the public could raise questions and provide feedback at a public drop-in event in the fall of 2019. Particular emphasis was also placed on consulting Metrolinx's Accessibility Advisory Committee (AAC) and TTC's *Advisory Committee on Accessible Transit* (*ACAT*). The voluntary committee provides advice on measures to accommodate the needs of passengers with disabilities, e.g. being equipped with a ramp, having an onboard safety attendant, or visual and audible stop announcements (TTC, 2021).

Some of the elements comprising the engagement strategy, such as informing and educating the public on the pilot, managing concerns, and promoting the service to encourage ridership (Diceman, 2020), resemble earlier projects conducted in European municipalities. A study on changing mobility awareness during a comparable AV shuttle pilot was able to demonstrate an increase in residents' level of awareness of and interest in mobility and transit issues (Baniewicz & Neff, 2020: 36). Continuous communication and promotion of the service therefore constituted a strongly influential factor. While mobility awareness is a multicausal phenomenon, it is also a critical precondition for a potential change in mobility habits, including a shift from individual car use to transit.

An objective of the West Rouge engagement strategy that stands out in comparison to other projects is to have the community's response and input inform the project plan. An interviewed expert correspondingly shared the view that involving the community as early as possible had the benefit of getting various user groups involved in the development of the project (I-02). The main opportunity to inform the shuttle's operation concerned its route options in the neighbourhood, which none of the prior pilots conducted across Canada had previously done (CAVCOE, 2019). Several of the residents' suggestions, which are documented in the *Public Consultation Report* (Diceman, 2020), were taken into consideration for the final route plan. These include passing the West Rouge Community Centre, covering a relatively large service area with a one-way loop, and prioritizing rider density. Beyond that, two community members' suggestions stand out with regard to improving local transit service. Firstly, the preference to use the shuttle service outside of commuter rush hour indicates a demand for mobility options by the older or younger population. And secondly, commuter need for smooth connections and reduced waiting times is indicated by the suggestion to coordinate timetables with the GO Train schedule. An issue the regional transit agency has been conscious of and trialling together with local transit partners, as it represents a potential point of friction, keeping residents from using transit (I-09-A).

Following the early engagement, further actions took place closer to the pilots' launch in the fall of 2021. These comprise an online public information session, an on-site shuttle demonstration and project information, and a pre-project survey. The latter represents the first of a series of surveys aimed to assess how residents' and users' attitudes towards automated shuttles change throughout the project timeline. Together with the shuttle operation itself, the events serve two final objectives of the communication and engagement strategy, which is to increase the public's familiarity with and therefore support for AVs (I-01) and "show how the partner agencies [TTC and Metrolinx] are collaborating to solve problems, making commutes easier and innovating" (Diceman, 2020: 5).

Project learnings and future applications

Although some interviewees voiced a concern that the pilot would merely serve promotional purposes or be of symbolic nature (I-07; 1-10), the City of Toronto argues that conducting the trial may lead to more encompassing learning that can inform future planning considerations. First and foremost, regarding the process of designing and procuring partially or fully automated vehicles. Secondly, by addressing questions to ensure a safe integration of AVs through the design of "neighbourhood-based transit services" and thirdly, with regard to "road design, maintenance, signage and transportation policy", (Toronto, n.d.). In addition to the published case study report on the West Rouge pilot, the review of policy documents and communication published over the past years makes it possible to deduce various benefits the pilot initiative could provide to the partnering agencies in light of future applications.

Above all, the City of Toronto and its project partners gained knowledge and understanding on the technological maturity and scenario competence of automated passenger shuttles. Relatedly, the published *Lessons Learned* largely address technical aspects that need to be considered when planning trial projects with AVs (Toronto, 2022b). For instance, that routes need to be planned in accordance with the specific vehicle's operational feasibility in order to successfully test all of its technological features, and that procuring multiple vehicles from a single vendor may reduce the risk of encountering manufacturing deficiencies (ibid.). In line with Stayton & Stilgoe's (2020) argument that greater emphasis needs to be put on the limitations of AV operational design domains and the likelihood of human-machine interaction, one of Toronto's learnings emphasizes that "Deliberate mixed use of manual and automated modes of driving may be appropriate if the vehicle cannot accommodate all design domains" (Toronto, 2022b: 3). Overall, the learnings resonate with the results of earlier demonstration projects conducted in Europe (see Chapter 2.2), AV shuttles require further development and testing before posing a viable alternative for transit operation in mixed traffic environments. Importantly, international safety and operational standards are still missing for automated shuttle vehicles, nor do AV shuttles conform to existing automotive industrial sector standards of transit buses (Anund et al., 2022: 11).

Concerning the location at hand, the pilot project fell short of testing "what the [potential] ridership actually is in outer Scarborough" (I-09-B) and gathering substantive ridership data. Relevant information would have concerned the circumstances under which residents or guests are willing to use a shared AV shuttle, the degree to which the selected route design could utilize ridership capacity as well as its impact on accessibility levels in suburban neighbourhoods (I-12). Gaining such insights into user motivation and perceived barriers could then inform future service characteristics, e.g. fixed or flexible routing, fare integration, and coordinated timetables with traditional transit. But to date, detailed service designs as well as accompanying policy incentives for AVs, e.g. convenient designs of pick-up and drop-off areas, or peak-hour fees for single occupancy vehicles to incentivize trip sharing and discourage vehicle traffic growth, remain a long way off.

At the current level of technological development, however, the experience of offering a service to the public would unlikely have led to an entirely different assessment of the technology's capabilities and thus its potential for service integration. Previous studies showed that thus far, the experience of using an automated mobility on-demand service either does not match the generally positive expectation that users have towards AVs (Nordhoff et al., 2019) or it positively affects trust in the technology, but does not yet increase interest in its future use (Wintersberger et al., 2020). However, effects in user acceptance and perception vary between user groups, in particular between seniors and youth. Conducting a pilot project and engaging different user groups can thus identify various needs and concerns that mobility providers, planners and policymakers need to consider when making infrastructure or policy decisions. Studies have also shown that active engagement and communication processes may positively affect user and resident awareness of alternative transport modes and the efforts municipal actors are making to improve sustainable mobility options (Baniewicz & Neff, 2020). This effect is not insignificant, as increasing awareness poses a critical precondition for any potential shift in mobility habits.

In sum, Toronto's pilot initiative undoubtedly enhanced the partnering agency's level of knowledge and expertise on automated mobility and added to the public's familiarity with mobility innovations, despite its early suspension. Although the pilot was not designed to affect the urban form of its location (I-10), it did highlight the need to reimagine the mobility system that supports suburban development patterns. In this sense, Toronto was certainly able to promote its leadership position in the testing of and planning for AVs in the region. Having substantiated its knowledge on the technology's capabilities and limitations, available vendors and necessary C-ITS infrastructure, the insights gained will support future decision-making and planning initiatives for AVs, be it as part of the transit network or the overall transportation system. Potential future applications may include the testing of automated vehicles along highways (I-01) or public service delivery vehicles, a use case highlighted in the city's Tactical Plan (Toronto, 2019a) and recently approved for testing through the provincial government's amendment of its Pilot Program. In the case of the two transit agencies, TTC and Metrolinx, future trials of first-/last-mile feeder systems, emphasized in the most recent long-range transportation plan for the GGH (Ontario, 2022), and the testing of automated bus platoons along segregated transit ways (I-09-A; I-15). Moreover, the learnings equally benefit future pilots with connected infrastructure that is relevant both at the municipal level as well as for the regional highway network (I-15).

4.4.2 Transportation Innovation Zones

One of the tactics listed in the City of Toronto's Tactical Plan refers to the development of "an innovation corridor and innovation zones to accelerate proof of concept pilots." (Toronto, 2019a: 60). The action titled *Testing Sandbox* is meant to provide an isolated environment in which industry actors can "play, cluster, and innovate quickly" (ibid.). It is inspired by universities across North America that have previously set up dedicated test environments in which AVs can be tested, while also reflecting the economic development efforts of the province's *Autonomous Vehicle Innovation Network* (AVIN) and its *Regional Technology Development Sites* (RTDS). For the City of Toronto, the advantage of installing an innovation zone is argued to be threefold. Firstly, it provides an environment in which AV technologies can be adapted to local needs – socially preferred directions of technological development. Secondly, as catalysts for cross-sector collaboration, they enable public sector learning and capacity building in relation to emerging technologies and their potential urban application (Toronto, 2021a). Thirdly, innovation zones contribute to the economic development of the city. In this sense, the tactic not only supports the overarching 2050 goal to *Expand Sectors* in Toronto that are related to the automated vehicle market (Toronto, 2019a: 59), but also constitutes a potentially valuable opportunity to align public and private sector interests at a time when commercial actors increasingly determine infrastructure and service provision (Docherty et al., 2022).

Conceptual Background

The purpose of installing *Transportation Innovation Zones* is elaborated in the chapter *AV Readiness 2022* of the Tactical Plan, where they are introduced as one of five projects to be realized by 2022. For the City of Toronto, defining a geographic area within the municipality in which new mobility technologies may be tested, roots in the idea of developing a streamlined framework to assess and approve pilot initiatives taking place in the public realm (Toronto, 2019a: 124). In that sense, it is a municipal response to the need of administering pilot initiatives and the growing interest to test new mobility technologies by private entities. In Canada, testing permits are provincially issued, but Ontario law merely requires applicants to inform the affected city of their trials, instead of also requiring its approval or support. In addition, the provincial pilot program does not specify in what areas public or private initiatives can or should conduct AV trials (I-04).

The National League of Cities (NLC) describes a comparable situation occurring in the United States. Numerous private companies invest substantial amounts of capital into developing and testing AV technology, encouraged by federal and state governments that issue legislative amendments (Perkins et al., 2018). A related concern is that private companies may push higher levels of government to pre-empt municipal authority for managing the introduction of AVs (I-16). The short-term impact is that cities face the roll-out of AVs regardless of their interests or needs (Perkins et al., 2018). In the long run, pre-emption laws could curtail the ability of cities to regulate services and ensure effective system performance (Siegel, 2017). The NLC asserts that "city leaders have the opportunity to play a more informed, active role in shaping" (Perkins et al., 2018: 2) how the autonomous future unfolds by working together with the private sector. To this end, managing piloting initiatives can provide an opportunity to "craft a localized approach to AV piloting that addresses specific municipal goals." (Perkins et al., 2018: 12).

In this vein, Toronto set itself the goal to develop a framework that facilitates private-sector trials, but also ensures that they are supported by the public and contribute to achieving the City's existing goals (Toronto, 2019a: 124). Who exactly will benefit from the technological experiments by being involved, the manner in and criteria with which participants will be evaluated or monitored and whether results will be made publicly available was not determined in the *AV Readiness 2022* (Toronto, 2019a).

Concept Revision

In 2020, Toronto's City Council and the Exhibition Place Board of Governors, a city-owned agency, established Toronto's first real-world *Transportation Innovation Zone* (TIZ) on the grounds of Exhibition Place along Lake Ontario (Fig. 4.8). The test bed is set to run for five years, until 2025, and represents the initial phase of the Transport Innovation Program, developed by Toronto's Transportation Services in collaboration with a variety of municipal divisions and agencies, by incorporating recommendations collected during a stakeholder engagement and review process (Toronto, 2021a).

Figure 4.8 Grounds of Exhibition Place set on the shore of Lake Ontario

Source: map by the author, based on *NEXT PLACE PLAN. Phase 1 Proposals Report for Exhibition Place*, by City of Toronto, 2020c.

In the newly conceived program, the notion of innovation extends beyond AVs or technology *per se* and defines transportation innovation in a more nuanced manner:

> *"… it involves products, services, and/or processes; it uses research, ideas, and knowledge in an applied way; it creates something new or applies knowledge in a new manner; it involves serving the public interest and generating net social and environmental benefits; and it can be done by any actor (communities, academia, governments, not for profit organizations, or private sector)."* (Toronto, 2021a: 8)

The core objectives of the program – namely, to learn about emerging transport innovations and support the local economy – remain unchanged, but the scope of applications considered relevant to the strategy was adjusted. Exemplary innovations that could be tested are specified as "devices that move on sidewalks or highways, sensors and monitoring devices, connectivity devices, smart lights and signals, signage, electric vehicle chargers, pavement materials, and paints." (Toronto, 2021a: 8). In addition to building on the principles of the 2019 *AV Tactical Plan*, the program is also based on Toronto's *Digital Infrastructure Plan Working Principles*, recognizing the growing significance of digital infrastructure, data management and standards as well as evidence-based decision-making. Together, these documents provide the core principles on which the program's governance structure and components are founded (Table 4.9).

Table 4.9 Core principles from council-approved strategies shaping the TIZ program

AV Tactical Plan	**Digital Infrastructure Plan Working Principles**
• Improve social equity, health and environmental sustainability; • Support economic sectors; • Enhance data privacy; • Improve road safety; • Integrate space-efficient and active travel modes; • Enhance the City's traffic management	• Create and sustain equity, inclusion, accessibility, and human rights; • Enable a well-run City; • Contribute to positive social, economic, and environmental benefits; • Operate in a way that protects the privacy of individuals and be safe from misuse, hacks, theft or breaches; • Be developed in a way that is democratic and transparent

Source: table by the author, based on *Transportation Innovation Challenges: Fostering Local, Outcomes-Oriented Transformation*, by City of Toronto, 2021a.

As part of the program's strategic alignment, the methodological reference was changed from the original concept. Rather than emphasizing accelerated technological trials conducted in "sandboxes", the City now refers to the concept of *Living Labs*, an institutional framework that provides boundary conditions for interdisciplinary research endeavours (Beecroft et al., 2018). The boundary conditions set by the City of Toronto not only comprise the transparent review of applicants, but include the provision of a target horizon, definition of minimum requirements, facilitation of assistance, and conducting the monitoring, data collection and evaluation (Toronto, 2021a: 8).

Taking inspiration from innovation programs by municipalities in North America and Europe, real-world test beds are regarded as a means to "learn about emerging technologies ahead of regulation, provide guard rails for implementation, and influence the nature of technology development" (Toronto, 2021a: 4). While interviewed experts questioned the ability of municipal actors to influence technological development (I-09-A), the program leadership argues that test beds not only allow municipal staff to learn about the impact of emerging mobility technologies, but may also inform how to strategically regulate or incentivize their application in order to harness potential risks and leverage their benefits (Toronto, 2021a). As policy advisors have previously argued, small-scale pilot initiatives can help reduce risks and enable cities to evaluate initial outcomes as they work to identify the most adequate policies (Urbanism Next, 2019). But the ambition behind Toronto's innovation program appears to go further, adjusting the instrument so that it steers transport innovation development towards societal values.

Implementation

Assuming an iterative approach for implementing the Transportation Innovation Program, its initial phase not only involves establishing a first testing ground at Exhibition Place, but also launching a challenge-based program. Through so-called *Transportation Innovation Challenges* (TICs), the City issues and administers calls for thematically specific and outcome-oriented trials. Issued calls are open to industry and academic actors interested in piloting mobility technologies and novel applications in the public realm (Toronto, 2021a). Potential trials are to advance the city's mobility goals related to safety enhancements for vulnerable traffic participants (Vision Zero Road Safety Plan), accessibility issues and the reduction of greenhouse gas emissions (Transform TO Net Zero Strategy). Participants are selected based on the criteria that they: a.) solve real problems; b.) need real-world testing and have not been commercially adopted in Toronto's transport environment; and c.) trial a solution that matches the environment (Toronto, 2021a: 13).

The first TIC was announced in 2020 as *Automated Sidewalk Winter Maintenance Challenge*. Ultimately, the challenge was not commenced due to restrictions imposed by the Covid-19 pandemic. However, the call addressed a use case that was previously elaborated in the *AV Tactical Plan* (Toronto, 2019a) and reflects a pressing issue for Toronto. Given the specific climate in the GTA, there is a particular need to test automated devices under exceptional conditions, whether in extreme snowfall or rain, near construction work or on gravel roads (I-08). The second Challenge launched by the City focused on automated micro utility devices (MUD) and was successfully implemented in April 2022. Its prime objective was "to demonstrate whether and how micro utility devices can overcome, improve, or address sidewalk challenges and navigate through competing uses in dense urban environments without posing safety risks to sidewalk users." (Toronto, 2022d).

The challenge was conducted mere months after Toronto's City Council banned the operation of automated MUDs on public roads in late 2021, in response to growing objections from accessibility community members that MUDs were causing an accessibility barrier on sidewalks. Since 2019, individual robotics companies such as Tiny Mile have been offering delivery services for food and goods using MUDs in downtown Toronto (Fig. 4.9). Although the provincial government announced the adoption of a corresponding revision to its AV pilot program to regulate their operation, the amendment has thus far not taken effect (Ontario, 2021a). A third Challenge, focusing on *Parking Sensors and Curbside Vehicle Detection*, is planned for 2023. Of the three Challenges published to date, the last bears the greatest potential to inform future regulations related to the city's parking strategy (Toronto, 2022d).

Figure 4.9 Toronto-based food delivery service Tiny Mile using automated micro utility devices

Source: photo by the author, 2021.

Beyond the program's initial phase, the intention is to expand the Challenges to citywide open calls. An internal Report for Action recognizes the programmatic limitation of focusing on private initiatives alone and references alternative methodologies, such as co-development programs or community-led approaches (Toronto, 2021a: 7). The latter in particular addresses a format based on active citizen engagement and co-creation, allowing residents of affected communities to provide feedback on and engage with trialled technologies (Belikow et al., 2021). As acknowledged in the internal document, "hosting trials in areas outside of Exhibition Place would support a more equitable geographic distribution of innovation benefits" (Toronto, 2021a: 10). But even more so, conducting trials in neighbourhoods affected by existing transportation challenges is essential to live up to the claim of testing innovative applications under real-world conditions, assess their impact and improve them to meet actual municipal needs. But notions of interviewed experts vary in that regard. While some stress the need of testing transport technologies in real-world conditions, e.g. to improve the interaction between pedestrians and cyclists at pick-up and drop-off locations (I-02; I-10), others assert that the focus should lie on segregated lanes or areas with limited interaction with car traffic, cyclists or pedestrians (I-04; 1-09).

Beyond the testing site, a critical factor in creating an added value for municipal development through trials is the public accessibility of results and knowledge transfer. To this end, the City's ambition is to monitor and evaluate trials on an annual basis and publish an aggregated summary of trial results on its Open Data portal. As part of the stakeholder engagement process, participants suggested evaluating technologies according to criteria, such as a.) providing benefits to the social fabric of the City for any group; b.) increasing social mobility and equity; c.) assisting in shifting people away from single occupant vehicles; d.) increasing the public good and benefit the end user; and e.) contributing to the environment and a reduction of GHG emissions (Deivendran, 2020: 4). Specifying three evaluation levels, namely, technical performance, public realm and program evaluation. To discuss trial results and reflect on the program's effectiveness in serving Toronto's needs, the intention is to hold annual public events that serve as a platform.

To what degree the City of Toronto will succeed in effectively facilitating continuous stakeholder engagement, collaboration and purpose-driven trialling is to be determined in the coming years. Furthermore, at this point it cannot be assessed whether the generated knowledge and learning processes are successful in directing the development of mobility innovations towards achieving municipal goals. The described efforts, however, indicate that municipal divisions are investing exhaustive energy into what the National League of Cities has called a localized approach to piloting emerging mobility technologies. Toronto's purpose-driven Transportation Innovation Challenges stand out in their effort to accommodate technological development through facilitated testing, while also intending to capture its benefits through public sector learning and capacity building.

4.5. Summary

Given the disruptive quality often associated with the industry's push for vehicle automation, this chapter addressed the critical question of what means and to what end planning authorities are preparing to manage the technological transition in the mobility sector. In the metropolitan region of Toronto, public sector actors have begun to define a role for themselves over the past decade. While the prime concern of the early years was to get municipal departments and agencies involved, to create awareness and to initiate a municipal conversation on the subject (I-16). The City of Toronto has since moved to actively shape the circumstances under which the introduction of AVs aligns with existing policy objectives. The framing of the task at hand shifted accordingly: rather than determining a municipal position that is either restrictive or supportive of AVs (Mitteregger et al., 2022), efforts shifted to clarifying how the introduction of automated vehicle technologies can support and fit into existing development strategies.

Although Canadian municipalities may lack legislative power, they play a significant role in managing the transition to AVs by prioritizing fields of application that generate public value (Steckler, 2019), by shaping the circumstances in which safe, sustainable and equitable deployment can be ensured (Stayton & Stilgoe, 2020) and by issuing incentivizing as well as disincentivizing measures to prevent new services from competing with existing public transit networks (Toronto, 2019a; Ontario, 2020a). Recent efforts by the City of Toronto that meet the first two tasks include the *West Rouge Automated Shuttle Trial* and its *Transportation Innovation Zone.* Both initiatives resemble institutional frameworks for testing emerging mobility technologies as a means of solving existing mobility challenges, while also enhancing public sector learning and promoting Toronto as a hub for innovation.

What is more, the short-term and small-scale pilots resemble one of the key planning approaches promoted in the context of AV planning preparations. Emphasized as a priority action in both municipal and provincial policy documents, they provide a means to "harness the potential of automated vehicles" (Toronto, 2019a: 127) in the near future, despite prevailing uncertainty about the exact timeline, business models and impacts of AVs. Other tools that are widely applied in planning for an uncertain future with AVs include scenario-building processes, the development of personas and modelling studies (I-02; I-06; I-07; I-09-B; I-15), all of which serve the purpose of weighing different impacts and multiple possible trajectories. Although modelling studies are not necessarily a new practice, their underlying assumptions, e.g. about travel behaviour, are radically shifting due to the introduction of new mobility services and technologies (I-15).

Multi-actor collaboration and the integration of perspectives constitute other recurring features of planning initiatives in the Toronto region. Be it as part of inter- and intra-municipal networking efforts, policy development or pilot projects, the issue of AVs is understood as a challenge that cannot possibly be solved by an individual stakeholder or sector alone. As one expert elaborated, the formation of working groups that include various perspectives ensures a better understanding of how the many first-, second- and third-order effects of AVs may impact local authorities and administrations (I-16). The integration of new mobility services, whether automated or not, essentially calls for the collaboration of multiple actors from the public and private sectors. However, the question remains as to whose interests are accommodated and whether existing policy objectives with which emerging mobility technologies are to align are effectively translated into practice.

To gain a better understanding of the extent to which identified policy goals and planning measures for AVs may in fact be translated into practice and what capacity planning officials have to influence transformative change in planning, Chapter 6 goes on to explore the planning cultural context of the Greater Toronto Area.

EXCURSUS

5. Acting in uncertainty: reflexive planning as a means forward

Scientists largely agree that there are "significant opportunities for transportation planners and policymakers to manage the implications of driverless cars" (Birnbaum et al., 2018: 6) through adequate policy and planning measures. As AVs are gradually introduced onto urban and rural streets, regulatory frameworks are required that align with existing policy goals and effectively minimize adverse effects (Chaudhry et al., 2022). Yet most municipalities are faced with a significant knowledge gap on the exact nature of the short-term, mid-term, and long-term impact of AVs and how to effectively manage the transition phase. Due to the early stage of vehicle automation and a corresponding lack of data, there is uncertainty about direct and indirect, i.e. system-wide effects as well as unintended consequences. Scholars argue that policymakers and planners need to integrate uncertainty into respective strategies and decision-making processes (Birnbaum et al., 2018) and develop alternative policy and planning approaches (Lewis & Anderson, 2020).

> *"Certainty is an ideological construct, which serves to reduce practitioners' understandings of the worlds they seek to plan and the options available to them."*
> (Hillier, 2017: 298)

Against the backdrop of uncertainties and unforeseeable developments that commonly accompany innovation and transformation processes, the discourse on flexible and exploratory approaches has expanded within planning theory and practice (Balducci et al., 2011). So-called "evolutionary approaches" (Bertolini, 2007: 1999) and "adaptive approaches" (Rauws, 2017: 35) have gained attention to address increasingly complex urban challenges. Acknowledging the need of recurring course corrections, such strategies are built on incremental planning and loose rules rather than on detailed regulations. Planning actors are challenged to embrace "non-linear temporalities" (Hillier, 2017: 308) and provide conditions for urban development to take place under varying future circumstances (Rauws, 2017). Along these lines, explorative, anticipatory and reflexive principles have also been highlighted in the context of AV planning and policy debates (Freudendal-Pedersen & Kesselring, 2016; Hopkins & Schwanen, 2018; McAslan et al., 2021).

Recommended means to act in the face of uncertainty about AVs include flexible planning approaches and responsive policies (McAslan et al., 2021), as well as strategies that allow policymakers and planners to learn about the technology and its wider societal impacts as it evolves (Birnbaum et al., 2018). To this end, cross-sectoral collaborations, short-term urban explorations and monitoring are often highlighted as valuable planning elements (McAslan et al., 2021).

Research suggests that particularly during the transition phase, when less mature automated vehicle systems are deployed and saturation levels remain low, there will be a significant need for policy instruments that mitigate negative effects on road safety, travel time and congestion levels (Chaudhry et al., 2022). Beyond that, learning processes and adaptive planning are also crucial when it comes to initiating systemic change in light of an AV future. This constitutes a complex process that affects various interdependent dimensions, e.g. cultural mobility practices, the built environment, vested stakeholder interests, established planning procedures, and institutional structures, which all contribute to the reproduction of a "system of automobility" (Urry, 2004: 32; Pflieger et al., 2009). If AVs are not to perpetuate the status quo but support an environmentally and equitably more sustainable mobility system, radical realignments in planning practice as well as in institutional arrangements and mobility behaviour are required.

The following chapter sheds light on reflexive planning principles specifically, as they characterize both strategies for managing uncertainty and methodological frameworks for transformational change processes. Reflexive principles enhance collaborative stakeholder processes and include self-confrontation, experimentation, dynamic feedback processes, tolerance of mistakes, and goal adjustments (Voß et al., 2006; Schwarz, 2014; Schäpke et al., 2018). Building upon literature from transition studies as well as social and planning theory, different notions of reflexivity are introduced, real-world laboratories are assessed as reflexive frameworks, and three dimensions relevant to planning for AVs are deduced.

5.1. Theories on reflexivity: embracing ambivalence & change

This section is based on the following, previously published paper:

Bruck, E. M. (2018). How to Plan for Transformative Change in light of New Mobility Technologies? A Discussion on Reflexivity as a Planning Principle and the Format of Real-world Laboratories. *plaNext – next generation planning*. 7: 100-116.

At the turn of the century, Voß et al. (2006) describe reflexive governance as "an emerging path of thinking and practice in societal governance and problem-solving" (419), called for by a growing discourse on social, environmental, and economic sustainability. The authors suggest a crucial differentiation of the concept. First, referring to the discourse on reflexive modernity as introduced by Beck (1994), reflexivity is understood as the condition of governance in the modern world, which is perpetually faced with the task of repairing unintended consequences induced by prior developments (Voß et al., 2006). Modernity is confronted with its destructive, even self-destructive, potential, its risks and its limitations (Schwarz, 2002). This first notion thus implies a material rather than cognitive self-confrontation. The second reading, which Voß and Kemp (2006) introduce as “second-order reflexivity” (7), refers to specific strategies, processes, and institutions, which emerge due to the condition of self-confrontation. Actors’ cognitive reflection is meant to prompt a “corresponding adaptation of problem-handling practices” (Voß et al., 2006: 437). Alternative strategies therefore actively explore uncertainty, ambivalences, and distributed control of problems, which become apparent in the confrontation of different rationalities (Voß & Kemp, 2006). The strategic elements Voß and Kemp (2006) propose for reflexive governance encompass (17–20):

- integrated (transdisciplinary) knowledge production,
- adaptivity of strategies and institutions,
- anticipation of the long-term systemic effects of action strategies,
- iterative participatory goal formulation,
- interactive strategy development.

In contrast to modern means of problem-solving, built upon scientific certainty and definitiveness, reflexive problem-solving remains inconclusive and temporal (Schwarz, 2014). By doing so, principles such as precaution, experimentation, tolerance of mistakes, and learning gain significance (Voß et al., 2006; Schwarz, 2014). The open-endedness of such processes reinforces Beck’s analysis that in an age of reflexive modernity, societies are continuously learning (Schneidewind et al., 2016). Reflexive strategies are thus vital for interdisciplinary and transdisciplinary processes, which acknowledge that there is not one, but various possible ways forward, with often contradicting future visions (Freudendal-Pedersen & Kesselring, 2016).

Lissandrello and Grin (2011) introduce an example of how reflexivity may be integrated into urban planning practice, which they frame as “a new tool for generating critical knowledge and dialogue” (223). A multi-stakeholder region dialogue on sustainable development in the Port of Amsterdam serves as a case study, which is structured into debates on past, present and future developments. Through an open and deliberative setting, participating stakeholders are encouraged to reconsider established planning practices and their institutional context. Assuming reflexivity, stakeholders’ imagination is then redirected “towards new visions of the future based on a redefinition of their past understanding” (Lissandrello & Grin, 2011: 243). In the process, planners took up the role of facilitating the stakeholder interaction, confronting differences, and redirecting imagination towards possible futures. While urban planning projects often develop reflexively, that is, through a perpetual coordination of a multitude of stakeholders and their respective forces (Jessen et al., 2008), the cited example of second-order reflexivity transcends mere cognitive actualization. Instead, it explores the capacity for change through a social learning process grounded in intentionality and consciousness (Lissandrello & Grin, 2011). The example shows that reflexive practices bear the potential to instigate social learning through self-confrontational interaction and to trigger structural changes through an inter-subjective redefinition of social realities (Freudendal-Pedersen & Kesselring, 2016). The approach is valuable to further considerations on guiding urban mobility transitions, as it emphasizes the "transformative potential of agency" (Lissandrello & Grin, 2011: 224).

5.2. Real-world laboratories as a reflexive framework for transformative change

The following section elaborates on the concept of "real-world laboratories" (German: Reallabore), which gained significant popularity amongst researchers focusing on systemic change processes towards more sustainable futures (Schneidewind et al., 2016; Wanner & Stelzer, 2019). Grounded in the previously described understanding of reflexive modernity, real-world laboratories provide an important approach for a "transformative science" that assumes an active role when studying processes of transformational change (Schneidewind et al., 2016). By collaborating with societal actors as part of real-world interventions, scientists become enablers of "collective social learning processes" (Schneidewind et al., 2016: 5). Scientists adopting a transformative research approach thus build on the epistemological tradition of pragmatism, transgressing the strict separation of knowledge and experience (ibid.). The following section introduces the concept of real-world laboratories and highlights learning and reflexivity as one of its main characteristics, which is critical for change processes to unfold.

5.2.1 The format of real-world laboratories

The concept of real-world laboratories belongs to a family of experimental and transdisciplinary research approaches, which have gained significant attention within the scientific community and public administrations in recent years (Heyen et al., 2018). Considered a methodological novelty within natural sciences, real-world laboratories have been inspired by the experimental turn in social and economic sciences, as well as by collaborative participatory planning processes (Schneidewind, 2014). Within sustainability studies, it has become pertinent to understand the complexity of technological, economic, institutional, spatial and cultural interdependencies through scientific observation and abstraction, but also to explore means of initiating and attending transformative change (Schneidewind, 2014; von Wirth & Levin-Keitel, 2020). Schneidewind and Singer-Brodowski (2014: 69) thus differentiate "transformative science" from "transformation science" by specifying that the former takes an active role, as scientists are intrinsically involved in the change processes they study. In their process designs, real-world laboratories thus combine approaches from transdisciplinary and action research (Schneidewind, 2015: 88).

Five core characteristics describe the conception of a real-world laboratory as an institutional framework (Schäpke et al., 2018: 96; Figure 5.1): a.) contribution to a sustainable transformation; b.) experiments as core research method; c.) transdisciplinarity as core research mode; d.) long-term orientation, scalability, and transferability of results; and e.) learning and reflexivity. The aim is to experiment with potential solutions to pressing challenges and to foster transformation by identifying where, when, and how one can intervene in an existing system (Schäpke et al., 2018). "Real-world experiments" (Wagner & Grunwald, 2015: 26) are considered a distinct feature of real-world laboratories and are commonly designed to generate evidence on actions that propel sustainability transformations (Schäpke et al., 2018). In an effort to bring science and society closer, transdisciplinary approaches are sought that allow researchers to collaborate with societal actors. The knowledge, which is generated through co-production and continuous methodological reflection, is context- and actor-specific, and can be divided into system knowledge (on what is), orientation knowledge (on what should or should not be) and transformation knowledge (on how change processes could be designed) (Schneidewind, 2014).

Figure 5.1 Core characteristics of real-world laboratories

Characteristics	**Phrase**
Contribution to transformation	sustainability oriented
Experiments as core research method	experimental
Transdisciplinarity as core research mode	transdisciplinary
Lerning and reflexivity	reflexive
Long-term orientation, scalability and transferability of results	long-term

Source: illustration by the author, based on *Jointly Experimenting for Transformation?*, by Schäpke et al., 2018; *Reallabore – Perspektiven für ein Forschungsformat im Aufwind*, by M. Wanner, and F. Stelzer, 2019.

As the concept of real-world laboratories is set to propel transformational change processes towards a more sustainable future, it is important that tested solutions can be continued beyond the duration of the laboratory. To this end, developed actions and initiatives need to include a long-term perspective and the option of being scaled, while insights need to be transferable to other areas (Schäpke et al., 2018; Parodi et al., 2018). Lastly, reflexivity and learning occur across the spectrum – from individual competency development, to social learning between participants, and transdisciplinary collaboration. In the form of (self-)confrontation with different values, norms, and cultures, as well as through interrelating and integrating different world views, reflexivity is crucial for transdisciplinary efforts to succeed. When effectively practiced, the negotiation of different perspectives can bring about “collective meaning making which nurtures ownership of, and participation in, the lab.” (Schäpke et al., 2018: 88).

Yet this is not to say that the outlined format is without limitations or constraints. The methodological challenges of real-world laboratories in the sustainability sciences concern the format’s threefold objective: 1. the scientific goal to generate new insights and knowledge, 2. the transformational goal to initiate social change processes, and 3. the educational goal to facilitate learning (Defila & Di Guilio, 2018). An equal treatment of these dimensions can cause non-scientific actions to prevail, while also demanding more specific criteria for selecting participants (ibid.). Initiating change through explorative actions entails an ethical responsibility for unintended consequences and challenges scientists to remain unbiased and open (Schäpke et al., 2017). Hence, it is crucial for such processes to continuously reflect on the social acceptance and legitimization of process design, objectives, and outcomes (ibid.).

Comparable research concepts

Similar concepts that have internationally gained attention in recent years include (urban or sustainable) “living labs”, “urban transition labs” or (sustainable) “niche experiments” (Schäpke et al., 2017: 30-35). These concepts are generally understood as temporary and spatially constrained spaces set up by scientific units in order to explore alternative practices and create new knowledge through multi-stakeholder processes (Heyen et al., 2018). Their objectives, as well as temporal and structural embedding, differ and often depend on local funding policies (Scholz, 2017). Living labs, for instance, were originally introduced in an effort to realize more sustainable products and services by exploring social practices and consumption patterns and integrating user feedback into prototype development. As so-called “open innovation” environments (Chesbrough, 2003: XXIV), where users’ creativity and ideas influence the development of services, products and societal infrastructure to the advantage of private businesses, they have often been called into question. Particularly when civic participation is limited to consultation and surveying, the claim of enabling co-production remains unfulfilled (Schäpke et al., 2017).

Urban transition labs, meanwhile, build upon theories of “transition management” and address greater processes of change with regard to sustainability issues beyond socio-technical innovation, often embodied by so-called “frontrunners” (Loorbach, 2010: 172). Finally, niche experiments derive from the discourse on “strategic niche management” (Schäpke et al., 2017: 28), which argues that socio-technical innovations originate in alternative niches before evolving into the mass market and societal mainstream. Niche experiments share a wider governance approach with urban transition labs, but differ inasmuch as scientists take a consulting and observing role instead of being actively involved (Schäpke et al., 2017). Real-world laboratories differ from the last two examples in that they often lack a systematic embedding into larger governance arrangements and may fall short of stabilizing efforts, upscaling the format, and transferring knowledge sustainably (Parodi et al., 2018).

The normative orientation of transformative science towards sustainability is another aspect of real-world laboratories, which has been criticized within the scientific community. Strohschneider (2014), for instance, questions whether such approaches depoliticize democratic decision-making and blur the difference between factual knowledge and morally justified action. Representatives of the field conversely argue that transformative science intends to bring science and society closer in order to proactively tackle the societal challenges pertinent to reflexive modernity through institutional realignments, transdisciplinarity, and co-production of knowledge (Schneidewind, 2015).

5.3. Reflexivity in urban planning with emerging mobility technologies

Keeping in mind urban planning initiatives for AVs, three dimensions of reflexivity may be deduced from the literature on transition studies, planning, and social theory, as well as from the description of real-world laboratories as institutional settings for transformational change. These dimensions illustrate principles crucial to managing uncertainty concerning of AV technologies, and to initiating long-lasting change processes.

5.3.1 Openness and flexibility

When considering the integration of reflexivity in urban planning processes, the question may arise to what extent such mechanisms and principles should be integrated into planning processes and adapted to suit a particular setting. Voß et al. (2006) argue that reflexivity needs to be integrated on all levels of government and suggest a “sequential opening and closing” (433) of governance processes in phases of problem analysis, goal formulation, strategy implementation, and actor participation. They understand opening as the integration of additional factors into the understanding of the problems, goals or strategies, as well as the expansion of knowledge through participation and greater diversity (Voß et al., 2006). Opening up planning and decision-making processes to additional stakeholders permits discursive deliberation and reflection on how the advantages and disadvantages of imminent decisions are perceived by different actors. Within the Responsible Research and Innovation field, such mechanisms have been stressed in particular in the context of technological innovations which, like automated driving, can have unintended and partially irreversible consequences for society and the environment (von Schomberg, 2011; Schneidewind et al., 2016).

Concerning planning and policy efforts for AVs, openness and flexibility has largely been emphasized in procedural terms. Scholars assert that legal regulations, including urban and land-use policies, need to be adaptive and responsive in order to accommodate possibly disruptive effects of AVs (Papa & Ferreira, 2018; González-González et al., 2020). Maintaining an openness for "what might emerge" thus entails the capacity for future change (Hillier, 2017: 310). To this end, the embedding of variations and continuous selection processes in preliminary explorations as well as in later planning phases can therefore make it possible to learn and adjust to evolving mobility projects or technologies (Bertolini, 2017: 156). Small and incremental developments towards automation gain relevance, becoming as relevant as continuous monitoring and assessment (Papa & Ferreira, 2018). Yet any short-term experimentation benefits from a frame of reference. Hillier (2017: 309) thus suggests to complement short-term, location-specific urban acts with overarching visions and strategic trajectories, which provide "justification and navigational context," but leave the ends of each line of knowledge open.

In technological terms, openness may further pertain to data, content, as well as software. According to the Open Knowledge Foundation, for instance, "Open means anyone can freely access, use, modify, and share for any purpose (subject, at most, to requirements that preserve provenance and openness)." (n.d.). By that definition, open data, open content, and open knowledge are promoted as a common good that is publicly accessible, rather than proprietary, and thus interoperable. Open-source products and software build on similar principles by embracing "open exchange, collaborative participation, rapid prototyping, transparency, meritocracy, and community-oriented development." (opensource, n.d.). Within the research and development landscape for AVs, numerous simulators, data libraries, operating systems, and automated driving assistance systems exist, which are open-source and allow newer research teams and developers to enter the field (Saoudi et al., 2022). Technologists assert that using open-source resources promotes collaboration, increases the chance of bugs and shared problems being resolved, and accelerates technological advancements (Singh, 2020). Yet the open-source principles as they are being practised amongst the AV research and development community does not extend to public reports on testing maturity. Unless governments such as the state of California enact respective regulation, companies do to not publicly share data on AV safety performance and environmental interactions (Boggs et al., 2020).

Finally, in spatial and infrastructural terms, openness and flexibility may be translated as a functional underdetermination instead of a tight fit. Maintaining an openness to what may lie ahead implies that structures and spatial arrangements are designed to be adaptive and variable. This concerns parking facilities, for instance, which could be repurposed as warehouses, logistical nodes, or urban production sites, if parking demand were to significantly decline in the future (Bruck et al., 2021). In light of the uncertainties surrounding the development and implications of AVs, Guerra and Morris (2018) argue for planning strategies that bring about environmental and social value regardless of the arrival of AVs: "Parking reform – while perhaps not as glamorous as putting smart sensors and communications devices into traffic lights – makes sense today, falls directly under the jurisdiction of local planners, and will only make more sense as automation reduces the need for parking spaces to be immediately adjacent to shops, apartments, and other destinations." (296). The robustness of potential plans and investments thus needs to be tested against various future scenarios, with and without emerging mobility technologies such as AVs (Guerra, 2016).

5.3.2 Exploration – learning – discourse

While much of the knowledge production on AVs is currently reserved for industry, research institutes, and selected transit agencies, further knowledge production and exchange is necessary beyond these realms. Public administration and planning departments are urged to build the knowledge and expertise necessary in order to harness potentials and mitigate risks of new mobility technologies. If the aforementioned short-term location-specific urban acts (Hillier, 2017) take on the shape of real-world laboratories or transition labs, they can provide valuable settings to explore questions of service equity, environmental sustainability, or infrastructural affordance. Not merely through the lens of technological advancement, but by studying the interdependence between technological, institutional, cultural, and economic dynamics and their location-specific manifestation (Schneidewind, 2018). Involving affected communities through transdisciplinary methods and approaches of "co-production" (Schäpke et al., 2018: 87) is thus essential, as learning alone does not yet result in systemic change. In exploratory environments, participants instead need to generate and test alternative ways of doing things in a creative and collaborative process (ibid.).

Long-term multi-stakeholder collaboration may then propel a "transformational literacy" (Schneidewind, 2018: 11), that is, the competence to understand the complex interrelation of influencing factors that keep the current system of automobility in place, while also being able to translate this knowledge into actions for more sustainable change. In terms of AVs, this would imply strategies of placing them in the service of a socially equitable and environmentally sustainable mobility system. If diverse stakeholder and community groups collaborate, "a broader knowledge base and more effective social learning" (Stirling, 2006: 258) becomes possible, which may include reframing problems and unlearning habitual ways of looking at things. Ultimately, collaboration and joint reflection of entrenched assumptions may lead to "new ways of seeing things" (Abbott, 2005: 249) and better outcomes.

Yet multi-stakeholder processes are often faced with the crucial challenge of motivating collective interest and cooperation (Voß & Kemp, 2006). Smith (2006: 327) elaborates that "actors come together with different motivations, perspectives and expectations; and, as a result, social learning will be plural and unlikely to be integrated automatically". Transdisciplinary processes might thus entail cultural and epistemic confrontations or participants who are reluctant to give up established practices (Singer-Brodowski et al., 2018). The diversity of world views may be viewed as a limitation that can erode action capacity (Voß & Kemp, 2006). Rather than striving for consensus and resolution, collaboration should thus focus on engagement and negotiation (Hillier, 2017). A reflexive discourse is not so much a consensually directed rational argumentation, but rather a mutual adaption of the actors' knowledge to a shared view of reality that allows for dissimilar problem definitions, goals and strategies (Voß et al., 2006). Stirling (2006) elaborates that the essence of reflexive strategies addresses the "inherently 'plural and conditional nature' of scientific understandings and technological potentialities" (260). To this end, reflexive planning strategies foster the adoption of various perspectives and aim at balancing multiple truths (Voß & Kemp, 2006).

5.3.3 Embedding of initiatives and actualizing local change

The influx of on-demand mobility services, sensor-based connectivity and self-driving vehicles has led to an increasing rationalization of urban flows and processes. After all, data-based mobility services, as well as artificial intelligence and predictive analytics, are built upon the conviction that better data or better models can substantively reduce, if not eliminate, uncertainties and risks (Hillier, 2017: 300). In contrast to such tendencies, Voß and Kemp (2006) elaborate that "the more problem-solving is disengaged from the full, messy, intermingled natural reality and oriented towards the worlds of specialists, the larger the share of interdependencies and dimensions of embeddedness ignored in the development and implementation of supposed solutions." (5). A key issue in the advancement of AV technologies, as companies and research institutes have harshly been confronted with the many borderline cases that occur in real-life traffic environments and have thus far limited the successful implementation of software-driven vehicles.

Yet the notion of *embedding* mobility technologies needs to transcend mere technological advancement, if experiments and applications are to bring forward "pattern-breaking systemic changes" (Hulgård, 2010: 297) such as the increase in shared ridership and the use of transit, the reduction of car ownership, and the reclaiming of public space. To this end, embedding real-world experiments into the affected social and spatial environment implies the involvement of all community groups, institutions, and governmental agencies who are crucial for successful implementation. Only then can the correlation between service applications, spatial environment, mobility culture, and institutional context be reflected and the specific local potential for change assessed. In particular, where the built environment strongly structures mobility habits and modes of transport, it is necessary to examine to what extent spatial arrangements promote or rather inhibit desired change processes (von Wirth & Levin-Keitel, 2020). The same applies to the regulatory and institutional context, as well as cultural habits and identities.

Moreover, local embedding helps to generate knowledge on the social relations, processes, and resources at hand and may facilitate the building of local ties (Jack & Anderson, 2002). On the one hand, institutional ties, which are a precondition for continuing explored practices beyond the testing phase and for creating a link to existing planning processes (Wirth & Levin-Keitel, 2020). To this end, transformational claims of real-world laboratories have to be translated to a local context and relate to its very specific challenges and needs (Heyen et al., 2018). On the other hand, to the affected communities themselves. Building upon the aforementioned "transformative potential of agency" (Lissandrello & Grin, 2011: 224), the self-empowerment of local communities is key to actualizing change. This entails that actions exploring systemic change in mobility, for instance, also address the power struggles and asymmetries that may underlie existing conditions (Schneidewind et al., 2016). In the context of real-world laboratories and transformative science approaches, power dynamics can be re-balanced "by strengthening niche actors through new forms of participation, by increasing the scope for action in relevant societal fields and by increasing reflexivity with regard to existing technologies and (political) strategies. Individuals or groups often act as pioneers who set precedents for change and increase awareness of its opportunities." (Schneidewind et al., 2016: 6)

5.4. Summary

As cities prepare for a possible advent of AVs, three notions of reflexivity may be of particular relevance to planners and policymakers. Firstly, following the understanding of Voß & Kemp (2006), reflexivity comes into play when an awareness of the unintended consequences of one's actions prompts the application of methods and principles that take the uncertainty about what is yet to come into account. Means to manage uncertainty and ambivalence of, for instance, technological developments include integrated knowledge production, adaptivity, anticipating long-term systemic effects, and iterative goal formulation (Voß & Kemp, 2006). To this end, planning practitioners may need to follow Huxley (2002: 152) and "confront the inescapable aspects of control" inherent to liberal strategies, as well as to technological solutionism. Turning to reflexive practices implies that these are "geared towards continued learning' rather than towards complete knowledge and maximization of control" (Voß & Kemp, 2006: 2007).

Secondly, reflexivity may be put to use in process designs that aim to mediate the perspectives of different stakeholders and relate multiple temporalities to each other. Through the confrontation with current challenges and their origin in past convictions shaped by specific histories, a reframing can take place that enables the redirection of stakeholders' imagination towards new visions for the future (Lissandrello & Grin, 2011). Particularly as conventional strategies in transportation planning aim to optimize the system of automobility and fail to admit its limitations in reducing environmental impacts and traffic congestion, Freudendal-Pedersen & Kesselring (2016) assert that it is necessary to find reflexive strategies in urban planning that are "to cope with the risks, uncertainties, and insecurities of second modernity and the age of flows" (576). Acknowledging that reflexive practices require an immense effort from all participants, urban planners can play a critical role by facilitating such processes with "projectivity, creativity and change" in mind (Lissandrello & Grin, 2011: 245).

Thirdly, reflexivity is a key lever and structuring element in transdisciplinary and experimental approaches such as real-world laboratories and transition labs. These are research environments set in real-world conditions that they intend to study and learn from by transcending the boundaries between science and society, observation and actions, as well as knowledge and experience. Through the analysis and reflection of systemic interdependencies and their limiting effects on path-altering change, knowledge is generated on how to initiate transformative change processes within socio-technical systems – a quality Schneidewind (2018) describes as transformative literacy. Such formats may be understood as long-term "research infrastructure" (Jahn & Keil, 2016: 249) or institutional frameworks, which provide transdisciplinary explorations and project initiatives with an overarching target horizon and a boundary condition (Beecroft et al., 2018: 77). By embedding research, learning, and evaluation into their process designs, they are structured by reflexivity. Yet real-world laboratories and transition labs differ from conventional pilot projects and living labs, which are increasingly applied to test emerging mobility technologies, in that they include a systemic perspective and deliberately aim to promote a change to the status quo. As with any explorative format, which benefits from comprehensive stakeholder participation, it is paramount to assess who acquires the right to generate knowledge and therefore strategic advantages. What are the circumstances, and who bears the risks?

In strategic terms and in terms of process design, notions of reflexivity are already put to use when planning for emerging mobility technologies (see e.g. Freudendal-Pedersen & Kesselring, 2016). In the Greater Toronto Area, notions of uncertainty and systemic interdependence were constitutive for policy frameworks such as the *AV Tactical Plan 2019-2021*. However, associated real-world trials such as pilots and transportation innovation challenges, do not yet pursue reflexive strategies that pertain to transformative, that is, path-altering change in mobility habits and patterns. In this regard, systemic and long-term thinking about the future implications of AVs has been largely confined to research endeavours and policy studies, but has not sufficiently entered societal discourse and public deliberation (Hopkins & Schwanen, 2018).

PART III. PAST DEVELOPMENTS

6. Planning culture as determining context for change

As municipalities commence planning preparations for AVs, many policy levers and regulatory measures mentioned in the literature as a means to mitigate negative impacts, e.g. curbside pricing or parking policies, are not necessarily novel planning tools. As one interviewee stated, many of the policy items introduced in relation to AVs had been previously considered by the City of Toronto, but were never adopted (I-02). The advent of AVs and the ongoing shift in the mobility system provide a new opportunity to introduce previously contested measures. Scholars such as Freemark et al. (2019) argue that anticipating the potential costs and risks of AVs could prompt municipalities to “reconsider policies widely recognized as effective in achieving key goals shared by cities but with significant hurdles in the current political climate, such as congestion pricing” (5).

Whether related policies and regulatory measures are indeed translated into practice, however, not only hinges on greater awareness of the negative impacts and societal costs of transportation. Time and again, political, institutional and public resistance have hindered the implementation of substantial policy change (Marsden & Docherty, 2013). The question of whether the advent of self-driving vehicles coincides, or even affects, novel practices that may in turn lead to planning transformations therefore requires more than understanding the newly formed actor constellations, overarching policy goals and planning measures. Furthermore, it is necessary to gain a deeper understanding of the planning and policy context (Legacy et al., 2019; Docherty et al., 2022) that affects the institutional capacity of planners to introduce alternative policies and practices.

The following chapter explores the challenges that the interviewed experts associate with AVs in relation to established land use and transportation planning practice (Table 6.1). According to Healey and Williams (1993), existing challenges may comprise so-called points of reference through which involved actors perceive opportunities, pressures as well as constraints on action. As such, perceived challenges can shed light on whether established means of action and traditional structures continue to be considered sufficient or whether they are in need of reform in the wake of changing circumstances, perhaps evoking a certain discomfort with mainstream planning (Christmann et al., 2020). Perceived challenges can further point towards new ideas and expectations that may deviate from existing planning practices, or alternative approaches that amend existing arrangements.

Perceived challenges are therefore taken as a starting point to analyze the broader planning cultural context of the Greater Toronto Area: the transportation system and the built environment as well as the organizational structures and institutional relations of the planning system. Present-day challenges and potentially deviant expectations are framed by a revision of their planning and institutional context in order to gain a deeper understanding of their historical embeddedness. The aim is to uncover some of the local specificities that may constrain or evoke patterns of transformative change and which essentially shape the diverging "transition pathways" (Geels & Schot, 2007) to future transportation systems with AVs. Before delving into the planning cultural context, the chapter opens with an overview of future challenges that involved actors generally associate with a widespread introduction of AVs (6.1). It then goes on to highlight challenges to the existing mobility and urban development practice in the GTA (6.2) and closes with governance challenges concerning regional coordination and the regulatory capacity of agencies (6.3).

Table 6.1 Overview of key challenges that experts associate with a possible introduction of AVs

Future challenges with automated vehicles	Existing mobility and urban development challenges	Challenges in institutional capacity and regulation
Induced Traffic • Aggravated traffic congestion, • Increased commuter distances, • Dominance of private AV use due to low adoption of ride-pooling in suburban neighbourhoods.	Competing interests over curb access • Ride-hailing and delivery services compete with buses and cyclists, • Curbside Management Strategy lacks regulatory measures, • Lack of political will to contain TNCs.	Regional transport coordination • Insufficient regional integration of transit services and fares, • Regional fragmentation in regulating ride-hailing companies, • Ineffective regional governance arrangements.
Transit Loss • Loss of transit ridership and operational budgets, • Technological inadequacy due to emphasis on small vessels.	Transit development • Low reliability of surface transit within the City of Toronto and the region, • High operational costs in suburban neighbourhoods and low access of trunk lines, • Historical underfunding of transit.	Institutional capacity & governmental interests • Provincial authority over municipal decision-making, • Planning inconsistency due to conflicting interests at different levels of government, • Limited fiscal capacity and funding dependency affects, • Constrained institutional capacity to regulate emerging mobility technologies.
Conflicts with active modes • Compromising active modes, • Competition for right of way, • Unsafe mode interaction.	Infrastructural capacity limits • High levels of regional car-dependency, • infrastructural capacity limits on highways and along major subway lines.	Policy enforcement • Insufficient uptake and enforcement of policies, e.g. HOV lanes or car-pooling programs, • Failure to achieve policy objectives.
Implications for urban form • Road-space separation, • Induced parking demand, • Urban sprawl in regional municipalities.	Urban development patterns • Low building densities, • functional segregation, • and lack of transit integration.	Institutional innovation • Institutional openness to innovate, • Culture of risk aversion, • Rethinking governance arrangements.
Liability, security and privacy • Accountability for system failure, • Privacy implications and cyber security measures.	Growing pains & regional policy • Disjuncture between long-term regional policy goals and municipal implementation.	
Labour implications • Re-skilling towards customer-centred service operators.		

Source: table by the author.

6.1. Future challenges of AVs

Induced traffic

Possible aggravation of Vehicle Kilometres Travelled (VKT), is a central concern for interviewed planning experts. As international research studies on the travel impact of AVs put forward in recent years (Auld et al., 2018; Zhang et al., 2018), private AVs could lead to an increase in total vehicle travel in various ways. While enhancing the mobility options of user groups such as elderly, children and the mobility-impaired is an important equity goal, transport simulations indicate that the use of private AVs could lead to an increase of urban VKT of up to 40 % (Hörl et al., 2019). Kimber et al. (2020) take chauffeuring of children as an example to highlight the potential negative consequences of non-commuting trips, including congestion at peak hours, exacerbated urban sprawl and added travel occurring "once parents are released from the burden of school runs" (143). Other reasons why the introduction of AVs may induce traffic include cruising, empty vehicles, increased convenience, low cost of travel time and the incentive of private owners to maximize their use in return for high purchase costs (Litman, 2022). If AVs are then also electric, owners may further increase their travel due to low fuel costs (ibid.). In effect, the widespread use of private AVs is likely to undermine the expected efficiency gains and may instead lead to a drastic increase of VKT, exacerbating existing network problems in a metropolitan region such as the GTA.

> *"When I started out, AVs were looked at as this huge solution to congestion. And then slowly, we realized, well, no, it could be actually the complete opposite. It could be the worst thing for congestion that there is."* (I-02)

Transport modelling studies that concluded that automated vehicle fleets could reduce traffic volume have shown that such benefits depend on a high adoption rate of ride-pooling services and SAVs (Boesch et al., 2016; Martinez & Viegas, 2017). But sharing an AV or even the same ride offers less convenience than owning a personal car and may cause delays (Litman, 2022). Similar sentiments were expressed by an interviewed expert, who noted that the use of ride-pooling services such as UberPool represents a "point of sensitivity" in the Toronto region (I-07). Statistics on the use of TNCs within Toronto show that lower demand for ride-pooling compared to non-shared ride-hailing is influenced by perceptions of travel time uncertainty, lower quality of social interaction and safety issues (Sarriera et al., 2017). Even before the sudden drop in ride-hailing trips due to Covid-19 pandemic in 2020, the number of shared trips began to decline in the fall of 2018 (Toronto, 2021c).

Urban density plays a critical factor in this regard. The existing data on ride-hailing shows that the likelihood of sharing a ride is far higher in dense urban neighbourhoods than in suburban and rural areas, where overall demand for services is lower and destinations are dispersed. In the City of

Toronto, roughly 15 % of all ride-hailing trips made between the fall of 2016 and the spring of 2017 were pooled and largely taken in downtown area of Toronto (Young et al., 2020). Suburban neighbourhoods such as Etobicoke and Scarborough were largely excluded from the UberPool offer.

A 2016 consumer survey on AVs in the GTA adds another layer of complexity by highlighting the impact that pricing schemes may have on future adoption rates. Namely, should private AVs be made available for purchase at a comparable price to conventional non-automated vehicles, consumers indicated a substantially greater interest in privately-owned AVs than in using on-demand shared services (Laidlaw et al., 2018). Even at a price of $0.50 per kilometre, automated sharing services are more likely to be used occasionally as an added mobility option and are unlikely to fully replace existing vehicle fleets, according to 2016 survey results (Laidlaw et al., 2018: 28). Results from a 2017 study based on focus groups with GTA residents were more nuanced, indicating that lower travel costs and avoidance of parking fees pose a significant motivation for urban residents to use SAVs, while suburban residents were more interested in using privately-owned AVs (Birnbaum et al., 2018). Thus, SAV adoption is significantly challenged by convenience, speed, reliability and car-ownership status, as well as land use patterns in suburban and rural areas (Litman, 2022: 21).

These are all indicators that the adoption of SAVs in the GTA is uncertain under current policies. Even more so, given that post-pandemic mobility patterns indicate a slow recovery of ride-hailing and transit ridership (Toronto, 2021c), while private vehicle use was less affected, causing congestion levels to return (Higgins et al., 2021). In order to promote a future scenario in which shared AVs dominate, governmental stakeholders in the region would need to seriously adopt policies such as fuel and road user fees, and advance roadway management strategies that incentivize shared vehicles by making their use more convenient and rapid (Litman, 2022). Although such policy actions are mentioned in both the 2041 RTP (Metrolinx, 2018) and the Transportation Plan for the Greater Golden Horseshoe (Ontario, 2022), neither plan gives them sufficient priority to achieve a comprehensive shift away from private vehicle use.

Transit loss

Another concern shared by experts is the potential loss of transit ridership due to competing automated on-demand services (I-05; I-06; I-07). In the Toronto context, the concern partly relates to the report *The Transportation Impacts of Vehicle-for-Hire in the City of Toronto* put forward by the City in 2019. Evaluating the transportation impact of so-called Private Transportation Companies (PTCs), the findings show that ride-hailing trips accounted for 5 to 8 % of the total daily traffic in downtown neighbourhoods in 2019 (Toronto, 2019b). Only a year later, in February 2020, ride-hailing accounted for 8 to 14 % of traffic (Toronto, 2021c). Data from 2019 also shows that 59 % of trips would otherwise have been made via transit, active modes, or not at all. This represents both a significant increase in VKT and a loss of transit. The most compelling factor for users to switch to other modes is that ride-hailing services offer significant travel time savings compared to transit, which may range from 5–11 minutes in Toronto's downtown area to 15–30 minutes in its inner suburbs (Toronto, 2019b: 30). In effect, the report acknowledges that PTCs compete with Toronto's surface transit routes. In an AV scenario, increased convenience and lower traveling costs could cause an even greater shift away from transit and thereby compromise the cost-effectiveness of public transit services (Litman, 2022). Particularly in environments such as the GTA where operating budgets largely rely on farebox revenue recovery, these could be significantly reduced[10]. In the long run, this could result in lower service quality and a social equity issue (I-02). Passengers who depend on transit, the so-called captive ridership, may face even higher fares and strained service (I-07).

At the same time, claims persist that automated mobility on-demand services bear the potential to have a positive impact on transit (Fraedrich et al., 2019). Relatedly, the City's report on PTCs states that ride-hailing services may also provide a viable alternative to transit, e.g. during periods of transit disruption or in suburban areas where transit access is particularly scarce during nighttime hours (Toronto, 2019b: 33). An interviewed expert asserts that the key issue with regard to AVs will be whether they are used to enhance the transit network, e.g. by improving cost-effectiveness, reliability and accessibility, or whether the deployment of AV use cases will end up undermining transit operations (I-05). At the user level, by competing with traditional transit service and offering higher levels of comfort. At the planning level, by diverting resources from transit improvements to AV-based solutions (Litman, 2021: 17). However, the need to invest in existing infrastructure or expand services differs within and beyond Toronto's city limits. Within the City of Toronto, the operation of AV shuttles is considered to be financially unviable for a transit company:

> *"We move 1.7 million people a day. Even on our books, what's considered a poor performing route still needs that 40-foot bus, because it carries so many people."* (I-05)
>
> *"All of these bus routes that we operate are very busy and so it makes sense to have the larger capacity vehicles. If there's a 40-foot bus or even a 30-foot bus that can carry 30 to 50 people and is automated, then that makes sense. And then actually we save a ton of money, if we can remove the operator. But in terms of those little pods that you're seeing right now, where it's like 10 people, there are very few areas across the city where that*

[10] Farebox recovery describes the extent to which the operating costs of a transit system are covered by passenger fares rather than public subsidies, as is the case with TTC and Go Transit.

makes sense for us. It could be something that we offer, but it's not going to be widespread and it's not going to replace any of our buses." (I-05)

In regional municipalities, in turn, demand-responsive feeder systems could in fact fill a significant first- and last-mile gap and reduce the number of people driving their private vehicle to a regional train station (I-09-A). In a similar vein, Metrolinx's *New Mobility Background Paper* states, "While public transit may risk losing ridership to emerging services in certain markets, this shift in service provision provides an opportunity for transit agencies to focus transit in areas where it is most effective." (Metrolinx, 2016: 32). In this context, automated on-demand ride-hailing is viewed as a means to expand the catchment area and geography of traditional transit corridors. An interviewee elaborated on this vision as follows:

> *"Early on, we said that transit needs to remain a backbone. We need to make it competitive to these options where we can, and it's mostly in the trunk corridors that we think there's a potential to focus in on. So, the subways, the rail lines, Frequent Rapid Transit network. Because, if you think about living in a condo that is attached to a subway, it's probably faster for you to go down the elevator and into the subway than it is for you to call an Uber."* (I-07)

Security issues in mixed traffic

Social equity concerns that AVs may reduce transit also raise concerns that active mobility options such as walking and cycling may be compromised (Stead, 2019). Particularly in Toronto's denser urban environments, where the proportion of pedestrians and cyclists is comparatively high, the introduction of AVs is associated with increased competition for curbside access and increased risk to other road users. Although it is emphasized that vehicle automation should increase safety on urban roadways, the interviewed experts expressed scepticism regarding its short-term performance feasibility, referring to recent technological setbacks due to failing to detect vulnerable road users and stopping in time (I-04). One expert noted that greater public awareness was necessary to ensure that pedestrians and cyclists know how to interact with AVs as their adoption rates increase (I-15). Another expert expected the construction of road-space dividers, should vehicles with higher automation levels be accepted. As a planning measure, this would significantly undermine ongoing efforts to reduce spatial barriers and foster so-called shared spaces. One expert doubted that fully automated vehicles will be able to navigate environments in which pedestrians can move freely between vehicles and envisions that AVs will either travel in separate lanes or not at all (I-10).

Implications for urban form

It is generally assumed that higher levels of comfort and convenience will lead to increased travel distances. As AVs could make longer trips more endurable (Litman, 2021), they are expected to induce urban sprawl, a troubling prospect for Toronto-based planning experts. The most recent projections indicate that the GTA's population is estimated to grow by an additional 2.9 million residents, or 41.3 %, by 2046 (Ontario, 2021c). While the Greenbelt – an ecosystem of productive farmland and environmentally valuable wetlands, waterways, and forests that encloses the Greater Golden Horseshoe (GGH) – constrains urban expansion in theory, the historical dominance of the automobile and low urban density in the region give reason to believe that AVs, if left unregulated, could drive suburban and rural sprawl. The *New Mobility Background Paper* commissioned by Metrolinx points out the risk of undermining existing policy goals aimed at overcoming the historical reliance on the car and low-density suburban developments:

> *"Widespread use of autonomous vehicles could hinder urban intensification, which is a provincially directed policy goal of governments across the GTHA. Access to driverless cars could increase the acceptability of long car commutes, and thus encourage more development outside major centres; it could also undermine efforts to increase land use densities around rapid transit stations."* (WSP, 2016: 42)

Another impact on urban form that is frequently addressed in the literature and policy documents on AVs relates to parking areas. In particular, ride-pooling services with AVs are widely assumed to reduce the number of necessary on-street parking spaces, which could be replaced by designated pick-up and drop-off zones, more public space and urban densification. The issue with the assumed benefits, however, is that the trade-off between necessary short-term parking and excess travel has not been sufficiently studied. Ultimately, replacing a parking area next to a transit station could result in a private AV making four trips between its home base and the station instead of two (I-07). Although shared AVs bear the potential to relieve the transport network, a lack of pick-up and drop-off areas and short-term parking options may equally lead to empty cruising (Kondor et al., 2020). This may be because the vehicle is waiting for the next passenger to book a ride or because it is returning to a central depot. Therefore, studies have shown that the operational range of shared AV fleets needs to be closely calibrated to user demand and relies on sufficient short-term parking for passenger interaction or waiting time between bookings (Zhang & Wang, 2020; Kondor et al., 2020). Otherwise, a reduction of long-term parking could very well lead to excess VKT.

Liability, security and privacy

In addition to the implications for transportation and urban development, the interviewed experts also expressed concerns about liability and data security related to AVs, which are essentially tied to service provision and passenger safety. While operational safety is a key concern to provincial governments (I-14; I-15), municipal governments and public transportation agencies must likewise address the issue of accountability in cases where an AV causes an accident due to system failure, platooning, higher traffic speeds or risk-taking (Ontario, 2020a; Litman, 2021). In a driverless future, questions arise about the division of responsibility between the agents who bear functional responsibility for technological vehicle components, algorithms and public infrastructure, as well as the division of responsibility and liability between different service providers who may cooperate in an integrated mobility system. For example, how are liability issues divided when customers transfer from public transit services to private mobility services? In the case of transit agencies, transit drivers currently play an important role by monitoring the passenger area and assisting, mediating or informing passengers:

> *"For people who need assistance, the driver is a safety person. Someone you can ask questions to get help or directions, if you need it. So how does that whole customer experience change with AVs?"* (I-05)

Regarding data generated by AVs and collected by service providers, experts address privacy implications and cybersecurity measures that need to protect against information misuse through tracking, facial recognition or data sharing (I-02; I-04). It is perhaps less of a challenge and more of a general concern that all government parties and planners should be required to engage in and develop a better understanding of the issue. Urban planning professionals specifically should be knowledgeable about the data collected by AVs, the public's data needs, the areas of built form and public space that may be affected by monitoring and the resulting privacy requirements (I-04). When it comes to ensuring privacy standards in public space, however, a limiting factor is that data collection regulations are administered by the provinces and federal government, leaving municipalities with an advocacy role at best.

Experts further address the issues of data standardization and institutional data exchange, which are particularly important to ensure comprehensive data collection, sharing and accessibility (I-08). If municipalities are to use AV mobility data to refine their transportation demand management, draw conclusions on operational compliance and inform potential infrastructure investments that are regionally aligned, service providers must provide data in a standardized format. Only then would it be feasible to augment operational data with that of other institutions, transit agencies or health authorities, and thus analyse the impact of AVs more holistically (Steckler et al., 2021: 27). To illustrate the importance of data collection and management, one of the initial planning programs for CAVs outlined in the *CAV Readiness Plan* is titled "Data Needs and Management Plan". Its conceptual description highlights some of the important aspects that municipalities and regions need to consider in order to ensure effective data exchange and consistent management: a data sharing model, data retention policies, digital infrastructure requirements, security and privacy requirements, as well as a data dictionary (Ontario, 2020a: 56).

Finally, one expert points out that the technology's adaptation to cold weather environments poses a critical safety issue that affects the potential adoption of AVs in the GTA. After all, heavy snowfall and rain can disrupt technological applications that AVs rely on. Accordingly, the *Tactical Plan* includes a related tactic which states, "The City of Toronto will address concerns around the environment by encouraging AV technology that is proven to contribute to road safety improvements in these conditions." (Toronto, 2019a: 78). The underlying assumption is that manufacturers will develop new means of responding to environmental constrains, such as high-definition maps or protective sensor coatings. However, it is too early to know whether technological advances will ultimately solve the associated issues and at what point such AVs will become commercially available, or, better yet, affordable.

Labour implications

Finally, experts addressed the concern of transit agencies and the taxi industry that vehicle automation could cause labour displacements in the transportation sector (I-05; I-16). Given that Toronto's transit agency alone employs more than 14,000 Torontonians and includes a large proportion of service personnel, the prospect of fully automated vehicles raises unease about labour issues. On the one hand, because automated vehicles could replace a large number of drivers. On the other hand, because shifting the workforce from front-end workers to higher-skilled back-end workers may not be feasible by retraining the existing labour force alone.

The economic restructuring underway in the region gives reason for such concerns. Globalization and automation processes have substantially affected the economic landscape in the metropolitan area surrounding Toronto, which has traditionally been characterized by the automotive manufacturing industry (Moffatt et al., 2021). Over the past two decades, an increasing number of companies have replaced routine and lower-skilled tasks with automation, while expanding their research activities and collaborations with universities and colleges (Wolfe & Goracinova, 2017). Furthermore, the transition to a knowledge economy has had uneven effects on the labour force and regional geography. While Toronto is faced with rapid economic growth and a hyper-concentration of knowledge-intensive jobs – highly specialized and often technology-related – medium-sized and smaller communities with traditionally large manufacturing sectors in particular are experiencing much slower growth (Blais, 2018; Moffatt et al., 2021).

Interestingly, however, research also shows that in cities such as Toronto, the growth of knowledge-intensive ICT and the finance sector has simultaneously boosted employment in transportation, warehousing and construction (Moffatt et al., 2021). This suggests that transit services play a critical role in attracting knowledge-intensive activities to an area (Blais, 2018). In terms of its large proportion of service personnel, the recent adoption of automated train control on Toronto's subway has thus far not eliminated any jobs. Instead, the agency invested in targeted re-skilling of operators to become customer service agents. This scenario is also being envisaged for automated on-demand services, which may no longer require a driver, but instead have a ride attendant on board that looks after passengers with special needs, e.g. the mobility impaired, elderly or children (NLC, n.d.).

6.2. Present challenges concerning mobility and urban development

With respect to the potential introduction of AVs in the Greater Toronto Area, experts point to a number of existing mobility and urban development challenges. Some of these issues specifically affect downtown Toronto, while others concern its suburban boroughs or transport development on an entirely regional scale. To structure the variety of issues, they are listed from a small to a large scale. This is consistent with one expert's assessment that impacts on downtown Toronto will mainly relate to its streetscapes and rights of way, while larger changes in land use may only occur around suburban transit nodes and in regional municipalities (I-10). The listing also takes into account the number of experts referring to an issue, without suggesting a prioritization.

6.2.1 Street design: Competing interests over curb access

When considering recent technological changes in the mobility system, several experts refer to the issue of growing competition for curb access between ride-hailing companies (e.g. Uber or Lyft) and public transit or cyclists (I-01; I-04; I-05). Given the rapid growth of new mobility services across North America, the curb has been termed "the next urban battleground" (Crawford, 2018). In downtown Toronto, Bay Street is cited as an example of ride-hailing companies undermining bus priority along the curb. Being a major arterial road cutting across the city's financial district, space is limited and demand for curb access particularly high:

> *"[The] constant pick-up and drop-offs from taxis and TNCs prohibit the flow of the bus service, which is serving a much higher number of people."* (I-04)

A data study published in 2019 by Transportation Services' Big Data Innovation Team on the local impacts of ride-hailing confirms the experts' observation. As the number of ride-hailing trips in the City of Toronto grew by 180 % between 2016 and 2019, the majority was concentrated in downtown Toronto or near transit stations, shopping destinations and postsecondary institutions in surrounding neighbourhoods (Toronto, 2019b; Fig. 6.1). Within the city centre, hotspots of pick-up and drop-off activity were in fact found along streets such as Bay Street and Wellington, which run through Toronto's Financial and Entertainment Districts (ibid.; Fig. 6.2.). The analysis further revealed that a significant proportion of pick-up and drop-off activity occurred within no-stopping areas for cars and near or on cycling infrastructure, posing a risk of collisions between passengers and cyclists. Despite indications that the conducted data analyses will inform the City's *Curbside Management Strategy* and lead to further research (Toronto, 2019b: 47), some interviewed experts remained sceptical about the report's potential to prompt substantial policy action.

Figure 6.1 Average PTC Drop-offs across the City of Toronto – September 2018

Source: From *The Transportation Impacts of Vehicle for Hire in the City of Toronto*, by City of Toronto, 2019b: 12.

Figure 6.2 Average PTC Drop-offs across in Downton Toronto – September 2018

Source: From *The Transportation Impacts of Vehicle for Hire in the City of Toronto*, by City of Toronto, 2019b: 12.

One interviewee addressed the report's lack of policy recommendations or regulatory measures (I-05). This is an important consideration, as a recent study showed that Toronto's Curbside Management Strategy, approved by the City Council in 2017, would require a corresponding update. Regulatory measures in the strategy that are relevant to the growing competition for curb access are either defined as long-term options or are generally absent (Lee, 2020). Several interviewees mentioned a lack of political will to contain the growing demand for ride-hailing and regulate curb access by service providers (I-05; I-06), while another noted that it was simply not the priority in the latest round of policy revisions by the City of Toronto (I-12). In order to prompt policy action on curb access priority, congestion charges or parking time, data analyses would have to indicate a more dramatic increase in traffic congestion or a public risk, one expert asserted:

> *"It's not a public safety issue, generally, it's not a public health issue. Just being a traffic nuisance isn't a good enough reason, from their perspective."* (I-06)

Planning and Institutional Context

The aforementioned *Curbside Management Strategy*, prepared by the City of Toronto in 2017, is a high-level policy framework that aligns with the Official Plan's curbside management policy (Toronto, 2022a: 2-36; Stout, 2021). In addition, the City has a number of different documents that inform the planning of Toronto's street network, the design of streetscapes and the use of curbsides (Table 6.2). The overarching document is the city's legally binding Official Plan, which was amended in 2014 to incorporate Complete Street principles. In 2020, the City Council also adopted Amendment 456 to include policies on AVs, shared mobility and other emerging mobility technologies in the Official Plan. The amendment was approved by the province in 2021, but has not come into effect at the time of writing.

Table 6.2 Policy and legal context for street and transportation development in the City of Toronto

Provincial Legislation	Date of Issue/Amendment	Agency
Public Transportation and Highway Improvement Act	• 1990	• Government of Ontario
Planning Act	• 1990	• Government of Ontario
Highway Traffic Act	• 1998	• Government of Ontario
Municipal Policies and Plans	**Date of Issue/Amendment**	**Agency**
Toronto Official Plan	• 2014 • 2020	• City Planning
Pedestrian Charter	• 2002	• Pedestrian Committee
Walking Strategy	• 2009	• Transportation
Complete Streets Guidelines	• 2017	• Transportation Services; • City Planning; • Toronto Urban Fellows; • Engineering and Construction Services

Curbside Management Plan	• 2017	• Transportation Services
Vision Zero 2.0 – Road Safety Plan	• 2019	• Transportation Services
TransformTO Net Zero Strategy	• 2021	• Environment & Energy Division
Cycling Network Plan	• 2019	• Transportation Services
Accessibility Design Guidelines	• 2021	• City Planning; • People & Equity; • Corporate Real Estate Management; • Parks, Forestry & Recreation; • Transportation Services
Streetscape Manual User Guide	• 2019	• City Planning
Municipal Programs	**Date** **of Issue/Amendment**	**Agency**
Street Furniture Program	• 2007	• Transportation Services
ActiveTO Program - Cycling Network Program - Quiet Streets - Complete Street Pilots	• 2020	• Transportation Services
CurbTO	• 2020	• Transportation Services; • Toronto Public Health
CaféTO	• 2021	• Transportation Services

Source: table by the author.

The discussion on the future management of curb access and street design touches on the issue of divisional responsibility in the City of Toronto. Several interviewees addressed the separation of powers and responsibilities between the City of Toronto's planning division and transportation division. The latter's responsibility was described as being focused on operational decisions regarding road systems, which tend to have a short-term planning horizon and to be of tactical nature (I-03; I-04). This includes managing traffic operations for people and goods, right-of-way, emergency and utility vehicles, work zones, the use of public space, as well as developing a pedestrian circulation strategy and bicycle plan. The city planning division, on the other hand, ensures that building volumes leave enough space for public space by specifying accessways and facades in its urban design guidelines. Beyond these two divisions, many other departments and agencies influence the various uses of Toronto's streets, e.g. Economic Development and Culture, Parks Forestry and Recreations or Toronto Public Health (Chapman, 2014). The repurposing of street space or parking and the balancing of competing interests for curb access thus poses an institutional challenge, despite individual examples of successful collaboration (I-06; I-10).

One such success is the development of Toronto's *Complete Street Guidelines,* published in 2017 in response to the Complete Streets policy that was incorporated into the 2014 Official Plan amendment. The Guidelines provide a comprehensive design framework and reference guide for safe and accessible streets that accommodate a range of users and uses. However, Toronto City Council never adopted the policy document, which calls into question its effective implementation, as its policies are not legally binding. The promotion of cycling and active mobility has also been hampered, according to some experts. Despite the growing awareness that Toronto needs to increase pedestrian and cycling safety, the expansion of the cycling network remained limited until 2019 (I-06; I-07). However, the views of experts interviewed on this issue differ, as another expert noted that investment in safety measures, such as bicycle lanes, lower speed limits and tighter curb radii, has increased along residential laneways in Toronto (I-10).

Such initiatives are likely due to updates to the city's *Vision Zero 2.0 – Road Safety Plan* and *Cycling Network Plan,* both of which were adopted by the City Council in the summer of 2019. The *Vision Zero 2.0* update, in particular, includes aspects of the Complete Streets concept and aims to increase traffic safety in every road reconstruction project by incorporating street design changes such as vehicle lane reductions, wider sidewalks, as well as the aforementioned safety measures. For Smith Lea & McClelland of the Centre for Active Transportation, the update represents a "more robust, proactive and targeted approach to eliminating serious injuries and fatalities on Toronto's roads." (2019), as it formalizes the principles of Complete Streets and enables municipal staff to implement them accordingly. In this sense, the strategy of combining the legally binding Vision Zero plan with elements from the *Complete Streets Guidelines* is more than a mere refinement of existing planning policy. It introduces new principles to the way streets are rebuilt in Toronto, with the primary goal of improving traffic safety. However, if implemented on a larger scale, these measures may subsequently impact people's mobility behaviour and the system as a whole.

One of the often-mentioned examples of a comprehensively converted main street is the *King Street Transit Priority Corridor*. Originally launched as a pilot initiative in 2017, its goal was to eliminate the traffic congestion along Toronto's busiest surface transit corridor while enhancing public space and economic vitality (Toronto, 2017c). Planning measures were sought that would be cost-effective and would deliver significant improvement within a short timeframe. To effectively prioritize streetcars and active travel along the two-and-a-half-kilometre route, cars were prohibited from driving through intersections and instead were required to turn right (Doucet & Doucet, 2022: 248). The 504 King streetcar line is no longer characterized by extensive waiting times and overcrowded cars. Average weekday ridership increased by 29 % in the first year of the pilot due to improved transit reliability and travel times (ibid.). Meanwhile, the number of cyclists nearly doubled, making King Street the second most popular street for cycling before the pandemic (Sanderson, 2019). In terms of public space, former parking bays have been repurposed as miniature seating areas and parklets that now invite people to socialize, rest or take a lunch-break (ibid.). In

2019, Toronto City Council voted to make the King Street Transit Priority conversion permanent, transforming its temporary streetcar stops and seating areas into permanent facilities.

Other precedents demonstrating that road safety and mobility improvements have an equally positive impact on public health and economic activity of local businesses include Toronto's *Bloor Street Bike Lane Pilot* (established in 2016) and, more recently, the *ActiveTO* and *CurbTO* programs. While the former primarily addressed safety issues and traffic risks, the latter programs were launched in response to challenges during the pandemic-related lockdowns in 2020. Under pressure from public health concerns and the need for a city-wide recovery plan, Toronto City Council tasked its transportation division and health commissioner with developing strategies to provide better physical distancing for pedestrians, cyclists and public transit riders (Toronto, April 30, 2020). In addition, City Council requested to review possibilities "of fast-tracking projects within the 10-Year Capital Plan for Vision Zero and cycling infrastructure" (ibid.). The motions are historic for Toronto in that they paved the way for the city's largest expansion of on-road cycling facilities in one year. Within the framework of the *ActiveTO* program, both temporary and permanent cycling facilities were installed along ten arterial segments across the city, including Bloor Street, Danforth Avenue, University Avenue and Yonge Street.

In turn, CurbTO was introduced to install temporary infrastructure measures along curbs, as a remedy to congested sidewalks and temporary parking problems in front of essential businesses (Toronto, 2020d). Curb Lane Pedestrian Zones provided space for pedestrian queues, and Temporary Parking Pick-Up Zones allowed drivers to briefly stop for groceries or pick up medications. After the program's launch, 81 pedestrian lane zones and 60 parking pick-up zones were temporarily established across the city. A significant, albeit modest, number considering that many of these zones were located along major or minor arterials, which together account for 1,175 kilometres across the City of Toronto. It is noteworthy, however, that the program is referenced as part of the implementation of the *AV Tactical Plan*, which includes short-term tactics for "7.1.3 Designated Loading Areas" (Toronto, 2019a: 99). While the evaluation of CurbTO is still pending, reports of pilot programs implemented under the ActiveTO program show distinct positive impacts.

Evaluation of the benefits of complete street projects in the GTA has not been consistently or systematically pursued, which has hampered the ability of municipalities to measure their compliance with provincial policy goals (Smith Lea et al., 2016: 44). However, evaluations of the *Destination Danforth Complete Streets pilot* and the *ActiveTO Midtown Complete Street Pilot* show that the pilot initiatives encouraged a shift to more active modes of transportation and significantly increased the sense of safety among cyclists and pedestrians (Toronto, 2022e; Carriere et al., 2022). Along Yonge Street, safety was also improved for food delivery workers, who accounted for 20 %

of all cyclists on the street in 2021. Importantly, in both instances, the combined improvements to cycling facilities and outdoor dining areas encouraged 30 % of survey respondents to visit the street and local businesses more frequently (Toronto, 2022e; Carriere et al., 2022). The identified disadvantages included inconsistent traffic reduction, while users continued to have concerns about finding parking, traffic congestion, crossing intersections with bicycles on the road and the accessibility for those with mobility needs (Toronto, 2022e; Carriere et al., 2022).

The above projects serve as examples of municipal planners attempting to resolve competing curbside uses by applying various tactics from both the Complete Streets Guidelines and Toronto's 2017 Curbside Management Strategy. Although recent studies point out that Toronto still lacks additional levers, such as dynamic pricing policies (Lee, 2020: 13-14), recent initiatives to change street design and improve active transport reflect what Hess (2009) has previously described as "cultural shifts in the expected roles of streets in contemporary cities, making arterial streets into places that support pedestrians and social activity" (22). Prior to these efforts, the design of Toronto's streets "primarily prioritized the fast, efficient movement of cars above all other modes" (Smith Lea et al., 2016: 1). This legacy has been both constraining and stimulating for alternative planning practices. Over the past decade, various policies and strategy documents have been introduced that lay the groundwork for a streetscape transformation that supports systemic goals:

> *"In a mature city like Toronto, the emphasis has to be on using the available road space more efficiently to move people instead of vehicles and on looking at how the demand for vehicle travel can be reduced in the first place. Reducing car dependency means being creative and flexible about how we manage urban growth. We have to plan in "next generation" terms to make walking, cycling, and transit increasingly attractive alternatives to using the car and to move towards a more sustainable transportation system."* (Toronto, 2022a: 2-34)

The important question thus remains to what extent the City is willing to inform its existing policy documents – the *Vision Zero 2.0 – Road Safety Plan*, the *Curbside Management Strategy*, the *Freight and Goods Movement Strategy* – based on the project evaluations and refine its policy approaches accordingly. Is the gathered evidence convincing enough for city officials to support the upscaling across the city network and to realize the objectives of the Official Plan?

6.2.2 Transport network: Transit and infrastructural capacity limits

In light of a possible future with automated mobility, experts are concerned with the challenge of promoting a greater mode shift to transit in the region as a whole and in the City of Toronto in particular. One of the reasons cited by a transit expert concerns the low reliability of the surface network, i.e. buses and streetcars. The City is home to the most extensive streetcar network, servicing 70 % of all transit trips (TTC, 2019), and a bus network with the highest ridership in North America. Yet its operation is hampered by slow travel speeds, traffic congestion and unreliable schedules, which is proving to be a competitive disadvantage in the context of new mobility options. A recent survey on passengers' choice of ride-hailing services showed that travel time and reliability are the most important factors influencing transit choice, while convenience, comfort and safety have greater impact on the use of ride-hailing services (Loa et al., 2019: 49).

For the transit network to remain competitive in an environment with an increasing number of mobility options, one interviewee argued that surface transit vehicles need to be prioritized on streets and at traffic lights throughout the network (I-05). Possible strategies to do so range from exclusive bus lanes to queue-jump and signal priority – strategies that could increase transit reliability and efficiency and are well known to the transit agency (TTC, 2019: 60-63). If automation and vehicle-to-infrastructure are used to improve the existing network transit priority can be enhanced (I-01). For example, streetcars and buses could benefit from streetlight communication and real-time data (I-05). Another interviewee added that it is not merely an issue of infrastructure provision but also fare distribution. If private mobility providers such as TNCs are integrated with the traditional transit network, suburban transit agencies in particular could receive part of the fare revenue (I-09-B). However, if private service providers compete with transit agencies in providing the service and gaining revenue, this could put an additional strain on suburban transit companies.

There are infrastructural capacity constraints associated with the challenge of promoting transit ridership, particularly on the main axes leading into downtown Toronto (I-04). Both the subway network and the two highways that function as primary links between the city centre and its suburban neighbourhoods and surrounding municipalities were congested in the years before 2019. Daily travel demand exceeded infrastructural capacity and led to peak time congestion. Toronto is therefore under pressure to enhance the capacity and operational efficiency of its mobility network without building new infrastructure. Given significant population and employment growth in the coming decades, as well as emerging trends such as ride-hailing companies that compete with transit and induce travel demand, the need for more competitive transit is ever more pressing.

Planning and Institutional Context

Although the *Metrolinx Act* requires that municipalities in the GTA have transportation master plans that are consistent with Ontario Ministry of Transportation policy (Irwin & Bevan, 2010: 13), as of 2022 the City of Toronto does not have a separate mobility strategy that complements its Official Plan (Table 6.3). Its Official Plan incorporates long-term transit planning as part of growth management policies that focus on "a pattern of compact centres, mobility hubs, and corridors connected by a regional transportation system, featuring fast, frequent, direct, inter-regional transit service with integrated services and fares" (Toronto, 2022a: 2-2). In line with the *2041 RTP* (Metrolinx, 2018: 58), urban growth and investments in transit are intended to reduce automobile dependency and thereby improve air quality. As with other municipalities in the GTA, e.g. Mississauga or Brampton, Toronto refers to the RTP as part of its broader policy context. Other documents that guide transit development include the TTC's *5-Year Corporate Plan & 10-Year Outlook,* as well as the City's road safety plan *Vision Zero 2.0* and climate action strategy *TransformTO Net Zero Strategy*.

Table 6.3 Policy and legal context for transit development in the City of Toronto and the Region

Provincial Legislation	Date of Issue/Amendment	Agency
Public Transportation and Highway Improvement Act	• 1990	• Government of Ontario
Planning Act	• 1990	• Government of Ontario
Highway Traffic Act	• 1998	• Government of Ontario
Environmental Assessment Act	• 1990	• Government of Ontario
Places to Grow Act	• 2005	• Government of Ontario
Metrolinx Act	• 2006	• Government of Ontario
Bill 107, Getting Ontario Moving Act	• 2019	•
O. Reg. 248/19: Interim Measures- Upload of Rapid Transit Projects	• 2019	•
Bill 171, Building Transit Faster Act, 2020	• 2020	•
O. Reg. 341/20: Ontario Line Project	• 2020	•
Regional Policies and Plans	**Date of Issue/Amendment**	**Agency**
Places to Grow: Growth Plan for the Greater Golden Horseshoe	• 2006	• Ontario Ministry of Housing
Connecting the GGH: A Transportation Plan for the Greater Golden Horseshoe	• 2022	• Ontario Ministry of Transportation
2041 Regional Transportation Plan	• 2018	• Metrolinx
Area specific or broad corridor multimodal studies and plans		
Highway corridor planning		
Metrolinx / Go Transit corridor planning		
Municipal Policies and Plans	**Date of Issue/Amendment**	**Agency**
Municipal Official Plans	• 2021	• City Planning
Toronto Official Plan	• 2014	• City Planning
5-Year Corporate Plan & 10-Year Outlook	• 2019	• Toronto Transit Commission

Vision Zero 2.0 – Road Safety Plan Update	• 2019	• Transportation Services
TransformTO Net Zero Strategy	• 2021	• Environment & Energy Division
Energy Conservation and Demand Management Plan	• 2019–2024	• Environment & Energy Division
Downtown Mobility Strategy	• 2018	• City Planning • Transportation Services • Economic Development & Culture • Environment and Energy • Fire Services • Parks, Forestry, and Recreation • Toronto Transit Commission (TTC) • Toronto Paramedic Services • Toronto Parking Authority (TPA) • Toronto Public Health

Source: table by the author.

The delivery of transit initiatives in Toronto and the Greater Toronto Area has recently undergone significant change. In 2019, the Ontario Ministry of Transportation put forward *Ontario Regulation 248/19* under the *Metrolinx Act*, which gives the provincial transit agency responsibility for planning, developing, and constructing some of the GTA's largest subway extensions in the coming years. The regulation follows years of negotiations over which level of government should be responsible for the TTC's subway system, given the significant investment, operating and maintenance costs, as well as the growing importance of the projects to the entire city region (Siemiatycki & Fagan, 2019). As a result, transit development in the Greater Toronto Area is more than ever subject to multifaceted governance arrangements between local transit agencies, Metrolinx and the Province.

The public transit system is deeply rooted in Toronto's urban fabric and the historical development. Its streetcar lines, which are a century old, serve a dense and walkable urban core and represent "the only true legacy rail system in Canada" (Spieler, 2021: 154). Toronto's downtown neighborhoods and commercial main streets were essentially built around the streetcar, making them the busiest surface transit routes in the city to this day (ibid.). In 1921, the Toronto Transit Commission was established as a municipally owned and operated organization to provide coordinated transit and modernize existing track and rolling stock (Doucet & Doucet, 2022). After World War II, some of the less frequented lines were replaced by buses, while others were upgraded with subways to support the city's growth. In effect, the streetcar system was reduced to eight lines by 1981 (Doucet & Doucet, 2022: 13). The TTC's intention to replace all streetcar lines with subways was successfully prevented by a group of transit advocates in 1972 and by the 1980s, the TTC resumed the expansion of its streetcar lines (Spieler, 2021).

In order to connect the city with what was then Greater Toronto, the provincial government established a commuter rail system known as GO Transit in the 1960s, which has been operated by Metrolinx since 2009. Today, the GO Transit network includes both a rail system and an extensive regional express bus system that form part of Greater Toronto's suburban transit network. Other BRT and express bus services are operated by Miway in Mississauga, YRT in York Region and Brampton Transit (ibid.). In sum, it is fair to say that the City of Toronto is serviced by an extensive transit system that was continuously expanded since the 1920s, although expansion projects have often been and continue to be described as "erratic planning driven by municipal and provincial politics" (Spieler, 2021: 154).

Looking at the interplay between transport planning and land use development during the same period, it is evident that there were significant differences in the coordination of land use and transportation planning (Miller & Soberman, 2003). The effects of which would manifest in high levels of congestion, low service reliability of the TTC's surface network and limited infrastructure capacity prior to the outbreak of the pandemic. As many scholars note, the prime era of integrated planning policy dates back to the 1950s, 60s and 70s when Metropolitan Toronto (Metro) was established by the Province of Ontario as an upper tier regional municipality (Miller & Soberman, 2003; Sorensen & Hess, 2015). The newly founded institution was put in place to coordinate and fund public services such as water supply, expressways, sewers, schools and public transit, thereby relieving suburban governments of associated planning responsibilities during a period of rapid growth (Frisken, 1991: 272).

Responsibility for public transit in metropolitan Toronto was assigned to the TTC, resulting in the enlargement of its servicing area from 35 to 240 square miles. In line with Metro's 1966 Transportation Plan, 35 miles of subway lines were built until the 1980s (Frisken, 1991). In contrast to the Transportation Plan, however, more than 20 % of the planned expressways were not constructed, representing a significant shift in the original focus of the transportation system (ibid.). Moreover, the constructed subway lines included extensions that were not initially planned but were the result of a metropolitan government increasingly under the influence of suburban municipalities growing in population. The extensions of the TTC's surface network were equally focused on suburban municipalities at the time – providing the conditions for high levels of suburban transit ridership compared to other North American cities (Spieler, 2021). In sum, transit development during this period took place in a highly coordinated and centrally planned manner and effectively impacted transit ridership (Miller & Soberman, 2003), even though it could not prevent the overall shift to the automobile in the city region.

In contrast to this era, the developments of the 1980s, 90s and 2000s were far less transit-oriented and coordinated (Miller & Soberman, 2003), ultimately leading the OECD to diagnose that Toronto's economic competitiveness in the early 2000s was significantly constrained by the region's underinvestment in infrastructure and its failure to keep pace with rapid growth (OECD, 2010). The consequence was congestion and sprawl, inadequate transit provision and a car-dependency of 71 % among GTA residents (ibid.). In the decade following the OECD report, the regional transit agency Metrolinx oversaw construction projects on existing transit systems, e.g. parking lots, GO railway tracks, tunnels and bridges as well as GO stations, and led major expansion projects, including the York Region VivaNext BRT, the Mississauga Transitway or the UP Express connecting Toronto Pearson International Airport to Union Station (Metrolinx, 2016: 18). Yet, despite all these efforts, an expert advisory panel of Toronto's Transportation Services and the TTC describes the state of transit in the Toronto region as virtually unchanged in 2019:

> *"Transit in Toronto and the surrounding region suffers from funding shortfalls and insufficient coordination and integration.*
>
> *Over the next 50 years, the Toronto region is projected to grow substantially faster than New York, Chicago, and Los Angeles. A well-functioning transit system is key to the region's continued economic success."* (IMFG, 2019: 5-7)

Aside from the long-debated and costly subway expansions, many of which are currently underway, there have also been recent transit improvements that do not require substantial infrastructure investments. Measures such as "changes to rights of way on roads or the implementation of bus rapid transit routes" and "bus priority lanes" (IMFG, 2019: 7) are not only recommended by an expert panel on transit improvements, but also by the interviewed experts in the context of an AV future. Further strategies include queue-jump lanes and signal priority (I-05). The aforementioned *King Street Transit Priority Corridor* serves as one such example in the City of Toronto, where low-cost interventions have been successful in delivering significant service improvements.

Building on the success of the King Street Pilot, Toronto's transportation division and TTC launched a partnership in 2020 to address the long-standing issue of slow and unreliable service. Data that was collected by the City between January 2019 and February 2020 shows that 22 % of buses and 34 % of streetcars on Toronto's streets experienced delays during that time (Toronto, 2021b). Under *RapidTO: Bus & Streetcar Priority*, the aim is now to improve reliability, speed and capacity by adding bus priority lanes on the TTC's busiest surface transit routes. An evaluation of the surface network resulted in prioritizing their implementation along six corridors in the years 2020, 2021 and beyond: Eglinton East, Jane Street, Dufferin Street, Finch East, Steeles West and Lawrence East (Toronto, 2020e). In line with recommendations from planning experts to prioritize transit in low-income neighbourhoods (Sanderson, 2019), the Eglinton East corridor – the first *RapidTO* priority bus line – focuses on improving transport equity by serving so-called Neighbourhood Improvement Areas in the inner suburbs.

According to the city's initial data evaluations, the introduction of *RapidTO* has resulted in shorter transit commuting times and increased transit reliability, while reducing travel times by car (Toronto, 2021b). However, critics point out that the interventions along Eglinton East include the elimination of stops, which contributes to the reduced travel times and makes it difficult to distinguish what impact the priority lane itself is having (Munro, 2022). Furthermore, network-wide effects remain absent as long as improvements are limited to individual corridors. This is viewed as a precondition not only for systemic benefits such as improved network performance, but also for the broad political support from residents necessary to continue and expand transit planning efforts on a larger scale (Munro, 2021). Nonetheless, as highlighted in the 2019 advisory report to Transportation Services and the TTC, service improvements represent incremental changes that are but one part of a multi-layered comprehensive transit planning approach (IMFG, 2019).

The main issue that will determine the success of any current and future transit improvements in the Toronto region remains funding the long-term costs of expansion, operation, maintenance and replacement (IMFG, 2019). The Toronto City Summit Alliance highlighted the issue as a key barrier to achieving the 2008 *Big Move* (Irwin & Bevan, 2010) and it remains true that balancing service levels with funding needs is a key challenge for the future of transit in the GTA (Siemiatycki & Fagan, 2019). In 2019, the TTC alone was two-thirds short of the funding needed to maintain the transit system in a "state of good repair" (Siemiatycki & Fagan, 2019: 9). Three years later and two years into the pandemic, the TTC's *2022–2036 Capital Investment Plan* again indicates a funding coverage of 40 % and $22.5 billion in unmet projected costs over a 15-year period (Toronto, 2022c: 27). Although critics point to service management as a key challenge to the success of the TTC (Munro, 2021), both the service issues and the diversification of funding streams are partly beyond the control of an individual transit agency and instead touch on issues of intergovernmental coordination and governance (see Chapter 6.3).

Adding to the challenges of funding and service provision, transit ridership in Toronto has been slow to recover from the dramatic decline in transit use due to the Covid-19 pandemic (Higgins et al., 2021). This is partly due to a persisting shift to driving and active transportation modes, which challenges assumptions about future travel demand and mode choice (ibid.). And while the interviewed experts and regional policy assessments assert that the manner in which transit is operated and planned in the Toronto region is not adequate to the changing realities, the transit priority measures mentioned above represent an instance of local planning authorities and governmental representatives expediting infrastructure measures in areas of greatest need: servicing essential workers and maintaining access to opportunities in underserved neighbourhoods. Even if effective improvement in system performance requires systemic and comprehensive implementation of such schemes (Higgins et al., 2021), *RapidTO* creates a precedent for cost-sensitive improvements and service operations. These are critical factors in a post-pandemic era in which transit agencies are struggling to attract ridership and sustain operating budgets, while increasingly challenged to compete with new mobility services that may one day be automated.

6.2.3 Urban development: Car-centric spatial patterns

The characteristics of urban form in the Greater Toronto Area are a critical dimension when considering future shifts in mobility patterns. The interviewed experts described the promotion of transit to be particularly challenging in historically car-dependent suburban districts, such as Etobicoke and Scarborough. In Etobicoke, for instance, transit accounts for an average of 20 % of all trips, compared to a mode share of 28 % for the City of Toronto as a whole (Malatest & Associates, 2018). Low transit demand in low-density areas renders the operation of conventional buses or streetcars unfeasible, making high-capacity transit lines difficult to access. Interviewees thus argued that the challenge of shifting people in the GTA to transit is not rooted in its transportation network:

> *"I really think it's a land use issue more than a transport issue."* (I-07)

In this light, closing the first-/last-mile gap through automated shuttles that can be operated at lower cost represents one of the focus areas in the GTA, as demonstrated by the automated shuttle pilots implemented in Toronto and neighbouring municipalities (see Chapter 4.4.1). Despite scepticism about the cost-effectiveness of smaller vessels within Toronto's city limits, experts acknowledge that shared automated feeder systems may contribute to improving the regional transit system in suburban municipalities (I-04; I-05; I-09-A). Depending on the type of service, benefits could range from relieving limited parking at GO transit stations to providing mobility options for the elderly population who have lived in car-dependent neighbourhoods all their lives and are unlikely to move (I-09-B), and achieving the 2041 RTP objective of better land use and transport integration:

> *"[AVs] might allow for intensification in high suburban growth centres or places with large surface parking lots. They could turn into spaces for living without your car."* (I-10)

However, interviewees also referred to the "growing pains" (Burchfield & Kramer, 2015: 19) of the rapidly expanding metropolitan region. These concern the challenge of achieving adequate density levels to support basic transit service, insufficient integration of land use and transit development, and decades of underfunding of transit and transportation infrastructure in the GTA (Irwin & Bevan, 2010: 8). Despite significant updates to the region's planning framework since 2006, interviewees shared the assessment that its development and growth centre policies supporting transit had little impact in subsequent years (I-03; I-07). Policies for transit-oriented development, for instance, have led to hardly any case studies outside of the City of Toronto (I-09-B), although the updated version of the 2017 *Growth Plan* and the new regional transportation plan, the *2041 RTP,* included policy goals to this effect. According to one expert, this was partly due to the fact that several of the new growth centres were planned in areas that already had land use plans in place, which aligned with earlier intensification levels and called for low-density, suburban development (I-07). In this sense, the insufficient implementation of progressive policies in the GTA has partly been affected by the time lag between planning practice and policy adaptation.

Other experts point to the challenge of successfully implementing TODs, which requires cooperation between transit agencies, local municipalities and developers. Insufficient coordination and alignment of plans can lead to what one expert described as "TAD – transit adjacent development" (I-09-A). Residents are then faced with inconvenient transfer points and station access points, often characterized by long and winding footpaths rather than seamless transfer. In this sense, creating successful TODs is not merely a matter of increasing densities along higher order transit stations, but also a matter of working effectively with developers and rigorously implementing station access plans that prioritize pedestrians and cyclists.

Planning and Institutional Context

The *Provincial Policy Statement* and *A Place to Grow: Growth Plan for the Greater Golden Horseshoe,* prepared by the Ontario Ministry of Municipal Affairs and Housing and in effect since May 2019, are the two main policy documents directing land use development as well as population and economic growth (Table 6.4). While the first document applies to all of Ontario and provides policy guidance on growth, environmental protection and public safety, the second is specific to the geographic area of the Greater Golden Horseshoe and sets out specific land use priorities, policies and targets (OAGO, 2021). Under the provincial *Planning Act*, municipalities must ensure that all "decisions affecting planning matters" (Ontario, 2020c: 2) are "consistent" with the Provincial Policy Statement. Under the *Places to Grow Act* municipalities must further ensure that their Official Plans conform to the provincial Growth Plan by revising official plans and incorporating relevant policy by a specified deadline. Official Plans (OP) are considered the primary planning instrument through which municipalities achieve comprehensive, integrated, and long-term planning (Ontario, 2020c). They lay out municipal development visions and key principles, and define policies on how and where urban development takes place.

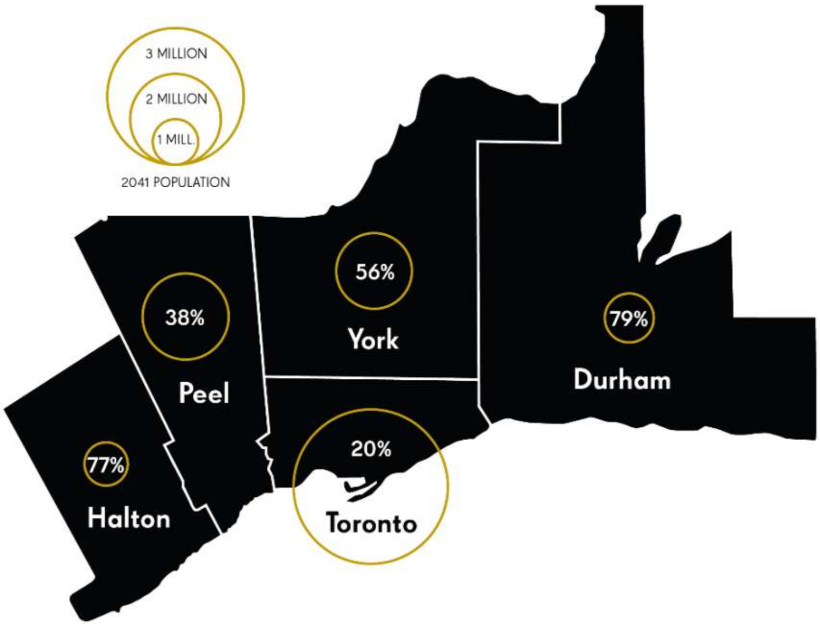
Table 6.4 Policy and legal context for urban development in the Greater Toronto Area

Provincial Legislation	Date of Issue/Amendment	Agency
Planning Act	• 1990	• Government of Ontario
Niagara Escarpment Planning and Development Act	• 1990	• Government of Ontario
Ontario Planning and Development Act	• 1994	• Government of Ontario
Highway Traffic Act	• 1998	• Government of Ontario
Oak Ridges Moraine Conservation Act	• 2001	• Government of Ontario
Places to Grow Act	• 2005	• Government of Ontario
Greenbelt Act	• 2005	• Government of Ontario
Provincial Policy Statement	• 2020	• Government of Ontario
Regional Policies and Plans	**Date of Issue/Amendment**	**Agency**
Greenbelt Plan	• 2017	• Ontario Ministry of Municipal Affairs and Housing
A Place to Grow: Growth Plan for the Greater Golden Horseshoe	• 2019	• Ontario Ministry of Municipal Affairs and Housing
Connecting the GGH: A Transportation Plan for the Greater Golden Horseshoe	• 2022	• Ontario Ministry of Transportation
2041 Regional Transportation Plan	• 2018	• Metrolinx
Municipal Policies and Plans	**Date of Issue/Amendment**	**Agency**
Municipal Official Plans	• 2021	• City Planning (City of Toronto)
Secondary Plans, Site Plans, etc.		

Source: table by the author.

In less than a century, the Toronto region – now known as Greater Toronto Area – grew rapidly from a relatively compact city of roughly 1.0 million inhabitants in the 1940s to a metropolitan region of 7.1 million inhabitants in 2021 (Ontario, 2021c). Until 2046, the region's population is projected to increase by another 2.9 million, making it the fastest growing region in Ontario. This is a remarkable trend for a region strained by infrastructure needs and an urban fabric heavily reliant on the automobile. Adding to the challenge, much of the projected growth is expected to occur in historically car-oriented municipalities (Fig. 6.3). To understand how AVs could contribute to transformative change in mobility and urban development requires a closer look at existing urban patterns and the policy and planning decisions that have shaped them.

Figure 6.3 Population growth projections across the GTA in percentage and total numbers



Source: illustration by the author, based on *Statistics Canada 2016 Census,* in *2041 Regional Transportation Plan: For the Greater Toronto and Hamilton Area*, by Metrolinx, 2018: 33.

The Toronto region has been described as a concentrated agglomeration consisting of two "realms" (Filion, 2000) or two urban structures (Miller & Soberman, 2003). A dense urban core, characterized by its legacy railway system, and a low-density suburban fabric that is "fragmented into large functionally specialized zones." (Filion, 2000: 163). Such a binary view is of course reductive in a cultural and socio-economic sense and ignores the existing diversity between neighbourhoods, but it has also been challenged in spatial terms. In recent years, scholars have highlighted the contiguous and relatively dense pattern of regional growth (Hess & Sorensen, 2015) that distinguishes the Toronto region from others North American cities and dates back to the governance and planning models of the mid-20th century. It is thanks to the planning system of the time that Toronto is renowned for its regional planning tradition and has historically been considered successful in ensuring coordinated and orderly growth (Miller & Soberman, 2003; Wheeler, 2003). Some scholars argue that it continues to structure the relationships between levels of government and real estate developers, and thus urban growth, in the region today (Sorensen & Hess, 2015).

Regional planning in the GTA dates back to the post-war period, when growing industries and population numbers created the need for "metropolitan coordination of physical infrastructure, land use, and housing" (White, 2007: 8). The first regional plan drawn on a metropolitan scale was commissioned by the *Toronto City Planning Board* in 1942 and conceived by planners Tracy D. leMay and Eugene Faludi (Sewell, 2009). The master plan envisaged substantial suburban expansions, separated from the existing urban core by a lavish greenbelt and served by a network of superhighways and transit lines, essentially translating international planning ideas to the local Canadian context (White, 2007). However, neither the master plan nor its commissioning body, a citizen-led planning board, won the approval of Toronto City Council, thus failing to make a lasting impact.

More crucial to subsequent planning efforts was the Ontario *Planning Act* of 1946, which contained two formative policies. For one, it gave municipalities the power to develop legally binding official plans, and secondly, it allowed multiple municipalities to form a joint planning board (White, 2007). In direct response, the *Toronto and York Planning Board* was established to assume planning responsibility for the City of Toronto and the 12 surrounding towns (White, 2007). The inter-municipal efforts were the first of their kind. They emphasized the need for regional planning and laid important groundwork with metropolitan water supply and wastewater studies as well as a transportation plan (White, 2007). Ultimately, these initial planning efforts were formalized through provincial action. By forming a two-tier metropolitan government comprising 13 municipalities, the province also established the *Metropolitan Toronto Planning Board* (MTPB) in 1954 (Frisken, 1991; White, 2007).

The MTPB took responsibility for an area that included both Metropolitan Toronto as well as 13 villages and rural municipalities in its vicinity. Coordinating issues ranging from transportation to land use plans, as detailed in Chapter 6.2.2. Responsibility for local planning, land use regulation and local public works was left to local governments (Sorensen & Hess, 2015). However, the board's powers were limited, as the Minister of Municipal Affairs retained the power to approve land subdivisions (White, 2007). Despite the fact that neither the 1959 draft of the Official Plan nor the later published second version were formally approved by Metro Toronto Council, the success of the Board in effectively coordinating planning efforts is largely due to the persuasiveness of its members, its close collaboration with municipal planners and its recommendations to the province (Miller & Soberman, 2003; White, 2007; Sorensen & Hess, 2015).

In contrast to the prevailing planning ideal of accommodating growth through garden cities or satellite towns, the MTPB defined contiguous urban development as its core planning principle (White, 2007). Its primary goal was to plan large areas comprehensively and ensure efficient provision of infrastructure (Sorensen & Hess, 2015). Accordingly, the concentric urban form took its shape from the engineering vision that water and sewer lines should be centrally managed: "if the region was to be serviced by a centralized lake-based system, the most appropriate regional form was a large, single urbanized area" (White, 2007: 17). Density and land-use distributions, arterial roads, as well as water and sewage systems were based on detailed population and job projections for each of Metro's planning districts. Municipal planners then translated these projections into municipal Official Plans that had to be approved by the Ontario Minister of Municipal Affairs, thereby granting them legally binding status (Sorensen & Hess, 2015). The established planning hierarchy and the new practice of subdivision control created a planning system that ensured that spatial development within the boundaries of Metro Toronto would proceed in a highly controlled and coordinated manner.

As part of the new governance arrangement, a planning process emerged that Sorensen & Hess (2015: 412) have described as "a radical suburb-building model" that shaped the residential (sub)urban fabric from the 1950s until the 1990s. Based on the so-called "Concession Blocks" created by the arterial road grid, municipal planners developed secondary plans with corresponding subdivisions and site plans that were negotiated with developers (Sorensen & Hess, 2015). Control over subdivisions gave municipal planners the power to influence detailed designs, including the location of housing typologies, but also to coordinate larger areas of development. Sorensen & Hess (2015) argue that this practice, which continues to this day, shaped highly contiguous residential structures. In contrast to scattered and fragmented development often associated with urban sprawl, suburban neighbourhoods in the Toronto region are clearly distinct from their rural hinterlands. In some cases, neighbourhood designs even conform to smart growth principles, such as diversity of housing typologies – high-density housing and residential towers were particularly encouraged at the time –, as well as interconnected street networks and public infrastructure (schools and parks) in walking distance (Hess & Sorensen, 2015).

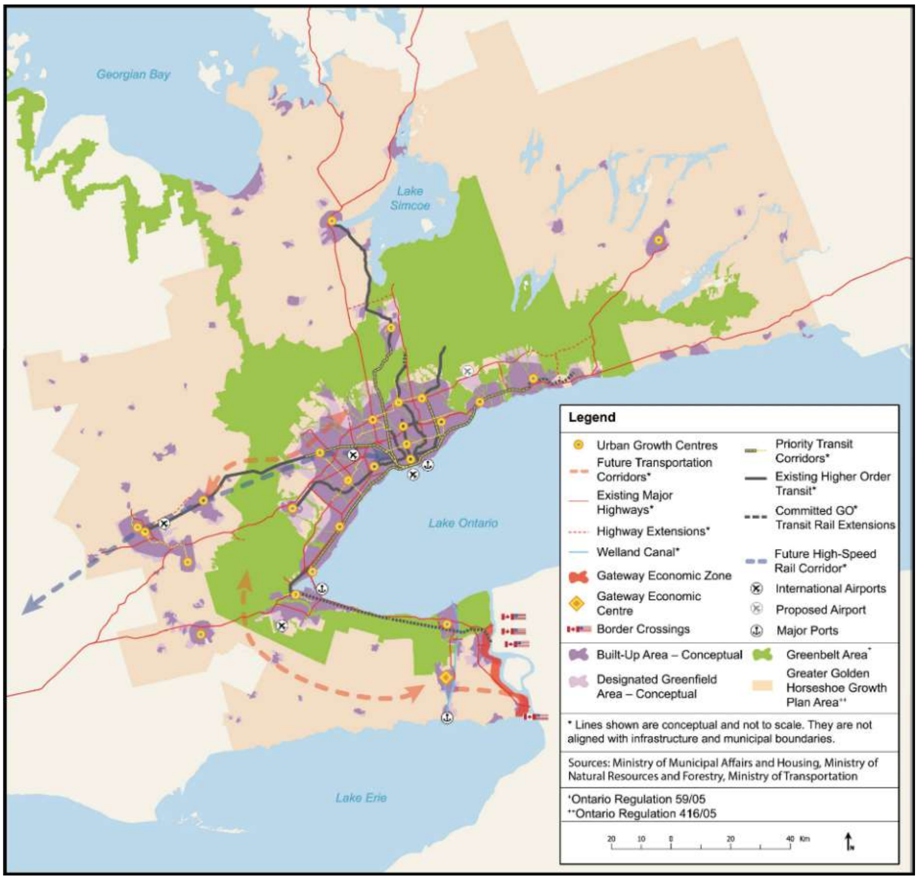
During the active years of the MTPB in the 1950s and 1960s, many of its principles – building expressways, suburban arterial roads and transit, increasing densities through rentals and dispersed industrial employment centres – were successfully implemented by the Metro government, the TTC and other agencies. Thanks largely to a broad consensus among stakeholders that metropolitan growth was necessary (White, 2007). In managing the progressing suburbanization, MTPB understood its role as that of an enabler that would serve growth without "resisting or fundamentally rearranging it" (White, 2007: 17). The resulting spatial structure would thus be characterized by relatively high densities and effective coordination between infrastructure and urban development, but segregated land use, high car-dependence and limited active transport (Sorensen & Hess, 2015). By the 1970s, most of Metro Toronto's land area, half of which was undeveloped in the 1950s, was built up (White, 2007; Sorensen & Hess, 2015).

However, with a looming economic recession, reduced governmental spending and a changing "academic climate in planning and the policy sciences" (Machler & Milz, 2015: 17), MTPB's approach to planning slowly began to lose approval and authority (White, 2007). In the planning world, the 1970s represented a turning point marked by the introduction of communicative planning principles, citizen participation and, specifically in Metropolitan Toronto, a shift in authority from metropolitan planners to local councils. Both top-down regional as well as urban planning was increasingly met with opposition. Well-known examples of citizen resistance to MTPB plans include the rejected construction of the Spadina Expressway in 1971 and the fight to preserve Toronto's streetcar lines (Chapter 6.2.2). When the Province of Ontario also established four new upper-tier municipalities – York in 1971 as well as Halton, Durham and Peel Regions in 1974 – and gave each its own planning authority, suburban municipalities were removed from MTPB's planning jurisdiction. The accumulation of developments eventually resulted in the abolition of the MTPB as an independent planning body and the transfer of planning responsibilities to the respective planning departments. It is important to note, however, that although the MTPB's operations ended after less than 15 years, the newly formed municipalities and planning departments retained the planning principles and processes it had put in place (Sorensen & Hess, 2015).

In the aftermath of this period and until the early 2000s, the Toronto region was without a regional planning body or regional development plan and vision. Popular and municipal sentiment at the time opposed centralized, comprehensive planning efforts at the provincial government level and instead called for municipal planning autonomy (White, 2007). Although planning responsibilities were never fully transferred to municipalities, efforts during the 1980s (*Planning Act* of 1983) and the 1990s (*Planning Act* of 1994) to reinstate regional planning by the Province of Ontario were not effective, regardless of the government's political leanings. Attempts to reform planning practice were equally unsuccessful. Despite the end of the MTPB in 1975, the hierarchical nature of the planning and control process established through the 1946 *Planning Act* remained in place and was adopted by the newly established regional municipalities (Sorensen & Hess, 2015). The upper-tier municipalities were responsible for providing population projections and infrastructure capacity calculations, while the local municipalities prepared detailed plans and ensured contiguous development. As a result, the rapid growth and expansion of housing that occurred from the 1970s onwards was essentially shaped by the application of subdivision plans and Secondary Plans drafted by planning departments based on their negotiations with developers. According to Sorensen & Hess (2015), the robust planning system in the Toronto region ensured that growth was carefully planned and regulated. However, there was a lack of transit integration, with almost no rapid transit lines built between the mid-1980s and mid-2000s (Horak, 2021).

In the 1990s, against a backdrop of rapid growth, public concerns about suburban sprawl, traffic congestion and lack of environmental protection began to rise (White, 2007). Although politicians and planners increasingly recognized that addressing the region's growth problems required regional coordination, it was not until 2006 that the province issued the *Growth Plan for the Greater Golden Horseshoe* – the first regional plan in 30 years (Fig. 6.4).

Figure 6.4 A Place to Grow Concept



Source: From *A Place to Grow. Growth Plan for the Greater Golden Horseshoe,* by Ministry of Municipal Affairs and Housing, Government of Ontario, 2020: 97.

Its development was preceded by two influential decisions on the part of the conservative government of the late 1990s. Firstly, the establishment of a non-governmental stakeholder group that developed the 2002 *Oak Ridges Moraine Conservation Plan.* A process that succeeded in managing competing interests by defining four zones with varying degrees of ecological conservation or urban development. And secondly, the launch of the *Smart Growth for Ontario* program. In both instances, the province took responsibility for regional planning through independent organizational bodies without reinstating centralized decision-making (White, 2007). Reflecting the changed expectations regarding planning processes and the role of government, public consultations were a key element in the subsequent development of the 2006 *Growth Plan*. Without a regional planning body in place, its implementation has since been the responsibility of local planning authorities.

Legislative changes paved the way for the Growth Plan, including the creation of the regional Greenbelt – a conservation zone consisting largely of farmland and rural areas, expanding the area previously protected under the Oak Ridges Moraine Conservation Plan (2001) and the Niagara Escarpment Plan (1973) – and the *Places to Grow Act* of 2005. The Growth Plan itself, which assumes a planning horizon to 2041, put forward much-debated planning ideas that build on the work of the Smart Growth program. For instance, focusing growth on nodes and corridors, urban intensification, improved regional transportation and mixed-use greenfield development (White, 2007). All measures aimed to tackle the challenges of car-oriented urban expansion, traffic congestion and segregated land use that have persisted since the 1970s (Sorensen, 2011). The policy mechanisms to achieve these objectives mainly stipulated that 40 % of new residential development should take place within the existing urban fabric by 2015. In addition, the plan identified *Urban Growth Centres* (UGCs), which required a minimum density of 150 to 400 people and jobs per hectare (Burchfield & Kramer, 2015), while greenfield developments on the urban fringe are to meet minimum density levels of 50 people and jobs per hectare by 2031 (Allen & Campsie, 2013). However, where exactly intensification was to take place and the extent to which land use decisions were linked to transportation planning was left to municipalities to determine within their OPs.

Although scholars such as White (2007) praise the 2006 Growth Plan as a historically unprecedented comprehensive plan, its impact on the region's development patterns and self-reinforcing planning system was limited (Sorensen & Hess, 2015). Early evaluations showed that between 2001 and 2011, 86 % of new residential development in the Toronto region occurred on greenfield sites and only 13 % of growth occurred within proposed UGCs (Burchfield & Kramer, 2015). In even greater contrast to the intended benefits of intensification, development patterns indicated that the population in older neighbourhoods in the inner and outer suburbs was shrinking. This resulted in underutilization of existing infrastructure, while substantial investment went into new infrastructure serving greenfield developments (Burchfield & Kramer, 2015). A review of municipal OPs showed that while municipalities adopted specified intensification targets, they largely treated them as "maximum" requirements rather than minimum thresholds (Allen & Campsie, 2013). The integration of land use and transportation was equally far from being implemented. In 2011, only 18 % of new residential development in the GTA was planned near frequent transit corridors and only 10 % was planned within 1 km of a regional transit station (Burchfield & Kramer, 2015: 15).

Although the 2006 Growth Plan was progressive in its policies, in sum, its overall success in relieving urban challenges was limited. The vision of a more compact region was constrained by a lack of direction on how to implement the objectives and where growth needed to occur to reduce congestion and foster sustainable communities (Allen & Campsie, 2013; Burchfield & Kramer, 2015). The mandate for 40 % intensification had proved too vague, limited housing options posed affordability challenges as single-family homes make up the largest share of housing in the region, and land use development lacked coordination and integration with transit expansion. The latter issue was partly a consequence of the fact that the 2006 Growth Plan was implemented two years prior to the publication of *The Big Move,* Metrolinx's corresponding regional transportation plan. In the meantime, municipalities set growth allocations in accordance with the 40 % intensification target, yet largely disregarding existing and future transit infrastructure. On the other hand, it was a consequence of policy documents that did not adequately direct development to transit-oriented areas by providing incentives, monitoring development and imposing penalties when municipalities and developers failed to do so (Allen & Campsie, 2013).

Against this backdrop, the Province of Ontario undertook a review process and adopted an updated version of the Growth Plan in 2017. The review found, among others things, that a large amount of land had already been allocated for greenfield development before the plan was published in 2006 (Allen & Campsie, 2013) and that population projections had overestimated actual growth rates in most municipalities, while underestimating the growth in the City of Toronto and Peel Region. To address some of the aforementioned shortcomings, the original intensification target was raised to 50 % of newly built developments by 2031 and 60 % thereafter. In addition, the minimum density requirements for greenfield developments were increased from 50 to 80 people and jobs per hectare. Other changes included the delineation of a *Natural Heritage System,* the introduction of a *prime employment area* designation for low-density industries (e.g. manufacturing, warehousing and logistics), minimum density targets in the vicinity of major transit stations and long-term residential housing supply assessments (OAGO, 2021: 2).

However, in the years following the reinstatement of regional planning in the GTA, there was a significant change in economic employment areas that was not reflected in the 2017 Growth Plan. Until the early 2000s, employment areas and industries were scattered across the Toronto region – a legacy of the MTPB (White, 2007) –, with many of the suburban employment clusters being characterized by a mono-functional urban fabric built to accommodate manufacturing and lacking transit access (Dobson et al., 2013). However, the change in economic drivers in the 2010s led to a significant shift in the spatial distribution and clustering of industries. While sectors such as manufacturing, wholesale trade and back office declined between 2006 and 2016, soft tech, finance, high-end business services, arts and design, higher education and logistics grew (Blais, 2018). Geographically, economic restructuring manifested itself in significant employment loss in areas of the Toronto region such as the inner suburbs of Toronto, southern Oshawa and Hamilton. Growth stagnated in the so-called *Suburban Knowledge-Intensive Districts* (SKIDs) and a hyper-concentration of economic activity took place in and around downtown Toronto. One of the few exceptions was the logistics industry, which registered employment growth across the region (ibid.).

Given that the Growth Plan's objective of concentrating jobs in designated Urban Growth Centres and Major Transit Station Areas has had little to no effect, scholars have emphasized the need to revise regional employment forecasts as well as municipal employment surveys to accurately capture employment developments and integrate datasets regionally (Blais, 2018; Clayton & Shi, 2019). The uniform designation of office space in the Urban Growth Centres (UGC) in the GTHA and the sole focus on growth in the Growth Plan fall short of accounting for more nuanced dynamics of varying intensity, transition and loss (Blais, 2018: 132). As a recent review has shown, only four of the 25 UGCs defined in the Growth Plan are likely to meet their 2031 density targets (OAGO, 2021: 5). Despite these analyses and recommendations, the most recent update to the Growth Plan – the 2019 *A Place to Grow: Growth Plan for the Greater Golden Horseshoe* – did not address the need for variation in terms of Urban Growth Centres and employment dynamics. It does, however, include lower intensification targets for urbanized areas and greenfield developments alike, which poses a critical setback for a more compact urban future.

Another amendment of the recent Growth Plan requires upper-tier municipalities to delineate Major Transit Station Areas (MTSA) along identified *priority transit corridors* and ensure that minimum density targets are planned within a 500 to 800 metre radius of a transit station (Ontario, 2019: 17). Planning and policy experts in the GTA have long advocated for effective implementation of developments that support transit, increase transit ridership, reduce housing and transportation costs for residents (Kim, 2019). Although the 2017 amendment of the Ontario Planning Act endorsed the definition of minimum densities within transit station areas, scholars point out that entrenched local opposition and so-called land banking by developers has stalled transit-oriented or transit-supportive developments (Siemiatycki & Fagan, 2019: 7). In line with interviewees' assessments, change in planning practice is taking place across the region, but has not yet reached the pace and scale necessary to address regional housing and transit challenges:

> *"It is striking that there are still stretches along Toronto subway lines and the GO rail network where little land-use intensification or redevelopment has occurred. This is changing, to be sure, as the redevelopment of surface parking lots, low-rise buildings, and shopping malls picks up momentum near rapid transit stations."*
> (Siemiatycki & Fagan, 2019: 7)

In this context, experts point particularly to the need to plan for transit-supportive developments that centre on bus routes and streetcar lines – lower-order transit systems that are extensive and heavily frequented in parts of the region – and that consist of mid-density housing rather than high-rise complexes often associated with TODs (Kramer, 2019; Lee & Kim, 2020). While the Growth Plan accounts for light rail and bus rapid transit lines, its MTSA requirement merely applies to the defined priority transit corridors, which address higher-order transit lines served by Metrolinx and exclude local transit. But along bus corridors in particular, investments in mid-density housing (e.g. stacked townhouses, low- and mid-rise apartment buildings, etc.) bear the potential to enable "gentle growth" (Lee & Kim, 2020) that could relieve the polarization between the recent boom in high-rise buildings and scattered low-density housing (CUI, 2018: 8). Doing so would require equal prioritization of lower transit station areas and corridors, as well as a change in land use plans and zoning rules that currently prevent multi-unit buildings from being added to low-density neighbourhoods (Kramer, 2019; Lee & Kim, 2020).

In the second review of the Growth Plan, 15 years after its initial publication in 2006, a report by the Ontario Auditor General's Office comes to a critical conclusion. According to the report, the Ontario Ministry of Municipal Affairs and Housing largely lacks sufficient data to evaluate the effectiveness of the Growth Plan in reaching its defined targets. Moreover, it is not equipped with the necessary procedures to ensure that land use planning in the region is consistent with the Planning Act and the Growth Plan (OAGO, 2021: 5). For instance, only three of the 20 single- and upper-tier municipalities in the GGH (excluding the City of Toronto) have achieved the 40 % intensification target by 2019. The assessment further concludes that amendments to plans by successive governments have affected the ability of municipalities to effectively translate GGH policies into their local plans. Studies conducted in response to the 2017 amendments had to be redone following the 2019 revisions (OAGO, 2021: 29). This shows that changes to land use planning practice in the region are challenged not only by vested interests and a robust planning system, but also by instability in the planning process caused by frequent ministerial changes and Zoning Orders that overrule municipal bylaws (ibid.).

However, as cities were again reviewing their Official Plans to align with the 2019 Growth Plan objectives by mid-2022, not all municipalities intended to manage growth over the next 30 years in the same manner as in the past. In late 2021, the City Council of Hamilton voted against a 60 % intensification target and instead requested municipal staff to plan for 81 % and "a manner that does not include an expansion to the City's urban boundary" (Hamilton, 2021). As bold as the city's decision was, its revised Official Plan and updated Land Use Plan have yet to be approved by the Minister of Municipal Affairs and Housing and are thus dependent on the goodwill of the provincial government. Within the planning community, positions diverge on the housing debate sparked by the Hamilton City Council vote. Proponents of compact urban development call on all levels of government to reform zoning laws, parking requirements and tax rules in order to provide the conditions for intensification (Crombie & Golden, 2022-01-18). While an opposing view holds that not all greenfield development in the Toronto region qualifies as sprawl (Clayton & Amborski, 2022), precisely because of Ontario's robust planning system, which provides for relatively compact and contiguous residential development (Sorensen & Hess, 2015).

Opinions differ, particularly on the question of whether greenfield expansions further drive up housing costs or, in turn, benefit housing affordability. The argument that urban infills reduce costs is based on the assumption that existing infrastructure is used more effectively, while new urban areas entail high development costs and infrastructure investments (Burchfield & Kramer, 2015). Meanwhile, the contention in favour of relatively compact but suburban development rests on the economic assumption that limiting urban expansion will increase land and housing prices, which in turn may cause households to move out of the Toronto region to areas that require even longer commutes (Clayton & Amborski, 2022). Yet, the latter position fails to recognize the inherent car-orientation of many suburban expansion projects. Spatial analyses of recent greenfield developments in the region show that even when medium-density housing recommendations have been adopted, public amenities often remain disconnected from adjacent neighbourhoods and typical retail typologies generate a more car- than pedestrian-oriented environment (CUI, 2018). As walkability remains largely unattractive, car-dependency is not reversed. On the contrary, the urban form all but requires inhabitants to own cars.

In terms of potential change in housing and land use development practice, the literature agrees with the interviewees' position that the general policy directions in the Growth Plan are technically conducive to change and that some change is already occurring. However, the challenge lies in translating these objectives in the context of a planning system that is based on "a powerful set of interlocking and mutually reinforcing institutional frameworks that are highly effective in regulating the production of new urban space" (Sorensen & Hess, 2015: 430). The recent reduction in required greenfield densities in the 2019 Growth Plan and the dispute over higher intensification targets by the City of Hamilton illustrate the difficulty of altering established practices that are reproduced not only by institutional structures and systems, but also by social norms, shared values and culture (Albrechts, 2011). In light of a potential future with automated mobility, the diverging views on how to manage growth are critical, as housing and employment locations, density levels, and parking provision have a significant impact on mobility choices and resulting traffic patterns.

6.3. Present challenges concerning regulatory capacity and governance

The spatial and mobility-related challenges described above are closely tied to the institutional capacity of planning departments and transit agencies to adequately respond to and plan for a changing mobility landscape. To better understand the scope for meaningful change requires a deeper insight into the institutional relations, planning hierarchy and governance arrangements of a planning system. In discussions with planning experts in the GTA, two particular challenges stood out as worthy of further elaboration: a.) regional coordination of transit planning efforts and b.) institutional capacity to implement new planning measures.

6.3.1 Regional transit coordination

Experts assert that AVs are inherently a regional issue that requires inter-municipal planning and service coordination (I-07; I-09-A; I-14). As daily travel patterns of passengers and goods cross municipal boundaries, regional standards, such as those related to v2v and v2i communications, cybersecurity, and safety issues, are significant. In addition to the various infrastructure, traffic, and vehicle standards that need to be aligned internationally (with the U.S.), nationally (with other provinces), and provincially (with municipalities in Ontario), a key issue concerns operational coordination and performance standards. The topic requires coordination across provincial and local levels of government, as vehicles must operate on different classes of roads that are under provincial, regional, and municipal authority:

> *"… how are you going to deal with congestion management as an example, when you've got automated vehicles? There's all sorts of opportunities opened up as a result of it. Certainly, congestion pricing and time slot allocation, like they do for planes are things that could be considered. But who is going to be managing that?"* (I-08)

Interviewees illustrated two examples where service provision may be challenged by insufficient inter-municipal coordination. The first example concerns the challenge of integrating first- and last-mile options at regional transit stations. Bridging the gap between the first and last mile requires partnerships between Metrolinx, the operator of the commuter rail system, and local transit agencies, which often struggle to serve suburban neighbourhoods due to low fare recovery ratios (I-09-B). In testing alternative means of providing flexible access to regional transit stations, Metrolinx has previously partnered with PTCs to trial on-demand and ride-sharing systems, effectively bridging technologies for AVs (Tutunzis, 2019).

Thus far, service integration remains a challenge and transferring between different systems represents a critical point of friction for passengers (I-09-A). In order for inter-municipal and inter-modal trips to become more attractive than driving one's own car, the timing of services and the integration of fares would need to be solved. Metrolinx's vision for the Toronto region is that of a fully integrated fare structure (Metrolinx, 2018: 43). Despite ongoing discussions between municipal and GTA transit representatives (IMFG, 2019), there are eleven different fare structures in the region, divided into four service categories: a.) municipal, b.) municipal premium express, c.) regional, and d.) specialized airport link (Metrolinx, 2018). Looking ahead, experts consider the potential deployment of AV-based shuttles as the final step of a broader transition in the regional transit system (I-09-A). Firstly, cost reductions and aligned timetables would need to be clarified, followed by the integration of on-demand services into the existing transit network, and only then would automated shuttles become relevant.

The second example concerns the regulatory inconsistencies that stand in the way of seamless provision of ride-hailing services across municipal borders in the Toronto region. Unlike other urban regions in Canada, municipalities in Ontario are responsible for regulating PTCs (Tabascio & Brail, 2021). Interviewees expressed concern about the regulatory delays and fragmentation that occurred when Uber first launched its service in the region (I-07). Upon its arrival in 2012, the company evaded regulations that traditionally applied to ground transportation services, i.e. the taxi industry, and instead operated "outside of regulations" (Brail, 2018: 55). The municipal government of Toronto struggled to develop a concise regulatory response, while the municipality of Mississauga decided to initially ban the service. It was not until 2016 – when Toronto was essentially pressured by a growing number of unregulated rides to legalize the operation of PTCs – that it finally enacted a regulatory framework and Vehicles-For-Hire Bylaw. An interviewed expert explained that other Canadian cities have become more cautious in permitting new mobility services due to Uber's aggressive arrival in the City of Toronto (I-12). The City Council of Mississauga, for instance, waited until 2017 before launching a one-year pilot program for PTCs and adopting a permanent regulation in 2019 (Mississauga, 2019). Other municipalities in the region that have adopted respective regulations include Brampton, Oakville and Vaughan (Tabascio & Brail, 2021).

While the adoption of regulations essentially accommodates the operation of PTCs, it enables municipalities to charge licensing fees, collect data and enforce safety measures (Brail, 2018). However, the critical question remains: Are cities collaborating? Analysis shows that approaches to regulating ride-hailing companies in the GTA vary across municipalities, with some facilitating regional travel while others create barriers for doing so (Tabascio & Brail, 2021). Moreover, open data strategies are an equally municipal affair. Thus far, there is a lack of an overarching goal (Goracinova et al., 2021) and the common model for data governance proposed in the CAV Readiness Plan (Ontario, 2020a).

If AVs are to accelerate the "hybridization" (Lenz & Fraedrich, 2016: 185) of public transit by providing more on-demand services that are neither buses nor taxis, coordinating the planning and operation of services across municipal boundaries will be even more important than it is today. Seamless transfer points between train lines, automated BRTs and AV-shuttle services will require not only infrastructure provision and consistent performance standards, but also robust partnerships and data sharing agreements between public and private operators as well as municipalities in the region (IMFG, 2019).

> *"In my experience, it always boils down to the people. [For the] technology there's easy solutions, but it's having those conversations and getting agreements and consensus. It's the institutional arrangements and memorandums of understanding."* (I-08)

Planning and Institutional Context

The issue of coordinating public transport in the Toronto region dates back to the 1970s, when metropolitan growth began to expand beyond the boundaries of the MTPB's jurisdiction without an institutional framework or regional planning agency to coordinate land use and transit planning in the new established suburban municipalities. Despite efforts by the provincial government to restructure the governance system in the GTA through the amalgamation of the City of Toronto in 1998, infrastructure provision, public transit and urban development continued to be fragmented within the region (Williams, 1999). In 2006, the subsequent government established the regional transit agency *Metrolinx* in an effort to strengthen cohesion and coordinate investment. Its mandate is to operate the provincially owned GO Transit and to plan, finance and develop an integrated regional transportation network (Horak, 2021). In 2008, the agency issued its 25-year regional transportation plan, *The Big Move – Transforming Transportation in the Greater Toronto and Hamilton Area*, whose preface emphasizes that "The concern about transportation issues has never been higher and public appetite for coordinated action on transportation has never been more pronounced." (Metrolinx, 2008: vi).

A decade into the agency's activities, the issue of transit coordination in the Toronto region is as contentious as ever. Even the revised 2018 RTP is far less ambitious in this regard when it states, "Governments have significantly increased their support for transit over the last decade and progress has been made on key areas such as regional fare and service integration, yet more formal coordination and region-wide policies are required." (Metrolinx, 2018: 74). The regional transit system is considered fragmented, entails fare structures that penalize riders for crossing boundaries or transferring between transit agencies (TRBOT, 2020: 8), and underserves neighbourhoods with high concentrations of low-income households (Allen & Farber, 2020). Horak (2021) compares regional transportation authorities established at the provincially level, noting that in Toronto "the development of rapid transit has been highly contentious, marked by frequent changes in plan and the repeated cancellation and deferral of transit projects." (244).

Proposals for a realignment of responsibilities and a revision of regional transit governance have been mounting for years among scholars, researchers and advisors (Neptis Foundation, 2014; IMFG, 2019; Siemiatycki & Fagan, 2019; TRBOT, 2020). The recent completion of major rapid transit expansions and the provincial decision in 2019 to shift planning and development responsibility for ongoing subway projects to the City of Toronto have made to the issue even more pressing. A 2019 advisory panel to the City of Toronto stresses:

> *"The Toronto region's economy depends on a modern, effective, and robust transit system. As the region grows, the current extent and state of transit threatens that economy.*

To address the challenges facing transit in the Toronto region, a concerted effort should be made to improve coordination in transit planning and operations."
(IMFG, 2019: 9)

Although Metrolinx was originally created for the very purpose of coordinating service integration, it lacks the necessary authority to do so effectively (Siemiatycki & Fagan, 2019). Since the agency's inception, the province has refrained from strengthening its "institutional foundations" (Horak, 2021: 252) and granting it dedicated revenue streams to increase its planning stability and predictability. A critical aspect of the discussion on regional transit governance is the distribution of power between levels of government – an issue with historical precedents (White, 2007) – and the lack of inter-municipal collaboration at the metropolitan level (Horak, 2021). Advisors therefore propose balanced governance models that ensure that municipalities and transit agencies maintain local autonomy, e.g. in the form of "a coordinating regional body in charge of mobility planning and coordination, and local bodies in charge of service" (IMFG, 2019:11). Or as a "cooperative body, in which independent transit agencies collaborate on key areas for integration like fare policy, scheduling, public information, and the distribution of revenues." (TRBOT, 2020: 2). While the first model is based on a division of responsibilities between a coordinating level and local transit bodies, the latter envisages a *Transit Federation* that is locally-driven through the cooperation of the existing transit agencies. Both models aim to achieve better integration of services and fares through improved decision-making between the key stakeholders.

The debate is critical in the context of a potential mobility future with AVs, as the needs of transit agencies are changing amid a general trend towards connectivity, mobility services and mobility-as-a-service solutions (Higgins et al., 2021). The role of transit agencies is evolving from service operators to "mobility integrators" (Townsend, 2020: 216), as the growing variety of mobility options increases the importance of bundling transport modes and payments (Calderón & Miller, 2020). Considering that AVs may contribute to a decrease in car ownership, the question is whether they will substitute or make accessible, e.g. higher-order regional transit or night-time transit services (Zhang et al., 2021). An organizational body that coordinates services, schedules and fares across all modes and mobility providers may be critical to ensure multimodal travel behaviour (Siematycki & Fagan, 2019; Calderón & Miller, 2020). Moreover, coordination and management of services is essential for data integration and prioritization of areas that need it most. Thus, the two governance models described above would not only provide the necessary institutional framework for effective integration of services and equitable transport planning that is integrated with urban development, but also for the development of overarching ICT solutions, data strategies and eventually perhaps even AV-based services.

6.3.2 Institutional relations: Capacity and governmental interests

The question of the extent to which municipal planners and the public sector are in a position to determine the direction of emerging mobility technologies such as AVs was received with scepticism by the interviewed experts. By some, simply because technological standards are set at a national and international level (I-09-A). At the same time, it was acknowledged that local planners, municipal leaders and transit agencies have the power to determine how technologies are applied and that there is value in municipalities taking a joint position when negotiating with technology companies and higher levels of government (I-09-A; I-16). A stance that resonates with findings from German municipalities (Fraedrich et al., 2019), where developing a joint municipal position on AVs is viewed as an important means to negotiate municipal interests with state and federal governments.

For other interviewed experts, the scepticism is rooted in the regulatory leverage of municipal planning divisions. One interviewee expressed reluctance to incorporate policies into existing planning documents that could subsequently be amended by the provincial government (I-06). The issue points to conflicts of interest between different levels of government regarding the priorities of the GTA's urban transportation system. But it also concerns institutional power relations inherent in the planning system at large.

> *"There are a lot of indirect things that we can do. But it does come down to a political willingness to exercise them."* (I-06)

The interviewed experts recalled recent planning initiatives aimed at reducing car dependency in Toronto that were overruled by provincial veto or amended to the extent of losing their impact (I-04; I-06). One example concerns the 2016 vote by Toronto City Council to impose road tolls along the Gardiner Expressway and Don Valley Parkway. The provincial government overruled the vote at the time, promising that the City would instead receive additional funding from the gas tax. What it did not foresee was that the subsequent government would eventually abolish these plans in 2019, significantly limiting Toronto's fiscal capacity to invest in transportation infrastructure (Siemiatycki & Fagan, 2019: 9). The promised gas tax funds were intended to cover part of the local transit operating costs (ibid.). Looking ahead, road tolls and other pricing schemes will become increasingly relevant levers as the adoption of electric vehicles promises to increase and gas taxes gradually lose their effect of providing governments with revenue (I-08; I-09-A). For municipalities that need to invest in transit expansion, service integration and infrastructural enhancements, it is significant whether they have the capacity to enact such policies or not. However, given the political climate, experts are as clear on the effectiveness of pricing schemes as they are on the likelihood of implementing them:

"I'd price the roads today, if we could. That would help so much." (I-09-B)

"There are other cities around the world that have already implemented TNC charges. I think New York already has a surcharge per ride. Chicago has one. Edmonton even has one. It's just that each city uses the charge towards different [goals]." (I-07)

In addition to institutional power relations between the province and municipalities, the road toll episode also highlights the impact of government inconsistency, which has repeatedly hampered the successful implementation of transit plans in Toronto (Horak, 2021). In this regard, one expert noted that emerging mobility technologies could benefit from a "party-agnostic" approach to regulation and management (I-08). Just as climate issues challenge governments to respond regardless of their political leaning, the emergence of automated vehicles should be viewed as an inevitable development driven by the private sector. Otherwise, Ontario's role within the new transportation landscape would shift if regulatory and funding strategies "change depending on the flavour of the government" (I-08), potentially affecting the region's economic competitiveness, accessibility and urban development.

Other experts point to the conflicting objectives that arise between economic development interests and mobility development aimed at sustainability or equity. At both the provincial and municipal level, interests in fostering economic competitiveness influence how emerging mobility technologies are regulated locally. Referring to the issue of ride-hailing companies, several interviewees shared the view that the City of Toronto is not prepared to regulate the service in line with current development goals (I-05; I-06; I-11). Particularly so, as recent data indicates that the majority of ride-hailing trips in Toronto compete with transit ridership (Toronto, 2019b: 27). Why cities tolerate technology companies introducing new services without approval may have different reasons. In this context, an interviewee elaborated that technology companies have reinforced a narrative according to which cities are forward-thinking if they permit the testing of emerging technologies, thereby enticing economic investment by the tech industry (I-12). Studies on San Francisco and Toronto have relatedly found that successful lobbying and advocacy on the part of the industry, as well as the political will to support technological innovation and its potential for job creation, are key factors (Flores & Rayle, 2017; Brail, 2018).

In the GTA, the rationale also aligns with the province's interest in not impeding innovation when it comes to regulating AV testing (I-04) and striking a balance between ensuring safety and staying out of the way of technological development (I-14). The strategy is rooted in the ongoing economic shift in the region – from a traditional automotive manufacturing hub to an innovation-oriented research and development landscape (Wolfe & Goracinova, 2017). In this context, the province has taken upon itself to foster this transition through initiatives such as the Automated Vehicle

Innovation Network – now the Ontario Vehicle Innovation Network – and a relatively welcoming environment for technology companies. In this context, Toronto's Transportation Innovation Zones (TIZ) may be understood as a local implementation of the same goal. They provide a dedicated testing environment for research and industry to join forces and thus drive technological innovation as well as economic development. Just as the "politics of job creation" (Spieler, 2021: 156) were at play when the major transportation plans of 1970s were drafted, they play a role today in attracting companies and economic activity to particular cities and regions through regulatory flexibility (Clark, 2020: 97).

Against this backdrop, some interviewees expressed concern about whether municipalities will be given the power to regulate AVs or whether private technology companies will be free to lobby for their interests (I-10; I-11; I-16). For a municipal planning department that strives for a more balanced transportation system, the strong institutional reliance on provincial approval and such conflicting policy goals create a regulatory dilemma. Although aware of the potential negative impacts of AVs and the need to adequately manage their introduction, proactive policy adoption appears futile to some:

> *"If our policies are just going to be watered down to not mean anything, then why would we bother putting it forward? In that environment, how much room is there for us to be anti-AV? It would also be perceived as anti-car."* (I-06)

Planning and Institutional Context

Two aspects appear to be critical to the capacity of municipal planners to guide urban and transportation development in the Toronto region. Firstly, the relationship between the municipality and the province as well as the policy overlay that affects how urban development and transportation priorities manifest spatially. Secondly, the influence of local electoral dynamics and short-term political considerations on long-term policy goals (Horak, 2021). The first issue is rooted in the Canadian Constitution, which assigns responsibility for defining municipal authority, planning abilities and sources of revenue to provincial governments (Taylor & Dobson, 2020). As a result, municipalities have a subordinate role with broad responsibilities, yet limited autonomy (Harchard, 2020).

The planning framework in the Greater Toronto Region is unique in the Canadian context in that it is one of two metropolitan areas in Canada subject to provincial urban growth and development policies (Taylor, 2020: 38). While other provinces also possess spatially targeted policies, they are not limited to a metropolitan area. The first instances of geographically specific policies that became legally binding on local Official Plans and zoning bylaws in the GTA were the 1973 *Niagara Escarpment Planning and Development Act* and the *Parkway Belt Planning and Development Act,* which enabled the province to develop respective land use plans (Taylor, 2020). The more recent 2005 *Greenbelt Act* and *Places to Grow Act* supplement the area-specific policies to which local municipalities are required to adhere. Through these policies and complementary plans, the Province of Ontario has a direct influence on spatial development in the region, but also relies on municipal planning departments to effectively translate its objectives and align infrastructure investments.

As described earlier (Chapter 6.2.2), Canadian cities are required to comply with provincial policies and plans. Moreover, planning amendments and newly designed policies submitted by municipal planning departments and city councils require provincial approval by the ministry concerned, e.g. the Ontario Ministry of Municipal Affairs and Housing or the Ministry of Transportation. In this sense, municipalities have responsibility for land use decisions and development plans, as well as for the design, construction and maintenance of their street network, but the province has the right to veto these plans or the adoption of related bylaws (legally anchored in the *Municipal Act and City of Toronto Act)*. As the case of the overruled Gardiner Expressway toll exemplifies, the planning hierarchy leads to frequent reversals and amendments in municipal planning. For Harchard (2020), this inability of municipalities to unilaterally enact changes represents a paternalistic relationship between municipalities and the province that "can lead to inefficiencies" and may "cause unclear accountability, as municipalities may be seen to control decision-making in certain policy areas, but in practice may be constrained by provincially controlled review boards" (4).

While provinces generally determine the sources of revenue available to municipalities, restrictions on municipal autonomy contribute to the inability of cities to easily adjust municipal costs and expenditures (Harchard, 2020). As property taxes and user fees constitute the main sources of revenue available to municipalities, the lack of flexibility to introduce additional taxes, e.g. tolls, parking fees, curbside fees, etc., significantly affects their ability to maintain or invest in new social and physical infrastructure (ibid.). A comparative analysis of fiscal spending autonomy has shown that Toronto has fewer tax options than metropolitan cities (Slack, 2017) at its disposal. In effect, this limits the efficiency and flexibility of the public sector to respond to changing circumstances (ibid.). For municipal transit and the TTC, for example, this has resulted in a significant portion of maintenance costs going unfunded, which has reignited the aforementioned debate on transit jurisdiction and the province's 2019 decision to transfer the responsibility for subway expansion projects in Toronto to Metrolinx. Moreover, the consistent reliance on provincial and federal subsidies for local transit development has had the effect that in the Toronto region, the successful implementation of any transit expansion, including those specified in the RTP, hinges on government priorities (Irwin & Bevan, 2010).

In terms of the impact of electoral dynamics on long-range policy goals in Toronto, a historical perspective provides contextualization. When the MTPB was abolished as an independent planning body in 1975, planning responsibilities not only transferred to the Planning Department of Metropolitan Toronto, but they were also placed under a more direct influence of elected politicians, i.e. the City Council and incumbent mayor. White (2007) elaborates that this change "was considered progressive and democratic at the time" but that it "undoubtedly contributed to putting the politics back into planning." (33). As subsequent decades have shown, political discrepancies have prevented large-scale transit investments from being successfully implemented in the Toronto region: "Liberal governments … often focused [on transit developments] within the city, where ridership is highest and their political support is greatest, while conservative governments support extensions to their electoral base in the suburbs." (Spieler, 2021: 156). Scholars have noted that the "lifestyle divide" (Horak, 2021: 251) that exists between inner-city constituents who live in dense, mixed-use, transit-oriented neighbourhoods and those who live in car-dependent suburbs has directly implications for political considerations (Walks, 2015).

Yet, the observation that electoral politics play a role in transit and transportation infrastructure planning applies to provincial and federal politics alike. Following the amalgamation of Metropolitan Toronto in 1998, Williams (1999) described how the divergent interests of the downtown Toronto constituency and suburban municipalities would inevitably lead to political tensions, which would increasingly affect provincial policymaking as populations grew. The provincial government's mode-specific decisions have historically been influenced by economic interests and jobs creation opportunities. For instance, the 1970s and 1980s were marked by significant efforts to build a transit industry in the region, essentially fuelling Toronto's 1972 *GO-Urban* plan and the completion of the light rail in Scarborough (Spieler, 2021). In contrast, the following decades until the late 2000s were characterized by comparatively little transit expansion and a dominant automotive manufacturing and supply industry. In the midst of the recent economic restructuring towards a knowledge economy – which builds on technology-related and knowledge-intensive activities and prompts car manufacturers in the region to redirect their efforts to electrification and automation – the Premier of Ontario is using gas tax cuts (much of which fund transit projects) and expansive infrastructure projects (subway lines to Northern Toronto or the newer and controversial Highway 413 project) as campaign promises to cater to the predominantly car-centred rural and suburban communities (Doucet & Doucet, 2022; Lorinc, 2022). Provincial and federal governments use geographically targeted infrastructure investments as an instrument to win support in key constituencies (Horak, 2021: 248).

As responsibility for transit planning and funding is spread across municipal, provincial and federal levels of government (Siemiatycki & Fagan, 2019), maintaining planning consistency and ensuring project completion is subject to political volatility. Transit plans such as Toronto's 2007 *Transit City*, which envisioned the expansion of light rail lines throughout the city, including its underserved inner suburbs, are dismissed by political opposition after years of planning (Doucet & Doucet, 2022). In 2010, the newly elected mayor used the planned light rail lines as campaign issue, arguing that they took away road space from drivers and represented a "war on cars" (Horak, 2021: 251). As a result, only two of the originally planned seven lines were built. Echoing the sentiment, the Premier of Ontario cancelled the City of Hamilton's LRT project in 2019, although millions of dollars had been invested in the project, only for it to be revived by a Liberal-leaning federal government (Doucet & Doucet, 2022). The politics of transportation development are thus not only highly controversial, but also rooted in the GTA's electoral geography and urban form (Walks, 2015). While some argue that the issue is not whether transit should be expanded, but where and how (Spieler, 2021), others contend that the GTA's car-oriented culture creates a self-reinforcing dynamic (Filion, 2018). Planning efforts that seek to bring transit, mixed-use, and denser communities to suburban neighbourhoods face a political backlash from suburban voters who perceive such projects as a threat to automobility and a car-dominated culture (ibid.).

6.4. Summary

The analysis of perceived challenges shows that all interviewed experts in the GTA are to some degree concerned about the "external costs" (Litman, 2021: 4) that the introduction of AVs may entail for the existing urban and traffic environment. The costs arising from an increase in traffic problems (e.g. congestion and urban sprawl), additional risks (e.g. conflicts with vulnerable road users and cyber security issues) and social equity issues (e.g. loss of transit and active modes, as well as reduced transit affordability) are extensively addressed. The experts further address the external costs that may arise from greater infrastructure requirements (e.g. enhancements to connectivity infrastructure, roadway designs, parking requirements and maintenance standards) and how flexible infrastructure solutions may alleviate the need for extensive short-term investments.

It is essential to note that these issues are perceived as challenges not only due to the vast amount of published research on AVs, but also due to the specificity of the GTA's planning cultural context. Its robust planning system continues to reinforce car-oriented urban expansion in the region and challenges a systemic shift towards more compact, transit-oriented and mixed-use neighbourhoods, despite the fact that these principles are embedded in existing policy documents and encapsulate the intended development vision for the GTA. An urban geography that is greatly shaped by low housing densities, poses a key challenge that will significantly influence the future uptake of AVs in the region. If left unregulated, such technological change is likely to increase vehicle travel and further strain existing infrastructure rather than ensure the much-needed relief in the GTA (Fagnant

& Kockelman, 2015). Against this backdrop, the analysis of planning cultural dimensions, including underlying institutional dynamics and governance arrangements, provides valuable insights into the capacity of planning actors to put the necessary regulations into place and mitigate or even prevent such a scenario. The issue of institutional capacity thus adds a political dimension to the question of whether planning authorities have sufficient financial and knowledge resources to prepare for a potential introduction of AVs (Freemark et al., 2019: 148).

The cases of Toronto and Hamilton demonstrate that municipalities intending to pursue transit-oriented, compact development initiatives, which align with regional policy but may deviate from existing practices, are constrained in effectively doing so in several ways. Firstly, due to the fact that the Province of Ontario holds decision-making authority over municipalities and has the power to overrule City Council votes. Secondly, and relatedly, municipalities have limited fiscal capacity, which is most evident in the transit realm, where municipalities and transit agencies are left dependent on provincial and federal funding provisions and thus government priorities. As a result, transit expansion is slow to materialize in areas where it is long overdue and particularly important in order to tackle car dependency, such as low-income suburban neighbourhoods. Finally, transport policies that are oriented towards a car-oriented culture and the interests of the industry may undermine efforts to alleviate transportation issues by delaying or even cancelling ongoing planning processes. Against the backdrop of these constraints, government consistency and institutionally aligned action have emerged as key governance challenges to achieving a socially, environmentally and economically sustainable future with AVs in the Toronto region.

In view of the question of whether planning for AVs may contribute to transformative change, the aforementioned constraints should not be misunderstood as insurmountable barriers. Instead, they form the setting within which processes of change take place and influence the pace at which alternative visions and strategies materialize. The example of a changing street building practice in Toronto shows that the longstanding efforts by planners, advocates and activists to put walkability and liveable streets on the political agenda have recently gained momentum amid the health crisis brought about by the Covid-19 pandemic. Since the early 2000s, a cultural shift has unfolded (Hess, 2009), which has continuously pushed for transformative change and was expedited in a moment of opportunity. In this regard, it is significant to note that the specific constraints of the broader planning context gave rise to the creative realignments in planning practices, e.g. the uptake of temporary pilots that later enabled the accelerated implementation of short-term improvements.

Against the backdrop of the planning cultural context, the assumed planning initiatives for AVs in the GTA are reassessed in Chapter 7 to determine whether and in what ways they in fact resemble novelties in planning practice.

PART IV. RECONSIDERING THE PATH AHEAD

7. Tracing patterns of change

Viewed from a distance, the transportation system in the Greater Toronto Area continues to be strained by a range of issues: high levels of car dependency, a post-pandemic return of traffic congestion (Spurr, 2021, as cited in Higgins et al., 2021: 27), insufficient transit integration across municipal boundaries, a prevalence of low-density and functionally segregated built form, as well as poor road safety for pedestrians and cyclists. As described in Chapter 6, numerous high-level policies, municipal OP amendments, as well as local strategies and planning measures have been introduced over the past two decades to reduce sprawl, increase transit reliance and promote road safety, among others. Despite this significant progress, institutional, political and cultural barriers have stood in the way of broader change. Given the persistence of these barriers, the question arises to what extent careful planning preparations for AVs, such as those commenced in the Greater Toronto Area and illustrated in Chapter 4, entail realignments in planning practice that go beyond the confines of existing planning means (Albrechts, 2011).

Using the example of *Urban Growth Centres*, a key policy of the 2006 Growth Plan by the Province of Ontario, it becomes evident that the preparation of progressive strategies and policies does not in itself ensure that they conform "to their transformative planning objectives" (Filion, 2018: 8). Nor that they are successfully translated into different "practice arenas" (Healey, 2006: 532) of planning. Scholars such as Bertolini (2017: 129) emphasize the complex dynamic between transport and land use development policies, mobility and location behaviour, as well as the broader societal context that must be considered when planning for transformative change in metropolitan mobility systems. Modifying a single component is unlikely to bring about substantial change and may instead lead to unintended consequences (Bertolini, 2017). In the case of Urban Growth Centres (UGC), municipalities that have adopted the policy have failed to effectively reverse car dependency (Filion, 2018). The focus on structural changes alone, in this case the implementation of high-order transit lines and increased densities around nodes, left the car-oriented features of the surrounding neighbourhoods unaddressed. To the effect, Filion (2018) argues, that suburban culture and car dependency are perpetuated rather than altered by the UGC policy.

Following Bertolini (2017), a critical mass of system components needs to be addressed and changed in a coherent direction to realize transformations. Higgins et al. (2021) translate an integrated approach to transportation and land use planning for suburban neighbourhoods in the GTA, citing land use changes (e.g. mixed-use development and interconnectivity), more attractive mobility services, as well as stakeholder engagement strategies as critical features alongside improved transit and higher densities. Yet, even if such plans are assumed, the question remains how to effectively translate them into practice. Importantly to the present research, the example of the UGC illustrates the possibility that new planning approaches and policies will be absorbed by established means of doing things – by planning actors, institutions, politicians as well as the general public (Albrechts, 2011) – if they do not accumulate enough power to sediment into the cultural ground that sustains current processes (Healey, 2006: 532).

The following chapter therefore focuses on identifying *whether* and *in what form* realignments in planning practice unfold in order to accommodate new policy solutions and become truly physically transformative (Evans et al., 2021). Change is not understood as a reactive process, but as a process of social innovation initiated by the agency of the planning actors involved (Christmann et al., 2020). To this end, two recurring theoretical concepts are integrated, namely that transformative change arises from endogenous potential, e.g. the inadequacy of existing practices or tools to meet emerging challenges, institutional gaps, creative agency, etc. (Streeck and Thelen, 2005), as well as from exogenous pressures, e.g. crises, shocks or a substantial political mandate (Bratzel, 1999). Given the persisting challenges of the Greater Toronto Area's transportation system and a potential future with AVs, the question arises whether the "time is ripe" (Füg & Ibert, 2020: 548) for new approaches in transportation and urban development to gain traction.

> *"AVs have the potential to impact the way that City staff plan for, prepare, and deliver services to the public."* (Toronto, 2019a: iv)

By revisiting ongoing planning initiatives for AVs in relation to past developments and existing challenges, it is possible to trace variations and patterns of incremental realignment in planning practice. These may occur in response to a growing discourse on AVs, but may equally well have emerged prior and independently of the issue that is now contributing to novel "assemblages" (McCann & Ward, 2012: 43). Following Christmann et al. (2020: 513), instances of unfolding change can be identified as recurring patterns across three analytical dimensions that strongly correlate with each other in practice: a.) actors & networks (7.1), b.) newly combined planning elements (7.2), and c.) institutions & institutionalization (7.3). In this vein, novelty in planning is not only considered a new reconfiguration of previously isolated policy or planning elements, such as the integration of transport and land use planning, but as a social process promoted by planning actors, organizational learning and realignments in interaction practices.

7.1 Actors & networks

In studying the planning initiatives for AVs in the Greater Toronto Area, the role of individual and collective agency stands out. In line with Streeck & Theelen's (2005) understanding that change processes can evolve endogenously when "actors of change" (Getimis et al., 2014: 292) push and promote novel practices, the following section reviews actors and actor networks that the interviewed experts referred to as influential forces in the context of AV-related planning initiatives. Christmann et al. (2020) describe strategic networks as temporary collaborations that actors join to achieve common goals. As such, networks are important enablers for overcoming entrenched perceptions and gaining political support for novel policies and planning approaches (Lelong, 2014).

As part of a social innovation process, however, founding networks also resemble a space "in which participants cultivate a growing discomfort with existing institutions." (Christmann et al., 2020: 511). Based on a critique of the status quo – existing planning principles, procedures or expectations – novel ideas and innovative approaches are conceived. In order to assess how individual actors contribute to potentially transformative change processes, their means of cultivating change within their institutional possibilities and constraints are examined. Firstly, by reviewing the initiatives launched during their tenure and through their promotion, and secondly, by analyzing the characteristics of strategic networks that have emerged.

7.1.1 Actors of change

At the municipal level, experts point to individual champions within Toronto's public sector who pushed the automated vehicle agenda through a variety of means and objectives. Some assert that the former General Manager of Toronto's Transportation Services division, Steve Buckley, was the initiating force behind the city's launch of planning and collaborative efforts on AVs in 2014 (I-11; I-03). During his 4-year tenure, the division laid the groundwork for municipal planning initiatives on AVs. One of Buckley's early achievements was a City Council resolution that enabled Transportation Services to independently commission post-secondary educational institutions, government agencies and non-governmental professional organizations with research projects of up to $100,000 Canadian (Toronto, 2014; I-03). With this leeway or institutional "play" (Streeck & Thelen, 2005: 18), the division was able to establish crucial research partnerships that led to the publication of David Ticoll's seminal discussion paper (2015) and several other studies that have since informed the city's policy and planning actions on automated vehicles (see Fig. 4.1).

In line with previous studies on innovation in planning practice (Vigar et al., 2014), interviewees stressed the significance of leadership from senior officials to ensure the adoption of new subjects and procedures by municipal staff (I-01; I-03; I-05; I-11). For a division traditionally "focused on maintaining the existing [transportation] system" (Hess, 2009: 19) and largely mandated by City Council (I-11), taking up monitoring efforts on AVs and developing a *Divisional Workplan* (Toronto, 2016a) prior to receiving an official council request is indicative of quite significant enterprising action – that is, deliberate activity aimed at establishing new social practices and alternative structures of collaboration (Bathelt & Glückler, 2014; Cajaiba-Santana, 2014). Given the disruptive impact that ride-hailing companies were having on Toronto's transportation system and the outlook that companies such as Google were working on automating such services, the initial impetus was to get ahead of the technological development (I-16; Toronto, 2019a: 122). The means to accomplish this was to proactively begin interdivisional learning about potential impacts and initiate a conversation about the municipal goals and objectives for a future with AVs (I-16).

Although the transportation division does not oversee the regulation of new mobility services once they are operational – instead, in the City of Toronto, the responsibility lies with the Municipal Standards and Licensing department – the former general manager's motivation was to proactively prepare for AVs and develop a holistic municipal stance (I-16). In effect, the subject of AVs was embedded into the transportation division. A divisional working group was formed and staff positions were assigned to the topic, which gradually took on more responsibility in coordinating AV-related initiatives within and beyond the municipality. In this vein, the City of Toronto did not share the dilemma of cities in the United States, which lack clarity in divisional responsibility over matters related to AVs (Freemark et al., 2019). Acknowledging Buckley's conviction in building capacity early and taking a municipal position on AVs (Buckley, 2022), in May 2016 Toronto City Council responded to Transportation Service's ventures by requesting the division to develop "recommendations on how the City of Toronto might prepare for the introduction of automated and autonomous vehicles." (Toronto, 2016c).

A number of AV initiatives and interest groups were launched in the years prior to the start of related planning work at the municipality of Toronto. Perhaps one of the earliest actor networks driving the topic is the Canadian Automated Vehicles Centre of Excellence (CAVCOE), which was launched in 2013 by two members of ITS Canada's Autonomous Vehicle Task Force. ITS Canada, in turn, is an industry association focused on the promotion of intelligent transportation systems. It called on governments, businesses and industries to plan and prepare for AVs from an early stage. Sharing the sentiment, CAVCOE asserted from the outset that AVs will not only "arrive on Canadian roads later this decade" but that they will impact "towns and cities and society as a whole" (CAVCOE, 2013). Toronto's transportation division began collaborating with the non-profit organization as part of its initial education and awareness efforts for municipal staff (I-16). In early 2015, CAVCOE conducted the first formal workshop on AVs at the City of Toronto, hosted by the transportation division (Toronto, 2016a).

The workshop jumpstarted a number of initiatives in the municipality of Toronto. On the one hand, exchanges between divisional leaders continued, notably leading to the formal establishment of the Interdivisional AV Working Group in 2016. On the other hand, partnerships were established with universities, international governments as well as provincial and federal departments of transportation (Toronto, 2016a). Concerning the latter, Toronto's transportation division was pivotal in urging its provincial and federal counterparts to establish overarching working groups on AVs (I-16). This is significant for two reasons. Firstly, by having a voice at the table in such a working group, municipalities have the opportunity to create awareness for municipal concerns about urban implications and add to a more balanced conversation on the subject (I-16). Secondly, municipal involvement and presence may prevent legislative decisions that could inhibit local regulation and oversight of emerging mobility services (I-16; Siegel, 2017). A critical means of gaining recognition from higher levels of government is via city partnerships such as the National Association of City Transportation Officials (NACTO) that released its first policy recommendation on AVs in 2016 and prepared a unified policy approach for cities through its *Blueprint for Autonomous Urbanism* (NACTO, 2019a).

Measured against the legacy of his initiatives, the former General Manager has proven particularly influential in the field of future mobility and digitization. His 2015 initiative to launch the Big Data Innovation Team, for example, was institutionalized in 2019 as the Data & Analytics Unit. The divisional working group on AVs and its interdivisional counterpart were also continued. The stabilization of institutional structures ensured that divisional capacity on these subjects was built proactively – a prerequisite for institutions to be responsive to future change (Rauws, 2017). The success of the former general manager's leadership therefore lay in securing the necessary financial resources for staff deployment and commissioned studies, in forging critical partnerships within and beyond the municipality and in establishing a planning approach for AVs based on systematic learning and knowledge-generating formats (Christensen, 1985: 67). Despite Steve Buckley's departure as General Manager of Transportation Services in late 2016, many of the initiatives commenced under his leadership continued: e.g. the AV team as a single point of contact, the interdivisional AV working group, research partnerships as well as internal assessments. In early 2018, staff from the divisional working group submitted the report to City Council that it had requested in 2016.

→ **Network of founders** | Incubation phase

When relating these initiatives to each other, it becomes evident that municipal planning efforts for AVs have been shaped by both inter-organizational relations and strategic alliances between like-minded experts (Lelong, 2014). The latter can often be identified in early phases of planning innovations as informal networks of founders (Christmann et al., 2020) established by pioneering practitioners.

In the GTA, such a network likely consisted of consulting technology experts who advocated for early preparation, senior officials at the City of Toronto, provincial actors and members of MACAVO – the Municipal Alliance of Connected and

Automated Vehicles in Ontario, set up in 2016 as a forum for municipalities and the private sector. A shared belief in imminent disruption due to AVs and the need to understand their impact served as the network's latent link: "The time for Ontario municipalities to prepare for this change is now." (Good Roads, n.d.).

Following the patterns and roles identified by Christmann et al. (2020), advisory technology experts may be viewed as formal "outsiders" in the planning domain who have a particular interest in urban and infrastructural development. Municipal officials engaging in the subject, on the other hand, may be considered "elite" professionals belonging to the planning community. As the initiative to prepare for AVs grew out of conversations concerning the regulation of ride-hailing in the City of Toronto, the first divisions to be involved in the AV network were Transportation Services, City Planning and Municipal Standards and Licensing. Together with formal outsiders to the planning community, initial ideas on how to prepare and plan for AVs were developed and efforts were made to spread awareness among government and public actors.

In the years following Buckley's departure, new tools were adopted as part of the division's AV planning activities, e.g. the preparation of the AV Tactical Plan (see Chapter 4.3.1), the commencement of an AV shuttle trial and the conception of Transportation Innovation Zones (see Chapter 4.4.1). All of these resemble explorative planning approaches that build on research, alternative methodologies and learning environments that are embedded in planning processes and strengthen municipal responsiveness (Christensen, 1985). In this sense, the adopted tools continued planning principles established under the previous general manager and that equally characterized efforts beyond planning for AVs, e.g. the 2017 King Street Pilot. With a change of leadership in late 2016, Barbara Gray, a transport planner known for progressive transport policies in favour of pedestrians, cyclists and transit riders, became General Manager of Toronto's transportation division (Spurr, 2016). Albeit having a distinct focus on sustainable mobility modes, the new general manager continues the professional legacy of the predecessor. Both have been active members of North American planning communities such as NACTO, which provide environments in which new policy models are circulated and variegated (Füg & Ibert, 2020: 545).

Nonetheless, some interviewees also spoke to a shift in the way the transportation division executes its mandate related to the change in leadership. Traditionally, the division has a short-term focus on keeping the street network in a "state of good repair" (Hess, 2009: 15). But under the new leadership, some perceive it to be taking on a strategic vision (I-11). The city's recent pilot projects (e.g. the King Street Pilot and AV Shuttle trial) and integrated mobility programs (e.g. ActiveTO, CurbTO and RapidTO), as well as the AV Tactical Plan, reflect this shift. While the former two examples encourage the use of sustainable mobility through explorative and temporary tactics that align with long-term policy objectives, the AV Tactical Plan explicitly links short-term actions to a "strategic vision for the ideal future transportation system" (Toronto, 2019a: viii). In this context, improved inter-divisional collaboration was addressed as another impact of the new leadership (I-11), perhaps reflected in the collaborative efforts of the interdivisional working group on AVs and the integrated perspective adopted by the AV Tactical Plan (see Chapter 4.3.1). In this respect, it is important to note that these initiatives originated under Buckley, but where successfully continued and likely variegated under Gray.

→ Patrons & Allies | Generating phase

For the early staffing initiative to continue, expand and bear practical fruit, the backing of actors with institutional power was critical. So-called "patrons" (Christmann et al., 2020: 510) emerge in early phases of innovation to endorse novel ideas and help put them into practice. In Toronto, it was significant that the AV team was backed by City Council and given an official mandate to develop recommendations on how the City could prepare in 2016. In addition to a government's level of resources (Freemark et al., 2019), its political representatives' understanding of and interest in new technologies is an influential factor in whether or not a municipality develops proactive policies (I-08). In this regard, the position of Toronto mayor John Tory, who favours technological disruption, is worth noting (Keil, 2017). It contributes to the region's welcoming environment for technology companies that is shared by the province (Ontario, 2020a).

Another influential role is played by "local allies" (Christmann et al., 2020: 510) who share the enthusiasm for a novel idea or practice and support initial implementations by linking it to local traditions. The subsequent general manager of the transportation division and senior staff appear to have played such roles, since divisional resources continued to be devolved to the issue of AVs despite uncertainty about the possible outcomes of projects such as the AV Shuttle Pilot or the Transport Innovation Zones. Through these examples, exploratory planning approaches and learning environments were continued, but with a greater emphasis on serving local needs and municipal challenges, as in the case of the Transportation Innovation Challenges (see Chapter 4.4.2). Moreover, the NACTO Designing Cities Conference was brought to Toronto in 2019 under Barbara Gray. Within its framework, numerous sessions addressed vehicle automation, emerging mobility technologies and managing mobility data and privacy (NACTO, 2019b), enabling planning professionals to share knowledge, exchange experiences and build capacity on these subjects. In this sense, the success of planning innovations not only depends on a continuity of resources, vision and leadership (Vigar et al., 2014), but likewise on professional communities through which policy ideas and practices are promoted, shared and modified (Füg & Ibert, 2020).

7.1.2 Networking

The pursuit of strategic stakeholder relations and networks is a key feature of AV planning initiatives in the Greater Toronto Area. The conviction that policy and planning preparation are essentially a collective effort reads unmistakable in the various documents published over the years:

> *"Preparing and integrating automated and autonomous vehicles into regional transportation systems is not something that can be done alone, but when all orders of government, and jurisdictions across the world, work together to advance the best possible future for urban mobility."* (Toronto, 2016a: 6)

> *"Preparing for a future with CAV requires intentional collaboration across various public agencies and with private sector organizations. Inside of each of the individual agencies, there are limits to the amount of time and resources that can be devoted to preparing policies and regulations, infrastructure and daily operations to support implementation of CAV. When combined, the impact of a coordinated effort and collective investment across provincial, regional and local agencies is significant and will help to understand the uncertain future while avoiding duplication in efforts."* (Ontario, 2020a: 49)

Considering the City of Toronto on its own, at least three types of network arrangements can be differentiated. Firstly, an intra-municipal network that grew to include representatives from over 30 divisions and agencies. Secondly, an external network that connects the municipality with universities and research institutes, government agencies and private sector organizations. This essentially promotes knowledge exchange between academia, industry and public agencies (Clark, 2020). And thirdly, an intermunicipal network of peer cities in Canada and across North America that share learnings and insights on policy development and application. Such networks, which are both informal and formal (e.g. contractual) channels for knowledge transfer, facilitate the flow of information, expertise, technologies and policies in parallel with administrative hierarchies (Peck & Theodore, 2010; Clark, 2020; Füg & Ibert, 2020). Depending on the structural characteristics, the pooling of diverse resources through network arrangements benefits the generative process that leads to novel ideas and resources (Vedres & Scotti, 2012).

Viewed through the lens of social innovation, network arrangements can further enable collective action and change processes (Lelong, 2014). To understand the underlying dynamics, network analysis explores governance mechanisms such as trust, reciprocity and reputation, but also takes into account the individual and collective resources of the actors involved (Vedres & Scotti, 2012; Lelong, 2014). The latter are transacted particularly often and may explain why certain alliances are formed. Following Lelong (2014: 218), actors dispose of different types of resources, which are regulated by political, economic, and institutional circumstances: a.) political (e.g. formal positions), b.) material (e.g. land ownership, physical infrastructure, financial resources) and c.) knowledge resources (e.g. procedural know-how, expert knowledge). In terms of the commencement of policy and planning efforts for AVs in Toronto, all of the above are significant.

The example of Toronto's Interdivisional AV Working Group (IDWG) demonstrates that the network arrangement has multiple effects. Following the initial workshop among divisional leaders, the intra-governmental network was formalized as a "forum for discussion, collaboration, and coordination on AVs with representatives from key impacted City divisions" (Toronto, 2016a: 3). With regard to favourable conditions for knowledge exchange, interviewees emphasized the leadership of the IDWG chair and his ability to successfully integrate the diverse perspectives of IDWG members (I-05; I-06). Beyond that, mutual trust and respect, openness and an encouraging environment were cited as influential criteria for network effectiveness. Informal mechanisms, such as reciprocal communication, were used to distribute information, but also to connect stakeholders and establish new links between regional agencies active in the AV sector (I-05). As such, the IDWG functioned as an intermediary space, facilitating the development of institutional capacity and the expansion of network relations. In this way, the translation of ideas into action was likely expedited (Powell, 1990).

Under the leadership of the transportation division, the IDWG also provided the necessary governance structure for collective decision-making (Reimer et al., 2014). This was particularly vital for the development of a joint policy framework – the AV Tactical Plan 2019–2021 (Toronto, 2019a). By taking stock of the manner in which various municipal divisions and agencies may be impacted throughout the transition to AVs (I-16), every division involved was able to contribute its perspective and ensure that identified policy actions align with existing strategies and goals (I-01). A report for action to the Public Works and Infrastructure Committee (Toronto, 2018a) describes the function of the policy framework as to ensure that "all divisions and agencies are following a consistent direction with respect to automated vehicles and the City's policies, plans, and strategies." (5). The commencement of the IDWG prior to the development of the Tactical Plan is noteworthy as it essentially acknowledges that the government needs to adapt to effectively tackle the challenges of emerging technologies (I-12).

Nevertheless, the IDWG is not entirely symmetrical, neither structurally, nor transactionally (Emirbayer & Goodwin, 1996). Structurally, the IDWG acknowledges the pioneering role of the Transportation Services division in initiating municipal efforts toward AVs, but it also reflects its political and material resources. On the one hand, the division received the necessary backing by the City Council to move forward. On the other hand, it disposes of greater financial resources than other divisions (Hess, 2009), which enabled it to assign the largest number of staff dedicated solely to AVs of any Canadian municipality in 2019 (I-09-A). Diverging resources, which interviewees particularly addressed in relation to transit agencies, are significant when it comes to planning and preparing for an emerging mobility technology, as they determine the scope of capacity development and ultimate agenda setting. Lastly, the division's infrastructural oversight and responsibility for the operating conditions of the transportation system as a political and material resource are not to be neglected in the context of AVs. Afterall, many of the short-term spatial changes concern infrastructural adaptions, parking and station areas.

Transactionally, the varying capacities to engage in the subject also affect the respective network dynamics. And so, all efforts to foster knowledge exchange, joint learning and capacity building across divisions were carried out by the AV team. One interviewee portrayed their efforts accordingly: "They're the pushers, the leaders, and they're doing all the heavy lifting." (I-05). To spread awareness on the subject of AVs and its potential impacts (I-16), the AV team not only had to host workshops for divisional representatives and subcommittees. It also held staff meetings and trainings with individual divisions (I-02). A significant effect of these engagement efforts was the trust engendered in the IDWG's work on AVs. In line with Powell's (1990: 305) assertion that trust reduces complex realities far more quickly than prediction, authority or bargaining, municipal actors showed more support for the AV-related initiative the more they understood its underlying arguments and intent (I-02).

For some actors, the AV team's proactive outreach and workshops had the purpose of instilling a sense of urgency in municipal actors to prepare, e.g. by shedding light on the extent of industry activity across the GTA (I-02; I-16). In turn, the more invested divisions were supported in developing their own work plans and studies. The exchange of expertise between the AV team and individual divisions was reciprocal in that the AV team not only disseminated knowledge, but also sought to learn from divisions and receive input on policy considerations for the city's AV Tactical Plan (I-02). Nonetheless, the overall network dynamic was strongly "directional" (Emirbayer & Goodwin, 1996: 367) and oriented towards the leadership of the AV team. In line with the intention stated in the 2016 Divisional Workplan that the division would take "a leadership role amongst the rest of the City of Toronto's divisions, agencies, boards, and commissions." (Toronto, 2016a: 2), the AV team exerts a distinct network centrality (Vedres & Scotti, 2012).

However, precisely because capacities and resources vary, the extent to which the generated knowledge is carried further into the respective agencies and divisions may differ. For instance, one interviewee expressed scepticism about whether the capacity building that has taken place among the members of the network is trickling upwards to senior management and executives in charge of pursuing respective policy change (I-05). Another interviewee pointed to the age of the working group members (mostly younger mid-level staff) and stressed that divisions and agencies are challenged to foster internal knowledge transfer in order to sustain learning and prioritize next steps (I-08). More confident perspectives shared pointed to the Tactical Plan's priority actions for which individual agencies took responsibility (I-01; I-02), implying that these require a certain level of organizational change and knowledge transfer.

In its capacity as a learning environment, the IDWG certainly posed a critical source of knowledge for actors with few resources. Perhaps providing what Powell (1990) described as "a transitional move until internal capacity is built up." (327). In this sense, sharing resources in preparation for an uncertain future likely represented another common goal of the actors who enrolled in the IDWG, even though it was not explicitly addressed as such. Last but not least, capacity building within the IDWG and its related projects, e.g. the AV-Shuttle pilot, cultivated a community of professionals within and beyond the municipal government who share a pool of knowledge about AVs (Christmann et al., 2020). Even if the IDWG did not continue in the short-term, the community of experts would be held together by a latent network that may be activated on short notice, perhaps in future moments of disruption (Ibert et al., 2022: 7). In fact, a likely future role of the IDWG may be to reassess successful collaboration between divisions and agencies as part of the monitoring and evaluation process of the Tactical Plan (I-02).

→ **Intermediaries** | Incubation phase

Within the municipality of Toronto, the AV team – institutionally located at the city's transportation division – acts as a significant intermediary agent. A role that can be identified in early phases of innovation (Christmann et al., 2020). On the one hand, its focus is on generating knowledge through partnerships with experts from the academic and private sectors. To this end, the AV team would cross the boundaries between government, academia, industry and the public, seeking input from various perspectives. On the other hand, it spread the generated knowledge within the municipality by facilitating learning environments for municipal divisions and enhancing interaction between stakeholders.

A key activity of the AV team was to translate the urgency of preparing for a potentially imminent disruption due to AVs into the remit of individual divisions (I-16). The insight into the level of private sector investments, that is, the amount of AV testing underway in the region, as well as the negative experience of being governmentally unprepared for the unexpected arrival of ride-hailing companies in 2012, undoubtedly functioned as drivers for joint learning and capacity building. The AV teams' ability to spread this awareness and facilitate joint learning helped to build the necessary trust and legitimacy for AV planning efforts to be joined and engaged by other divisions (Bathelt & Glückler, 2014).

7.2 Newly combined planning elements

The recombination of planning elements is relevant to the quest of identifying patterns of change, insofar as novelties in planning practice are rarely entirely new. To a much greater degree, they represent a new "linkage or fusion of two or more elements that have not been previously joined in just this fashion, so that the result is a qualitatively distinct whole" (Barnett, 1953, as cited in Gillwald, 2000: 11). The individual elements may comprise planning ideas, procedures and organizational forms, that represent a significant alternative to the status quo by being newly assembled. Viewed as processes of social innovation, new practices and forms of thinking tend to adopt a normative stance as they aim to improve collective well-being (Dawson & Daniel, 2010). Yet, perceptions of what constitutes a social benefit vary widely among planning actors and public stakeholders, so that what may be considered an improvement by some is perceived as a setback by others (Cajaiba-Santana, 2014). In effect, social innovations often entail controversies and even conflicts, which may be perceived as generative for new ideas and concepts (Christmann et al., 2020).

Against the backdrop of present-day challenges in the Greater Toronto Area transportation system, three themes stand out as being intensely debated and suggesting potential avenues for social change – that is, modal priority, street space design as well as regional transit integration and infrastructure provision. In order to investigate the extent to which the potential introduction of AVs adds to new perspectives in these fields of practice, e.g. in terms of regulatory measures, public service provision, or the design of and investment in physical structures, the analysis takes the recently published policy frameworks on automated mobility as a starting point.

7.2.1 Modal priority

The issue of modal priority stands at the centre of change dynamics in the transportation system. Both in relation to new mobility technologies and the continued diversification of services, and in the wake of the Covid-19 pandemic, which has simultaneously increased car dependency and active transport (Ciuffini et al., 2021; Harris & Branion-Calles, 2021). In the GTA, the issue is closely tied to questions of infrastructure capacity and network efficiency as population growth is projected to continue. To fight gridlock and improve network capacity, the recently adopted transportation plan for the region, *Connecting the GGH: A Transportation Plan for the Greater Golden Horseshoe* (Ontario, 2022), aims to strike a balance between road infrastructure expansion and transit provision, as an interviewed expert noted:

> *"Well, the ideal is that the network behaves efficiently. But transit, ideally, will always make up our transportation system."* (I-14)

In the years leading up to the adoption of the GGH Transportation Plan, the Ministry conducted an internal scenario study assessing the effects of new mobility services and emerging technologies – referred to in the document as "potential disruptors" (Ontario, 2022: 61). Early findings indicated that policies with the greatest potential to support regional transportation goals include transit investments, incentivizing shared use and AVs as a first and last-mile solution in combination with road pricing (I-15). Of these initially identified policy measures, the final version of the GGH Transportation Plan explicitly lists transit investments and the testing of AV shuttles as policy actions. Incentivizing shared vehicle use at the regional level is indirectly addressed through a policy on "connected managed lane network" (Ontario, 2022: 19). In the Transportation Plan, this is envisioned to encompass HOV lanes or dedicated bus lanes, but without corresponding pricing policies, which interviewees consider highly unlikely given the current political climate (see Chapter 6). Travel demand management policies, which are mentioned instead, include the promotion of telecommuting and flexible work hours (Ontario, 2022).

Against this backdrop, it is hardly possible to conclude that a shift in modal priority is being sought at the regional level of the GTA. Although necessary transit investments are prioritized, their scope is overshadowed by the aim of infrastructure development through additional highway projects and corridor expansions (Ontario, 2022: 30). Measures known to induce overall vehicle travel, increase car-oriented sprawl and run counter to the stated ambition of reducing GHG emissions. In a future with AVs, such effects are likely to be amplified and cause other policy measures that bear the potential for change to remain inconsequential.

In Toronto's *AV Tactical Plan*, modal priority is addressed by the city's ambition to take a "transit-centric approach to automation" (Toronto, 2019a: 122). Transit enhancement is described as benefitting multiple policy goals at once: "Automation in transit can contribute to the goals of this Tactical Plan, by ensuring a more space-efficient mode of travel, a more seamless system for the user, less acute demand across the transportation system, and improved safety." (Toronto, 2019a: 94). Corresponding with the findings on German city's policy focus, various measures are outlined to ensure transit priority, strengthen its attractiveness and avoid competing service offers (Fraedrich et al., 2019).

Firstly, the application of infrastructure connectivity (v2v and v2i communication) along specific corridors as a means to enhance transit priority, increase reliability and improve information availability (Toronto, 2019a: 90). Although the planned White Paper on enhancing transit priority has not been published at the time of writing, the City of Toronto and TTC did move on to implement and evaluate priority bus-only lanes on selected corridors in 2020 and 2021. As part of the *RapidTO: Bus & Streetcar Priority* program the City has issued plans to install RapidTO bus lanes along six bus routes identified as the most heavily used corridors in the TTC's *5-Year Service Plan & 10-Year Outlook* (TTC, 2019). The first stage of corridor implementation includes the installation of transit signal priority, e.g. extended green lights or shortened red lights and traffic signal coordination. In the future, the system may be scalable to include broadcasting features of real-time road and traffic conditions, as well as two-way V2I and V2X communications (Ontario, 2020a: 18-19). The infrastructure measure further corresponds with Toronto's *MoveTO 2021–25*, a preliminary action plan to accelerate the rollout of smart traffic signals, intelligent intersections and the aforementioned Advanced Transit Signal Priority system (Toronto, 2020b).

A second means of promoting transit through AV technologies, addressed in the Tactical Plan, concerns the integration of low-level automation, e.g. driver safety assistance technology. Related short-term actions include the definition of pilot corridors and the evaluation of available technology to clarify procurement needs (Toronto, 2019a: 81). Based on the expectation that traffic capacities may be enhanced without extensive infrastructure investment, lower-level vehicle automation may be of particular interest to transit agencies (Spurr, 2020). Segregated bus corridors, for instance, could provide future testing environments for the assessment of respective technologies (I-09-A; 1-15). At the time of writing, transit-related planning actions did not exceed trials with AV shuttle buses. However, as emphasized by an interviewee, testing AV shuttles is equally rooted in a transit-centric approach, as it creates an opportunity for transit agencies to learn about the technology's capabilities and limitations (I-01).

The third measure to enhance transit priority in an AV-based transportation system addresses pricing models and transit incentives through value propositions, which are meant to ensure that transit remains more affordable than AV alternatives (Toronto, 2019a: 100-101). Although it may be too early to draft exact pricing schemes for a transportation system with self-driving vehicles, research shows that the lower operating costs of AVs will likely pose a significant challenge for transit agencies in the GTA. Not only due to self-driving shuttles or taxis, which may compete with transit (Litman, 2021). More importantly, market surveys conducted in the GTA have shown that consumer preference for owning private AVs far outweighs interest in on-demand shared vehicle use (Laidlaw et al., 2018). As a consequence, if more people take up long-distance commuting rather than using transit services, agencies may be faced with revenue loss, potentially leading to a decline in service quality and detrimental impacts on social equity (I-07) and the environment.

In addition to promoting transit use, the Tactical Plan's goal to "increase space efficiency" (Toronto, 2019a: 89) also entails efforts to enhance the mode share of active transportation, high occupancy vehicles and combined-purpose vehicles. Yet, concrete actions to promote a modal shift are only tentatively addressed. Policy options to ensure that active modes are prioritized "alongside AV infrastructure upgrades" (Toronto, 2019a: 91) and that the introduction of AVs is coordinated with the City's plans for HOV lanes are mentioned but not yet developed in the 2019 edition of the policy framework. Similar to Connecting the GGH, congestion charges or electronic road pricing measures, which may further incentivize high-occupancy vehicles, are left unaddressed in the AV Tactical Plan, despite the fact that successful enforcement of local HOV lanes has posed a challenge in Toronto (I-06). Existing examples are toll-free, limited to individual corridors and lack a broader application in order to have a meaningful impact on sustainability objectives or transport levels.

Overall, the language on modal priority remains non-prescriptive in the AV Tactical Plan. It identifies significant planning goals concerning transit use, a more balanced mode distribution and improved system performance. Yet, the measures listed to disincentivize single-occupancy trips and ensure "less acute demand across the transportation system" (Toronto, 2019a: 97) are outlined as future intentions, rather than short-term actions that might equally tackle current levels of car-dependency. Even though the Tactical Plan's underlying transport management approach resonates with German planning professionals' stance that a potential increase in car use requires deliberate planning action (Fraedrich et al., 2019), the specific timing of its implementation is left open. For the near future, the ambition outlined in the Tactical Plan appears to be focused on vehicle throughput (e.g. through smart signals) and the enhancement of modal choice, as an interviewed expert noted:

> *"We think private vehicles are always going to be around, whether we like it or not. It's really just a matter of making it so that we're changing the way people would like to move and making it easier for them."* (I-02)

Finally, the goals of increasing public transit use and other space-efficient modes are not tied to corresponding land use effects – yet. Research on the impacts of AVs on land use planning regulations, standards and guidelines is equally listed as forthcoming (Toronto, 2019a: 127). Planned studies are to address potential changes in parking demand, including a possible shift to suburban overnight parking locations as well as potential impacts on urban sprawl due to a decline in perceived travel costs (I-06). Integrated studies on AV-based services such as these are critical to gaining a deeper understanding of how new mobility technologies affect land use and, in turn, how land use change may affect travel patterns with new mobility technologies. As elaborated by local scholars (Higgins et al., 2021), bus rapid transit systems (BRT) that run along priority bus lanes or new mobility services using AV shuttles, do not effectively alter travel patterns, if implemented on their own. Instead, supporting measures are required that address corresponding changes in land use (e.g. mixed-use development, higher densities) and in residents' mobility habits (ibid.). Accommodating "gentle growth" (Lee & Kim, 2020: 4) along BRT corridors may provide multiple benefits: improving transportation system performance (Higgins et al., 2021), ensuring transit funding through ridership fares (Siemiatycki & Fagan, 2019) and reducing the polarization between high-rise developments and dispersed, low-density housing (CUI, 2018: 8). But policy linkages of this kind that go beyond the integration of novel technologies and touch on land use are thus far limited in Toronto's Tactical Plan.

→ First links between elements | Generating phase

Although new links between highlighted policy elements in *Connecting the GGH* and the *AV Tactical Plan* remain limited, recent practice examples do resemble integrated approaches. As part of Toronto's RapidTO program, for instance, the concept of Priority Bus Corridors (introduced in the 2041 RTP, Metrolinx, 2018: 64) is recombined with other planning elements, including infrastructure connectivity that may support a potential transition to automated mobility.

The program is not only conceptualized to improve on-street transit operation by establishing priority bus lanes and combining them with transit signal priority (Toronto, 2021b), but also integrates cycling infrastructure, utilizes tactical measures (e.g. red street paint and signage) and gives priority to Neighbourhood Improvement Areas (NIAs). In this way, it integrates the goal of better transit system performance with improved service provision and accessibility for low-income neighbourhoods – a policy objective of Toronto's Poverty Reduction Strategy.

Concerning the overall transportation system, the integration of infrastructure connectivity and priority bus lanes along suburban arterials presents a promising approach to improving system performance in the GTA. On the one hand, because connected infrastructure and communication technologies can contribute to better throughput, increase service frequency and align service with travel demand (Higgins et al., 2021: 40). On the other hand, because the GTA's suburban arterials provide sufficiently wide street sections for the integration of frequent bus services, which could subsequently be paired with mid- to high-density, mixed-use redevelopment (Lee & Kim, 2020; Higgins et al., 2021). In combination, these strategies bear the potential of reducing car dependency while increasing transit use and active mobility.

Risk of absorption: Novel planning practices are always at risk of being absorbed by established approaches, institutional constraints and entrenched culture (Albrechts, 2011). Mobilizing political support and fostering cross-sector relations are perhaps the greatest challenges to ensuring the persistence and expansion of planning approaches such as the RapidTO program. Firstly, because scaling the strategy to the citywide network requires buy-in from suburban councillors as well as constituents. Secondly, because extending priority bus corridors and ensuring infrastructural consistency across municipal boundaries hinges on intermunicipal agreements and regional transit coordination among multiple agencies. And thirdly, because integrating frequent transit corridors with housing development also requires the openness and willingness of private developers to forge equitable development visions.

7.2.2 Street space design

The design of streetscapes and road infrastructure is related to the question of modal priority. The recent health crisis has once again illuminated that streets are public spaces that are vital for public health, quality of life and economic vitality. As demand for mobility and delivery services grows, the redistribution of road space becomes a critical task. Related planning measures outlined in

Toronto's AV Tactical Plan range from street network classification to street design standards and elements of curbside management.

The motivation underlying street reclassification addresses a scenario in which pick-up and drop-off activity by self-driving vehicles increases significantly along major and minor arterials. To avoid consequential traffic congestion and reduced throughput, particularly along streets with surface transit, a policy is proposed to designate Toronto's local streets as AV "facilitators" (Toronto, 2019a: 93). Subsequently, pick-up and drop-off spots for passenger vehicles and deliveries could be installed in close proximity to office or residential buildings, but along side streets rather than on the arterials themselves. The proposed policy resonates with Toronto's Curbside Management Strategy, which encourages "off-street pick-ups and drop-offs, loading, and parking activity" (Toronto, 2017d: 6) as a general principle to free up on-street curbside space. It also mentions the possibility of using commercial laneways for off-street loading and deliveries in downtown Toronto (Toronto, 2017d: 9).

In principle, the suggested policy represents an important tool to tackle network performance and manage congestion. In the context of an AV future, however, the described tactic fails to differentiate its application based on neighbourhood characteristics and land use along local streets. The results of a modelling study on the implications of AVs for traffic and land use have shown that an SAV scenario in which pick-up and drop-off activity occurs at every possible household address may cause traffic volume to substantially increase on lower-order streets (Bruck & Soteropoulos, 2022; see also Chapter 2.2). In residential neighbourhoods, the additional traffic could negatively affect the public space and its permeability for pedestrians and cyclists. In addition, increasing traffic throughput along major arterials at the cost of lower order streets may cause the rebound effect of incentivizing additional use of private or shared AVs, if not complemented by policies explicitly promoting transit and restricting individual passenger trips.

In terms of defining street design standards for a future with AVs, all of the proposed measures (lower speed limits, reduced lane widths, dynamic street use and curbside management) refer to existing planning tools in Toronto's *Complete Street Guidelines* (2017b), which do not necessarily rely on the uptake of AVs (Toronto, 2019a: 92). The only exception being significantly lower lane widths along arterials, as future vehicle automation could enable safe operation in a reduced space (Larco & Tierney, 2020: 124). As elaborated in Chapter 6.2.1, the City of Toronto has made significant progress in implementing Complete Street principles in recent years. Either as part of pilot initiatives launched in 2020, e.g. along Danforth Avenue, or as part of street reconstructions which must adhere to the City's 2019 Vision Zero 2.0 – Road Safety Plan Update. Although intentions to transform road space into complete streets are by no means new, e.g. the Danforth

Avenue Planning Study dates back to 2016, the recent expansion of such principles through pilot programs amounts to a significant shift in perspective for Torontonians.

After years of opposition to narrowing traffic lanes in favour of other modes, the Covid-19 pandemic has led public officials to recognize that adequately sized public spaces are an essential resource for the public's wellbeing (Bowerman, 2022). Keeping a physical distance when accessing healthcare facilities, walking in the park and cycling suddenly became a matter of public safety. As a consequence, the global health emergency had a catalytic effect on the planning concepts for a more sustainable and healthier mobility system that had been in place for years (Ibert et al., 2022). In need for an immediate response, the City Council voted on a Pandemic Mobility Recovery Strategy, which fast-tracked planning solutions that provide more space for pedestrians, cyclists and transit riders (Toronto April 30, 2020). Furthermore, Council members came to support a historic expansion of cycling infrastructure. Although the city is still far from achieving its Ten-Year Cycling Network Plan target of installing more than 500 km (Toronto, 2016b), the installation of 40 km of on-street cycling lanes in 2020 has been impactful in encouraging active transportation modes and increasing a sense of safety (Carriere et al., 2022).

Finally, regulating curbside use represents another means of managing the additional demand for street space due to AVs. Most of the actions outlined in the Tactical Plan are again features of so-called curbside management strategies and digital parking management tools: designated pickup and drop-off locations, curbside pricing and sensor-based detection of curb use (Rye et al., 2022). They all represent valuable tools to manage current curbside activities, including loading/unloading of goods, pick-up and drop-off activities as well as accessible boarding/disembarking (Toronto, 2017d). A study on pricing options for curbside management in Toronto has further shown that progressive hourly pricing models may have a positive effect on reducing cruising and congestion, lowering CO2 emissions and more evenly distributing parking demand (Stout, 2021). Integrating such measures as part of complete street projects may thus extend their impact on transit use and emissions. Of the measures outlined in the Tactical Plan, pick-up and drop-off zones have recently been tested as part of the 2020 CurbTO pilot program, and curbside senses that may enhance on-street parking management will be piloted as part of the Innovation Challenge on "parking and curbside vehicle detection" (Toronto, 2022d).

→ First links between elements | Generating phase

The street-building measures outlined in Toronto's AV Tactical Plan largely concern infrastructure measures and are not linked to other planning objectives. However, looking at recent practice examples, e.g. the Destination Danforth Complete Streets pilot and the ActiveTO Midtown Complete Street Pilot, shows that municipal planners have undertaken significant efforts to collaborate and create integrated strategies to transform major arterials.

As with the RapidTO program, mobility issues are not limited to improving active transport and ensuring traffic safety, although these objectives are critical. Beyond that, they are linked to other fields of public value such as economic vitality, place-making and local identity. Since the programs essentially build on the City's Complete Street Guidelines, the integration of these objectives is not conceptually new, yet their translation into practice through a short-term pilot project may be considered a procedural novelty. Planning features that have contributed to their successful implementation include comprehensive stakeholder and public engagement strategies, as well as impact assessments and performance evaluations (Toronto, 2022e).

In the context of a potential transition to AVs, the City's Pandemic Mobility Recovery Strategy also included a pilot for pick-up and drop-off zones, which gained urgency in order to relieve congestion in front of critical businesses. Together with further measures, such as dynamic pricing schemes and vehicle detection sensors, pick-up and drop-off zones provide a means to reduce on-street parking, incentivize the use of active modes for short distances and reduce CO_2 emissions (Stout, 2021).

Risk of absorption: The elaborated instances of transforming major urban arterials rely on the favourable conditions of a temporary pilot framework and the increased awareness of the value of streets as public spaces during the Covid-19 pandemic. The general public and political debate on the redistribution of street space, however, is still ongoing and certainly contested. Planning professionals recommend further application, city-wide scaling and additional policies, e.g. pricing models (Lee, 2020; Beattie, 2021). Evaluation reports for the conducted complete street pilots do not necessarily indicate a risk for being absorbed by an entrenched traffic culture (Carriere et al., 2022). Instead, it is a matter of mobilizing City Council support to translate the examples to other areas, above all the car-centric suburban neighbourhoods.

7.2.3 Regional transit integration & infrastructure provision

Substantial changes in the transportation system of the GTA is not least linked to the question of regional transit planning and improved service integration. In a future scenario with AVs, this is all the more true as cross-border travel and operations will hinge on having overarching standards in place. These fundamentally concern "data, security, privacy, physical infrastructure, interoperability, safety, design and maintenance" (Ontario, 2020a: 37). But for public transit specifically, interoperability of fleets and services also pertains to the coordination of routes, schedules and fare structures. Given the complexity of the regional transit system today (see Chapter 6), this is already a considerable challenge in the GTA. An AV future will only increase the urgency to overcome system divisions and ensure smooth cross-boundary travel, as growing economic competition between AVs may lead to the erosion of the role, purpose and viability of transit as a whole (Docherty et al., 2022: 5). Forging the necessary collaborations for an interoperable transit system is therefore as much an issue of balancing accessibilities and strengthening economic opportunities across the region, as of ensuring overall public value and public quality of life (Docherty et al., 2022).

The GTA's policy and strategy documents on AVs address intermunicipal and cross-sector collaboration in the operation of public transit in an AV future with regard to three main issues. Firstly, concerning the mentioned standards for safety and communication infrastructure as well as network management. This is particularly the case for the *CAV Readiness Plan* (Ontario, 2020a), which has a distinct focus on infrastructure and emphasizes the rollout of V2I connectivity as the first stage of a transition to connected and automated mobility (see Chapter 4.3.3). Given the comprehensive scope of the recommendations on municipal collaboration in this field, it stands out that the GTA continues to lack a multi-level governance structure for C-ITS standards, data management and infrastructure provision (Goracinova et al., 2021). Relevant provincial actions, e.g. improved data collection practices and open data efforts, are mentioned in the long-term transportation plan *Connecting the GGH* (Ontario, 2022: 32), but have not been commenced at the time of writing. Meanwhile, municipalities and transit agencies are implementing V2I communication infrastructure, as evidenced by Toronto's RapidTO program, but without the necessary framework to ensure cross-jurisdictional interoperability. For instance, both Toronto and Durham buses have on-board transit signal priority (TSP) devices, yet, these can only communicate with roadside infrastructure in their respective municipalities (Devitt & Tan, 2020: 15). This is but one example of how effective integration of novel technologies hinges on corresponding institutional change.

Secondly, cross-agency collaboration is addressed with respect to the potential integration of first- and last-mile automated feeder systems and the implementation of corresponding pilot projects (Toronto, 2019a; Ontario, 2020a; Ontario, 2022). From a transit system perspective, a key argument for testing the specific use case is the potential to close service gaps in the existing network (Toronto, 2019a: 94). From a service provider's perspective, another interest lies in its potential to reduce operating costs (I-09-A) while increasing equity of access in terms of communities served – two influential criteria for the relative merits and drawbacks of any transit project (Siemiatycki & Fagan, 2019: 9). Accordingly, the *CAV Readiness Plan* states, "CAV transit vehicles could potentially provide cost savings while also offering improved service coverage and reliability both geographically and temporally, as they can cover more space and provide service at times that may be less desirable for vehicle operators or financially unsustainable to operate a formal service." (Ontario, 2020a: 4, Appendix A). In *Connecting the GGH* (Ontario, 2022), a policy action likewise addresses improved accessibility by noting that future legislation and guidelines for AV services are to consider “Access to transportation among underserved and Indigenous communities” (45).

Areas and neighbourhoods that could benefit from AV-based shuttle services are potentially many across the Toronto region, if integrated systematically as feeder services for the high-order transit network, i.e. the GO train network, subway lines as well as LRT/BRT corridors. In the literature, it is argued that small-vessel AV fleets could close the first/last mile by connecting residential neighbourhoods to transit hubs and nodes (Fraedrich et al., 2019). Although far fewer neighbourhoods in the City of Toronto than in the region as a whole are affected by lack of transit coverage or inadequate rapid transit connections, affected neighborhoods often face equity issues and have not received adequate investments in the past (Abdelwahab et al., 2021: 4). However, various factors affect whether mobility services generate added benefit when used as a feeder mode: proximity to rapid transit, availability of subsidies, parking costs at the destination and expected waiting times at transfer locations (ibid.). This again points to the persisting challenge of fragmented fares in the Toronto region and the added cost of intermodal trips (TRBOT, 2020). For the greater metropolitan region, the service model is considered a significant transit addition and is thus included as a potential policy action in the *Connecting the GGH* long-range transportation plan (Ontario, 2022: 45).

The AV shuttle trials conducted in the West Rouge neighbourhood in Eastern Toronto and in Whitby, Durham Region, resemble two recent examples of transit agencies testing this use case (see Chapter 4). In terms of service integration, schedule alignment and smooth transfers, however, few insights could be gained due to the early stage of the technology’s development. The summary of Toronto’s learnings states its drawbacks accordingly: “Automated shuttle technology needs further development to become a feasible alternative for long-term service in truly mixed traffic environments”. It is worth noting, however, that the regional transit agency Metrolinx has launched a number of pilots testing on-demand microtransit systems with non-automated vehicles in the GTA (Metrolinx, 2021). One example is located in the City of Vaughan, which is partnering with Metrolinx and York Region Transit (YRT) in trialing a “Mobility On-Request service” (Vaughan, 2022). During morning and evening rush hours, participants can request a ride through an App and are then taken to either the Rutherford or Maple GO Rail Station by a YRT-operated vehicle (Vaughan, 2022). Compared to the AV shuttle pilots, which largely gathered insights on technology and infrastructure performance, recent microtransit trials such as the one in Vaughan bear the potential to test service characteristics and flexible routing in low-density neighbourhoods (I-09-B), collect data on ridership (Young et al., 2020) and gain insights on implications for regional transit use, suburban car-dependency and parking demand at transit hubs (Ontario, 2020a).

An aspect, which thus far has not been sufficiently addressed in inter-agency feeder service trials, concerns their linkage to land use changes in the affected areas (Higgins et al., 2021). In order to achieve effective mode shift in car-dependent communities, thereby relieving the overall transportation system, transit investments require supportive strategies. Such strategies include increased mixed-use development, diversified service provision including micromobility options and incentivizing measures to tackle entrenched mobility habits and travel patterns (Higgins et al., 2021; Laidlaw et al., 2018). One exception is the conversion of existing parking facilities at GO Station areas to transit-oriented developments, as projected in the *CAV Readiness Plan* (Ontario, 2020a: 42) and the *Connecting the GGH* (Ontario, 2022: 31). However, the development model does not tackle the root cause of car dependency in existing neighbourhoods, as outlined in the introduction to this chapter, nor does it necessarily meet the housing needs of lower- and middle-income households (Lee & Kim, 2020).

Thirdly, intermunicipal and cross-sector collaboration for the operation of public transit in an AV future is addressed with regard to establishing a Regional Integrated Mobility Platform (Ontario, 2020a: 57). Its underlying intention being to advance a region-wide approach to offering shared mobility services and to provide a single digital solution, which "could improve trip planning for users, increase the efficiency of their travel and potentially improve station access" (Ontario, 2020a: 4, Appendix A). The concept resembles an integrated Mobility-as-a-Service (MaaS) platform (Calderón & Miller, 2020) that, however, hinges on overcoming service fragmentation, inadequate stakeholder collaboration and a lack of shared strategies, e.g. concerning data sharing and infrastructure provision (Higgins et al., 2021; Goracinova, 2021). While the *CAV Readiness Plan* outlines actions on the necessary legislature and policy frameworks, key partnerships, deployment and implementation (Ontario, 2020a: 57), it does not suggest how exactly the underlying institutional framework might look or what role transit agencies might take. In recent years, various solutions have been proposed on how to improve regional transit governance (Neptis Foundation, 2014; Siematycki & Fagan, 2019; TRBOT, 2020). To date, the subject remains a contested and highly politized topic in the Toronto region (Horak, 2021). And yet, institutional arrangements that account for cross-boundary travel patterns in a highly connected urban region such as the GTA would be vital to sustain a strong public transit network in an AV-dominated transport future.

→ Unconnected elements | Incubating phase

Concerning integrated transit planning approaches that could strengthen the GTA's regional transportation system, regional policy documents, academic studies and policy briefs outline several promising policy and planning elements. Yet, to date, these elements have not been connected to an extent that amounts to a planning novelty. Concepts for an integrated transit region have not yet mobilized "sufficient allocative, authoritative, and imaginative force" (Healey, 2006: 527) to travel beyond the institutional environment in which they were conceived and become embedded in other institutional practice arenas. Such examples include, for instance, the Regional Integrated Mobility Platform, sketched out in the framework of the CAV Readiness Plan (Ontario, 2020a), or the on-demand microtransit pilot projects, which thus far have built on project-based transit partnerships and relied on public funding, therefore being limited to favourable conditions.

Nonetheless, on-demand microtransit pilots hold significant potential to close service gaps and improve access to regional rapid transit lines in underserved communities. Yet, further linkages to land use development, stakeholder engagement and supporting policies are required for microtransit services to incentivize a mobility shift away from private vehicles (I-09-A).

Risk of absorption: Thus far, Metrolinx has coordinated and managed integrated mobility initiatives on a project basis. In order for the transit system to remain competitive in an AV future where private AVs are likely to provide greater convenience and affordability for long-distance commutes, sustained funding streams and a more encompassing institutional framework are required to deliver the services currently being trialled in a consistent, interoperable and integrated manner. But also to sustainably promote collaboration between municipalities and transit agencies (Goracinova et al., 2021).

7.3 Institutions & institutionalization

Following Christmann et al. (2020), the institutional context of planning practice comprises the third analytical dimension in which patterns of incremental change may be traced. Drawing on social theory and relational geography, institutions are understood as "stabilizations of mutual expectations and correlated interaction." (Bathelt & Glückler, 2014: 341). This conception contrasts with institutionalist notions that portray institutions as organizations or conceive them as "frameworks of norms, rules, and practices which structure action in social contexts" (González & Healey, 2005: 2058). From a relational perspective, interaction practices and mutual expectations emerge in response to or even against formal rules "– they are shaped by them but in a rather contingent manner" (Bathelt & Glückler, 2014: 346). A key feature of a relational conception of institutions is its compatibility with the multiplicity of rationalities, network dynamics and cultural structures that shape urban development (Emirbayer & Goodwin, 1996; Healey, 2006; Bathelt & Glückler, 2014). When institutions resemble established patterns of social practice that are based on shared expectations, e.g. among urban planners, policymakers and municipal staff, institutionalization may be perceived as the consolidation of new procedures, goals and resource allocations.

How institutionalized practices may stand in the way of realizing new policy was previously elaborated by Hess (2009) with regard to street planning in the City of Toronto. In spite of changing expectations regarding the role of urban streets and the integration of new policy visions for urban arterials, they have not been systematically acted upon, as they "… have not yet permeated the existing institutional framework" (Hess, 2009: 22). Put more explicitly, the institutional relationships, bureaucratic routines and resource allocation were not sufficiently modified to match the newly adopted policy (ibid.). To examine the extent to which the previously described planning novelties – emerging actor constellations (see Chapter 7.1) and newly combined planning elements (see Chapter 7.2) – coincide with a reassessment and perhaps even realignment of interactive practices, they are placed in relation to existing institutional arrangements and shared expectations. These are deduced from the planning cultural challenges elaborated in Chapter 6 and supplemented by internal and external critique that may indicate their loss of legitimacy. The means of realizing these novelties are then examined in more detail and their potential contribution to new institutional arrangements is weighed.

Shared expectations and deviations

The review of planning cultural challenges has revealed several distinct ways in which existing institutional arrangements impede substantial change in transport planning at both the municipal and regional level in Toronto: a.) provincial authority over municipal planning decisions, b.) fiscal constraints affecting transit planning, c.) division of responsibility for transport planning between municipal divisions and agencies, and d.) insufficient coordination of transit planning and operations at a regional level. With regard to the first point, the expert interviews reveal a discomfort with the existing power asymmetry between the province and the municipal planning department. In the expectation that proactive restrictions on the introduction of AVs will be overruled by the province, municipal planners take a conservative approach in adapting legally binding policy as an alternative strategy (the municipal Official Plan). It is not a case of deliberate neglect of institutional adaptation – a form of institutional change that Streek and Thelen (2005) characterize as *drift* – but a strategic underemphasis and a wait-and-see attitude towards automated mobility adopted due to limited political resources to challenge prevailing political standpoints (see Chapter 4.3.2). In this respect, the presence of institutional discomfort confirms external analyses that existing institutional arrangements cause inefficiencies in responding to changing circumstances (Harchard, 2020). Nevertheless, their potentially eroding legitimacy has not (yet) led to deviant practices.

Secondly, the issue of Canadian municipalities' spending capacity and the effect of fiscal constraints on transit provision in the Toronto Area was not explicitly discussed during the expert interviews (see Chapter 6.3.2). Although it is likely that a technological shift towards electric and automated vehicles will affect municipal revenue streams and require new models to compensate for the loss (Fagan et al., 2021), it lies beyond the scope of this study to analyse potential deviations in established funding practices and municipal budget allocations since the commencement of planning practices for AVs. The endorsement of Toronto's transportation division to commission independent research and take up preparations on automated mobility issues does not yet indicate a change in revenue streams or the goals for which municipal budgets are being used. In fact, interviewees emphasized the lack of political appetite for introducing new fiscal measures, e.g. charges for ride-hailing companies, which may negatively affect private technology companies. A political strategy that is decoupled from transportation concerns (Tabascio & Brail, 2021) and instead driven by the intent to accommodate technology companies and benefit from innovation and economic growth potential (Brail, 2017). Although charging ride-hailing companies represents but one of multiple fiscal measures that the City of Toronto could technically implement to regulate the transportation system and generate revenue that could then be used for public infrastructure investments or service provision. According to a 2016 review of the City's revenue options (Toronto, 2016d), the *City of Toronto Act* affords it the authority to introduce parking fees, road pricing and a motor vehicle registration tax. Notably, the motor vehicle registration tax represents another example of a political decision, made by a progressive municipal government in 2008 but undone by its successor, who perceived it as being anti-car (Doucet & Doucet, 2022).

With respect to the third issue – the division of responsibility for municipal transport planning, which affects modal priority, infrastructural measures and street-building in Toronto – it is possible to identify "institutional discomfort" as well as initial deviations from institutionalized practices. While external critique of city congestion levels, transit reliability and road safety has been mounting for years, internal discomfort addresses the disconnect between short-term operational decisions and the long-term objectives of municipal transportation planning (I-06). In an effort to bridge this gap, Toronto's 2019 AV Tactical Plan integrates a long-term vision with short-term actions and explicitly assumes a transit-centric approach. Furthermore, the recently initiated RapidTO, ActiveTO and CurbTO programs not only represent planning strategies, which apply temporary, short-term actions that promote the Official Plan's vision of a public realm supporting "active transportation and public transit use" (Toronto, 2022a: 3-2). They also deviate procedurally from standard policy tools and street-building practices based solely on road classification systems, plans and zoning regulations (Hess, 2009). In a political environment where transport planning and street building efforts play into electoral politics (Horak, 2021), applying old tools does not suffice to accommodate the balance of interests required to translate overarching policies into practice (Hess, 2009). In this sense, the tactical approach forged under the recent programs contributes to the embedding of Complete Street principles while also shifting institutional relationships by building on comprehensive interdivisional collaboration and the integration of policy agendas.

Lastly, with regard to regional coordination of transit planning and operations, interviewees did not necessarily address institutional discomfort despite extensive external critique (see Chapter 6.3.1). Instead, the importance of collaborating at both the municipal and intermunicipal level was emphasized, e.g. concerning the previously addressed challenge of service and fare integration. The extent to which institutional relations have evolved in recent years at the level of the GTA exceeds the scope of this research. Nevertheless, it is possible to address the institutional arrangements that frame pilot projects for new service models that may benefit the evolution of the GTA's regional transit system. After all, as a form of urban experimentation, pilot projects "are inevitably governance experiments even if they are not conceived as such" (Rocle & Salles, 2018, as cited in Evans et al., 2021: 177). In Toronto, the AV Shuttle Pilot was successfully launched in partnership between the City of Toronto, the municipal transit agency TTC and the regional transit authority Metrolinx (see Chapter 4.4). The key stakeholders would also need to collaborate if such service models were to be launched with non-automated vehicles, as shown by the microtransit pilot in Vaughan.

Additional collaborations were sought with the Ontario Ministry of Transportation, the shuttle operator and the vendor, while also making an effort to engage the affected community and train municipal staff such as first responders (Toronto, 2022b). Whether the actors involved, but also other municipalities in the region, can build on the experience gained from the AV Shuttle Pilot hinges upon two aspects: the successful capture of its process learnings and the consolidation of multi-agency collaboration (Evans et al., 2021). As noted in the CAV Readiness Plan (Ontario, 2020a), municipalities would benefit from a common testing approach and intermunicipal partnerships by sharing knowledge and resources. To effectively inform future transit planning and contribute to an integrated regional strategy, monitoring and evaluation efforts need to exceed operational technicalities and also provide insights into organizational change within municipal divisions or in cross-agency collaboration, the limitations and failures of pilots, and the necessary conditions under which such AV service models generate public value by making transit more accessible, equitable and safe (Stayton & Stilgoe, 2020; Evans et al., 2021).

In addition to realigning existing institutional arrangements, it is important to acknowledge the purposeful constitution of the Interdivisional AV Working Group as a new practice of social interaction (Bathelt & Glückler, 2014). The novelty of the IDWG for municipal planning is twofold. On the one hand, the IDWG provides a structure for collaborative and interdisciplinary work across 30 municipal divisions and agencies, resembling a social innovation in its own right (Cajaiba-Santana, 2014). On the other hand, it provides a space for proactive collective learning, exchange and critical reflection for municipal actors (Friend et al., 2016). Rather than outsourcing the task, Toronto's municipal government invested "in internal capacity and working in a dynamic, proactive way" (Mazzucato, 2021: 59). That is, years, if not decades, before automated mobility's widescale adoption. In relation to the issue of proactive planning, interviewees referenced not so much a critique but a negative experience: The City's unpreparedness for the sudden arrival of ride-hailing companies in 2012. Four years passed before the municipality issued a set of regulations that essentially opened up its ground transportation to the new service, rather than providing a value-based and policy objective-oriented framework (Brail, 2018). A distinct event, from which interviewees noted that municipal staff may have learned a lesson (I-11).

The interdivisional working group on AVs and the many other efforts to build internal capacity, e.g. the AV shuttle trial, contrast the previous experience. Municipal actors appear eager to build the necessary knowledge and planning capacity to be responsive in the face of "foreseen as well as unforeseen change" (Rauws, 2017: 32). Even if AV technologies evolve in an entirely different manner than currently envisaged, the capacity building process has ensured the preparation of various policy elements that could be reassembled for the respective solutions and has led to the consolidation of interdivisional relations that may be reactivated in the future. For Ibert et al. (2022), these qualities constitute critical resources during disruptive events that favour the prepared mind. As such, intra-municipal efforts to prepare for AVs have not only strengthened cross-sector collaboration and integrated policy development, but also fostered a general culture of learning (Ibert et al., 2022) and led to the integration of adaptive planning principles (e.g. short-term planning actions, review periods, etc.).

The question arises to what extent these and other faculties – for instance, the openness to try new approaches and take risks in order to create learning opportunities – are organizationally embedded in the divisions and agencies involved in the preparation for AVs. Based on the interviewees' input, the revision of network dynamics has shown that the transfer of information within networks does not necessarily equate to effective dissemination of knowledge within the divisions and agencies involved. Instead, promoting broader institutional learning that may then have a lasting effect on planning practice requires a realignment of internal structures, e.g. the establishment of divisional working groups, or a cultural change (Evans et al., 2021). Interviewees addressed several factors that affect the internal consolidation of new knowledge and practices on AVs, including the anticipated urgency to act (I-08), divisional staff commitment (I-02; I-06) and institutional openness to innovate (I-05). Taking into account that divisions and agencies dispose of varying capacities and resources, it is fair to conclude that the experience of participating in the IDWG and its related initiatives will be unevenly translated into the everyday practices of involved stakeholders. Perhaps even to the extent that some agencies will not establish internal mechanisms to transfer the learnings at all.

→ **Institutional void for deviant ideas** | Generating phase

The first instance of the realization of innovative approaches often takes place outside of a dominant institutional order, in so-called institutional voids (Hajer, 2003: 175). These emerge particularly under changing political conditions and in relation to new themes such as environmental politics or technological innovation, where novel approaches challenge existing rules and norms. Although pilot projects were a common tool of the Toronto transportation division well before the commencement of the 2017 King Street Pilot, the initiative stands out as a far more comprehensive effort that was launched precisely due to an institutional void. That is, there was no single authority responsible for solving the challenge at hand (Hajer, 2003), requiring a multi-divisional effort instead (Toronto, 2017c).

Moreover, the particular project resembled an early example of a new political openness for municipal policy experiments in Toronto, which equally benefited the AV shuttle trial (I-06). As Hughes et al. (2020) argue, local pilot projects have become a means of closing the gap between municipal policy objectives, e.g. on climate mitigation, and pursuing actual progress. The temporary and locally constrained framework of pilots allows governments to test the feasibility of a new technology or policy approach without spending too many resources (I-14). As such, the measure appeals to municipalities that are constrained by limited public resources and are commonly reluctant to take risks.

Another institutional void that appeared in relation to AVs concerns horizontal collaboration between divisions on this novel subject. In the absence of an institutional structure for interdivisional knowledge exchange on and joint monitoring of emerging mobility technologies, the newly initiated Interdivisional AV Working Group, as well as the AV team as an intermediary agent, have filled this gap.

7.3.1 Putting novelties into practice

Recent urban developments in Toronto show that planning novelties based on a reconfiguration of elements have by and large been implemented through adaptive strategies and within the framework of pilot projects. The development certainly mirrors a widespread trend towards the application of different forms of experimentation in urban planning processes (Scholl & de Kraker, 2021). Yet, Toronto's examples may also be understood as a distinct response to its planning cultural context and suggest a certain level of institutionalization, that is, a realignment of practice dynamics.

In general, pilot projects represent a relatively quick and resource-sensitive means to test and explore new concepts, e.g. in the fields of urban mobility, energy or ICT provision. In contrast to field experiments and formats that take a more scientific approach, e.g. transition experiments in sustainable real-world laboratories (see Chapter 5), pilot initiatives do not necessarily require the production of empirical evidence, that is, the systematic collection and evaluation of data (Caniglia et al., 2017). Nonetheless, their objectives frequently include learning (Scholl & de Kraker, 2021), which can serve municipalities to inform better decision-making for a permanent scheme (Sanderson, 2019). Possible shortcomings emphasized by scholars include a lack of dissemination strategies and a disconnect from the local urban development agendas, causing many of them to insufficiently address broader social, political and economic challenges (Scholl & de Kraker, 2021).

In the City of Toronto, not only are temporary pilot projects being launched to test AV shuttles, but they are also applied as part of the ActiveTO and CurbTO programs, with the RapidTO program following an adaptive strategy. Notably, in all of these instances, the City of Toronto is formally in charge of the development and execution of the interventions. As such, the projects largely serve a dual purpose: to resolve a local challenge or need, e.g. increasing street safety and economic vitality, and drawing lessons that may be applied elsewhere (Scholl & de Kraker, 2021). According to Evans et al. (2021), municipalities gain the opportunity to adapt their internal processes and structures when they act as enablers of urban experimentation. They further argue that organizational realignments and effective experimentation by municipal planning actors constitute prerequisites for broader urban transformation, or for that matter upscaling of novel planning approaches (Evans et al., 2021). At this point, it is important to recognize that the latest pilot projects in Toronto have built on the successful experience of the 2017 King Street Pilot – the first instance in the last decade to implement surface transit priority and public space enhancements along a major arterial (see Chapter 6.2.1). A key project for the City that has affected the local discourse on mobility as well as the municipality's capacities:

> *"The King Transit pilot shows that we can improve our streets with only minor tweaks and changes in design; that piloting and iteration – something the digital sector is very proud of – is valuable in city building, too."* (Sanderson, 2019)

In fact, the notion of iterative or incremental project implementation, promoted in the context of technology-centred smart city discourse, addresses another point of criticism among scholars. From an equity perspective, the incremental application of policies that commonly entail the distribution of access, opportunities and resources may produce inequalities between affected areas (Clark, 2020: 132). Over time, persistent incrementalism through pilot projects may not only lead to a poorly integrated patchwork (Hodson et al., 2018), but also compound and embed inequalities (Clark, 2020). In this sense, whether infrastructure investments are limited to pilot initiatives or scaled up to the entire network not only affects their contribution to the overall network performance, but also has consequences for Toronto's equity goals, e.g. improving access to opportunities (Toronto, 2022a: 2-4). Although such critique cannot be refuted by Toronto's initiatives, which have all been geographically constrained, it is possible to determine an underlying dimension of municipal process learning that may pose a critical signifier for their long-term transformative potential.

> *"A pilot helps the City to try out new ideas, relatively quickly and cost-effectively. A pilot allows the city to test something live in the street, measure what's working and what's not, hear public feedback, and make refinements, as needed. A pilot also needs to be feasible and simple to implement."* (Toronto, 2017c: 8)

Following the above distinction of experimental formats, one can argue that the significant success of the 2017 King Street Pilot built on the very fact that it exceeded the common understanding of pilot projects. Preceded by comprehensive studies and scenario modelling, the pilot study was embedded in a larger urban development plan for Toronto's Downtown area (Toronto, 2017c). One of the core components of the pilot's implementation strategy was a novel monitoring approach (Kuperman, 2018) that allowed the City to analyse how operational changes affected transit use, cycling and walking, while also exposing its impact on adjacent roads and the broader inner-city network (I-01; Attfield, 2018). It differed from previous monitoring efforts in that it employed street sensing technologies to collect data, including intersection cameras and video analytics, Bluetooth readers and automatic vehicle location technology – all measuring multimodal volumes and travel times (Kuperman, 2018; Toronto, 2019e). Based on the generated evidence, the City was able to publicly communicate the operational effectiveness of the transit priority scheme and tie together three influential factors that led to the initiative's success: tangible operational improvements, cost-effectiveness and stakeholder engagement (Sanderson, 2019; Doucet & Doucet, 2022).

As Evans et al. (2021) have argued for other cities, the King Street Pilot had the important institutional effect of building capacity among involved agencies and stakeholders. Toronto's Big Data Innovation Team – one of the organizational units founded under the former General Manager of the transportation division – was able to leverage data science capabilities "in-house" (Kuperman, 2018: 16), which were made public through the City's open data portal and project-based dashboards. Moreover, the monitoring and engagement strategies made it possible to responsively adjust operational measures and design features based on public input (Toronto, 2019e). As noted by an interviewee, it is not only a matter of collecting evidence, but of knowing how to effectively and inclusively communicate one's findings (I-12). In the case of the King Street Pilot, the procedure proved successful as it strengthened public support for the project, while also generating important learnings for the municipality on how to calibrate operational, regulatory and physical measures in order to effectively improve surface transit performance. According to the City's own project report (Toronto, 2019e: 32), the King Street Pilot was paradigmatic for the City in demonstrating that inter-divisional collaboration between urban planning, transportation planning and the transit agency are vital to the success of transit projects.

Furthermore, the project laid the groundwork for the joint development of the transit agency's *5-Year Service Plan and 10-Year Outlook*, which informed the *RapidTO: Bus & Streetcar Priority* plan issued in 2020 and the five priority bus corridors identified therein. It also entailed a concept plan for curb lane uses, e.g. curb lane cafés, which were later rolled out as part of the *CaféTO – Outdoor Dining* program in the wake of the Covid-19 pandemic. These examples illustrate how numerous planning elements developed in advance or as potential expansions of the pilot project ensured that municipal divisions were able to respond with comprehensive schemes when the unexpected health crisis hit in early 2020 and Toronto City Council requested strategies that would ensure better physical distancing for pedestrians, cyclists and public transit riders (see Chapter 6.2.1). As argued by Ibert et al. (2022), the diligent preparation of municipal actors and the availability of existing planning elements ensured that a number of novel approaches were successfully implemented in a moment of disruption. Three aspects require emphasis in this regard.

Firstly, the implementation of temporary pilot projects presents a distinct strategy to promote locally contested planning visions on sustainable mobility and redistribution of street space. This is particularly the case in a planning context such as that of Toronto, where political interests, mobility culture and institutional arrangements have worked against the implementation of planning visions in recent years. A key difference to other cities that have pursued formats of urban experimentation is that Toronto's pilot projects were initiated, conceptualized and led by municipal divisions themselves (Scholl & de Kraker, 2021). This speaks to the leadership competencies within the municipality, which are critical to successfully managing the politics of modal priority (I-10).

Secondly, since the implementation of the King Street Pilot in 2017, certain components of the pilot projects appear to have stabilized, implying that process learning and internal upscaling of results must be effective in the City of Toronto (Evens et al., 2021). The abovementioned programs are by and large shaped by collaborative efforts across municipal divisions, enhanced data science capabilities and integrated impact evaluations. Together with comprehensive stakeholder strategies, these practices have played a strategic role in building trust and credibility for the initiatives. The recurrence of these components further indicates that the City of Toronto appears to have succeeded in building the internal structures and mechanisms necessary to capture procedural learning and to organizationally embed new practices (Evans et al., 2021). Notably, both the RapidTO program and the CurbTO pilot project include planning elements that refer to AV-technologies and are mentioned in the AV Tactical Plan.

Thirdly, the recently installed programs show that the formal division of responsibility and power between municipal departments has remained unchanged. Building on a relational understanding of institutions as patterns of interaction (Bathelt & Glückler, 2014: 346), the institutional embedding of these practices resembles a substantial change, even as they continue to rely on the same formal basis of laws and regulations. On the one hand, because the underlying goals are more closely linked to the City's overarching long-term objectives, e.g. supporting the use of transit and active transportation, building vibrant streets and "improving the access to opportunities" (Toronto, 2022a: 2-4). On the other hand, because the interaction dynamics and relations between the actors involved have changed. Interdivisional collaboration across thematic silos and the pursuit of multiple goals (e.g. equitable access, environmental sustainability and economic vitality) stand at the core of the aforementioned efforts in Toronto. Changing these practices without contradicting the regulatory framework resembles a form of change, which Streek & Thelen (2005) characterize as institutional layering.

Returning to a possible future with AVs, these changes are significant in several ways. On the one hand, because they leave a lasting imprint on the environment in which AVs may one day be introduced. As argued by local scholars, "COVID-19-related changes to the built environment, such as road closures, alongside demands to increase the safety and convenience of micromodes that divide limited urban road space for use by more types of vehicles, all stand to limit access by private vehicle – autonomous or not – in more urban settings." (Higgins et al., 2021: 35). On the other hand, linking the introduction of AVs to broader public interests such as equitable distribution of opportunities, promotion of environmentally sustainable travel patterns and ensuring quality of life (Docherty et al., 2022) requires integrated strategies and institutional realignments by municipal agencies. Practice dynamics, organizational structures and external stakeholder relations may all require adaptation. Yet, through the implementation of the abovementioned pilot projects and programs that foster integrated strategies tackling multiple policy goals, the respective realignments are already being translated into agencies' "day-to-day operations" (Evans et al., 2021: 177).

In the context of a broader urban transformation, the significant question arises to what extent the City will succeed in scaling the incremental steps of the past years beyond the exceptional conditions of the inner city – where transit and active mobility are traditionally favoured – and the catalytic effect of the Covid-19 pandemic. Only then would Toronto have a chance to bring about truly transformative change for the city's transportation system and refute the aforementioned criticism that pilot projects lead to piecemeal solutions, omitting broader change. An upscaling of the recent planning advancements would not only require the successful realization of the five routes defined in the RapidTO Plan or the permanent installation of individual bicycle lanes. Such an upscaling would significantly surpass these measures and entail that the City adopt a network approach to its transit priority strategy and ActiveTO program. That is, seek strategies to systematically and comprehensively improve its surface transit network (Higgins et al., 2021), expand a contiguous network from its downtown core to its nature-based recreational areas and far into its car-dependent inner suburbs.

A necessary precondition for a broader urban transformation of this kind is that the lessons learned from Toronto's pilots are organizationally embedded and that the approach is consolidated by realigning the institutional relations that are necessary for its implementation (Evans et al., 2021). Yet, Toronto's planning cultural context also demonstrates that beyond a change in planning discourse, several years of study preparation, novel planning procedures and the realignment of institutional practices – all of which are either in place or unfolding – mobilizing sustained political will is perhaps the greatest hurdle to overcome. Here, Toronto faces the idiosyncratic challenge of bridging the apparent divide between suburban and inner-city mobility cultures and taking a decisive step towards a city-wide, environmentally sustainable and socially equitable transportation system – with or without automated vehicles. As Holz-Rau et al. (2022) assert, even though drivers' willingness to accept restrictive measures in favour of the future appears low, it is often higher than that of political representatives in charge of deciding their implementation.

→ **Extraordinary conditions |** Generating phase

In the early phase of a novel planning approach, its exploration relies on beneficial conditions, that is, situations in which activities are exempt from existing rules and where potential critics are in the minority (Christmann et al., 2020). Along these lines, pilot projects in Toronto are more likely to receive the necessary backing from local councillors, if their subject matter aligns with their political agenda. An interviewee illustrated the intricacy by noting, "You're not going to be able to locate the first transit pilot in the ward of a Councillor who's very pro-car." (I-06).

Accordingly, the 2017 King Street Pilot and a great number of the cycling network extensions accelerated as part of Toronto's 2020 Pandemic Mobility Recovery Strategy are located in the inner city, where councillors have traditionally been in favour of transit and active transportation. However, in the wake of the pandemic and in need of ensuring safe travel as well as economic recovery, the City was also able to accelerate a transit priority corridor, which particularly connects low-income neighbourhoods in the traditionally car-dependent inner suburbs (Toronto, 2020e). In this sense, the health emergency opened a valuable window of opportunity to implement required changes (Ibert et al., 2022).

However, there is also a risk that the legitimacy of programs that were commenced in the early days of the pandemic will quickly wane. The timeframe for initiating novel practices is limited (Ibert et al., 2022). Planning actors are thus challenged to utilize the generated knowledge, evidence and governance processes to stabilize emerging approaches. As much as political drivers affect where and to what end pilots are launched, they equally determine their legacy (Savini & Bertolini, 2019).

7.4 Summary

> *"… an important, often overlooked relationship between endogenous and exogenous change: for external shocks to bring about fundamental transformation, it helps if endogenous change has prepared the ground. Endogenous evolution of a social system may generate potentials that, when activated by interested parties in response to changing external conditions, can provide the foundation for a new logic of action."* (Streeck & Thelen, 2005: 22)

Planning initiatives for automated mobility in Toronto and the Greater Toronto Area are affected by both exogenous and endogenous forces. Perceived external pressures to prepare due to the surge of industry activity in the region and legal amendments issued by the provincial government created a latent urgency. Yet, it was particularly the negative experience of having been unprepared for the sudden emergence of ride-hailing companies in the early 2010s that mobilized senior planning officials in Toronto to initiate new practices and proactively learn about AVs. Gaining an understanding of the potential impacts of an emerging technology, and thus being reasonably prepared for the unexpected, served as a significant driver to action.

In pursuit of the question of whether the preparation for AVs contributes to a transformation in planning practice, patterns of change were identified, some of which are specific to AV-related planning and some of which have evolved in parallel but are now being modified into novel "assemblages" (McCann & Ward, 2012: 43). In relation to AVs, for instance, the establishment of the Interdivisional AV Working Group represents an unprecedented institutional framework established to join forces for learning about the emerging technology and ease collective decision-making in the elaboration of an integrated policy framework on AVs. Its novelty lies in the comprehensive collaborative effort, proactive engagement with a subject of uncertain future relevance and openness to exploratory practices. In essence, the IDWG has contributed to the cultivation of learning environments that bridge municipal silos and inform ongoing planning processes. In this way, recent efforts in the City of Toronto contrast with previous assessments that the adaptiveness of Canadian public administrations to effectively manage emerging technologies is held back by risk aversion, outdated instruments and skill gaps (Clarke, 2020: 100).

Recent planning examples illustrate how organizational change in Toronto's transportation division (e.g. the AV team, the divisional working group on AVs and the Data & Analytics Unit) have promoted knowledge transfer and mainstreaming of AV policy (Birchall et al., 2021). Short-term actions and policy elements developed as part of the AV Tactical Plan are integrated into ongoing implementation projects and strategies – a resource-efficient strategy that creates opportunities for synergistic effects (ibid.). Conceptually, planning schemes such as transit priority lanes are not necessarily changed by the anticipation of automated vehicle technologies, but they are complemented by related policy elements (e.g. advanced signal priority). In a similar vein, the concept of pick-up and drop-off zones does not strike as a particularly new planning measure. However, in combination with digital parking technology and perhaps automated pricing, it is gaining relevance in the wake of a broader shift towards mobility services.

Overall, these examples indicate a shift in the priorities of the transportation division and the consolidation of new planning modes, which have gained relevance over the past decade and have therefore also shaped the adopted planning initiatives for AVs. The former pertains to a stronger alignment between the transportation division's short-term operational actions and Toronto's long-term policy goals, e.g. strengthening public health, promoting economic vitality and increasing access to opportunities and social equity. As interdivisional collaborations intensify, policy agendas are more successfully integrated. The latter, in turn, concerns the consolidation of explorative planning approaches that embrace alternative methodologies (e.g. real-world trials and pilots, scenarios or modelling), knowledge generation (e.g. through exchange formats, comprehensive monitoring and data science capabilities) and continuous learning. Pilot projects and tactical procedures have become a "vehicle" for the introduction of locally contested principles by securing acceptance through comprehensive stakeholder engagements, open-ended processes and integrated impact evaluations. Provided that these attributes are maintained through the "institutionalization into the structure, systems, social norms, shared values and, most of all, culture" (Albrechts, 2011: 19) of planning, they will significantly shape the introduction of AV technologies in the coming years. Continuity in leadership and vision, shaped in part by shared professional communities, has contributed to the institutionalization of these features over the past decade and reveals the capacity of planning actors to distinctly alter existing forms of practice.

While these are noteworthy instances of incremental realignment in planning practice, they contrast with a concurrent stasis in other fields. As emphasized at various points in the previous chapters, effective transport policy relies on being bundled. That is, efforts to increase transit reliability, pedestrian and cyclist safety and off-street parking will only promote a wider mode shift and relieve congestion, if they are complemented with policies that disincentivize single-occupancy vehicle use. To date, preparation for AVs has had no significant effect on the prioritization of available transport demand management measures, e.g. road use pricing models – policy measures considered highly important to mitigate the potential negative side effects during the transition to vehicle automation (Chaudhry et al., 2022). An exception may be the city-wide Parking Strategy, which is planned for 2023 (Toronto, 2022d) and therefore cannot be assessed or commented on.

Relatedly, no significant change could be identified with regard to intermunicipal transit provision and infrastructural coordination between agencies, although related policy actions are specified in the CAV Readiness Plan (Ontario, 2020a). The regional transportation-land use planning regime is similarly characterized by institutional and political inertia. Scholars have highlighted private sector-driven land development, a culture of automobility, fractured planning responsibilities, insufficient knowledge mobilization and a lack of political will as significant barriers for meaningful change (Filion, 2018; Higgins et al., 2021: ii). Awareness of the negative impacts that the introduction of AVs may entail, e.g. increased regional travel and sprawl due to lower transportation costs, has thus far had little effect within the regional planning regime. At the time of writing, the increasingly emphasized need for transit-supportive development, suburban densification and urbanization, as well as complete communities has not been sufficiently linked to the introduction of emerging mobility technologies (Lee & Kim, 2020; Higgins et al., 2021).

The analysis of patterns of change in the wake of technological system change thus shows both realignments and stasis in planning practice. Returning to the issue of municipal planners being prepared for the unexpected, the question arises to what extent organizational changes, new modes of planning and acquired faculties will become routinized and sediment into the cultural ground of planning practice (Healey, 2006: 532). Drawing on the principles of resilience thinking, Ibert et al. (2022) argue that in light of recurring disruptions, planning practice needs to cultivate a general ability to adapt to changing circumstances. Relevant principles comprise "... a greater willingness to act experimentally; think in scenarios (including those that play out worst-case developments); establish a learning orientation through monitoring and evaluation; and establish a cooperative, intersectorally coordinated administrative culture" (ARL, 2021, as cited in Ibert et al., 2022: 8–9). Recent practice examples from Toronto and the expert interviews show that all of these faculties are being cultivated at a municipal level. Yet, it is noteworthy that the issue of learning how to change institutionally in order to adequately tackle new planning challenges has not been equally addressed by different divisions and agencies. As institutional capacities and resources differ significantly, it is reasonable to conclude that the broader institutional impact will unfold unevenly and thus affect some "practice arenas" (Healey, 2006: 532) more than others.

Moreover, the analysed policy documents on how municipalities, planning authorities and public agencies should prepare for a technological disruption such as AVs primarily focus on technical knowledge and a "redundancy of stock solutions" (Ibert et al., 2022: 8). Organizational and cultural changes that are required to embed new principles and novel modes of planning (Evans et al., 2021), such as explorative, learning based and open-ended formats, are not addressed. This not only reveals a gap in awareness of the procedural and organizational properties that constitute institutional responsiveness, but indicates that planning approaches for AVs are focused on technical performance rather than broader urban transformation. Relatedly, political and institutional intricacies cause a dilemma in municipal planners' preparedness. Planning experts interviewed in the GTA largely agree that the disruptive nature of AVs is rooted in the risk of induced demand, exacerbated congestion and further sprawl. And yet, these are precisely the practice fields in which policy adjustments and realignments in practice are delayed. In this sense, the case of Greater Toronto also demonstrates how, despite diligent and comprehensive preparatory efforts, political and institutional dynamics may compromise the targeted regulation of the expected.

8. Weighing the transformative potential of automated mobility

The transformative potential of automated mobility in the early 21st century is at best relative to the contextual factors against which it is evaluated. What may appear self-evident requires far greater scrutiny in the literature on the potential implications of AVs and in public communication of research findings, given that balanced assessments are frequently compromised for the sake of narrative. In response to the recurring assertion that municipal planners should prepare for the disruptive nature of automated vehicles (Sperling, 2018; Legacy et al., 2019; Docherty et al., 2022), this thesis advocates for a more differentiated understanding of transformative change processes in mobility, spatial development and planning practice. In order to deconstruct its meaning in the context of vehicle automation, the research centred on the transformation of planning practice, which can likewise only be qualified as such when analysed in its historical and cultural context (Cajaiba-Santana, 2014).

A case study analysis on how planning professionals in the Greater Toronto Area in Canada prepare for the potential introduction of AVs was used to explore whether the advent of automated vehicle technologies contributes to substantial realignments in planning. In this vein, commenced AV initiatives were analyzed not only as historically and geographically situated practices, but also as social processes that can set in motion endogenous change within the planning profession. The enquiry did not adopt a normative stance to establish *why* planning practice should change in anticipation of future transportation systems with AVs. Instead, an interpretative research approach was assumed to explore *how*, in *what form* and to *what end* deviations in planning practice occur. In doing so, the research highlights the agency of planning professionals to initiate change that is not imminently disruptive, but may over time accumulate into what can retrospectively be described as a "transformative moment" (Healey, 2006: 541).

To discern patterns of change at the micro level of municipal and regional planning, an analytical framework was applied that is rooted in neo-institutionalist and social scientific understandings of transformation (see Chapter 2.3). Seen as gradually unfolding processes of realignment, such notions distinctly contrast with ideas of radical fractures and path dependency (Streeck & Thelen, 2005; Dolata, 2011; Christmann, 2020). To emphasize the role of agency, the analytical framework applied draws on a model of social innovation in spatial planning that allows the analysis of "procedural patterns" (Christmann et al., 2020: 497) across multiple dimensions and along distinguishable phases of innovation (see Chapter 3). The integration of this model made it possible to identify subtle deviations in planning practice that would otherwise have gone unnoticed or been interpreted as reproductive instances sustaining continuity rather than inducing change (Streek & Thelen, 2005; Mahoney, 2000).

The empirical study conducted as part of this research endeavour followed an in-depth case study approach, which centred on proactive planning initiatives launched in the Greater Toronto Region in Canada since 2014. Its prime objective was to explore the extent to which planning transformations emerge in the context of a transition to automated mobility. To this end, the study first explored the constellation of actors engaged in planning initiatives for AVs, their means and tools of preparation, the temporal progression of the processes and the objectives of the planning initiatives (sub-question I). Secondly, the expectations and challenges associated with the introduction of AVs served as entry points for analysing how planning initiatives for automated mobility relate to the planning cultural context in which they take place, e.g. urban structures and transportation systems, planning frameworks and institutional relations (sub-question II). This made it possible to draw links between past developments and current strategies, as well as to scrutinise the contextual forces that give rise to, but also constrain, planners' capacity to translate new planning approaches and visions into action. Lastly, the present thesis analysed the extent to which patterns of change, e.g. temporal variations in ideas and concepts, widening institutional gaps and lines of conflict, can be traced in relation to planning efforts for AVs (sub-question III).

The following section summarizes several valuable insights that can be derived from answering the research questions before introducing the main findings related to planning preparations in the GTA (8.1.1), the broader planning environment (8.1.2), identifiable patterns of change (8.1.3) and the temporal multiplicity of change (8.1.4). The thesis closes with a reflection on the methodological approach and an outlook for future research.

8.1. Insights into transformative change in planning practice

The following synthesis (Table 8.1) provides an overview of insights that can be deduced from the analysed case study on change processes in planning practice. They serve as key learning points for both scholars and planning practitioners on how municipalities may prepare for and effectively shape the ongoing technological system change towards automation. Insights can also be drawn from a new direction in transportation planning that embraces the uncertainties of our time and is rooted in noteworthy organisational and cultural change within planning institutions. Precisely because institutional realignments and substantial shifts in planning unfold gradually, the current time lag between policy development and the commercialization of AVs needs to be recognized as an opportunity to rethink established practice dynamics and forge social innovation.

Table 8.1 Overview of insights and key learning points on planning change in the context of AVs

Insights	Findings
Joint municipal positions on AVs and emerging mobility technologies are in need of greater momentum 7.1.1. Actors of change	• In the GTA, municipal stakeholders have made an effort to bring local concerns over AV effects on transportation, public health and urban form to the attention of higher levels of government; • beyond that, a regional policy framework, the CAV Readiness Plan, was developed, which outlines the need for infrastructural alignment, shared performance standards and operational coordination; • yet thus far, corresponding governance arrangements have not been put into action, which hampers inter-municipal consistency concerning short-term infrastructural issues as well as long-term spatial concerns.
Intricate goal conflicts embedded in local policy frameworks and strategies require further policy attention 7.2.3. Modal priority	• Toronto's policy stance sets itself apart from other fast-growing cities in that it aims to capture public value by fostering AV-related innovation without constraining commercial interests; • further policy considerations need to address how possible conflicts between economic and sustainability-oriented goals can be negotiated as part of concrete planning actions and strategies.
When municipally organized, testing environments and pilot programs can present institutional frameworks and a mode of planning to shape the transition to automated mobility according to local needs 4.4.2. Transportation Innovation Zones	• Within so called *Innovation Challenges,* the City of Toronto is able to direct technological advancements towards societal needs by determining the circumstances for technological testing and negotiating its interests with private sector actors; • the advantage of municipally anchored pilot programs lies in the potential to resolve pressing challenges and needs, while also generating institutional knowledge that can be applied elsewhere.
Learning networks provide a critical resource that needs to be captured through internal knowledge sharing mechanisms 7.1.2. Networking	• The successful consolidation of AV-related expertise within Toronto's transportation division relies on organizational and procedural changes; • however, institutional change is not equally addressed across divisions and agencies and hinges on available resources, perceived urgency to act, commitment of senior staff and institutional openness to innovate.
The extent to which defined goals and policies are actualized relies on the dynamics of the broader planning environment 6.3.1. Regional transit coordination 6.3.2. Institutional relations: Capacity and governmental interests	• The ability of planners to introduce novel modes of planning and enact effective regulation for automated mobility in the GTA is fundamentally influenced by existing planning hierarchies and institutional relations; • the scope of plausible change in the wake of technological disruption and the potential impact of adopted policies must be measured against the institutional dynamics of the broader planning environment.
Institutional responsiveness to unexpected change requires cultural and organizational change in planning divisions and agencies 7.3 Institutions & institutionalization	• New faculties are being cultivated in the wake of uncertainty and complexity, e.g. experimental and adaptive modes of planning, continued learning and monitoring as well as intersectoral collaboration; • greater policy and planning attention needs to be given to the organizational change required to embed these new principles and planning modes into the everyday planning practice.
Integrated and exploratory planning modes provide a means to overcome resistance to alternative mobility visions 7.3.1. Putting novelties into practice	• In the City of Toronto, short-term pilot programs have recently served as successful proof of concept for multimodal environments and added to the institutionalization of interdivisional collaboration; • to win public and political support, tactical interventions are combined with extensive monitoring, communication and engagement strategies.
The great potential of delayed AV commercialization lies in promoting social innovation 8.1.4. Velocities of change	• In the City of Toronto and the GTA, planning actors are ahead of technological advancements in terms of policy preparation; • this makes it all the more urgent to promote social innovations in new governance arrangements, greater inter-municipal collaboration and openness towards community-based approaches.

Source: table by the author.

8.1.1. Preparing for automated mobility in the Greater Toronto Area

Governmental Interests

In line with the findings of Fraedrich et al. (2019), interests to engage in policy and planning for AVs, and the corresponding objectives, vary between levels of government and between jurisdictions in the Greater Toronto Area. The Canadian federal government's responsibilities are largely limited to setting and enforcing standards, e.g. concerning motor vehicle safety and cybersecurity (Canada, 2021), leaving the implementation of regulatory measures to provincial and municipal levels of government. The provincial government of Ontario, for its part, is largely concerned with issues of operational safety, infrastructure provision and economic growth opportunities (see Chapter 4), but has recently expanded its policy actions to include considerations on how AVs may impact transportation systems (Ontario, 2022). With an initial focus centred on creating a business-friendly environment for technology companies, which many North American regions hope to attract (Steckler et al., 2021), planning experts in the Toronto region highlighted the need for a joint municipal stance on AV regulation to make higher levels of government recognize local concerns. The notion confirms another finding by Fraedrich et al. (2019: 171) that the planning and transportation concerns of German municipalities have not been sufficiently met by federal policy and research priorities.

A closer look at the policy objectives of the City of Toronto, a municipal outlier in preparing for AVs in Canada, shows that they are not as deliberately focused on safeguarding the city's welfare system as in Germany (Fraedrich et al., 2019: 168). The broad range of policy objectives outlined in Toronto's *AV Tactical Plan* indicates instead that they may well be at odds with each other and require future trade-offs. The introduction of automated mobility is to take place in the field of tension between a transit-centric approach and the city's ambition to foster AV-related industry sectors and strengthen its position as a hub for research and development. The dual interest affects both the language of Toronto's *AV Tactical Plan* and its way of planning for AVs. The transit-centric stance is clearly expressed in the policy framework's goal to "increase space efficiency" (Toronto, 2019a: 89), that is, to increase the mode share of active transportation, transit, high-occupancy vehicles and combined-purpose vehicles. It also underlies municipal efforts to conduct an AV shuttle trial and correlates with recent initiatives to utilize communication infrastructure (transit signal priority) to the advantage of rapid transit corridors (Toronto, 2021b).

Beyond this, however, strategies to manage transport demand and reduce overall car use do not receive priority in the Tactical Plan. Although important policy levers to tackle the induced travel demand due to AVs are acknowledged in the policy framework, the timing of their implementation is not specified. Expert statements who stressed that political decision-makers lack the appetite to regulate and possibly constrain technology companies providing new mobility services indicate that this is a conscious choice. The general stance towards new technologies is non-restrictive, welcoming and "technology agnostic" (Lanyon et al., 2017: 5). As described by one interviewee, the notion implies that policymakers and planning actors maintain a general openness to various technological solutions, including modes, operational scales and ownership models, and instead focus on achieving the city's goals and objectives (I-01).

A non-prescriptive stance on the form (mode) of the technology or provider (ownership model) also characterizes the city's *Innovation Challenges*, launched within the framework of the Transportation Innovation Zones – an innovation program that grew out of the AV Tactical Plan to foster economic activity and learning in the public sector (Toronto, 2021a). Notably, the City does not define technological requirements for the innovative solutions to be tested, yet it does prescribe by what means, i.e. Toronto's transportation needs, and under what circumstances they shall be deployed. To this effect, such planning efforts may be viewed as a form of shaping the transition to AVs by deliberately accommodating technological development focused on local needs. This kind of policy approach contrasts with previous findings according to which fast-growing cities demonstrate a high level of preparedness and policy prioritization, but intentionally withhold interference to allow private investments to drive change (Freemark et al., 2019: 145). Toronto's planning and policy stance on AVs sets itself apart in that it actively interferes in an effort to capture potential benefits, but without constraining commercial interests.

This leads to a number of important questions. Whose needs are being deliberated through these initiatives? Do the economically oriented activities support or work against the city's goal of increasing space efficient mobility? And what other transport planning measures are being implemented that may ensure a truly transit-centric scenario in a future with AVs? These questions cannot be answered conclusively within the scope of this research, but they open up avenues for future scientific enquiries that may help evaluate the effectiveness of these initiatives as they progress. One important conclusion can be drawn at this point, however. The oft-stated policy recommendation that municipalities should ensure the alignment of local pathways to AV deployment with existing development goals and public sector interests (Fraedrich et al., 2019; Freemark et al., 2019; Docherty et al., 2022) falls short of recognizing intricate goal conflicts, which may be embedded in local plans and agendas themselves.

Policy framework: anticipatory, flexible, adaptive

Toronto's municipal policy framework for AVs represents one of the few such documents developed solely on the subject of AVs. Rather than preparing entirely new policy directions for 2050, the development goals of the AV Tactical Plan were derived from existing policy documents.

To this effect, AVs are viewed as a "tool toward a future that has already been envisioned" (Toronto, 2019a: viii). As previously argued, providing a roadmap that aligns with the existing strategies of municipal divisions and agencies reduces the financial strain on municipalities with limited resources (Freemark et al., 2019: 148). It also carries the advantage of creating more efficient policies, catering to multiple goals and creating synergies (Birchall et al., 2021).

Given the uncertainty of future developments, e.g. industry progress in developing AVs and public acceptance, the framework and the implementation of its short-term action items ("tactics") are meant to be reviewed, adjusted and updated every three years. As such, the framework builds on distinct planning principles: anticipation (i.e. proactive preparation for an uncertain future through explorative formats and continuous learning), flexibility (i.e. a long-term and broad vision framing short-term actions) and adaptiveness (i.e. periodic evaluation and revision of its effectiveness). Aligned with and measured against a long-term vision, the proactive and action-based planning approach is strategic (Albrechts & Balducci, 2013), yet leaves "room for change" (Rauws et al., 2014: 135).

At the time of writing, the only publicly available assessment of completed tactics concerns the conducted AV Shuttle Pilot in West Rouge. Toronto's gathered learnings on the pilot project speak to a telling asynchronicity that characterizes the present moment in vehicle automation. The readiness of municipal planners to learn about the mixed traffic operation, network integration and policy amendments of AVs is confronted with an absence of universal technology standards, incoherent infrastructure requirements and manufacturing deficiencies (Toronto, 2022b). These shortcomings not only limit the ability to assess the technology's public value, e.g. in providing better transit access in underserved areas, but also lead to critical "mode confusion" (Stayton & Stilgoe, 2020: 18), meaning that the level of technological capability is overestimated and that the necessary requirements for the safe operation of automated systems are left unclear on behalf of manufacturers.

Moving forward, two learnings require greater public deliberation. Firstly, that potential infrastructure investments required may be far higher than publicly communicated by industry representatives (I-09-B). A significant aspect, as it could present a critical barrier to non-fragmented adoption, given the lack of municipal funding for large-scale infrastructure investments (Fraedrich et al., 2019). Secondly, the shared learning that "Deliberate mixed use of manual and automated modes of driving may be appropriate if vehicle cannot accommodate all design domains" (Toronto, 2022b: 3) resonates with a recent plea by social scientists to downplay the industry's aspiration of vehicle autonomy and the full replacement of human beings (Stayton & Stilgoe, 2020). A valuable insight, therefore, is to recentre the focus of public policy to "new arrangements of shared human-machine control and collaboration" (Stayton & Stilgoe, 2020: 18) and to the environmental conditions under which AV technologies can effectively provide better service for people (Clark, 2020).

The policy principles of the AV Tactical Plan and the experience of the AV shuttle trial are relevant to the previously addressed innovation challenges that the City of Toronto conducts at its Transportation Innovation Zone (TIZ). Following a phased approach (Toronto, 2021a), which again leaves room for change, the TIZ provides an institutional framework for the public sector to shape the ongoing transition in the mobility sector. By prioritizing fields of application that generate public value (Steckler, 2019), the ambition is to "set the direction of change toward societal needs, enabling bottom-up, impact-driven experimentation" (Toronto, 2021a: 7). While the municipality is making progress in shaping the circumstances for safe, sustainable and equitable deployment of transportation innovations (Stayton & Stilgoe, 2020), two aspects critical to its own goals have not been put into action. Firstly, the program's geographic expansion beyond the current TIZ and its programmatic broadening to include "community-first" approaches as described in its proposal have not been realized (Toronto, 2021a: 7). Secondly, trials have thus far not addressed mobility as a service technology, which may provide a pathway to mitigating the competitive thread of AVs by integrating new mobility services with existing public transit networks (Docherty et al., 2022).

Networks and knowledge transfer

In the Greater Toronto Area, the planning and research initiatives that have been launched over the past decade on the subject of automated vehicles have involved all actor groups: government, academic research, industry and society (see Chapter 4). Clearly, not all of these actor groups were equally engaged or had the necessary resources (i.e. political, material and technical means) to get involved. Looking at government, and more specifically planning professionals, this case study shows that even within a municipality such as the City of Toronto, which has devolved substantial funding to the subject of AVs (Freemark et al., 2019), institutional capacities and resources vary greatly across divisions and agencies. To redress the resulting imbalance in knowledge, familiarity and capacity building on the subject, the inception of intra- und inter-jurisdictional public sector networks has played a critical role in the GTA. At the municipal level, the *Interdivisional AV Working Group (IDWG)* of the City of Toronto serves as an example of joint monitoring and learning, while the *Ontario Smart Mobility Readiness Forum*, which continues the efforts of the *CAV Readiness Initiative,* provides a similar platform at the regional level.

In addition to professional communities for planners such as NACTO through which novel concepts, policies and values are disseminated (Füg & Ibert, 2020), networking initiatives are pivotal in cultivating a shared pool of knowledge about AVs (Christmann et al., 2020). The community of experts that participants become part of resembles a latent network that persists even after funding-based initiatives are discontinued. As such, they bear the potential of being reactivated, even on short notice, when future moments of disruption call on their expertise (Ibert et al., 2022: 7). Interestingly, however, the analysis of public sector networks in the GTA showed that greater knowledge does not necessarily equate to greater preparedness at the level of the individual agency. Whether voluntary networks, such as those in the GTA, in fact provide what Powell (1990) describes as transitional spaces before building up internal capacity depends on the ability of agencies to consolidate the acquired knowledge and establish internal mechanisms to transfer the learnings.

In the case of the GTA, the following factors could be identified as influential to whether or not agencies establish internal knowledge-sharing mechanisms: the level of institutional resources, the perceived urgency to prepare, the commitment of senior staff and the institutional openness to innovate. For the City of Toronto specifically, it can be concluded that municipal divisions and agencies have acquired substantial knowledge of vehicle automation and its potential implications for the various policy fields over the past decade. Yet, the extent to which divisions and agencies take further steps and embed the acquired knowledge into their everyday practice varies. Given the influencing factors listed, the unevenness of resources identified by Freemark et al. (2019) is but one factor affecting in which arenas of practice AV-related policy and planning interventions materialize. The relevance of additional factors such as the perception, commitment and openness to innovation of individuals, highlights the intrinsic motivation and role of experts in processes of planning preparation (Füg & Ibert, 2020). Whether proactive capacity building is sustained and next steps are prioritized essentially hinges on endogenous forces.

8.1.2. Planning for automated mobility as a situated practice

Acknowledging planning initiatives for AVs as practices situated in a specific time, place and social setting (Healey, 2007; Albrechts & Balducci, 2017), the identified planning and policy actions were analyzed in relation to their planning cultural context (e.g. urban structures and transportation systems, planning frameworks, institutional relations). Although the effort was initially driven by an interest to establish the contextual specificity of planning initiatives, doing so led to significant insights into the capacity of planning professionals to introduce novel modes of planning and enact effective regulation (Docherty et al., 2022). Analysis of the broader planning environment in which policy frameworks for AVs are developed proved critical to understanding the extent to which defined goals and policies may be translated into practice. In this light, examining planning actions for AVs in relation to the planning cultural context that both gave rise to them and is being changed by them reveals the plausible extent of the changes involved (Marsden & Docherty, 2013).

In the Greater Toronto Area, institutional, political and cultural barriers have stood in the way of meaningful change in car-oriented land development patterns and regionally prevailing car dependency over the past two decades. Fifteen years after the release of the 2006 *Growth Plan for the Greater Golden Horseshoe*, initially praised for its comprehensiveness and progressive policies, it has shown limited effect in reaching its objectives and targets, e.g. higher densities, more compact transit-oriented communities, etc. (OAGO, 2021; see Chapter 6). In addition, efforts to build a cohesive regional transit system have been challenged by insufficient funding, limited coordination between municipalities and transit agencies as well as insufficient authority by the regional transit agency (Siemiatycki & Fagan, 2019). As a consequence, services and fare structures remain fragmented, reinforcing social inequalities and car dependency. If the current transportation system were to be merely overlayed with AVs, overall vehicle travel will likely increase, exacerbating current congestion levels and infrastructure strains and posing a competitive threat to existing transit networks (Docherty et al., 2022). In effect, it could undermine provincial objectives to fight gridlock and improve network capacity (Ontario, 2022), as well as municipal goals to foster a shift to space-efficient modes (Toronto, 2019a).

In this context, the response of planning professionals to the potential risks and external costs of introducing AVs is not merely a question of having the willingness, financial resources and freedom to develop local policy (Freemark et al., 2019). Instead, it is also a matter of underlying institutional dynamics, politics and governance arrangements (see Chapter 6). At the municipal level, planning efforts are inevitably affected by the interests of City Council members and, in the case of Toronto, the pro-technology stance of the former mayor (Keil, 2017). Whether planning and policy initiatives are approved thus hinges on the capacity of senior planning officials to mobilize strategic power and gain political patronage from decision-makers. Given that the implementation of long-range policy goals on mobility issues and transit planning in particular, has been historically contested and subject to electoral politics, experts assert that more effective institutional frameworks for political coordination and greater recognition of evidence-based planning are needed (Siemiatycki & Fagan, 2019; Horak, 2021). In Toronto, a lack of political alignment pertains to urban and suburban mobility interests as well as to integrated transportation and land use developments.

In this respect, it is important to note that municipal planning and policy action are also significantly affected by provincial interests. As the Province of Ontario holds decision-making authority over municipalities, it has the power to overrule any City Council vote or policy amendment that is not in line with provincial priorities. The hierarchical relation between municipalities and the province may lead to institutional inefficiencies and "unclear accountability, as municipalities may be seen to control decision-making in certain policy areas, but in practice may be constrained by provincially controlled review boards" (Harchard, 2020: 4). In relation to planning and policy initiatives for AVs, it became apparent that even though regulatory responsibility is clearly divided between levels of government and within the municipality of Toronto itself (Freemark et al., 2019), in practice it may be more ambiguous. For instance, a more critical stance on AVs, perhaps arguing in favour of restrictive parking regulations, would risk provincial dismissal in the current political context. This has led some planners to take a conservative approach to adapting policies for AVs so as not to be overruled.

In a context where North American cities are joining forces to prevent higher levels of government from issuing legislation that pre-empts municipal authority over AVs (I-16; Siegel, 2017), the governance arrangement in the GTA creates a conflicting situation. Municipal planners are well aware of the risks AVs could pose to the local transportation system (e.g. induced demand, exacerbated congestion and further sprawl) as well as the policy options legally available to mitigate such effects, e.g. road or curbside pricing. Yet the lack of political capacity curtails ambitions to introduce or even prioritize targeted regulation of this kind. The underlying institutional interdependences thus demonstrate that the broader planning cultural context is crucial both for the scale of planning and policy change and the rate at which it may occur. In contrast to the notion of path-dependency, the following section shows that the confines imposed by institutional arrangements may nonetheless inspire enterprising action, "perhaps in response to new and as yet incompletely understood external conditions" (Streeck & Thelen, 2005: 18).

8.1.3. Traceable patterns of change in planning practice

Lastly, the enquiry was motivated by the question of whether the ongoing technological system change in transportation contributes to transformative change in planning. Drawing on theoretical notions of transformation as a gradually evolving process shaped by many instances of exploratory deviation and realignment (Streeck & Thelen, 2005; Dolata, 2011), the analysis centred on endogenous change emerging from within the planning profession. Viewed through the lens of social innovation, change was explored as a proactive process fostered by the agency and social learning of planners (Ibert et al., 2015). The case study on planning initiatives for AVs in the GTA reveals that organizational, cultural and practice-based realignments are in fact changing existing forms of transportation planning at the municipal level (see Chapter 7). In turn, no significant changes were identified at the metropolitan level of Toronto, particularly with respect to intermunicipal transit provision and the integration of transportation and land use issues.

The following section summarizes the identified patterns of change as defined by Christmann et al. (2020) and elaborated in Chapter 7. These pertain to phases of incubation, in which novelties exist in a pre-conceptual state (Füg & Ibert, 2020), and generation, when new linkages between pre-existing elements are explored under favourable conditions (see Chapter 2.3.2).

Incubation: Proactive learning, monitoring and intersectoral collaboration

The disruptive experience of ride-hailing companies arriving on Toronto's streets and municipal divisions struggling to find an adequate response provided the basis and impetus for proactive planning action once automated vehicles emerged as a potential future on the mobility horizon **> Negative experience**. The possibility that AVs could significantly reduce the cost of ride-hailing services, thereby aggravating their competition with public transit options, prompted senior planning officials at the municipality of Toronto to embrace the subject far earlier than any other city in Canada **> Actors of change**. While mobility services are typically regulated by a division called Municipal Standards and Licencing, it was the general manager of the transportation division who took on the task of initiating a broader conversation among city staff on what impacts AVs might have and how the City can prepare for their potential introduction. While the initial conversations took place among representatives of the transportation, city planning and licensing divisions, early efforts to create awareness and provide educational formats on the subject were carried out in collaboration with external technology experts **> Network of founders**.

Two organizational changes were initiated by senior planning officials in the early years. Firstly, a divisional Working Group and an AV team were established in the city's transportation division. The latter not only undertook monitoring efforts and partnerships with academic institutions, but also developed a *Divisional Workplan 2016 – 2018* (Toronto, 2016a) on how to prepare for AVs. Furthermore, it forged relations with higher levels of government and advocated for provincial and federal working groups to ensure that municipal concerns about the long-term implications of AVs were recognized. Given that the operations of the transportation division are traditionally overseen by the municipal council, these initiatives resemble significant enterprising actions **> Deviant ideas**. The second organizational change took the form of an *Interdivisional AV Working Group*, which was formally launched in 2016. What started as a voluntary network for shared learning on AVs **> Institutional void** grew into an unprecedented institutional framework for collaborative policy development and coordination, involving representatives from thirty municipal divisions and agencies. The AV team again took on a pivotal role in deliberately engaging municipal divisions and translating the relevance of AV-related preparation to their respective policy fields **> Intermediaries**. The core motivation was to initiate a comprehensive learning process that would allow the City to adopt a nuanced stance on the technology, which is grounded in a systemic understanding of its benefits and adverse effects (I-16). To this end, the institutional framework involved all divisions that could be directly and indirectly affected should AVs be introduced on Toronto's streets in the years ahead.

Generation: Shared policy framework, collaborative projects and initial policy diffusion

In May 2016, the staff initiative to proactively build capacity and a municipal position on AVs was formally endorsed by the municipal council, which issued an official request to develop recommendations on how the City of Toronto should prepare for AVs (Toronto, 2016c). Support from actors with institutional power who frequently act as **> Patrons** of novel planning visions is important for alternative efforts to continue, expand and be translated into action. Moreover, the change in leadership that took place within the transportation division in 2016 did not upend any of the adopted actions. On the contrary, divisional resources continued to be devolved to the issue of AVs and new planning modes were prepared, e.g. the integrated municipal policy framework and the AV Shuttle Pilot. Senior staff and the subsequent manager of the transportation division acted as influential **> Local allies** who not only shared the enthusiasm for the novel idea, but also ensured that planning efforts for AVs tied into existing policy. In this sense, a qualitative shift took place in the years under the new leadership.

The exploratory planning approaches that had been set in motion by the previous general manager in the wake of uncertainty and potential future disruption were continued, yet with a greater emphasis on existing strategies, local challenges and municipal needs. This is evident in the municipal policy framework for AVs, the *Automated Vehicles Tactical Plan*, which assumes a long-term vision for 2050 by building on existing policy objectives, which thereby provide direction for any short-term action on AVs. It also characterizes commenced pilot initiatives, the *West Rouge Automated Shuttle Trial* and the *Transportation Innovation Zones*, which provide temporary frameworks for the public sector to learn about and build capacity in new mobility technologies while promoting research and development efforts that align with public interests. Although the two examples are certainly the most prominent instances of AV-related policy implementation, they rely on favourable environmental conditions, e.g. external funding and alignment with provincial interests in promoting Toronto as a hub for innovation **> Extraordinary conditions**.

In terms of how novel modes of planning and policy ideas are embedded in the everyday practice of municipal divisions, emergency programs commenced in the wake of the Covid-19 pandemic provide more telling examples of AV policy mainstreaming (Birchall et al., 2021). The programs implemented promote rapid transit corridors and conversion of curbside use while integrating AV-related infrastructure elements. As such, they may be considered early instances of newly combined planning concepts. Mobility issues and emerging technology solutions are distinctly linked to other areas of practice, e.g. public health, economic vitality, access to opportunities and social equity **> First links between elements**. In this sense, they reflect a heightened appreciation for the broader public value of an effective public transit system and adequate space for active mobility, which was elevated in the wake of a global health crisis **> Extraordinary conditions**.

Yet these programs also resemble newly combined planning concepts in that they build on the institutional capacity and exploratory approaches that have been developed in recent years. These include short-term and open-ended formats to test novel ideas, careful monitoring and impact evaluations to generate knowledge and publicly communicate results, as well as comprehensive stakeholder engagement strategies. Moreover, they stand for successfully integrated policy agendas and greater interdivisional collaboration. By linking all of these elements, integrated exploratory tactics are forged as a new mode of planning that successfully balances multiple interests (Hess, 2009) and enables planners to overcome entrenched resistance to alternative mobility visions.

A new direction in transportation planning

Given the fact that these change processes are ongoing and not analysed in retrospect, the identified patterns are tentative and historically contingent (Levin-Keitel & Othengrafen, 2016; Christmann et al., 2020). Nonetheless, they indicate a potential change of direction in transportation planning in the City of Toronto. The question is whether the described instances of integrated and exploratory transportation planning will be further consolidated and scaled, or whether recent initiatives will lose momentum. In this regard, it is important to recognize the organizational and cultural changes that have unfolded in Toronto's planning divisions over the past decade. On the one hand, newly formed working groups and staff teams have enabled greater knowledge transfer and coordination, helping to embed new planning principles and competencies. On the other hand, a cultural change is taking place, characterized by greater openness to experimentation, continued learning in planning processes and intersectoral coordination. These changes are noteworthy, as they increase public agencies' institutional responsiveness to change (Rauws, 2017) and enable the rapid implementation of novel transportation solutions in a moment of disruption.

To the extent that integrated, exploratory tactics in transportation planning have been replicated, they have been impactful in both transforming urban streetscapes in Toronto into multimodal environments and in translating action-based policy for AVs into practice. Yet their successful implementation is still strongly dependent on the favourable conditions of a specific political mandate. To consolidate further, achieve wider impact and effectively shape the transition to AVs in favour of broader collective interests (Higgins et al., 2021), the mode of planning would need to be translated into multiple locations and embrace further fields of practice, e.g. urban densification and intermunicipal public transit provision. Doing so would require successful political alignment at the municipal level of Toronto and sustained partnerships for integrated mobility planning at the metropolitan level in the GTA. Within the given constraints, however, the identified patterns reveal a distinct capacity for planners to redirect the social practices – institutional and procedural arrangements – necessary to put transformative visions into action.

It may be too early to proclaim that the patterns identified amount to a transformative moment for planning practice in Toronto. Yet they set noteworthy precedents for path-altering dynamics. As organizational and procedural change within planning authorities and public agencies has thus far received little attention in the comprehensive policy documents outlining how municipalities ought to prepare for AVs, such aspects require far greater consideration. Particularly so, as procedural and institutional realignments may be pivotal for strategies aimed at linking emerging mobility technologies to broader urban transformation, rather than mere technical performance (Evans et al., 2021).

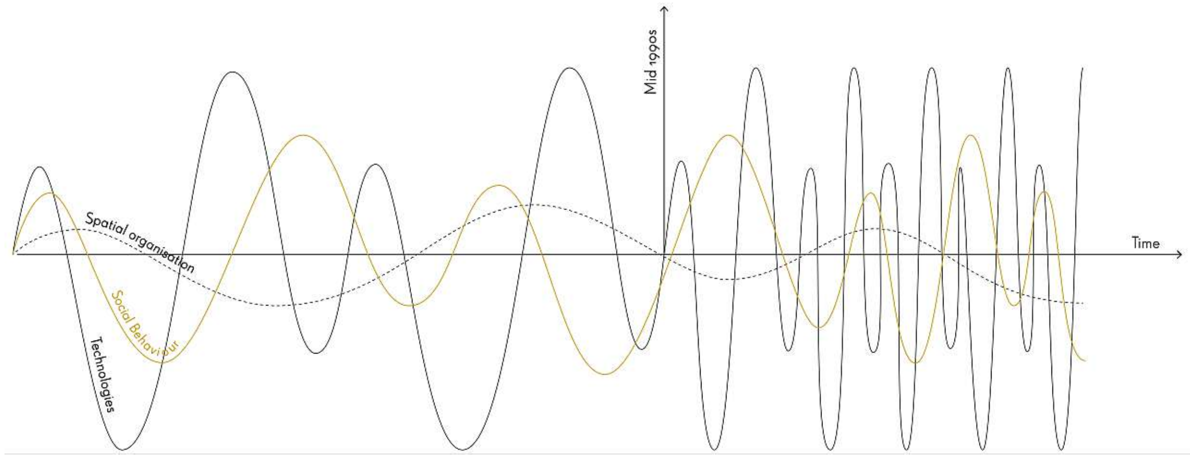
8.1.4. Velocities of change

The case study on planning initiatives in the Greater Toronto Region and the City of Toronto is unique in demonstrating that the agency of planning actors can significantly accelerate social change. Even to the effect that it outpaces the speed of technological advancement (Cajaiba-Santana, 2014) and confronts planners with the often underappreciated advantage of a valuable lead.

As argued by social scientists such as Ogburn (1922, as cited in Godin, 2010) and others, the velocities and rates of change differ across the various domains of society, culture, economy, politics, science and technology (Adam et al., 2008) and, for that matter, urban processes. Ogburn in particular argued that the overlay of material (e.g. technological) and socio-cultural (e.g. institutions, policy, behavioural patterns, etc.) processes of change in the modern world reveals a frequent lag between the accelerated rate of material inventions and socio-cultural adaptation (Godin, 2010). The industry-driven race for vehicle automation over the past decade and a half appeared to exemplify the observation that the public sector has been relatively slow to adapt transport policies compared to the accelerated pace of technological change (Marsden & Docherty, 2013).

Yet disparate speeds of change beg the critical question of who needs to adapt and with what consequence (Adam et al., 2008). Adding to these layers that of the built environment, and with it another velocity of change that takes place over a much longer timeframe (Fig. 8.1), the question pertains to substantial public investments, balancing of interests and long planning horizons. For transformative change to occur in the built environment, which also affects substantial change in mobility, land use and transport policy, development practices, as well as mobility and location behaviour would all need to change in a coherent direction (Bertolini, 2017: 130). An enormous challenge that calls for an extended time horizon.

Figure 8.1 Pace of change of various transformation processes



Source: illustration by the author, based on Alaily-Mattar et al., 2019, as cited in *Digital Transformation and Spatial Development*, by M. Weinig, and A. Thierstein, 2020: 532.

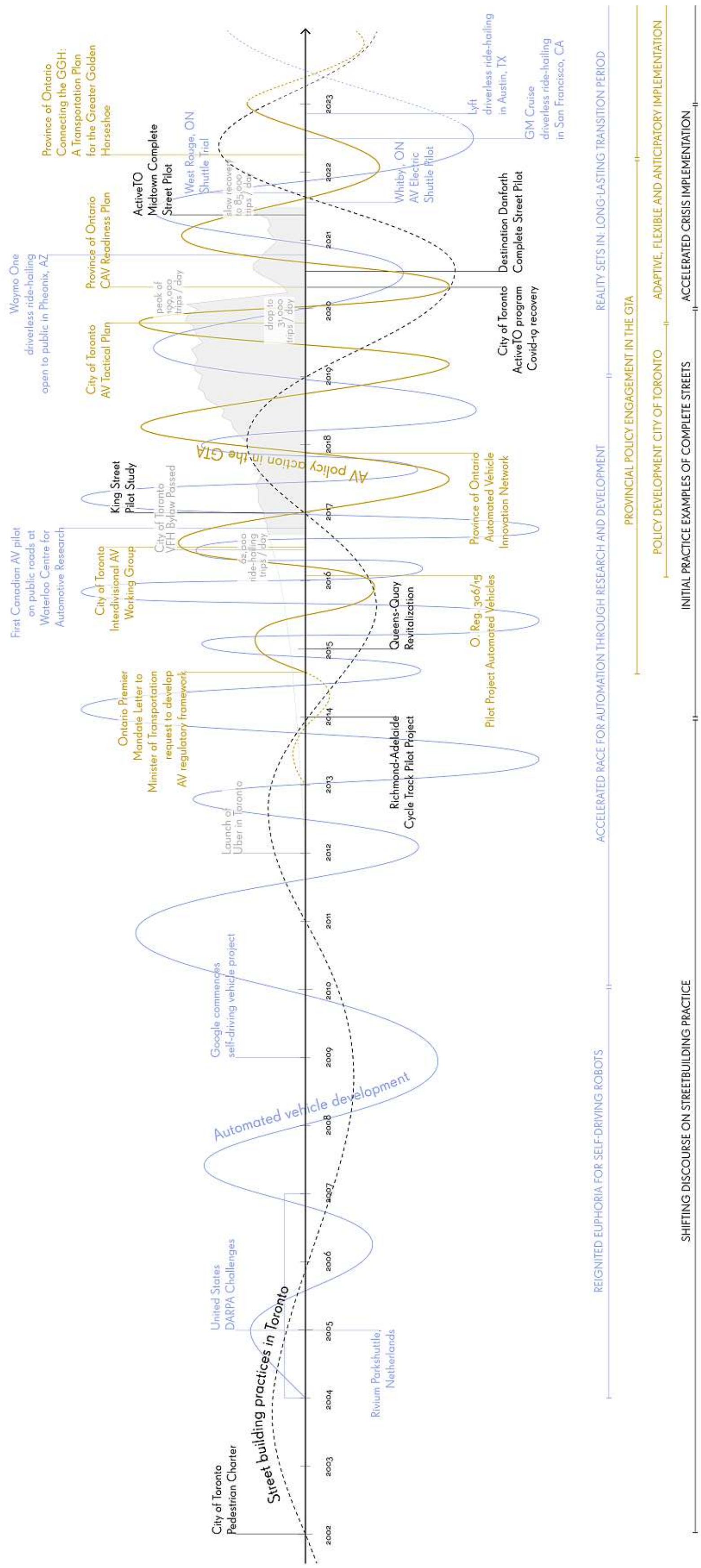
Superimposing the temporal dynamics observable in the case of planning initiatives for AVs in the Greater Toronto Area (Fig. 8.2) shows that although the public sector may have initially been slow to respond, policy and planning activities in the region intensified significantly after 2016 (see also Fig. 4.1). At the provincial level, policy and regulatory adaptations related to AVs were certainly spurred by the ongoing economic restructuring, bearing the potential to diversify the region's mobility sector and strengthen its economic competitiveness (Wolfe & Goracinova, 2017). At the municipal level of Toronto, the timing and form of the planning response was greatly influenced by the past experience of having been inadequately prepared for the arrival of ride-hailing companies (Brail, 2017). With vehicle automation on the horizon and the potential entry of further companies into the mobility as a service market, preparedness for Toronto's municipal planners implied getting "ahead of further developments and long-term potential impacts [of AVs]" (Toronto, 2019a: 122).

The planning initiatives on AVs launched by the City of Toronto, thus contrast previous assessments that policy and planning professionals are necessarily "forced into reacting" (Legacy et al., 2019: 97) to the arrival of emerging mobility technologies. The identified patterns of change indicate instead that new institutional frameworks, interaction dynamics and organizational arrangements were proactively sought through the creative agency of senior planning officials (Albrechts, 1999). Municipal policy and planning action on AVs was not only accelerated in the mid 2010s, it also entailed a noteworthy change in planning practice. In this sense, the identified patterns of change illustrate a keen awareness that traditional planning modes, which in part date back to the advent of the automobile, are inadequate in managing the "uncertainties of rapid change" (Hillier, 2017: 307) in the early 21st century. Moreover, they show that the initial impetus by actors of change was met by an institutional climate conducive to new ideas in planning practice (Albrechts, 2011: 20). Not only did actors with institutional and political power back AV initiatives due to political interests, but a younger generation of transportation planners became involved, exhibiting a greater openness to new practices and planning modes (Weinig & Thierstein, 2020).

At the same time, recent examples of integrated and exploratory transportation planning, which include elements of AV policy and indicate its successive mainstreaming, must be viewed in their historical context. In doing so, it becomes clear that the policy and planning changes, which quite literally paved the way for the rapid implementation of multimodal environments as part of Covid-19 emergency programs, span nearly two decades. Within this timeframe, the planning discourse on street building has shifted (Hess, 2009), new approaches based on Complete Street designs have been developed and implemented across the region (Smith Lea et al., 2016), and comprehensive guidelines have been prepared as a toolbox for planners to draw from (Toronto, 2017b; Chapman, 2014). Certainly, the accelerated pace of change in Toronto's recent street-building activities provides a telling example of how windows of opportunity may be harnessed for transformative action when planning experts are well prepared (Ibert et al., 2022: 6). Yet, the two decades of incremental change in institutional arrangements and practice dynamics also illustrate with what time lag new planning visions and policy approaches materialize in the built environment.

The current situation thus highlights the disparate rates of change in policy making, planning practice, spatial development and technological advancement. As the technological setbacks of recent years have significantly altered the timeline for commercial deployment of AVs (Steckler et al., 2021), societal change in terms of policy-making has overtaken the pace of technological innovation in places such as the City of Toronto (Cajaiba-Santana, 2014). Yet the merit of the delayed commercialization of AVs is far greater than what Ogburn once described as "sufficiently slow to permit time for study and planning" (Ogburn, 1937a, as cited in Godin, 2010: 289). Given the extensive knowledge on how AVs may impact transportation, civic life and urban form, the present time lag needs to be recognized as a unique opportunity to further promote social innovation in planning. Be it in the form of new governance arrangements, greater inter-municipal collaboration or the integration of community-based approaches. Whether the advent of AVs reinforces the status quo or instead fosters meaningful change in mobility habits and urban environments greatly hinges on the capacity of planners to redirect the social practices that stand in the way of implementing alternative visions and policies. It is therefore all the more urgent to seize the present moment of asynchronicity and mobilize the necessary institutional, political and cultural forces to ensure that vehicle automation truly works in favour of broader collective interests.

Figure 8.2 The temporal multiplicity of planning for automated mobility in the GTA



Source: illustration by the author, based on *The Transportation Impacts of Vehicle-for-Hire in the City of Toronto,* by the City of Toronto, 2019b; *The Transportation Impacts of Vehicle for Hire in the City of Toronto October 2018 to July 2021,* by the City of Toronto, 2021c; *Planning for Shared Automated Vehicles,* by S. Buckley, 2022.

8.2. Outlook on further research

The first aim of this thesis was to contribute to the academic discussion on managing the technological, social and cultural transition to automated mobility systems by exploring whether planning professionals assume novel modes of practice in their preparations. By applying an analytical framework for social innovation in planning that distinguishes recurrent patterns of change even in phases of incubation and generation (Christmann et al., 2020), it was possible to trace realignments in planning practice as tentative novelties, before they may become accepted as "innovations" by the wider planning community and established as a new means of planning (Ibert et al., 2015).

The approach proved fruitful, insofar as it was possible to identify critical features of capacity building among planners that have thus far received little attention in the literature on policy and planning preparation for AVs. The results provide evidence for the importance of organizational and cultural realignments within public agencies and planning departments, beyond the acquisition of technical knowledge and competencies. Faculties cultivated as part of the process of preparing for AVs in the City of Toronto include cross-sectoral collaboration and knowledge exchange, openness to act experimentally as well as adoption of an overall learning orientation through continuous monitoring and evaluation (ARL, 2021, as cited in Ibert et al., 2022: 8–9). These findings highlight the significance of institutional change in the public sector, that is, shifts in shared expectations and forms of interaction (Bathelt & Glückler, 2014). Municipalities and public agencies that have not yet embedded the subject of AVs in their institutional framework or are in the process of doing so (Freemark et al., 2019) can benefit from these findings and should direct their attention to these matters.

The forms of organizational change identified range from designated staff teams, to working groups within individual departments, to interdivisional working groups bridging sectoral perspectives within a municipality. Given that the study focused on recent events, further statements on the durability of different kinds of organizational change exceed its scope. The present findings are nonetheless valuable for further studies on the aptitude and limitations of different kinds of organizational change in relation to specific institutional settings. The research reinforces previous findings by Freemark et al. (2019) that the level of an agency's resources is critical to its ability to proactively engage in monitoring and policy-making, and to designate staff positions to the task. The results extend this knowledge by showing that the intrinsic motivation and role of planning professionals, including their openness to innovation, are equally pivotal. Moreover, political and material resources further influence whether learnings of individual actors are successfully disseminated and the respective policy is mainstreamed. To this end, governmental funding programs should further encourage organizational capacity building, particularly among public agencies and municipalities constrained by limited resources.

A second aim was to promote a differentiated understanding of the transformative potential of automated mobility by distinguishing between its meaning for transportation systems, urban development and planning practice as well as by examining the context-dependency of such claims. To exercise closer scrutiny of how the local planning environment and societal context affect the extent of plausible change, a planning cultural understanding was integrated into the analytical framework. In this respect, the research highlights the significance of intermunicipal governance arrangements and of institutional dynamics arising from the planning hierarchy between different levels of government in metropolitan regions such as the GTA. The findings demonstrate that both dimensions may significantly affect the institutional and political capacity of planning professionals to shape AV-related regulations and introduce novel means into planning practice. While the development of a municipal policy framework outlining long-term policy objectives is critical to align emerging mobility services with public interests, it is not sufficient to effectively manage the transition to AVs. In a metropolitan region characterized by highly interconnected travel patterns but heterogenous levels of transit service and infrastructure roll out, successful policy coordination and multi-level governance arrangements are key.

These issues open up avenues for further research on regional governance arrangements in different international settings and their effectiveness in fostering coordinated policy development, common standards, shared data bases and integrated service provision. In the context of diversifying mobility technologies, e.g. ride-hailing, on-demand microtransit services, car- and bike-sharing, etc., investigating best practice examples for cross-jurisdictional transport integration is promising regardless of a potential integration of AVs. To this end, future studies should adopt an integrated perspective and scrutinize correlated policy fields, e.g. transport and land use changes, implications for service performance and social equity, and corresponding fare structure reforms. Finally, the findings suggest that further policy studies giving greater attention to municipal tax options and fiscal autonomy of cities in different international regions are required in order to propose more nuanced recommendations on how to mitigate adverse effects, strengthen existing transit networks and sustain municipal revenue streams in a future scenario with AVs.

A third aim of this thesis was to gain methodological insight into the possibilities and limitations of tracing the patterns of currently unfolding change in planning practice. In this respect, the application of the analytical framework on social innovation in planning (Christmann et al., 2020) proved valuable, as it made it possible to qualify realignments in interaction dynamics and organizational arrangements as early patterns of change. The openness and time of the interviewed experts to engage in comprehensive discussions and share insights on the process of preparing for AVs was critical for the applicability of the framework in studying such a young planning phenomenon. However, the analysis of patterns of change was challenged by the fact that the analytical framework for the case study was refined after the interviews had already been conducted. In this respect, future applications of the analytical framework for social innovation in planning by Christmann et al. (2020) will benefit from a closer alignment between interview design and analytical dimensions. Moreover, the conducted research does not present generalizable findings on the level of municipal preparedness across the GTA, as they are limited by the selected number of interviewed experts and the temporality of the perspectives. Future research will thus benefit from an even broader selection of interview partners in order to take stock of a greater variety of perspectives, including those from other municipalities in the case study region. It will certainly constitute a valuable effort to return to these findings in several years and examine the extent to which the identified patterns of change have been absorbed by established modes of planning, or instead consolidated and scaled to in fact represent a "transformative moment" (Healey, 2006: 541).

BIBLIOGRAPHY

Abbott, J. (2005). Understanding and Managing the Unknown: The Nature of Uncertainty in Planning. Journal of *Planning Education and Research, 24*(3), 237–251.

Abbott, J. (2012). Planning as Managing Uncertainty: Making the 1996 Livable Region Strategic Plan for Greater Vancouver. *Planning Practice & Research, 27*(5), 571–593.

Abdelwahab, B., Palm, M., Shalaby, A., & Farber, S. (2021). Evaluating the equity implications of ridehailing through a multi-modal accessibility framework. *Journal of Transport Geography, 95*, 103147.

Abotalebi, E., Nesheli, M., Pillai, P., & Petrunić, J. (2021). *New Mobility and Autonomous Vehicles Impacts on Greenhouse Gas Emissions in Metro Vancouver*. CUTRIC - Canadian Urban Transit Research and Innovation Consortium. https://cutric-crituc.org/wp-content/uploads/2022/03/New-Mobility-and-Autonomous-Vehicles-Impacts-on-Greenhouse-Gas-Emissions-in-Metro-Vancouver.pdf

Adam, B. (2003). Reflexive Modernization Temporalized. *Theory, Culture & Society, 20*(2), 59–78. https://doi.org/10.1177/0263276403020002004

Adam, B., Hockey, J., & Thompson, P. (2008). *Researching Lives Through Time: Time, Generation and Life Stories.* Timescapes Working Paper Series No. 1. https://timescapes-archive.leeds.ac.uk/wp-content/uploads/sites/47/2020/07/WP1-Researching-Lives-Through-Time-June-2008.pdf

Albrechts, L. (1999). Planners as catalysts and initiators of change. The new structure plan for flanders. *European Planning Studies, 7*(5), 587–603.

Albrechts, L. (2011). Transformative practices: Where strategic spatial planning meets social innovation. In Strategic Spatial Projects. Routledge.

Albrechts, L., & Balducci, A. (2013). Practicing Strategic Planning: In Search of Critical Features to Explain the Strategic Character of Plans. *disP - The Planning Review, 49*(3), 16–27.

Albrechts, L., & Balducci, A. (2017). Introduction. In L. Albrechts, A. Balducci & J. Hillier (Eds.), *Situated Practices of Strategic Planning* (pp. 31–38). Routledge.

Alessandrini, A., Campagna, A., Site, P. D., Filippi, F., & Persia, L. (2015). Automated Vehicles and the Rethinking of Mobility and Cities. *Transportation Research Procedia, 5*, 145–160.

Alessandrini, A., & Filippi, F. (2004). Ex-ante evaluation of nine cybernetic transport systems. Proceedings. The 7th International IEEE Conference on Intelligent Transportation Systems, 994–999.

Alexander, C., Ishikawa, S., & Silverstein, M. (1977). *A Pattern Language: Towns—Buildings—Construction.* Oxford University Press.

Allen, J., & Farber, S. (2020). Planning transport for social inclusion: An accessibility-activity participation approach. *Transportation Research Part D: Transport and Environment, 78*, 102212.

Allen, R., & Campsie, P. (2013). *Implementing the Growth Plan for the Greater Golden Horseshoe.* Neptis Foundation. https://neptis.org/sites/default/files/growth_plan_2013/theneptisgrowthplanreport_final.pdf

Ambrosius, E. (2018, Dezember 4). *Autonomous driving and road markings* [Conference presentation]. IRF & UNECE ITS Event, Geneva, Switzerland. https://unece.org/sites/default/files/2022-04/Eva%20Ambrosius%20-%20Autonomous%20Driving%20and%20Road%20Markings.pdf

Anund, A., Ludovic, R., Caroleo, B., Hardestam, H., Dahlman, A., Skogsmo, I., Nicaise, M., & Arnone, M. (2022). Lessons learned from setting up a demonstration site with autonomous shuttle operation – based on experience from three cities in Europe. *Journal of Urban Mobility, 2*, 100021.

Appadurai, A. (1996). *Modernity at Large*. U of Minnesota Press.

Appleyard, B., & Riggs, W. (2018). A vision for livability. In W. Riggs (Eds.), *Disruptive Transport. Driverless Cars, Transport Innovation and the Sustainable City of Tomorrow* (pp. 189–203). Routledge.

Attfield, P. (2018, September 13). *Large-scale harvesting of data helping to create 'smart cities' of tomorrow.* The Globe and Mail. https://www.theglobeandmail.com/business/article-large-scale-harvesting-of-data-helping-to-create-smart-cities-of/

Auld, J., Verbas, O., Javanmardi, M., & Rousseau, A. (2018). Impact of Privately-Owned Level 4 CAV Technologies on Travel Demand and Energy. *Procedia Computer Science, 130*, 914–919.

Balducci, A., Boelens, L., Hillier, J., Nyseth, T., & Wilkinson, C. (2011). Introduction: Strategic spatial planning in uncertainty: theory and exploratory practice. *The Town Planning Review, 82*(5), 481–501.

Baniewicz, A., & Neff, C. (2020). Auswirkungen auf die Mobilitätswahrnehmung durch die Einführung eines autonomen Shuttlebusses. In A. Riener, A. Appel, W. Dorner, T. Huber, J. C. Kolb, & H. Wagner (Eds.), *Autonome Shuttlebusse im ÖPNV* (pp. 25–37). Springer.

Bathelt, H., & Glückler, J. (2014). Institutional change in economic geography. *Progress in Human Geography, 38*(3), Art. 3.

Baur, N., & Christmann, G. (2021). Fallauswahl und Generalisierung. In A. J. Heinrich, S. Birchall, A. Million, & J. Stollmann (Eds.), *Handbuch qualitative und visuelle Methoden der Raumforschung* (pp. 121–135). transcript.

Beattie, S. (2021, Dezember 31). *At least 58 people died on Toronto's streets this year—A „failure" for Vision Zero, advocates say*. CBC. https://www.cbc.ca/news/canada/toronto/toronto-vision-zero-1.6300706

Beck, U. (1994). The Reinvention of Politics: Towards a Theory of Reflexive Modernization. In U. Beck, A. Giddens, & S. Lash (Eds.), *Reflexive Modernization: Politics, Tradition and Aesthetics in the Modern Social Order* (pp. 1–55). Stanford University Press.

Beck, U., Bonss, W., & Lau, C. (2003). The Theory of Reflexive Modernization: Problematic, Hypotheses and Research Programme. *Theory, Culture & Society, 20*(2), 1–33.

Beecroft, R., Trenks, H., Rhodius, R., Benighaus, C., & Parodi, O. (2018). Reallabore als Rahmen transformativer und transdisziplinärer Forschung: Ziele und Designprinzipien. In A. Di Giulio & R. Defila (Eds.), *Transdisziplinär und transformativ forschen. Eine Methodensammlung* (pp. 75–100). Springer Fachmedien Wiesbaden.

Beggs, G., Northey, R., & Sweet, M. (2017). *GTA West Corridor Advisory Panel Report*.

Beiker, S. (2016). Deployment Scenarios for Vehicles with Higher-Order Automation. In M. Maurer, J. C. Gerdes, B. Lenz, & H. Winner (Eds.), *Autonomous Driving: Technical, Legal and Social Aspects* (pp. 193–211). Springer.

Beiker, S. A. (2019). Deployment of Automated Driving as an Example for the San Francisco Bay Area. In G. Meyer & S. Beiker (Eds.), *Road Vehicle Automation 5* (pp. 117–129). Springer International Publishing.

Belikow, A., Bonsall, T., Xiao, J., Kohn, S., & De Blois, M. B. (2021). *City Case Studies. An Analysis of Five Living Labs*. McGill University. https://static1.squarespace.com/static/6026a7d20243be4f22c8a256/t/6078c1246ebaf120fad95f56/1618526507618/202104_CaseStudies_Toronto.pdf

Bellon, T. (2022, June 18). *How free-wheeling Texas became the self-driving trucking industry's promised land*. Reuters. https://www.reuters.com/business/autos-transportation/how-free-wheeling-texas-became-self-driving-trucking-industrys-promised-land-2022-06-17/

Bertolini, L. (2007). Evolutionary Urban Transportation Planning: An Exploration. *Environment and Planning A: Economy and Space, 39*(8), 1998–2019.

Bertolini, L. (2017). *Planning the Mobile Metropolis: Transport for People, Places and the Planet*. Pelgrave.

Birchall, S. J., MacDonald, S., & Slater, T. (2021). Anticipatory planning: Finding balance in climate change adaptation governance. *Urban Climate, 37*, 100859.

Birnbaum, L., Sweet, M., Comeau, É., & Olsen, T. (2018). *Driverless Cars in the Greater Toronto and Hamilton Area: Focus Group Findings*. Ryerson University School of Urban and Regional Planning. https://assets.metrolinx.com/image/upload/v1663240156/Documents/Metrolinx/Driverless_Cars_Focus_Group_Report_20180413a.pdf

Blais, P. (2018). *Planning the Next GGH*. Neptis Foundation. https://neptis.org/publications/planning-next-ggh

Bloomberg Philanthropies. (2017, October 23). *Bloomberg Philanthropies Launches First-Ever Autonomous Vehicles Map, A Living Inventory of Cities Planning for a Driverless Future*. Bloomberg Philanthropies. https://www.bloomberg.org/press/bloomberg-philanthropies-launches-first-ever-autonomous-vehicles-map-living-inventory-cities-planning-driverless-future/

Blyth, M. (2002). *Great Transformations: Economic Ideas and Institutional Change in the Twentieth Century*. Cambridge University Press.

BMK. (2020). *Testberichte. Tests auf Straßen mit öffentlichem Verkehr in Österreich gemäß der Automatisiertes Fahren Verordnung. Zeitraum: 2016– 2021*. Bundesministerium für Klimaschutz, Umwelt, Energie, Mobilität, Innovation und Technologie. https://www.bmk.gv.at/dam/jcr:f400638c-6fbd-477f-94c1-65e431203d73/Testberichte_laufend_20220314.pdf

Boesch, P. M., Ciari, F., & Axhausen, K. W. (2016). Autonomous Vehicle Fleet Sizes Required to Serve Different Levels of Demand. *Transportation Research Record, 2542*(1), Art. 1.

Boggs, A. M., Arvin, R., & Khattak, A. J. (2020). Exploring the who, what, when, where, and why of automated vehicle disengagements. *Accident Analysis & Prevention, 136*, 105406.

Booth, P. (2011). Culture, planning and path dependence: Some reflections on the problems of comparison. *The Town Planning Review, 82*(1), Art. 1.

Bösch, P. M., Becker, F., Becker, H., & Axhausen, K. W. (2018). Cost-based analysis of autonomous mobility services. *Transport Policy, 64*, 76–91.

Bowerman, G. (Host). (2022, September 1). Toronto Election: The case against a strong mayor system (No. 067) [Audio podcast episode]. In *Spacing Radio*. http://spacing.ca/toronto/2022/09/01/podcast-spacing-radio-067-toronto-election-the-case-against-a-strong-mayor-system/

Brail, S. (2017). Promoting innovation locally: Municipal regulation as barrier or boost? *Geography Compass, 11*(12), e12349.

Brail, S. (2018). From Renegade to Regulated: The Digital Platform Economy, Ride-hailing and the Case of Toronto. *Canadian Journal of Urban Research, 27*(2), 51-63.

Bratzel, S. (1999). Conditions of success in sustainable urban transport policy change in „relatively successful" European cities. *Transport Reviews, 19*(2), 177–190.

Braun-Thürmann, H. (2005). *Innovation*. Transcript.

Brinkmann, S. (2013). *Qualitative Interviewing*. Oxford University Press.

Brinkmann, S. (2014). Unstructured and Semi-Structured Interviewing. In P. Leavy (Eds.), *The Oxford handbook of qualitative research* (pp. 277–299). Oxford University Press.

Broussard, M. (2019). *Artificial Unintelligence*. The MIT Press.

Bruck, E. M. (2019). Automatisierte Mobilitätsdienste als Wandlungsimpuls für suburbane Räume? In J. Fiedler (Eds.), *Broadacre city 2.0 – postfossil, ein urbanistisches Szenario für 2050*. Haus der Architektur Graz.

Bruck, E. M., Scheuvens, R., & Berger, M. (2021). Steuerung und Gestaltung von räumlichen Schnittstellen der Mobilität. In M. Mitteregger, E. M. Bruck, A. Soteropoulos, A. Stickler, M. Berger, J. S. Dangschat, R. Scheuvens, & I. Banerjee (Eds.), *AVENUE21. Politische und planerische Aspekte der automatisierten Mobilität* (pp. 133–158). Springer.

Bruck, E. M., & Soteropoulos, A. (2021). Automatisiertes und vernetztes Fahren (avF): Berücksichtigung des lokalen, räumlichen Kontextes und räumliche Differenzierung. In M. Mitteregger, E. M. Bruck, A. Soteropoulos, A. Stickler, M. Berger, J. S. Dangschat, R. Scheuvens, & I. Banerjee (Eds.), *AVENUE21 Band 2: Politische und planerische Aspekte der automatisierten Mobilität*. Springer Vieweg.

Bruck, E. M., Soteropoulos, A., Berger, M., & Scheuvens, R. (2020). *Straßenräumliche Wirkungen und Verträglichkeit des autonomen Fahrens im Raum Wien*. TU Wien.

Bruck, E., & Soteropoulos, A. (2022). Traffic-land use compatibility and street design impacts of automated driving in Vienna, Austria. *Journal of Transport and Land Use, 15*(1), 137–163.

Buckley, S. (2022, August 12). *Planning for Shared Automated Vehicles* [PowerPoint slides].

Burchfield, M., & Kramer, A. (2015). *Growing Pains: Understanding the new reality of population and dwelling patterns in the Toronto and Vancouver regions*. Neptis Foundation. https://neptis.org/publications/growing-pains-understanding-new-reality-population-and-dwelling-patterns-toronto-and

Burton, E., Jenks, M., & Williams, K. (1996). The Compact City. A Sustainable Urban Form? Routledge.

Cajaiba-Santana, G. (2014). Social innovation: Moving the field forward. A conceptual framework. *Technological Forecasting and Social Change, 82*, 42–51.

Calabrese, L. M. (2004). Reweaving UMA: Urbanism Mobility Architecture [Doctoral dissertation, TU Delft]. TU Delft Repository. https://repository.tudelft.nl/islandora/object/uuid%3A369662a0-ed16-4545-970c-2608375ee571

Calderón, F., & Miller, E. (2020). A literature review of mobility services: Definitions, modelling state-of-the-art, and key considerations for a conceptual modelling framework. *Transport Reviews, 40*(3), 312–332.

Canada. (2022). *2030 EMISSIONS REDUCTION PLAN: Canada's Next Steps for Clean Air and a Strong Economy*. Minister of Environment and Climate Change. https://publications.gc.ca/collections/collection_2022/eccc/En4-460-2022-eng.pdf

Canada, T. (2021, August 13). Connected and automated vehicle safety: What you need to know. ASF 14722195; ASF. https://tc.canada.ca/en/road-transportation/innovative-technologies/connected-automated-vehicles/connected-automated-vehicle-safety-what-you-need-know

Caniglia, G., Schäpke, N., Lang, D. J., Abson, D. J., Luederitz, C., Wiek, A., Laubichler, M. D., Gralla, F., & von Wehrden, H. (2017). Experiments and evidence in sustainability science: A typology. *Journal of Cleaner Production, 169*, 39–47.

Carreras, A., Daura, X., Erhart, J., & Ruehrup, S. (2018). *Road infrastructure support levels for automated driving*. Proceedings of ITS World Congress, Copenhagen, Denmark. https://www.inframix.eu/wp-content/uploads/ITSWC2018-ASF-AAE-Final-paper_v4.pdf

Carriere, K., Hasham, A., Simor, D., & Smith Lea, N. (2022). *The ActiveTO Midtown Complete Street Pilot Evaluation Report is now live*. Park People, The Centre for Active Transportation. https://www.tcat.ca/wp-content/uploads/2022/03/ActiveTO-Midtown-Complete-Street-Intercept-Study-FINAL-Accessibility-Checked.pdf

Casprig, A. (2009). Planungskultur: Plastikwort oder Passepartout? *PNDonline*, 2, 1-10.

CAVCOE. (2013). *Canadian Automated Vehicles Centre of Excellence Launched*. https://www.cavcoe.com/news/news_rls_2013-11-11.pdf

CAVCOE. (2019). *Best practices for automated vehicle trials in North American municipalities*. A Research Report for the City of Toronto. https://www.toronto.ca/wp-content/uploads/2019/10/9014-TS_CAVCOE_City_Tor_AV_Trials_final_rpt.pdf

Cavoli, C., Phillips, B., Cohen, T., & Jones, P. (2017). *Social and behavioural questions associated with Automated Vehicles: A Literature Review*. London.

Ceder, A., & Yim, Y. (2003). *Integrated Smart Feeder / Shuttle Bus Service*. https://escholarship.org/uc/item/5bz576tn

Chapman, F. (2014). *Complete Streets: From Policy to Implementation in Toronto* [Powerpoint slides]. http://www.tcat.ca/wp-content/uploads/2014/10/Complete-Streetsnonotestoronto_Chapman.pdf

Chaudhry, A., Thomas, P., Hu, B., Roussou, J., Gebhard, S., Weijermars, W., Veisten, K., Augustin, H., Zach, M., Ponweiser, W., Potts, L., Ziakopolous, A., & Morris, A. (2022). *Policy Recommendations for Connected, Cooperative, and Automated Mobility*. LEVITATE Policy Recommendations Deliverable 8.4. https://levitate-project.eu/wp-content/uploads/2022/06/D-8.4-Policy-Recommendations.pdf

Christensen, K. S. (1985). Coping with Uncertainty in Planning. *Journal of the American Planning Association, 51*(1), 63–73.

Christmann, G. B., Ibert, O., Jessen, J., & Walther, U.-J. (2020). Innovations in spatial planning as a social process – phases, actors, conflicts. *European Planning Studies, 28*(3), Art. 3.

Christmann, G., Ibert, O., Jessen, J., & Walther, U.-J. (2018). How Does Novelty Enter Spatial Planning? In W. Rammert, A. Windeler, H. Knoblauch, & M. Hutter (Eds.), *Innovation Society Today: Perspectives, Fields, and Cases* (pp. 247–272). Springer Fachmedien.

CityMobil2. (2016). *Final publishable summary report*. https://cordis.europa.eu/docs/results/314/314190/final1-final-publishable-report.pdf

Ciuffini, F., Tengattini, S., & Bigazzi, A. Y. (2021). Mitigating Increased Driving after the COVID-19 Pandemic: An Analysis on Mode Share, Travel Demand, and Public Transport Capacity. *Transportation Research Record: Journal of the Transportation Research Board*, 03611981211037884.

Clark, J. (2020). *Uneven Innovation: The Work of Smart Cities*. Columbia University Press.

Clarke, A. (2020). Data Governance: The Next Frontier of Digital Government Research and Practice. In E. Dubois & F. Martin-Bariteau (Eds.), *Citizenship in a Connected Canada: A Research and Policy Agenda* (pp. 97–117). University of Ottawa Press.

Clayton, F., & Amborski, D. (2022). *Is All Greenfield Development in the Greater Toronto and Hamilton Area Sprawl? A Resounding No*. Toronto Metropolitan University. https://www.torontomu.ca/centre-urban-research-land-development/blog/blogentry68/

Clayton, F., & Shi, H. Y. (Eva). (2019). *Time to Transition Municipal Employment Surveys into an Annual GGH-Wide Employment Survey*. Toronto Metropolitan University. https://www.torontomu.ca/content/dam/centre-urban-research-land-development/pdfs/Projects/CUR_Policy_Report_Municipal_Employment_Surveys.pdf

CNC – Canadian National Committee of the World Road Association (2015). *CANADA-National Report*. Strategic Direction Session ST 4. Infrastructure Optimizing Road Infrastructure Investments And Accountability. XXVth World Road Congress, Seoul, South Korea.

CodeRedTO. (2018). *Mixed Signals. Toronto Transit in a North American Context*. https://coderedto.com/wp-content/uploads/2018/11/CodeRedTO_MixedSignals.pdf

Confino, M. (1994). Present Events and the Representation of the past: Some Current Problems in Russian Historical Writing. *Cahiers du Monde russe, 35*(4), 839-868.

Council of Ministers. (2017). *Canada's National Highway System Annual Report 2017*. Council of Ministers Responsible for Transportation and Highway Safety. https://www.comt.ca/Reports/NHS%20Annual%202017.pdf

Crawford, S. (2018, August 29). *How Curbs Became the New Urban Battleground*. Wired. https://www.wired.com/story/how-curbs-became-the-new-urban-battleground/

Crombie, D., & Golden, A. (2022, Januar 18). *We cannot sprawl our way to housing affordability*. The Toronto Star. https://www.thestar.com/opinion/contributors/2022/01/18/we-cannot-sprawl-our-way-to-housing-affordability.html

CUI – Canadian Urban Institute. (2018). *What is the Missing Middle? A Toronto housing challenge demystified*. https://www.evergreen.ca/downloads/pdfs/2018/What_is_the_Missing_Middle_Evergreen_CUI_s2.pdf

Cyganski, R. (2016). Automated Vehicles and Automated Driving from a Demand Modeling Perspective. In M. Maurer, J. C. Gerdes, B. Lenz, & H. Winner (Eds.), *Autonomous Driving: Technical, Legal and Social Aspects* (pp. 233–253). Springer.

Dandekar, H. C. (1986). Some Uses and Potentials of Qualitative Methods in Planning. *Journal of Planning Education and Research, 6*(1), 42–49.

Dawson, P., & Daniel, L. (2010). Understanding social innovation: A provisional framework. *International Journal of Technology Management, 51*(1), 9–21.

de Abreu e Silva, J., & Melo, P. C. (2018). Does home-based telework reduce household total travel? A path analysis using single and two worker British households. *Journal of Transport Geography, 73*, 148–162.

Dean, J., Wray, A. J., Braun, L., Casello, J. M., McCallum, L., & Gower, S. (2019). Holding the keys to health? A scoping study of the population health impacts of automated vehicles. *BMC Public Health*, 19(1), 1258.

Deeg, R. (2005). Change from Within: German and Italian Finance in the 1990s. In W. Streeck & K. Thelen (Eds.), *Beyond Continuity: Institutional Change in Advanced Political Economies* (pp. 169–202). Oxford University Press.

Defila, R., & Di Giulio, A. (2018). Reallabore als Quelle für die Methodik transdisziplinären und transformativen Forschens – eine Einführung. In A. Di Giulio & R. Defila (Eds.), *Transdisziplinär und transformativ forschen* (pp. 9–35). Springer Fachmedien Wiesbaden.

Deivendran, S. (2020). *Transportation Innovation Zones September 2020 Stakeholder Workshops*. Report- Part 2 of 4. Results Summary [TIZ Workshops Report]. https://www.toronto.ca/wp-content/uploads/2020/11/9822-TS_TIZ-Workshops-Report-Part-2-Results-Summary.pdf

Deloitte, & OCE. (2020). *AVIN ecosystem analysis and roadmap 2020. Strengths, challenges, and opportunities across Ontario's automotive and mobility ecosystem*. Deloitte LLP & Ontario Centres of Excellence. https://www.ovinhub.ca/wp-content/uploads/2021/04/FY2018-2019-OCE-AVIN-Annual-Report_FINAL-2019-06-28.pdf

Derer, M., & Geis, F. (2020). Entwicklungen im ÖPNV. In A. Riener, A. Appel, W. Dorner, T. Huber, J. C. Kolb, & H. Wagner (Eds.), *Autonome Shuttlebusse im ÖPNV: Analysen und Bewertungen zum Fallbeispiel Bad Birnbach aus technischer, gesellschaftlicher und planerischer Sicht* (pp. 3–14).

Detroit. (2018). *Strategic Plan for Transportation*. City of Detroit. https://detroitmi.gov/sites/detroitmi.localhost/files/2018-10/Detroit-Strategic-Plan-For-Transportation.pdf

Devitt, G., & Tan, M. (2020). *Intelligent Transportation Systems (ITS) Strategy*. IBI Group with Parsons.

Diceman, J. (2020). *Automated Shuttle Trial Public Consultation Report. Phase 1: September 9 to October 31, 2019*. https://www.toronto.ca/wp-content/uploads/2020/01/9698-AV-Shuttle-Trial-Consultation-Report-Phase-1-FINAL.pdf

Dobson, I., Miller, G., Morton, K., Shah, Y., Jattan, C., & Lamont, K. (2013). *Strategic Regional Research: A Region in Transition*. Canadian Urban Institute. https://canurb.org/publications/greater-toronto-region-in-transition/

Docherty, I., Stone, J., Curtis, C., Sørensen, C. H., Paulsson, A., Legacy, C., & Marsden, G. (2022). The case for 'public' transport in the age of automated mobility. *Cities*, *128*, 103784.

Dolata, U. (2011). Soziotechnischer Wandel als graduelle Transformation. *Berliner Journal für Soziologie, 21*(2), 265–294.

Doucet, B., & Doucet, M. (2022). *Streetcars and the Shifting Geographies of Toronto: A Visual Analysis of Change. In Streetcars and the Shifting Geographies of Toronto*. University of Toronto Press.

Duarte, F., & Ratti, C. (2018). The Impact of Autonomous Vehicles on Cities: A Review. *Journal of Urban Technology, 25*(4), 3–18.

Durham Region. (2017). *Durham Transportation Masterplan 2017*. The Regional Municipality of Durham. https://durhamtmp.files.wordpress.com/2018/07/durhamtmp_finalreport_2018-07-09-web-accessible.pdf

Edelmann, A., Stümper, S., & Petzoldt, T. (2021). Cross-cultural differences in the acceptance of decisions of automated vehicles. *Applied Ergonomics, 92*, 103346.

Eliot, L., & Fagan, M. (2021). *Developing Urban Mobility Policy in Response to Autonomous Vehicles: A Multi-Party Policy Development Simulation*. Harvard Kennedy School. Taubman Center for State and Local Government. https://www.hks.harvard.edu/sites/default/files/Taubman/AVPI/Taubman%20AVPI%20Simulation_11-2021.pdf

Emirbayer, M., & Goodwin, J. (1996). Symbols, Positions, Objects: Toward a New Theory of Revolutions and Collective Action. *History and Theory, 35*(3), 358–374.

Erhardt, G. D., Roy, S., Cooper, D., Sana, B., Chen, M., & Castiglione, J. (2019). Do transportation network companies decrease or increase congestion? *Science Advances, 5*(5), eaau2670.

Evans, J., Vácha, T., Kok, H., & Watson, K. (2021). How Cities Learn: From Experimentation to Transformation. *Urban Planning, 6*(1), 171–182.

Fagan, M., Comeaux, D., & Gillies, B. (2021). *Autonomous Vehicles are Coming: Five Policy Actions Cities Can Take Now to Be Ready*. Kennnedy School Taubman Center for State and Local Government Harvard University. https://www.urbanismnext.org/resources/autonomous-vehicles-are-coming-five-policy-actions-cities-can-take-now-to-be-ready

Fagnant, D. J., & Kockelman, K. (2015). Preparing a nation for autonomous vehicles: Opportunities, barriers and policy recommendations. *Transportation Research Part A: Policy and Practice, 77*, 167–181.

Fanelli, M. J., & Stoddard, F. J. (2022, May 25). *States Lead the Way on Autonomous Vehicle Regulation as Federal Law Looms on the Horizon*. Morgan Lewis. https://www.morganlewis.com/pubs/2022/05/states-lead-the-way-on-autonomous-vehicle-regulation-as-federal-law-looms-on-the-horizon

Fehr & Peers. (2018). *San Francisco Curb Study*. https://www.fehrandpeers.com/curbs-of-the-future/

Fehr & Peers. (2019). *Cincinnati Curb Study*. Prepared for City of Cincinnati and Uber Technologies. https://www.fehrandpeers.com/curbs-of-the-future/

Filion, P. (2000). Balancing Concentration and Dispersion? Public Policy and Urban Structure in Toronto. E*nvironment and Planning C: Government and Policy, 18*(2), 163–189.

Filion, P. (2018). Enduring Features of the North American Suburb: Built Form, Automobile Orientation, Suburban Culture and Political Mobilization. *Urban Planning, 3*(4), 4–14.

Flores, O., & Rayle, L. (2017). How cities use regulation for innovation: The case of Uber, Lyft and Sidecar in San Francisco. *Transportation Research Procedia, 25*, 3756–3768.

Földes, D., & Csiszár, C. (2018). Framework for planning the mobility service based on autonomous vehicles. 2018 Smart City Symposium Prague (SCSP), Czech Republic, 1–6.

Fraedrich, E., Heinrichs, D., Bahamonde-Birke, F. J., & Cyganski, R. (2019). Autonomous driving, the built environment and policy implications. *Transportation Research Part A: Policy and Practice, 122*, 162–172.

Freemark, Y., Hudson, A., & Zhao, J. (2019). Are Cities Prepared for Autonomous Vehicles? *Journal of the American Planning Association, 85*(2).

Freudendal-Pedersen, M., & Kesselring, S. (2016). Mobilities, Futures & the City: Repositioning discourses – changing perspectives – rethinking policies. *Mobilities, 11*(4), 575-586.

Friedmann, J. (1967). A Conceptual Model for the Analysis of Planning Behavior. Administrative Science Quarterly, 12(2), 225-252.

Friedmann, J. (2005). Planning Cultures in Transition. In S. Bishwapriya (Ed.), *Comparative Planning Cultures*. Routledge.

Friend, R. M., Anwar, N. H., Dixit, A., Hutanuwatr, K., Jayaraman, T., McGregor, J. A., Menon, M. R., Moench, M., Pelling, M., & Roberts, D. (2016). Re-imagining Inclusive Urban Futures for Transformation. *Current Opinion in Environmental Sustainability, 20*, 67–72.

Frisken, F. (1991). The Contributions of Metropolitan Government to the Success of Toronto's Public Transit System: An Empirical Dissent from the Public-Choice Paradigm. *Urban Affairs Quarterly, 27*(2), 268–292.

Füg, F., & Ibert, O. (2020). Assembling social innovations in emergent professional communities. The case of learning region policies in Germany. *European Planning Studies, 28*(3), 541–562.

Fürst, D. (2007). Planungskultur. Auf dem Weg zu einem besseren Verständnis von Planungsprozessen? *PNDonline*, III/2017.

Gavanas, N. (2019). Autonomous Road Vehicles: Challenges for Urban Planning in European Cities. *Urban Science, 3*(2), 61.

Geels, F. W. (2002). Technological transitions as evolutionary reconfiguration processes: A multi-level perspective and a case-study. *Research Policy, 31*(8), 1257–1274.

Geels, F. W., & Schot, J. (2007). Typology of sociotechnical transition pathways. *Research Policy, 36*(3), 399–417.

Getimis, P. (2012). Comparing Spatial Planning Systems and Planning Cultures in Europe. The Need for a Multi-scalar Approach. *Planning Practice & Research, 27*(1), 25-40.

Getimis, P., Reimer, M., & Blotevogel, H. (2014). Conclusion: Multiple Trends of Continuity and Change. In M. Reimer, P. Getimis, & Blotevogel, H. H. (Eds.), *Spatial Planning Systems and Practices in Europe A Comparative Perspective on Continuity and Changes*. Routledge.

Geurs, K., Münzel, K., Duran, D., Gkavra, R., Graf, A., Grigolon, A., Hansel, J., Kirchberger, C., Klementschitz, R., Martinez Ramirez, L., & Pappers, J. (2022). *A multidimensional mobility hub typology and inventory. SmartHubs Deliverable D 2.1.* https://www.smartmobilityhubs.eu/_files/ugd/c54b12_819c85702a6442c6bebb18538fb93516.pdf

Ghielmetti, M., Steiner, R., Leitner, J., Hackenfort, M., Diener, S., & Topp, H. (2017). Flächiges Queren in Ortszentren—Langfristige Wirkung und Zweckmässigkeit. http://www.mobilityplatform.ch/de/shop/show-item/product/24100/?q=fl%C3%A4chiges%20queren&tx_solr%5Bfilter%5D%5B0%5D=facet_212_stringM%253AAktiv&tx_solr%5Bpage%5D=0&cHash=6b09fe1968d32b1011e3865d5564cc4a

Gillwald, K. (2000). Konzepte sozialer Innovation. Wissenschaftszentrum Berlin für Sozialforschung.

Gläser, J., & Laudel, G. (2009). *Experteninterviews und qualitative Inhaltsanalyse als Instrumente rekonstruierender Untersuchungen*. VS Verlag für Sozialwissenschaften.

Godin, B. (2010). Innovation Without the Word: William F. Ogburn's Contribution to the Study of Technological Innovation. *Minerva, 48*(3), 277–307.

González, S., & Healey, P. (2005). A Sociological Institutionalist Approach to the Study of Innovation in Governance Capacity. *Urban Studies, 42*(11), 2055–2069.

González-González, E., Nogués, S., & Stead, D. (2019). Automated vehicles and the city of tomorrow: A backcasting approach. *Cities, 94*, 153–160.

González-González, E., Nogués, S., & Stead, D. (2020). Parking futures: Preparing European cities for the advent of automated vehicles. *Land Use Policy, 91*, 104010.

Good Roads. (n.d.). *MACAVO. Technical Solutions.* Good Roads. https://goodroads.ca/technical-solutions/macavo/

Goracinova, E., Huh, L., & Wolfe, D. A. (2021). *Integrated Mobility and the Governance of Urban Transit – Innovation Policy Lab*. Munk School of Global Affairs & Public Policy, University of Toronto. https://uttri.utoronto.ca/files/2022/01/Goracinova-et-al_IntegratedMobilityUrbanTransit_KnowledgeSynthesis_Dec21.pdf

Graham, S., & Marvin, S. (1996). *Telecommunications and the City: Electronic Spaces, Urban Places*. Routledge.

Guerra, E. (2016). Planning for Cars That Drive Themselves: Metropolitan Planning Organizations, Regional Transportation Plans, and Autonomous Vehicles. *Journal of Planning Education and Research, 36*(2), 210–224.

Guerra, E., & Morris, E. A. (2018). Cities, Automation, and the Self-parking Elephant in the Room. *Planning Theory & Practice, 19*(2), 291–297.

Hacker, J. S. (2005). Policy Drift: The Hidden Politics of US Welfare State Retrenchment. In W. Streeck & K. Thelen (Eds.), *Beyond Continuity: Institutional Change in Advanced Political Economies* (pp. 1–39). Oxford University Press.

Hagenzieker, M. P., Boersma, A. M., Nuñez Velasco, J. P., Ozturker, M., Zubin, I., & Heikoop, D. D. (2021). *Automated buses in Europe: An inventory of pilots.* https://repository.tudelft.nl/islandora/object/uuid%3A2665ce22-5e9c-4875-ac2c-faab9287328f

Hajer, M. (2003). Policy without polity? Policy analysis and the institutional void. *Policy Sciences, 36*(2), 175-195.

Hajer, M., & Dassen, T. (2014). *Smart about Cities: Visualising the Challenge for 21st Century Urbanis*m. nai010

Hall, P. (1997). *Cities of Tomorrow: An intellectual history of urban planning and design in the twentieth century*. Wiley.

Hall, T. (2014). *Planning Europe's Capital Cities: Aspects of Nineteenth-Century Urban Development*. E & FN Spon.

Hamilton, C. of. (2021, November 22). *Hamilton City Council votes against urban boundary expansion*. https://www.hamilton.ca/government-information/news-centre/news-releases/hamilton-city-council-votes-against-urban-boundary

Harchard, T. (2020). *It Takes Three: Making Space for Cities in Canadian Federalism (IMFG Perspectives Nr. 31)*. University of Toronto, Institute on Municipal Finance and Governance. https://tspace.library.utoronto.ca/bitstream/1807/103012/3/IMFG_%20No.31%20Perspectives_Hachard_Nov2020.pdf

Harris, M. A., & Branion-Calles, M. (2021). *Changes in Commute Mode Attributed to COVID-19 Risk in Canadian National Survey Data*. Findings, February.

Healey, P. (2006). Relational complexity and the imaginative power of strategic spatial planning. *European Planning Studies, 14(4)*, 525–546.

Healey, P. (2007). *Urban Complexity and Spatial Strategies: Towards a Relational Planning for Our Times*. Routledge.

Healey, P. (2013). Circuits of Knowledge and Techniques: The Transnational Flow of Planning Ideas and Practices. *International Journal of Urban and Regional Research, 37*(5), 1510-1526.

Healey, P., & Williams, R. (1993). *European Urban Planning Systems: Diversity and Convergence*. Urban Studies, 30(4–5), 701-720.

Heinrichs, D., Rupprecht, S., & Smith, S. (2019). Making Automation Work for Cities: Impacts and Policy Responses. In G. Meyer & S. Beiker (Eds.), *Road Vehicle Automation 5* (pp. 243–252). Springer International Publishing.

Hess, P. M. (2009). Avenues or Arterials: The Struggle to Change Street Building Practices in Toronto, Canada. *Journal of Urban Design, 14*(1), 1–28.

Hess, P. M., & Sorensen, A. (2015). Compact, concurrent, and contiguous: Smart growth and 50 years of residential planning in the Toronto region. *Urban Geography, 36*(1), 127–151.

Heyen, D. A., Brohmann, B., Libbe, J., Riechel, R., & Trapp, J. H. (2018). *Stand der Transformationsforschung unter besonderer Berücksichtigung der kommunalen Ebene*. Deutsches Institut für Urbanistik (Difu) und Öko-Institut.

Higgins, C., Farber, S., Shalaby, A., Habib, K. N., Miller, E., Brail, S., Widener, M., Diamond, S., & Páez, A. (2021). *An Integrated Approach to Transit System Evolution*. University of Toronto Transportation Research Institute. https://uttri.utoronto.ca/files/2022/01/An-Integrated-Approach-to-Transit-System-Evolution.pdf

Hillier, J. (2017). Strategic spatial planning in uncertainty or planning indeterminate futures? A critical review. In L. Albrechts, A. Balducci, & J. Hillier (Eds.), *Situated Practices of Strategic Planning*. Routledge.

Hodson, M., Evans, J., & Schliwa, G. (2018). Putting Urban Experiments into Context: Integrating urban living labs and city-regional priorities. In M. Simon, H. Bulkeley, L. Mai, Kes McCormick, & Y. Voytenko (Eds.) *Urban Living Labs*. Routledge.

Holz-Rau, C., Wachter, I., Feiertag, P., Randelhoff, M., Scheiner, J., Wächter, L., & Zimmermann, K. (2022). MOBILITÄTSWENDE – WIDER DEN LÄHMENDEN OPTIMISMUS. *Nachrichten der ARL,* 1/2022, 16–21.

Hopkins, D., & Schwanen, T. (2018). Automated Mobility Transitions: Governing Processes in the UK. Sustainability, 10(4), 956.

Horak, M. (2021). Building rapid transit in Canada: The problem of governance. *Anuario de Derecho Municipal*, 14, 243–258.

Hörl, S., Becker, F., Dubernet, T., & Axhausen, K. W. (2019). *Induzierter Verkehr durch autonome Fahrzeuge: Eine Abschätzung*. Institut für Verkehrsplanung und Transportsysteme, ETH Zürich. https://ethz.ch/content/dam/ethz/special-interest/baug/ivt/ivt-dam/vpl/reports/1401-1500/ab1433.pdf

Howell, A., & Tan, H. (2020). Chapter 2. Forces of change, assumptions, first order impacts and implications. In A. Howell & K. Lewis Chamberlain (Eds.), *Multilevel Impacts of Emerging Technologies on City Form and Development (pp. 17–71)*. University of Oregon.

Hughes, S., Yordi, S., & Besco, L. (2020). The Role of Pilot Projects in Urban Climate Change Policy Innovation. *Policy Studies Journal, 48*(2), 271–297.

Hulgård, L. (2010). Social entrepreneurship. In K. Hart, J.-L. Laville, & A. D. Cattani (Eds.), *The Human Economy* (pp. 293–300). Polity Press.

Hutter, G., & Wiechmann, T. (2022). Time, Temporality, and Planning – Comments on the State of Art in Strategic Spatial Planning Research. *Planning Theory & Practice, 23*(1), 157–164.

Huxley, M. (2002). Governmentality, Gender, Planning. A Foucauldian Perspective. In P. Allmendinger & M. Tewdwr-Jones (Eds.), *Planning Future: New Directions for Planning Theory* (pp. 136–153). Routledge.

Ibert, O. (2003). *Innovationsorientierte Planung: Verfahren und Strategien zur Organisation von Innovation*. VS Verlag für Sozialwissenschaften.

Ibert, O., Baumgart, S., Siedentop, S., & Weith, T. (2022). Planning in the Face of Extraordinary Uncertainty: Lessons from the COVID-19 Pandemic. *Planning Practice & Research, 37*(1), 1–12.

Ibert, O., Christmann, G., Jessen, J., & Walther, U.-J. (2015). Innovationen in der Räumlichen Planung. In BBSR (Eds.), *Innovationen in der räumlichen Planung* (pp. 171–182).

Ibert, O., & Müller, F. C. (2015). Network dynamics in constellations of cultural differences: Relational distance in innovation processes in legal services and biotechnology. *Research Policy, 44*(1), 181–194.

IMFG – Institute on Municipal Finance and Governance (2019). *Expert Advisory Panel on the Transit Responsibilities Review: Summary Report*. Munk School of Global Affairs & Public Policy, University of Toronto. https://www.toronto.ca/legdocs/mmis/2019/ex/bgrd/backgroundfile-138952.pdf

Irwin, N., & Bevan, A. (2010). *Time to get serious: Reliable funding for GTHA Transit / Transportation Infrastructure.* Transportation and Other Infrastructure Working Group Discussion Paper. Toronto City Summit Alliance. https://institute.smartprosperity.ca/sites/default/files/publications/files/Reliable%20funding%20for%20GTHA%20TransitTransportation%20Infrastructure.pdf

ITF – International Transport Forum. (2018). *The Shared-Use City: Managing the Curb*. International Transport Forum -OECD. https://www.itf-oecd.org/sites/default/files/docs/shared-use-city-managing-curb_3.pdf

Jack, S. L., & Anderson, A. R. (2002). The effects of embeddedness on the entrepreneurial process. *Journal of Business Venturing, 17*(5), 467–487.

Jackson, G. (2005). Contested Boundaries: Ambiguity and Creativity in the Evolution of German Codetermination. In W. Streeck & K. Thelen (Eds.), *Beyond Continuity: Institutional Change in Advanced Political Economies* (pp. 1–39). Oxford University Press.

Jahn, T., & Keil, F. (2016). Reallabore im Kontext transdisziplinärer Forschung. *GAIA, 25*(4), 247–252.

Jessen, J., Meyer, U. M., & Schneider, J. (2008). *Stadtmachen.eu Urbanität und Planungskultur in Europa ; Barcelona, Amsterdam, Almere, Manchester, Kopenhagen, Leipzig, Sarajevo, Zürich*. Karl Krämer Verlag.

Jessen, J., & Walther, U.-J. (2010). Innovation in der Stadtplanung? In A. Harth & G. Scheller (Eds.), *Soziologie in der Stadt- und Freiraumplanung: Analysen, Bedeutung und Perspektiven* (pp. 283–295). VS Verlag für Sozialwissenschaften.

Jin, S. T., Kong, H., Wu, R., & Sui, D. Z. (2018). Ridesourcing, the sharing economy, and the future of cities. *Cities, 76*, 96–104.

Jürgens, L. (2020). Konnektivitätsveränderungen im ÖPNV-Netz durch die Einführung eines autonomen Shuttlebusses. In A. Riener, A. Appel, W. Dorner, T. Huber, J. C. Kolb, & H. Wagner (Eds.), *Autonome Shuttlebusse im ÖPNV: Analysen und Bewertungen zum Fallbeispiel Bad Birnbach aus technischer, gesellschaftlicher und planerischer Sicht* (pp. 39–54). Springer Berlin Heidelberg.

Kamleithner, C. (2020). *Ströme und Zonen. Eine Genealogie der »funktionalen Stadt«*. Birkhäuser.

Kaplowitz, G., Coia, J., & Yang, H. (2021). *Perfecting Policy with Pilots. All Pilots Spreadsheet*. University of Oregon. https://www.urbanismnext.org/resources/perfecting-policy-with-pilots-all-pilots-spreadsheet-uo-2020

Karndacharuk, A., Wilson, D. J., & Dunn, R. (2014). A Review of the Evolution of Shared (Street) Space Concepts in Urban Environments. *Transport Reviews, 34*(2), 190-220.

Keil, R. (2017). Toronto Alles Uber: Being Progressive in the Age of Progressive Conservative Urbanism. *Alternate Routes: A Journal of Critical Social Research, 28*. https://www.alternateroutes.ca/index.php/ar/article/view/22423

Kim, C. (2019). *The Way to GO. Advancing transit-supportive development in the Greater Toronto and Hamilton Area*. PEMBINA Institute. https://www.pembina.org/pub/way-go

Kimber, S., Siegel, L., Cohen, S., & Thomopoulos, N. (2020). Chapter Five—The wider use of autonomous vehicles in non-commuting journeys. In D. Milakis, N. Thomopoulos, & B. van Wee (Eds.), *Advances in Transport Policy and Planning* (pp. 125–148). Academic Press.

Knieling, J., & Othengrafen, F. (2009). En Route to a Theoretical Model for Comparative Research. In F. Othengrafen, & J. Knieling (Eds.), *Planning Cultures in Europe*. Routledge.

Kondor, D., Santi, P., Le, D.-T., Zhang, X., Millard-Ball, A., & Ratti, C. (2020). Addressing the „minimum parking“ problem for on-demand mobility. arXiv:1808.05935. http://arxiv.org/abs/1808.05935

Kramer, A. (2019). Inside and Outside: A Meditation on the Yellowbelt. In A. Bozikovic, C. Case, J. Lorinc, & A. Vaughan (Eds.), *House Divided: How the Missing Middle Will Solve Toronto's Affordability Crisis* (pp. 142–153). Coach House Books.

Krasner, S. D. (1988). Sovereignty: An Institutional Perspective. *Comparative Political Studies, 21*(1), 66–94.

Krawchenko, T. (2011). Regional special purpose bodies for transportation and transit in Canada: Case studies of Translink and Metrolinx. *Canadian Journal of Regional Science / Revue Canadienne Des Sciences Régionales, 34*(1), 1–8.

Kuperman, D. (2018, September 28). *King Street Transit Pilot and other Strategies to improve Surface Transit Performance in the City of Toronto*. University of Toronto Institute of Transportation Engineers Student Chapter. https://uttri.utoronto.ca/news/overview-of-the-king-street-transit-pilot/

Laidlaw, K., Sweet, M., & Olsen, T. (2018). *Forecasting the Outlook for Automated Vehicles in the Greater Toronto and Hamilton Area using a 2016 Consumer Survey*. Ryerson University School of Urban and Regional Planning. https://transformlab.torontomu.ca/wp-content/uploads/2018/03/Laidlaw_Sweet_Olsen_Report3_scenarios_20180309.pdf

Lanyon, R., Khan, F., & Deivendran, S. (2017, October 30 – November 2). *Preparing for Automated Vehicles: Working Across Silos at the City of Toronto* [Conference presentation]. NACTO Designing Cities, Chicago, IL, United States. https://nacto.org/wp-content/uploads/2017/09/Preparing-for-Automated-Vehicles-Working-Across-Silos-at-the-City-of-Toronto.pdf

Larco, N., & Tierney, G. (2020). Chapter 5. Impacts on Urban Design. In A. Howell & K. Lewis Chamberlain (Eds.), *Multilevel Impacts of Emerging Technologies on City Form and Development* (pp. 115–141). University of Oregon.

Lee, J. (2020). *Sharing the Curbside. Advancing curbside management in the City of Toronto*. The Pembina Institute. https://www.pembina.org/reports/sharing-the-curbside-final.pdf

Lee, J., & Kim, C. (2020). *Transit Supportive Development Along Bus Corridors: Opportunities for the Greater Toronto and Hamilton Area*. PEMBINA Institute. https://www.pembina.org/reports/transit-supportive-development-along-bus-corridors.pdf

Legacy, C., Ashmore, D., Scheurer, J., Stone, J., & Curtis, C. (2019). Planning the driverless city. *Transport Reviews, 39*(1), 84–102.

Lelong, B. (2014). Grasping micro-macro-interactions in urban development politics: A multidimensional network approach to collective action. *Historical Social Research, 39*(2), 203–234.

Lenz, B., & Fraedrich, E. (2016). New Mobility Concepts and Autonomous Driving: The Potential for Change. In M. Maurer, J. C. Gerdes, B. Lenz, & H. Winner (Eds.), *Autonomous Driving: Technical, Legal and Social Aspects* (pp. 173–191). Springer.

Levin-Keitel, M., & Othengrafen, F. (2016). Planungskultur – auf der Suche nach einem kontemporären Verständnis räumlicher Planung? *disP - The Planning Review, 52*(4), 76-89.

Lewis, R., & Anderson, M. (2020). Impacts on Land Use. In A. Howell & K. Lewis Chamberlain (Eds.), *Multilevel Impacts of Emerging Technologies on City Form and Development* (pp. 97–113). University of Oregon.

Lissandrello, E., & Grin, J. (2011). Reflexive Planning as Design and Work: Lessons from the Port of Amsterdam. *Planning Theory & Practice, 12*(2), 223-248.

Litman, T. (2021). *Autonomous Vehicle Implementation Predictions Implications for Transport Planning*. Victoria Transport Policy Institute.

Litman, T. (2022). *Implications for Transport Planning*. Victoria Transport Policy Institute.

Loa, P., Hawkins, J., & Nurul Habib, K. (2019). *Vehicle for Hire Bylaw Review. Report 4: Evaluating the Impacts of Private Transportation Companies on Travel Behaviour through a Stated Preference (SP) Survey*. University of Toronto. https://uttri.utoronto.ca/files/2020/04/UTTRI-Report-Vehicle-for-Hire-4-Loa.pdf

Lorinc, J. (2022, June 1). *LORINC: Highway 413 and Doug Ford's tactical whataboutism*. Spacing Toronto. http://spacing.ca/toronto/2022/06/01/lorinc-highway-413-and-doug-fords-tactical-whataboutism/

Lyons, G. (2018). Getting smart about urban mobility – Aligning the paradigms of smart and sustainable. *Transportation Research Part A: Policy and Practice, 115*, 4–14.

Machler, L., & Milz, D. (2015). *Innes—The Evolution of Communicative Planning Theory*. AESOP.

Madadi, B., van Nes, R., Snelder, M., & van Arem, B. (2021). Multi-stage optimal design of road networks for automated vehicles with elastic multi-class demand. *Computers & Operations Research, 136*, 105483.

Mahoney, J. (2000). Path Dependence in Historical Sociology. Theory and Society, 29(4), 507–548.

Mahood, Q., Van Eerd, D., & Irvin, E. (2013). Searching for grey literature for systematic reviews: Challenges and benefits. *Research Synthesis Methods, 5*(3), 221–234.

Malatest & Associates. (2018). *Transportation Tomorrow Survey 2016. City of Toronto. Summary By Ward.* Prepared for the Transportation Information Steering Committee. http://dmg.utoronto.ca/pdf/tts/2016/2016TTS_Summaries_Toronto_Wards.pdf

Manderscheid, K., & Cass, N. (2022). A socio-ecologically sustainable mobility regime: Can we move beyond the car? Editorial for the special issue "Shapes of socio-ecologically sustainable mobility regimes". *Applied Mobilities, 0*(0), 1–14.

Markoff, J. (2010, October 9). *Google Cars Drive Themselves, in Traffic*. The New York Times. https://www.nytimes.com/2010/10/10/science/10google.html

Marsden, G., & Docherty, I. (2013). Insights on disruptions as opportunities for transport policy change. *Transportation Research Part A: Policy and Practice, 51*, 46–55.

Marsden, G., Docherty, I., & Dowling, R. (2020). Parking futures: Curbside management in the era of 'new mobility' services in British and Australian cities. *Land Use Policy, 91*, 104012.

Martijnse-Hartikka, R. (2020). *Ambitious goals for robot bus piloting in the FABULOS project*. Forum Virium Helsinki. https://forumvirium.fi/en/ambitious-goals-for-robot-bus-piloting-in-the-fabulos-project/

Martinez, L. M., & Viegas, J. M. (2017). Assessing the impacts of deploying a shared self-driving urban mobility system: An agent-based model applied to the city of Lisbon, Portugal. *International Journal of Transportation Science and Technology, 6*(1), 13-27.

Martínez-Díaz, M., & Soriguera, F. (2018). Autonomous vehicles: Theoretical and practical challenges. *Transportation Research Procedia, 33*, 275–282.

Mazzucato, M. (2021). *Mission Economy. A Moonshot Guide to Changing Capitalism*. Penguin Random House UK.

McAslan, D., Gabriele, M., & Miller, T. R. (2021). Planning and Policy Directions for Autonomous Vehicles in Metropolitan Planning Organizations (MPOs) in the United States. *Journal of Urban Technology, 28*(3–4), 175–201.

McCann, E., & Ward, K. (2012). Assembling Urbanism: Following Policies and 'Studying Through' the Sites and Situations of Policy Making. *Environment and Planning A: Economy and Space, 44*(1), 42–51.

Merriam, S. B., & Tisdell, E. J. (2015). Qualitative Research: A Guide to Design and Implementation. Jossey-Bass.

Metrolinx. (2008). *The Big Move. Transforming Transportation in the Greater Toronto and Hamilton Area.* https://www.metrolinx.com/thebigmove/Docs/big_move/TheBigMove_020109.pdf

Metrolinx. (2013). *The Big Move Baseline Monitoring Report.* https://www.metrolinx.com/en/regionalplanning/bigmove/The_Big_Move_Baseline_Monitoring_Full_Report_EN.pdf

Metrolinx. (2016). *Discussion Paper for the Next Regional Transportation Plan. Greater Toronto and Hamilton Area.* https://assets.metrolinx.com/image/upload/v1663240135/Documents/Metrolinx/RTP_Discussion_Paper_EN.pdf

Metrolinx. (2018). *2041 Regional Transportation Plan. For the Greater Toronto and Hamilton Area.* http://www.metrolinx.com/en/regionalplanning/rtp/Metrolinx%20-%202041%20Regional%20Transportation%20Plan%20%E2%80%93%20Final.pdf

Metrolinx. (2021). O*n-Demand Mircotransit Considerations and Observations.* Ontario Smart Mobility Readiness Forum. https://www.ovinhub.ca/wp-content/uploads/2021/07/1-On-Demand-and-Microtransit-ODMT-%E2%80%93-Metrolinx.pdf

Metrolinx. (n.d.). *Development of the Draft 2041 Regional Transportation Plan: GTHA Regional Traveller Personas and the Residents' Reference Panel*. Metrolinx. https://www.tac-atc.ca/sites/default/files/conf_papers/development_of_the_draft_2041_regional_transportation_plan_gtha_regional_traveller_personas_and_the_residents_reference_panel.pdf

Milakis, D., Arem, B. van, & Wee, B. van. (2017). Policy and society related implications of automated driving: A review of literature and directions for future research. Journal of Intelligent Transportation Systems, 21(4), 324-348.

Miller, E., & Soberman, R. (2003). *Travel Demand and Urban Form*. Neptis Foundation. https://neptis.org/publications/travel-demand-and-urban-form

Mississauga. (2019, June). *Transportation Network Companies Pilot*. City of Mississauga. https://www.mississauga.ca/projects-and-strategies/city-projects/transportation-network-companies-pilot/

Mitteregger, M., & Soteropoulos, A. (2021). Chancen vergangener Fehler: Flächenpotentiale am Weg zu einem automatisierten Mobilitätssystem. In M. Mitteregger, E. M. Bruck, A. Soteropoulos, A. Stickler, M. Berger, J. S. Dangschat, R. Scheuvens, & I. Banerjee (Eds.), *AVENUE21. Politische und planerische Aspekte der automatisierten Mobilität* (pp. 315–338).

Mitteregger, M., Bruck, E. M., Soteropoulos, A., Stickler, A., Berger, M., Dangschat, J. S., Scheuvens, R., & Banerjee, I. (2022). *AVENUE21. Connected and Automated Driving: Prospects for Urban Europe*. Springer.

Moffatt, M., Coutinho, A., & McNally, J. (2021). *Made in Ontario: A Provincial Manufacturing Strategy*. Smart Prosperity Institute, University of Ottawa. https://on360.ca/policy-papers/made-in-ontario-a-provincial-manufacturing-strategy/

Mohr, L. B. (1969). Determinants of Innovation in Organizations*. *American Political Science Review, 63*(1), 111 – 126.

Moulaert, F., Martinelli, F., González, S., & Swyngedouw, E. (2007). Introduction: Social Innovation and Governance in European Cities: Urban Development Between Path Dependency and Radical Innovation. *European Urban and Regional Studies, 14*(3), 195–209.

Munro, S. (2021, Oktober 6). *RapidTO: Real Transit Improvement, Or Smoke and Mirrors?* Steve Munro. https://stevemunro.ca/2021/10/06/rapidto-real-transit-improvement-or-smoke-and-mirrors/

Munro, S. (2022, Mai 21). *Evolution of Travel Times on RapidTO Bus Routes 2020-2022 (Part 1).* Steve Munro. https://stevemunro.ca/2022/05/21/evolution-of-travel-times-on-rapidto-bus-routes-2020-2022-part-1/

NACTO. (2019a). Blueprint for Autonomous Urbanism: Second Edition. https://nacto.org/publication/bau2/

NACTO. (2019b). *NACTO designing cities 2019*. Toronto, Canada. https://nacto.org/wp-content/uploads/2019/09/2019_Program_Book_REVISED.pdf

Narayanan, S., Chaniotakis, E., & Antoniou, C. (2020). Chapter One - Factors affecting traffic flow efficiency implications of connected and autonomous vehicles: A review and policy recommendations. In D. Milakis, N. Thomopoulos, & B. van Wee (Eds.), *Advances in Transport Policy and Planning* (pp. 1–50). Academic Press.

Neptis Foundation. (2014). *Governance: The third rail that powers integrated regional transit*. Neptis Foundation. https://neptis.org/publications/governance-third-rail-powers-integrated-regional-transit

Nesheli, M. M., Li, L., Palm, M., & Shalaby, A. (2021). Driverless shuttle pilots: Lessons for automated transit technology deployment. *Case Studies on Transport Policy, 9*(2), 723–742.

NLC – National League of Cities. (n.d.). *Autonomous Vehicles: Future Scenarios*. http://avfutures.nlc.org/

Nordhoff, S., de Winter, J., Payre, W., van Arem, B., & Happee, R. (2019). What impressions do users have after a ride in an automated shuttle? An interview study. *Transportation Research Part F: Traffic Psychology and Behaviour*, 63, 252–269.

OAGO – Office of the Auditor General of Ontario. (2021). *Value-for-Money Audit: Land-Use Planning in the Greater Golden Horseshoe*. https://www.auditor.on.ca/en/content/annualreports/arreports/en21/AR_LandUse_en21.pdf

OECD. (2010). *OECD Territorial Reviews: Toronto, Canada 2009*. Organisation for Economic Co-operation and Development. https://www.oecd-ilibrary.org/urban-rural-and-regional-development/oecd-territorial-reviews-toronto-canada-2009_9789264079410-en

OGRA – Ontario Good Roads Association. (2019, March 5). *Ontario Municipalities Create World's Longest, Preferred Corridor for Testing of Autonomous Vehicles (AVs) and Related Technologies between Windsor and Ottawa*. https://www.transnomis.com/wp-content/uploads/2019/03/2019-03-13_OGRAHeadsUpAlert-Ontario-Municipalities-Create-World%E2%80%99s-Longest-Preferred-Corridor-for-Testing-of-Autonomous-Vehicles-AVs-and-Related-Technologies.pdf

Olsen, T., Laidlaw, K., & Sweet, M. (2018). *Automated Vehicles in the Greater Toronto and Hamilton Area: Overview from a 2016 Consumer Survey Part A: Summary and Discussion*. Ryerson University School of Urban and Regional Planning. https://transformlab.torontomu.ca/wp-content/uploads/2018/03/Olsen_Laidlaw_Sweet_Report1_PartA_summary_20180309.pdf

Online Etymology Dictionary. (n.d.). Origin and meaning of transform. In Online Etymology Dictionary. Retrieved March 24, 2023, from https://www.etymonline.com/word/transform

Ontario (2006). Metrolinx Act, 2006, S.O. 2006, CHAPTER 16.

Ontario (2014). *Archived - 2014 Mandate letter: Transportation.* Government of Ontario. http://www.ontario.ca/page/2014-mandate-letter-transportation

Ontario (2019). *A Place to Grow. Growth Plan for the Greater Golden Horseshoe.* Office Consolidation, August 2020.

Ontario (2020a). *CAV Readiness Plan. Final Report*. Government of Ontario, Ministry of Transportation. https://www.ovinhub.ca/wp-content/uploads/2020/05/CAV-Readiness-Plan-Final-Report-2020-04-03-1.pdf

Ontario (2020b, August 18). *Ontario Drives Innovation in the Automotive Sector.* https://news.ontario.ca/en/release/58024/ontario-drives-innovation-in-the-automotive-sector

Ontario (2020c). *Provincial Policy Statement*. https://www.ontario.ca/page/provincial-policy-statement-2020

Ontario (2021a). *Proposed Amendments to Ontario Regulation 306/15: Pilot Project—Automated Vehicles and Revised Regulations of Ontario 1990, Regulation 628: Vehicle Permits – Summary*. https://www.ontariocanada.com/registry/showAttachment.do?postingId=39087&attachmentId=50976

Ontario (2021b). *Ontario Cooperative Truck Platooning Pilot Program Conditions*. http://www.mto.gov.on.ca/english/trucks/cooperative-truck-platooning-conditions.shtml

Ontario (2021c). *Ontario population projections*. Government of Ontario, Ministry of Finance. http://www.ontario.ca/page/ontario-population-projections

Ontario (2022). *Connecting the GGH: A Transportation Plan for the Greater Golden Horseshoe*. Government of Ontario, Ministry of Transportation.

Open Knowledge Foundation. (n.d.). *The Open Definition*. http://opendefinition.org/

opensource. (n.d.). *What is open source?* https://opensource.com/resources/what-open-source

Othengrafen, F. (2010). Spatial Planning as Expression of Culturised Planning Practices: The Examples of Helsinki, Finland and Athens, Greece. *The Town Planning Review, 81*(1), 83-110.

Othengrafen, F., & Reimer, M. (2013). The Embeddedness of Planning in Cultural Contexts: Theoretical Foundations for the Analysis of Dynamic Planning Cultures. *Environment and Planning A: Economy and Space, 45*(6), 1269-1284.

OVIN – Ontario Vehicle Innovation Network. (2021). *Toward a Green Mobility Future: Drivers for Growth and Ontario's Strengths*. OVIN Insights Specialized Series December 2021. https://www.oc-innovation.ca/wp-content/uploads/2021/12/OVIN_Quarterly-Specialized-Report_December-2021.pdf

OVIN – Ontario Vehicle Innovation Network. (n.d.). *Smart Mobility Readiness Forum*. OVIN - Ontario Vehicle Innovation Network. https://www.ovinhub.ca/ontario-smart-mobility-readiness-forum/

Owen, G. (2014). Qualitative Methods in Higher Education Policy Analysis: Using Interviews and Document Analysis. The Qualitative Report, 19(26), 1–19. https://doi.org/10.46743/2160-3715/2014.1211

Paez, A. (2017). Gray literature: An important resource in systematic reviews. *Journal of Evidence-Based Medicine, 10*(3), 233–240.

Panetta, K. (2017, August 15). *Top Trends In The Gartner Hype Cycle For Emerging Technologies 2017*. Gartner. https://www.gartner.com/smarterwithgartner/top-trends-in-the-gartner-hype-cycle-for-emerging-technologies-2017

Panetta, K. (2019, August 29). *5 Trends Appear On The Gartner Hype Cycle For Emerging Technologies 2019*. Gartner. https://www.gartner.com/smarterwithgartner/5-trends-appear-on-the-gartner-hype-cycle-for-emerging-technologies-2019

Papa, E., & Ferreira, A. (2018). Sustainable Accessibility and the Implementation of Automated Vehicles: Identifying Critical Decisions. Urban Science, 2(1), 5.

Peattie, L. (1983). Realistic planning and qualitative research. *Habitat International, 7*(5), 227–234.

Peck, J., & Theodore, N. (2010). Mobilizing policy: Models, methods, and mutations. *Geoforum, 41*(2), 169–174.

Perkins, L., Dupuis, Ni., & Rainwater, B. (2018). *Autonomous Vehicle Pilots Across America* [Municipal Action Guide]. NLC - National League of Cities.

Pflieger, G., Kaufmann, V., Pattaroni, L., & Jemelin, C. (2009). How Does Urban Public Transport Change Cities? Correlations between Past and Present Transport and Urban Planning Policies. *Urban Studies, 46*(7), 1421–1437.

Portland. (2018). *Portland 2035. Transportation System Plan* (Ordinance No: 187832, 188177, 188957). City of Portland. https://www.portland.gov/sites/default/files/2019-08/tsp-full-draft-v18.12.10_sm.pdf

Powell, W. W. (1990). Neither market nor hierarchy: Network forms of organization. In B. M. Staw, & L. L. Cummints (Eds.), *Research in Organizational Behavior: An Annual Series of Analytical Essays and Critical reviews* (pp. 295–336). JAI Press.

Prior, L. (2003). *Using Documents in Social Research*. SAGE Publications.

Rammert, W. (1999). *Technik. Stichwort für eine Enzyklopädie*. (TUTS - Working Papers, 1-1999). Berlin: Technische
Universität Berlin, Fak. VI Planen, Bauen, Umwelt, Institut für Soziologie Fachgebiet Techniksoziologie. https://nbn-resolving.org/urn:nbn:de:0168-ssoar-8811

Rauws, W. (2017). Embracing Uncertainty Without Abandoning Planning: Exploring an Adaptive Planning Approach for Guiding Urban Transformations. *DisP - The Planning Review, 53*(1), 32-45.

Rauws, W. S., Cook, M., & Van Dijk, T. (2014). How to Make Development Plans Suitable for Volatile Contexts. *Planning Practice & Research, 29*(2), 133–151.

Region of Peel. (2019). *Let's Move Peel. Long Range Transportation Plan 2019.* Region of Peel. https://www.peelregion.ca/transportation/projects/media/pdf/long-range-transportation-plan-full-report-2019.pdf

Reimer, M., & Blotevogel, H. H. (2012). Comparing Spatial Planning Practice in Europe: A Plea for Cultural Sensitization. *Planning Practice & Research, 27*(1), 7-24.

Reimer, M., Getimis, P., & Blotevogel, H. H. (2014). Spatial planning systems and practices in Europe: A comparative perspective. In M. Reimer, P. Getimis, & Blotevogel, H. H. (Eds.), *Spatial Planning Systems and Practices in Europe: A Comparative Perspective on Continuity and Changes*. Routledge.

Rivolin, U. J. (2012). Planning Systems as Institutional Technologies: A Proposed Conceptualization and the Implications for Comparison. *Planning Practice & Research, 27*(1), 63-85.

Robertson, A., Kogan, D., & Sweet, M. (2022). *Consumer Interest and Policy Implications of Highly Automated Vehicles in the Greater Toronto and Hamilton Area: 2016-2021*. School of Urban and Regional Planning, Toronto Metropolitan University. https://transformlab.torontomu.ca/portfolio-item/policyautomatedvehiclesgtha/

Ronald, N., Thompson, R. G., & Winter, S. (2016). Comparison of Constrained and Ad Hoc Demand-Responsive Transportation Systems. *Transportation Research Record, 2563*(1), 44–51.

Roos, D. (1971). *Summary Report: The Dial-A-Ride Transportation System*. MIT Urban Systems Laboratory.

Roos, D., & Alschuler, D. (1975). Paratransit—Existing issues and future directions. *Transportation, 4*(4), 335–350.

Rye, T., Tully, S., Godin, G., Schmalholz, N., & Hertel, M. (2022). *Parking and SUMP. Using parking management to achieve your SUMP objectives effectively and sustainably*. European Platform on Sustainable

Urban Mobility Plans. https://park4sump.eu/sites/default/files/2022-10/SUMP2.0%20Topic%20Guide%20on%20Parking%20management%20and%20SUMP_EN.pdf
SAE International. (2018, June 15). *Taxonomy and Definitions for Terms Related to Driving Automation Systems for On-Road Motor Vehicles – J3016_201806*. SAE Standards. https://www.sae.org/standards/content/j3016_201806/
Sam Schwartz. (2017). *New Mobility Playbook 1. Appendix B. Technical Report*. Prepared for Seattle Department of Transportation King County Metro. https://www.seattle.gov/Documents/Departments/SDOT/NewMobilityProgram/AppendixB.pdf
Sanderson, N. (2019, Juni 20). *Analysis: The permanent King Street transit way is a model for all Toronto*. Spacing Toronto. http://spacing.ca/toronto/2019/06/20/analysis-the-permanent-king-street-transit-way-is-a-model-for-all-toronto/
Saoudi, O., Singh, I., & Mahyar, H. (2022). *Autonomous Vehicles: Open-Source Technologies, Considerations, and Development.* arXiv:2202.03148.
Sarriera, J. M., Álvarez, G. E., Blynn, K., Alesbury, A., Scully, T., & Zhao, J. (2017). To Share or Not to Share: Investigating the Social Aspects of Dynamic Ridesharing. *Transportation Research Record, 2605*(1), 109–117.
Savini, F., & Bertolini, L. (2019). Urban experimentation as a politics of niches. Environment and Planning A: Economy and Space, 51(4), 831-848.
Schaller, B. (2017). *Empty Seats, Full Streets. Fixing Manhattan's Traffic Problem*. Schaller Consulting. http://schallerconsult.com/rideservices/emptyseats.pdf
Schäpke, N., Stelzer, F., Bergmann, M., Singer-Brodowski, M., Wanner, M., Caniglia, G., & Lang, D. J. (2017). *Reallabore Im Kontext transformativer Forschung: Ansatzpunkte zur Konzeption und Einbettung in den internationalen Forschungsstand*. Leuphana Universität. https://d-nb.info/1127111027/34
Schäpke, N., Stelzer, F., Caniglia, G., Bergmann, M., Wanner, M., Singer-Brodowski, M., Loorbach, D., Olsson, P., Baedeker, C., & Lang, D. J. (2018). Jointly Experimenting for Transformation? *GAIA - Ecological Perspectives for Science and Society, 27*(S1), 85–96.
Schneidewind, U. (2014). Urbane Reallabore – ein Blick in die aktuelle Forschungswerkstatt. *PNDonline, 3*, 1–7.
Schneidewind, U. (2015). Transformative Wissenschaft - Motor für gute Wissenschaft und lebendige Demokratie. *GAIA - Ecological Perspectives for Science and Society*, 24(2), 88–91.
Schneidewind, U. (2018). *Die Große Transformation: Eine Einführung in die Kunst gesellschaftlichen Wandels*. Fischer Taschenbuch.
Schneidewind, U., & Singer-Brodowski (2014). *Transformative Wissenschaft: Klimawandel im deutschen Wissenschafts- und Hochschulsystem*. Marburg: Metropolis.
Schneidewind, U., Singer-Brodowski, M., Augenstein, K., & Stelzer, F. (2016). *Pledge for a transformative science: A conceptual framework*. Wuppertal Institute for Climate, Environment and Energy. https://epub.wupperinst.org/frontdoor/index/index/docId/6414
Scholl, C., & de Kraker, J. (2021). Urban Planning by Experiment: Practices, Outcomes, and Impacts. *Urban Planning, 6*(1), 156–160.
Schwarz, U. (2002). *Neue deutsche Architektur, Eine Reflexive Moderne*. Hatje Cantz.
Schwarz, U. (2014). Reflexive Moderne und Architektur Revisited. In M. Buchert (Eds.), *Reflexives Entwerfen* (pp. 256). JOVIS Verlag.
Seattle, D. of T. (2017). *APPENDIX C. Preliminary Automated Mobility Policy Framework*. New Mobility Playbook. Version 1. Seattle Department of Transportation. https://www.seattle.gov/documents/Departments/SDOT/NewMobilityProgram/AppendixC.pdf
Sewell, J. (2009). *The shape of the suburbs: Understanding Toronto's sprawl*. University of Toronto Press.
SFMTA. (2017, November 9). *Guiding Principles for Emerging Mobility Services and Technologies*. San Francisco Municipal Transportation Agency. https://www.sfmta.com/reports/guiding-principles-emerging-mobility-services-and-technologies-0
Shaheen, S., Chan, N., Bansal, A., & Cohen, A. (2015). *Shared Mobility: A Sustainability & Technologies Workshop: Definitions, Industry Developments, and Early Understanding*. Transportation Sustainability Research Center, University California Berkeley. http://innovativemobility.org/wp-content/uploads/2015/11/SharedMobility_WhitePaper_FINAL.pdf

Shi, H. Y., Sweet, M., & Rajevan, N. (2019). *Automated Vehicles in the Greater Toronto and Hamilton Area: Overview from a 2018 Consumer Survey. Part A: Summary and Discussion*. School of Urban and Regional Planning, Ryerson University. https://transformlab.torontomu.ca/wp-content/uploads/2018/03/Olsen_Laidlaw_Sweet_Report1_PartA_summary_20180309.pdf

Shladover, S. E. (2016). *The Truth about Self-Driving Cars. They are coming, but not the way you may have been led to think*. Scientific American.

Shladover, S. E. (2018, Mai 14). *Practical Challenges to Deploying Highly Automated Vehicles* [Conference presentation]. Drive Sweden, Göteborg, Sweden. https://www.drivesweden.net/sites/default/files/content/bilder/practicalchallenges4drivesweden.pdf

Shulman, E. (2018). *Technological Middle Ages* [Video]. TED Conferences. https://www.ted.com/talks/ekaterina_shulman_jan_2018/transcript

Siegel, N. (2017, Oktober 28). *City Observatory - Autonomous Vehicles: Does federal preemption shut down the laboratories of democracy?* City Observatory. https://cityobservatory.org/autonomous-vehicles-does-federal-preemption-shut-down-the-laboratories-of-democracy/

Siemiatycki, M., & Fagan, D. (2019). *Transit in the Greater Toronto Area: How to Get Back on the Rails*. Institute on Municipal Finance and Governance. https://tspace.library.utoronto.ca/handle/1807/96710

Simons, H. (2009). *Case Study Research in Practice*. SAGE Publications Ltd.

Singer-Brodowski, M., Beecroft, R., & Parodi, O. (2018). Learning in Real-World Laboratories. A Systematic Impulse for Discussion. *GAIA - Ecological Perspectives for Science and Society, 27*(1), 23-27.

Singh, A. (2020). *Open source holds the key to autonomous vehicles*. Canonical. https://canonical.com/blog/open-source-economics-hold-the-key-to-autonomous-vehicles

Slack, E. (2017). *How Much Local Fiscal Autonomy Do Cities Have? A Comparison of Eight Cities around the World*. IMFG Perspectives. Institute on Municipal Finance and Governance, University of Toronto. https://ideas.repec.org/p/mfg/perspe/19.html

Smith, A. (2006). Niche-based Approaches to Sustainable Development: Radical Activists versus Strategic Managers. In J.-P. Voß, D. Bauknecht, & R. Kemp (Eds.), *Reflexive Governance for Sustainable Development* (pp. 313–336). Edward Elgar Publishing.

Smith Lea, N., & McClelland, R. (2019). *Toronto's Vision Zero 2.0 Update Incorporates a Complete Streets Approach*. Complete Streets for Canada. https://www.completestreetsforcanada.ca/torontos-vision-zero-2-0-update-incorporates-a-complete-streets-approach/

Smith Lea, N., Mitra, R., Hess, P., Quigley, B., & Loewen, N. (2016). *Complete Street Transformations in the Greater Golden Horseshoe Region*. Toronto: Clean Air Partnership.

Sorensen, A. (2011). Toronto Megacity: Growth, Planning Institutions, Sustainability. In A. Sorensen & J. Okata (Eds.), *Megacities: Urban Form, Governance, and Sustainability* (pp. 245–271). Springer Japan.

Sorensen, A., & Hess, P. (2015). Building suburbs, Toronto-style: Land development regimes, institutions, critical junctures and path dependence. *The Town Planning Review, 86*(4), 411–436.

Soteropoulos, A., Berger, M., & Ciari, F. (2019). Impacts of automated vehicles on travel behaviour and land use: An international review of modelling studies. *Transport Reviews, 39*(1), Art. 1.

Soteropoulos, A., Mitteregger, M., Berger, M., & Zwirchmayr, J. (2020). Automated drivability: Toward an assessment of the spatial deployment of level 4 automated vehicles. *Transportation Research Part A: Policy and Practice, 136*, 64–84.

Soteropoulos, A., Bruck, E. M., Berger, M., Egoldt, A., Holst, A., Richter, T., & László, Z. (2021). Automatisierung, öffentlicher Verkehr und Mobility as a Service: Erfahrungen aus Tests mit automatisierten Shuttlebussen. In M. Mitteregger, E. M. Bruck, A. Soteropoulos, A. Stickler, M. Berger, J. S. Dangschat, R. Scheuvens, & I. Banerjee (Eds.), *AVENUE21. Politische und planerische Aspekte der automatisierten Mobilität* (pp. 75–106). Springer.

Sperling, D. (2018). *Three Revolutions. Steering Automated, Shared, and Electric Vehicles to a Better Future*. Island Press.

Spieler, C. (2021). *Trains, buses, people: An opinionated atlas of US and Canadian transit*. Island Press.

Spurr, B. (2016, December 9). *New transportation boss says car is no longer king*. The Toronto Star. https://www.thestar.com/news/gta/2016/12/09/new-transportation-boss-says-car-is-no-longer-king.html

Spurr, B. (2020, November 27). *The TTC wants to test 'platoons' of driverless buses*. The Toronto Star. https://www.thestar.com/news/gta/2020/11/27/the-ttc-wants-to-test-platoons-of-driverless-buses.html

Stayton, E., & Stilgoe, J. (2020). It's Time to Rethink Levels of Automation for Self-Driving Vehicles. *IEEE Technology and Society Magazine, 39*(3), 13–19.

Stead, D. (2019). Automated Vehicles and Active Transport: Making the Connections. In I. Ionescu, V. Munoz Sanz, & R. Dijkstra (Eds.), *Robocar and Urban Space Evolution. City changes in the age of autonomous cars*. TU Delft, Urban Design Section at the Faculty of Architecture and the Built Environment.

Stead, D., & Cotella, G. (2011). Differential Europe: Domestic Actors and Their Role in Shaping Spatial Planning Systems. *disP - The Planning Review, 47*(186), 13-21.

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

Steckler, B. (2019). *Navigating New Mobility: Policy Approaches for Cities*. University of Oregon https://scholarsbank.uoregon.edu/xmlui/handle/1794/25190

Steckler, B., Howell, A., Coia, J., & Kaplowitz, G. (2020). *Perfecting Policy with Pilots: New Mobility and AV Urban Delivery Pilot Project Assessment*. University of Oregon. https://www.urbanismnext.org/resources/perfecting-policy-with-pilots-new-mobility-and-av-urban-delivery-pilot-project-assessment

Steckler, B., Howell, A., Larco, N., & Kaplowitz, G. (2021). *A Framework for Shaping the Deployment of Autonomous Vehicles and Advancing Equity Outcomes*. Knight Autonomous Vehicle Initiative. University of Oregon. https://www.urbanismnext.org/resources/a-framework-for-shaping-the-deployment-of-autonomous-vehicles-and-advancing-equity-outcomes

Stiglic, M., Agatz, N., Savelsbergh, M., & Gradisar, M. (2015). The benefits of meeting points in ride-sharing systems. *Transportation Research Part B: Methodological, 82*, 36–53.

Stirling, A. (2006). Precaution, Foresight and Sustainability: Reflection and Reflexivity in the Governance of Science and Technology. In J.-P. Voß, D. Bauknecht, & R. Kemp (Eds.), *Reflexive Governance for Sustainable Development*. Edward Elgar Publishing.

Stout, M. (2021). *Underpriced and Undervalued. Exploring curbside pricing policies in Toronto*. PEMBINA Institute. https://www.pembina.org/pub/underpriced-and-undervalued

Streeck, W. (2009). Institutions in History: Bringing Capitalism Back. In G. Morgan, J. L. Campbell, C. Crouch, O. K. Pedersen, & R. Whitley (Eds.), *THE OXFORD HANDBOOK OF COMPARATIVE INSTITUTIONAL ANALYSIS* (pp. 659-686). Oxford University Press.

Streeck, W., & Thelen, K. (2005). Introduction: Institutional Change in Advanced Political Economies. In W. Streeck & K. Thelen (Eds.), *Beyond Continuity: Institutional Change in Advanced Political Economies* (pp. 1–39). Oxford University Press.

Tabascio, A., & Brail, S. (2021). Governance matters: Regulating ride hailing platforms in Canada's largest city-regions. *The Canadian Geographer / Le Géographe Canadien, 66*(2), 278–292.

Taiebat, M., Stolper, S., & Xu, M. (2019). Forecasting the Impact of Connected and Automated Vehicles on Energy Use: A Microeconomic Study of Induced Travel and Energy Rebound. *Applied Energy, 247*, 297–308.

Taylor, Z. (2020). Theme and Variations: Metropolitan Governance in Canada. *IMFG Papers on Municipal Finance and Governance, 49.*

Taylor, Z., & Dobson, A. (2020). Power and Purpose: Canadian Municipal Law in Transition. *IMFG Papers on Municipal Finance and Governance, 47.*

Telepak, G., & Augustin, H. (2018). Automated vehicles in a major European city – a technical perspective on urban transport policy options: The case of Vienna. 2018. https://doi.org/10.5281/zenodo.1441037

Thelen, K. (2003). How Institutions Evolve: Insights from Comparative Historical Analysis. In D. Rueschemeyer & J. Mahoney (Eds.), *Comparative Historical Analysis in the Social Sciences* pp. 208–240). Cambridge University Press.

Thomas, G. (2011). A Typology for the Case Study in Social Science Following a Review of Definition, Discourse, and Structure. *Qualitative Inquiry, 17*(6), 511–521.

Ticoll, D. (2015). *Driving Changes: Automated Vehicles in Toronto*. Munk School of Global Affairs, University of Toronto. https://uttri.utoronto.ca/files/2016/04/Driving-Changes-Automated-Vehicles-in-Toronto.pdf

Toronto (n.d.). *About the Trial*. https://www.toronto.ca/services-payments/streets-parking-transportation/transportation-projects/automated-vehicles/automated-vehicles-pilot-projects/automated-shuttle-trial/book-a-shuttle-trip/

Toronto (2014, May 6). *PW30.6 Framework for External Research Collaborations for Transportation Services*. City of Toronto, Public Works and Infrastructure Committee. http://app.toronto.ca/tmmis/viewAgendaItemHistory.do?item=2014.PW30.6

Toronto (2016a). *PREPARING FOR AUTONOMOUS VEHICLES. Divisional Workplan 2016-2018*. City of Toronto, Transportation Services. https://www.toronto.ca/wp-content/uploads/2018/01/8f04-AVs-TS-Workplan.pdf

Toronto (2016b). *Toronto Ten Year Cycling Network Implementation Plan. Connect, Grow, Renew*. IBI Group Professional Services (Canada) Inc. https://www.toronto.ca/wp-content/uploads/2019/01/94e8-Cycling-Implementation-Plan-Table-of-Contents-Section-1-4.pdf

Toronto (2016c, May 16). *PW13.14 Preparing the City of Toronto for Autonomous Vehicles*. http://app.toronto.ca/tmmis/viewAgendaItemHistory.do?item=2016.PW13.14

Toronto (2016d, October). *City Revenue Fact Sheet*. City of Toronto. https://www.toronto.ca/city-government/budget-finances/city-finance/long-term-financial-plan/city-revenue-fact-sheet/

Toronto (2017a). *VISION ZERO. 2017-2021 Toronto's Road Safety Plan*. City of Toronto, Transportation Services. https://www.toronto.ca/wp-content/uploads/2017/11/990f-2017-Vision-Zero-Road-Safety-Plan_June1.pdf

Toronto (2017b). *Toronto Complete Streets Guidelines Edition 1. Volume 1*. https://www.toronto.ca/services-payments/streets-parking-transportation/enhancing-our-streets-and-public-realm/complete-streets/complete-streets-guidelines/

Toronto (2017c). *Proposed King Street Transit Pilot: Bathurst Street to Jarvis Street* (Report for Action EX26.1). https://www.toronto.ca/legdocs/mmis/2017/ex/bgrd/backgroundfile-104940.pdf

Toronto (2017d). *Curbside Management Strategy: Improving How Curbside Space Is Used* (Report for Action). City of Toronto, Transportation Services Division. https://www.toronto.ca/legdocs/mmis/2017/pw/bgrd/backgroundfile-109153.pdf

Toronto (2018a). *Preparing the City of Toronto for Automated Vehicles* (Report for Action PW26.4). City of Toronto, Transportation Services. https://www.toronto.ca/legdocs/mmis/2018/pw/bgrd/backgroundfile-110665.pdf

Toronto. (2018b). *Downtown Mobility Strategy. TOCore*. https://www.toronto.ca/legdocs/mmis/2018/pg/bgrd/backgroundfile-114262.pdf

Toronto (2018c). *Minding the Gap—Request for Authority to Receive Federal Funding for an Automated Shuttle Pilot Project* (Report for Action PW31.07). https://www.toronto.ca/legdocs/mmis/2018/pw/bgrd/backgroundfile-117633.pdf

Toronto (2019a). *Automated Vehicles Tactical Plan*. https://www.toronto.ca/wp-content/uploads/2020/02/7ec4-TS_AV-Tactical-Plan_Technical-Report.pdf

Toronto (2019b). *The Transportation Impacts of Vehicle-for-Hire in the City of Toronto* (Research & Analysis). City of Toronto, Transportation Services, Big Data Innovation Team. https://www.toronto.ca/wp-content/uploads/2019/06/96c7-Report_v1.0_2019-06-21.pdf

Toronto (2019c). *Attachment 3: Automated Vehicles Tactical Plan: Consultation Summary*. https://www.toronto.ca/legdocs/mmis/2019/ie/bgrd/backgroundfile-138571.pdf

Toronto (2019d). *City of Toronto Electric Vehicle Strategy Supporting the City in achieving its TransformTO transportation goals*. https://www.toronto.ca/wp-content/uploads/2020/02/8c46-City-of-Toronto-Electric-Vehicle-Strategy.pdf

Toronto (2019e). *The Future of King Street: Results of the Transit Pilot* (Report for Action EX4.2). https://www.toronto.ca/legdocs/mmis/2019/ex/bgrd/backgroundfile-131188.pdf

Toronto (2020a). *Amendment 456 To The Official Plan* (By-Law 242–2020). City of Toronto, Planning and Housing Committee. https://www.toronto.ca/legdocs/bylaws/2020/law0242.pdf

Toronto (2020b). *MoveTO 2021-25: Congestion Management Interim Action Plan and Non-Competitive Contract for Smart Signals* (Report for Action IE17.6). https://www.toronto.ca/legdocs/mmis/2020/ie/bgrd/backgroundfile-157804.pdf

Toronto (2020c). *NEXT PLACE PLAN. Phase 1 Proposals Report for Exhibition Place*. https://www.toronto.ca/legdocs/mmis/2020/ep/bgrd/backgroundfile-148017.pdf

Toronto (2020d, April 27). *City of Toronto launches CurbTO plan to address more than 100 hot spots*. https://www.toronto.ca/news/city-of-toronto-launches-curbto-plan-to-address-more-than-100-hot-spots/

Toronto (2020e). *EGLINTON EAST -PRIORITY BUS LANES.* https://www.toronto.ca/legdocs/mmis/2020/ex/bgrd/backgroundfile-152214.pdf
Toronto (2020f). *Guidelines for Submitting a Work Zone and Law Enforcement Interaction Plan to the City of Toronto*. City of Toronto, Transportation Services. https://www.toronto.ca/wp-content/uploads/2020/12/92dd-TS_AV_TRIP-Guidelines.pdf
Toronto (2021a). *Transportation Innovation Challenges: Fostering Local, Outcomes-Oriented Transformation* (Report for Action). https://www.toronto.ca/legdocs/mmis/2021/ie/bgrd/backgroundfile-165845.pdf
Toronto (2021b). *RapidTO: Bus & Streetcar Priority. Phase 1 Consultation (October to December 2021).* https://www.toronto.ca/wp-content/uploads/2021/10/96f2-2021-10-04-RBSP-Slides-CC.pdf
Toronto (2021c). *The Transportation Impacts of Vehicle for Hire in the City of Toronto October 2018 to July 2021* (Research & Analysis). City of Toronto, Transportation Services, Data & Analytics Unit. https://www.toronto.ca/wp-content/uploads/2021/11/98cd-VFHTransportationImpacts2021-11-23.pdf
Toronto (2022a). *Official Plan*. Office consolidation as of March 2022. https://www.toronto.ca/city-government/planning-development/official-plan-guidelines/official-plan/
Toronto (2022b). *West Rouge Automated Shuttle Trial Case Study*. https://www.toronto.ca/wp-content/uploads/2022/09/9114-TSWest-Rouge-Automated-Shuttle-Case-Study.pdf
Toronto (2022c). *Toronto Transit Commission. 2022 Operating Budget and 2022-2031 Capital Budget & Plan. Briefing to Budget Committee*. https://www.toronto.ca/legdocs/mmis/2022/bu/bgrd/backgroundfile-175216.pdf
Toronto (2022d). *Innovation challenge call for applications: Parking and curbside vehicle detection*. https://www.toronto.ca/wp-content/uploads/2022/11/890d-TSInnovation-Challenge-Call-for-ApplicationsParking-Sensors-Curbside.pdf
Toronto (2022e). *Attachment 9 Complete Streets Study Summary Report.* https://www.toronto.ca/wp-content/uploads/2022/02/8d46-CityPlanning-DanforthAvenue-Complete-Streets-Summary.pdf
Townsend, A. M. (2020). *Ghost Road. Beyond the Driverless Car*. W. W. Norton & Company.
TransForm Lab. (2018). *Benchmarking Public Opinion on Automated Vehicles: Comparing Toronto to Other Jurisdictions*. Toronto Metropolitan University. https://transformlab.torontomu.ca/wp-content/uploads/2018/11/Benchmarking-Public-Opinion-on-Automated-Vehicles.pdf
TRBOT – Toronto Region Board of Trade. (2020). *Erasing the Invisible Line: Integrating the Toronto Region's Transit Networks*. Toronto Region Board of Trade. https://bot.com/Resources/Resource-Library/Erasing-the-Invisible-Line
TTC – Toronto Transit Commission. (2019). *NEXT STOP, EVEN BE*TTER. *2020-2024 & beyond. 5-year Service Plan & 10-year Outloook*. Toronto Transit Commission. https://ttc-cdn.azureedge.net/-/media/Project/TTC/DevProto/Documents/Home/About-the-TTC/5_year_plan_10_year_outlook/Attachment-1-TTC_5_year_SP_web_accessible_R3.pdf?rev=69cfa3fbb3034d8a8ca5aaff03bf6a17&hash=9208204C7255C70154C0DFD161BA16F9
TTC – Toronto Transit Commission. (2020). *TTC Fleet Procurement Strategy and Plan* (For Action 2047.5). Toronto Transit Commission. https://ttc-cdn.azureedge.net/-/media/Project/TTC/DevProto/Documents/Home/Public-Meetings/Board/2020/October_22/Reports/5_TTC_Fleet_Procurement_Strategy_and_Plan.pdf?rev=ed6e2828628c484daf919cc64b83b111&hash=32DE90249784BB0438C9B4E266C1D718
TTC – Toronto Transit Commission. (2021, June 24). ACAT Meeting 367 Jun 24. https://www.ttc.ca/public-meetings/advisory-committee-on-accessible-transit---acat/2021/Meeting-367-Jun-24?tab=1
Tutunzis. (2019, Juli 15). *Grabbing a Lyft to GO*. Metrolinx News. https://blog.metrolinx.com/2019/07/15/grabbing-a-lyft-to-go/
Urbanism Next. (2019). *POLICY BRIEF - AVs in the pacific northwest: Reducing greenhouse gas emissions in a time of automation*. University of Oregon. https://www.urbanismnext.org/resources/policy-brief-avs-in-the-pacific-northwest-reducing-greenhouse-gas-emissions-in-a-time-of-automation
Urry, J. (2004). The 'System' of Automobility. *Theory, Culture & Society, 21*(4–5), Art. 4–5.
van Wee, B., Milakis, D., & Thomopoulos, N. (2020). Chapter Thirteen—Overall synthesis and conclusions. In D. Milakis, N. Thomopoulos, & B. van Wee (Eds.), *Advances in Transport Policy and Planning* (pp. 315–326). Academic Press.

Vaughan. (2022). *Rutherford and Maple GO Mobility On-Request Pilot Project*. City of Vaughan. https://www.vaughan.ca/about-city-vaughan/projects-and-initiatives/transportation-projects/rutherford-and-maple-go

Vedres, B., & Scotti, M. (2012). Introduction. In B. Vedres & M. Scotti (Eds.), *Networks in Social Policy Problems* (pp. 1–12). Cambridge University Press.

Venturi, M. (2006). Wandel im Planungsverständnis für Städte im Wandel – Blick über die Grenzen. In K. Selle (Eds.), *Zur räumlichen Entwicklung beitragen. Konzepte. Theorien. Impulse* (pp. 322–340). edition stadt | entwicklung.

Vigar, G., Cowie, P., & Healey, P. (2014). *Success and Innovation in Planning: Creating Public Value*. Royal Town Planning Institute. https://www.rtpi.org.uk/research/2014/february/success-and-innovation-in-planning-creating-public-value/

Vogel, S. K. (2005). Routine Adjustment and Bounded Innovation: The Changing Political Economy of Japan. In W. Streeck & K. Thelen (Eds.), *Beyond Continuity: Institutional Change in Advanced Political Economies* (pp. 1–39). Oxford University Press.

Vogt, W. (2005). Historische Entwicklung von Verkehrsnetzen. In G. Steierwald, H. D. Künne, & W. Vogt (Eds.), *Stadtverkehrsplanung: Grundlagen, Methoden, Ziele* (pp. 403–430). Springer.

von Schomberg, R. (2011). *Towards Responsible Research and Innovation in the Information and Communication Technologies and Security Technologies Fields*. A Report from the European Commission Services. Publications Office of the European Union. https://op.europa.eu/en/publication-detail/-/publication/60153e8a-0fe9-4911-a7f4-1b530967ef10

von Wirth, T., & Levin-Keitel, M. (2020). Lokale Nachhaltigkeitsexperimente als raumwirksame Interventionen: Theoretische Grundlagen und Handlungskonzepte. *GAIA - Ecological Perspectives for Science and Society, 29*(2), 98–105.

Voß, J.-P., & Kemp, R. (2006). Sustainability and reflexive governance: Introduction. In J.-P. Voß, D. Bauknecht, & R. Kemp (Eds.) *Reflexive Governance for Sustainable Development* (pp. 26). Edward Elgar Publishing.

Voß, J.-P., Kemp, R., & Bauknecht, D. (2006). Reflexive Governance: A View on an Emerging Path. In J.-P. Voß, D. Bauknecht, & R. Kemp (Eds.), *Reflexive Governance for Sustainable Development* (pp. 419–437). Edward Elgar Publishing.

Wagner, F., & Grunwald, A. (2015). Reallabore als Forschungs- und Transformationsinstrument Die Quadratur des hermeneutischen Zirkels. *GAIA - Ecological Perspectives for Science and Society, 24(1)*, 26–31.

Wagner, J., Baker, T., Goodin, G., & Maddox, J. (2014). *Automated Vehicles: Policy Implications Scoping Study. Technical Report Nr. 600451-00029–1*. Southwest Region University Transportation Center. https://trid.trb.org/view.aspx?id=1303053

Walks, A. (2015). Stopping the 'War on the Car': Neoliberalism, Fordism, and the Politics of Automobility in Toronto. *Mobilities, 10*(3), 402–422.

Wang, B., Ordoñez Medina, S. A., & Fourie, P. J. (2018). Operator and user perspectives on fleet mix, parking strategy and drop-off bay size for autonomous transit on demand. *Arbeitsberichte Verkehrs- und Raumplanung*, 1370.

Wanner, M., & Stelzer, F. (2019). *Reallabore—Perspektiven für ein Forschungsformat im Aufwind*. Wuppertal Institut für Klima, Umwelt, Energie. https://epub.wupperinst.org/frontdoor/index/index/docId/7360

Weed, M. (2005). „Meta Interpretation": A Method for the Interpretive Synthesis of Qualitative Research. *Forum Qualitative Sozialforschung / Forum: Qualitative Social Research, 6*(1).

Weinig, M., & Thierstein, A. (2020). Digital Transformation and Spatial Development – Will the Balance between Public Sector and Civil Society Change? In T. Dillinger, M. Getzner, A. Kanonier, & S. Zech (Eds.), *50 Jahre Raumplanung an der TU Wien studieren – lehren – forschen*. Jahrbuch des Instituts für Raumplanung der TU Wien 2020 (pp. 530–541). NWV Verlag GmbH.

Wevolver. (2020). *2020 AUTONOMOUS VEHICLE TECHNOLOGY REPORT. The guide to understanding the current state of the art in hardware & software for self-driving vehicles*. Wevolver.

Wheeler, S. M. (2003). The Evolution of Urban Form in Portland and Toronto: Implications for sustainability planning. *Local Environment, 8*(3), 317–336.

Whitby. (2022). *Whitby Autonomous Vehicle Electric shuttle pilot conclusion*. Durham Region Transit. https://www.durhamregiontransit.com//en/Modules/News/index.aspx?newsId=8f023c34-99b8-4e0c-845b-c087457dfb46

White, R. (2007). *The Growth Plan for the Greater Golden Horseshoe in Historical Perspective*. The Neptis Foundation. https://neptis.org/sites/default/files/historical_commentary/historicalcomm_web_200711291.pdf

Wiechmann, T. (2018). Planungstheorie. In ARL – Akademie für Raumentwicklung in der Leibniz-Gemeinschaft (Ed.) *Handwörterbuch der Stadt- und Raumentwicklung* (pp. 1771–1784).

Williams, G. (1999). Institutional capacity and metropolitan governance: The Greater Toronto Area. *Cities, 16*(3), 171-180.

Wintersberger, P., Frison, A.-K., Thang, I., & Riener, A. (2020). Mensch oder Maschine? Direktvergleich von automatisiert und manuell gesteuertem Nahverkehr. In A. Riener, A. Appel, W. Dorner, T. Huber, J. C. Kolb, & H. Wagner (Eds.), *Autonome Shuttlebusse im ÖPNV: Analysen und Bewertungen zum Fallbeispiel Bad Birnbach aus technischer, gesellschaftlicher und planerischer Sicht* (pp. 95–113). Springer.

Wolfe, D., & Goracinova, E. (2017). *Regional Resilience and Ontario's Automotive Cluster: Its Future in the Digital Age*. Innovation Policy Lab, Munk School of Global Affairs, University of Toronto. https://munkschool.utoronto.ca/ipl/files/2017/04/Goracinova-Wolfe-S5-2017-ConfPaper.pdf

Wolfram, M., Frantzeskaki, N., & Maschmeyer, S. (2016). Cities, systems and sustainability: Status and perspectives of research on urban transformations. *Current Opinion in Environmental Sustainability, 22*, 18–25.

WSP. (2016). *New Mobility Background Paper. Full Report. Technical Paper 4 to support the Discussion Paper for the Next Regional Transportation Plan*. WSP Canada Group Limited. https://assets.metrolinx.com/image/upload/v1663240156/Documents/Metrolinx/04_New_Mobility_Report_EN.pdf

WSP, & OCE. (2019). *ONTARIO CAV ECOSYSTEM ANALYSIS 2019*. WSP Canada Group Limited and Ontario Centres of Excellence. https://www.ovinhub.ca/wp-content/uploads/2021/04/avin-ecosystem-analysis-final-report-2019.pdf

Yin, R. K. (2014). *Case study research: Design and methods*. SAGE Publications.

Young, M., Farber, S., & Palm, M. (2020). The true cost of sharing: A detour penalty analysis between UberPool and UberX trips in Toronto. *Transportation Research Part D: Transport and Environment, 87*, 102540.

Zankl, C. & Rehrl. (2018). *Digibus 2017 - Erfahrungen mit dem ersten selbstfahrenden Shuttlebus auf öffentlichen Straßen in Österreich*. Salzburg: Salzburg Research. http://www.digibus.at

Zapf, W. (1989). Über soziale Innovationen. *Soziale Welt, 40(1/2)*, 170–183.

Zhang, W., & Guhathakurta, S. (2018). Residential Location Choice in the Era of Shared Autonomous Vehicles. *Journal of Planning Education and Research, 41*(2), 135-148.

Zhang, W., Guhathakurta, S., & Khalil, E. B. (2018). The impact of private autonomous vehicles on vehicle ownership and unoccupied VMT generation. *Transportation Research Part C: Emerging Technologies, 90*, 156–165.

Zhang, W., & Wang, K. (2020). Parking futures: Shared automated vehicles and parking demand reduction trajectories in Atlanta. *Land Use Policy, 91*, 103963.

Zhang, Y., Farber, S., & Young, M. (2021). Eliminating barriers to nighttime activity participation: The case of on-demand transit in Belleville, Canada. *Transportation, 49*, 1385-1408.

Zupan, D. (2018). *Leitbildwechsel—Dynamiken und Charakteristika städtebaulicher Innovationsprozesse*. Detmold: Dorothea Rohn.

LIST OF TABLES

LIST OF FIGURES

ACRONYMS

ADS	Automated Driving Systems
ADAS	Advanced Driver Assistance Systems
AM	Automated Mobility
AMOD	Automated Mobility on Demand
AVs	Automated Vehicles
BRT	Bus Rapid Transport
CVs	Connected Vehicles
GGH	Greater Golden Horseshoe
GTA	Greater Toronto Area
HOV	High-occupant vehicles
MaaS	Mobility-as-a-service
MPO	Metropolitan Planning Organization
MTPB	Metropolitan Toronto Planning Board
ODD	Operational Design Domain
OP	Official Plan
PTC	Private Transportation Company
RTP	Regional Transportation Plan
SAE	SAE Levels of Driving Automation
SAV	Shared Automated Vehicle
TDM	Transportation Demand Management
TNC	Transport Network Company
UGC	Urban Growth Centre
V2I	Vehicle-to-infrastructure communication
V2V	Vehicle-to-vehicle communication
V2N	Vehicle-to-network communication
V2X	Vehicle-to-everything communication
VKT	Vehicle Kilometres Travelled
VMT	Vehicle Miles Travelled

APPENDICES

APPENDIX A: Sample Information Letter

Interview Study: Shaping the transition to automated mobility

Author: Emilia M. Bruck, M.Sc

Research context

This interview study comprises the empirical part of my doctoral dissertation, which I am pursuing at the Institute for Spatial Planning of the Vienna University of Technology, Austria. Its core focus is an in-depth case-study of the planning and policy actions for AVs initiated in the Greater Toronto Area (GTA) since 2014.

The study builds on previous research conducted as part of the project AVENUE21 – Connected and Automated Driving: Prospects for Urban Europe (2016 – 2021, TU Wien). Individual research questions were adapted from an online survey on "Stakeholders and Fields of Action in Cities" conducted in winter 2018/2019 (Mitteregger et al., 2022: 33).

Objective

The aim of the interview study is to gain knowledge on the urban planning and policy measures that planning professionals in the GTA are using to prepare for a potential transition to automated mobility (aM). To this end, I assess the perceived relevance of specific planning steps based on the following dimensions:

1. Existing urban development principles as well as policy and planning considerations for AVs;
2. the urban integration of pilot projects;
3. and the design of learning processes in the wake of transformative change.

The interviews are conducted as semi-structured conversations based on the following interview guide. Interviewees are kindly asked to expand on any given question and pose clarifying questions at their own discretion.

Formalities

Digital recordings are used for strictly scientific purposes and retained for the minimum necessary period of time. All digital recordings will be disposed following research completion. Transcripts will be de-identified and kept for the purpose of potential future research.

The views and opinions obtained through the interviews will be de-identified and assigned to stakeholder groups. Responses will not be disclosed as representative positions of any public or private institution.

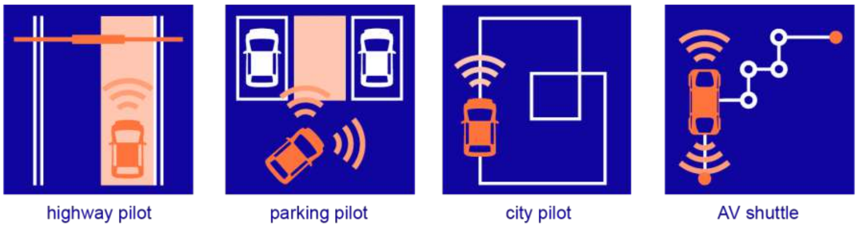
Should direct quotes be included in the publication of research findings, the transcripts will be returned to the interviewee in order to review and verify the accuracy of the transcription.

APPENDIX B: Interview guide

Conceptual clarification

The interview study focuses on highly automated vehicles, i.e. SAE Level 4 vehicles that can operate with or without an on-board operator in designated lanes or in restricted environments, urban areas and street types. Moreover, the focus lies on automated car and ride sharing as well as public mobility services. These include automated highway and parking systems as well as on demand vehicles and shuttle buses (see Fig. 1).

Figure 1 Fields of application during for Level 4



Source: From *AVENUE21. Connected and Automated Driving: Prospects for Urban Europe*, by Mitteregger et al., 2022: 60.

Thematic background

The following interview study focuses on the near future and the potentially long transition period to automated mobility. Despite technological progress, the initial deployment phase will be characterized by varying degrees of automation operating in mixed traffic scenarios, with highly automated vehicles limited to designated roads and less complex operational environments. The infrastructural and spatial requirements for safe deployment need to be determined with regard to specific service models, their share in mixed traffic and the spatial context.

The planning challenge during a transition phase consists of anticipating the opportunities and risks that automated vehicles (AVs) could pose for the Greater Toronto Area. Municipal and regional planning actors have a responsibility to ensure a smooth transition to automated mobility despite the prevailing uncertainties. Against this backdrop, the pressing question for many municipalities is: how can the transition to automated mobility be effectively managed? In this vein, the interview focuses on relevant policy and planning initiatives developed in the Greater Toronto Area (GTA) as well as the broader institutional context in which they are embedded.

Introduction

1. Does your understanding of the transition period to automated mobility differ from the description above? If so, how?
2. Since when has automated mobility been discussed in your institution?
3. How relevant do you consider it is for municipal planners to prepare for AVs early on?

Part 1: Policy and planning actions in Toronto

1. The Official Plan, the Congestion Management Plan and the TransformTO constitute several of Toronto's core planning instruments on which the AV Tactical Plan is built. These documents comprise various principles, goals and measures that direct Toronto's spatial and transportation development.

   How would you describe the overarching urban mobility vision that frames Toronto's planning and policy response to automated mobility?

2. In order to align the potential deployment of AVs with existing urban development goals, documents such as the Official Plan or the Complete Street Guidelines will require adaptation.
   How can uncertainty about future developments with AVs be dealt with when considering policy adaptations or new policy options?

3. Toronto's AV Tactical Plan includes the ambition of increasing space-efficient and active modes of travel. As modes and service types diversify, new travel options emerge.
   How do you envision a desirable mode share distribution by 2050, once AVs are more widely adopted in Toronto and the Greater Toronto Area?

Part 2: Urban integration of pilot projects

1. The "Minding the Gap" pilot project is a joint effort between the City of Toronto, the Toronto Transit Commission (TTC) and Metrolinx with the ambition of launching a self-driving shuttle bus in 2020. The project scope largely resembles that of international precedents by focusing on first and last-mile connections to transit hubs.

   What does the City of Toronto gain from conducting pilot projects such as Minding the Gap within its jurisdiction?

2. To date, AV pilots have largely focused on promoting technological development. However, the participation of prospective user groups is receiving increasing attention.

   What are opportunities and constraints of public engagement when it comes to exploring emerging mobility technologies and why?

3. The feasibility of deploying automated vehicles varies according to urban fabric and street typologies. By including the short-term measure of identifying corridors or areas for early AV adoption, the Tactical Plan recognizes phased deployment.

   In which areas of Toronto or the GTA do you consider a near-term deployment of automated vehicles most useful to existing transport development goals and why?

Part 3: Design of learning processes

1. In view of widespread uncertainties about the potential implications of AVs, the results of the preceding survey revealed a planning dilemma. Despite the perceived need for action on the part of local authorities, a lack of clarity prevailed on how to prioritize specific planning steps.

   Could you reflect on the process of preparing for automated mobility within the City of Toronto and Greater Toronto Area?

2. Much of the knowledge production on AVs has been reserved for industry, research institutes and selected transit agencies. Local authorities and planning agencies are urged to catch up and substantiate their understanding of the potential impact of AVs on traffic, urban environments and quality of life in order to make informed decisions about the regulatory and infrastructural circumstances for deployment.

   In your experience, what constitutes a productive learning environment for the City in order to generate knowledge about emerging mobility technologies and why?

3. My last question concerns reflection on past challenges, desired futures and present constraints. With regard to automated mobility, the reassessment of existing policy frameworks and planning processes may be required.

   What is the relevance of monitoring, evaluation and adaptation in planning for new mobility technologies and why?

APPENDIX C: Expert interviews[11]

Municipal staff, Transportation Services Division, City of Toronto, interview on August 14th, 2019

Municipal staff, Transportation Services Division, City of Toronto, interview on August 16th, 2019

Transportation planning and policy scientist, School of Urban and Regional Planning, Toronto Metropolitan University, interview on August 23rd, 2019

Urban planning staff, City Planning Division, City of Toronto, interview on August 28th, 2019

Senior planning staff, Strategy & Service Planning Division, Toronto Transit Commission, interview on August 30th, 2019

Senior planning staff, City Planning Division, City of Toronto, interview on September 4th, 2019

Transportation and urban planning professional, WSP Global Inc., interview on September 6th, 2019

Transportation planning and policy professional, WSP Global Inc., interview on September 11th, 2019

Senior policy advisor, Mobility Integration, Planning and Development Division, Metrolinx, interview on September 18th, 2019

Senior advisor, Regional Planning, Planning and Development Division, Metrolinx, interview on September 18th, 2019

Urban planning and policy scientist, Department of Geography and Planning, University of Toronto, interview on September 18th, 2019

Transportation modelling and planning scientist, Department of Civil & Mineral Engineering, University of Toronto, interview on September 22nd, 2019

Innovation policy scientist, Institute for Management and Innovation, University of Toronto, interview on September 23rd, 2019

Transportation policy manager, Transportation Policy Branch, Policy & Planning Division, Ontario Ministry of Transportation, interview on September 26th, 2019

Planner, Transportation Planning Branch, Policy & Planning Division, Ontario Ministry of Transportation, interview on October 1st, 2019

Transportation planning professional, Kimley-Horn and Associates Inc., interview on January 27th, 2023

---

[11] On one occasion the expert interview was conducted with two interviewees from the same division.

COPYRIGHT ACKNOWLEDGEMENTS

Figure 1, Preface Copyright owned by A. Soteropoulos, and M. Mitteregger, used with permission, retrieved from *AVENUE21 Review Meeting Proceedings* (2017).

Figure 4.2 Copyright owned by WSP Canada Group Limited and Ontario Centres of Excellence, used with permission, retrieved from *ONTARIO CAV ECOSYSTEM ANALYSIS 2019* (2019: 22): https://www.ovinhub.ca/wp-content/uploads/2021/04/avin-ecosystem-analysis-final-report-2019.pdf

Figure 6.1 and 6.2 Copyright owned by City of Toronto, used with permission, retrieved from *The Transportation Impacts of Vehicle-for-Hire in the City of Toronto* (2019: 12): https://www.toronto.ca/wp-content/uploads/2019/06/96c7-Report_v1.0_2019-06-21.pdf

Figure 6.4 Copyright owned by Queen's Printer for Ontario, 2020, used with permission, retrieved from *A Place to Grow. Growth Plan for the Greater Golden Horseshoe* (2022: 97): https://files.ontario.ca/mmah-place-to-grow-office-consolidation-en-2020-08-28.pdf

Figure 1, Appendix B Copyright owned by M. Mitteregger et al., used with permission, retrieved from *AVENUE21. Connected and Automated Driving: Prospects for Urban Europe* (2022): https://link.springer.com/book/10.1007/978-3-662-64140-8

All figures and tables © Emilia M. Bruck, unless otherwise noted.

CURRICULUM VITAE

Emilia M. Bruck, MSc

Area of expertise

- Spatial implications of digitization and automation processes,
- Spatial and urban planning research centred on managing the spatial effects of emerging technologies and transformative change processes.

Education

2017 – 2023	Doctor of Science (Dr.techn in Spatial Planning), TU Wien, AT
2012 – 2014	Master of Science (MSc in Urbanism), TU Delft, NL
2008 – 2012	Bachelor of Architecture (BArch in Architecture), Academy of Fine Arts Vienna, AT

Professional experience

since 10/2021	University Assistant, Research Unit of Local Planning, TU Wien, AT
since 11/2016	Scientific Staff Member, future.lab Research Center, TU Wien, AT
08 – 09/2019	Visiting Scholar, School of Urban & Regional Planning, Toronto Metropolitan University, CA
09/2016 – 02/2017	Lecturer, Institute of Urban Design & Landscape Architecture, TU Wien, AT
11/2015 – 08/2016	Urban Planner, stadtland, Wien, AT
04/2014 – 03/2015	Assistant Urban Designer, KuiperCompagnons, Rotterdam, NL

Research projects

Q1/2022 – Q2/2023	Project Assistant, *Räumliche Handlungsmöglichkeiten im Kontext Multilokalität und ländlicher Raum,* funded by Austrian Ministry for Agriculture, Forestry, Regions and Water Management
Q4/2021 – Q3/2022	Project Lead, *Querschnittstudie Raumwirksamkeit der Digitalisierung in Wien,* commissioned by the Municipal Department 18 (MA 18) - Urban Development and Planning, Vienna City Administration
Q4/2020 – Q2/2022	Project Coordinator, *ÖREK-Partnership Spatial Dimensions of Digitization,* commissioned by the Austrian Conference on Spatial Planning – ÖROK
Q2 - Q4/2020	Project Lead, *auto.WAVES - Straßenräumliche Wirkungen des automatisierten Fahrens,* commissioned by the Municipal Department 18 (MA 18) - Urban Development and Planning, Vienna City Administration
Q4/2016 - Q4/2020	Project Assistant, *AVENUE21 - Connected and Automated Driving: Prospects for Urban Europe*, 2016-2020, funded by the Daimler and Benz Foundation

Teaching experience

2023S Design Studio and Excursion *HARD AM LIMIT – Short time action for long time change* | Co-Conception and teaching

2022W Lecture and Exercise *Integrated Development Planning* | Co-Lecturer

2022S Design Studio *Reimagining rural downtowns* | Co-Conception and teaching

2022S Lecture and Exercise *Urban development projects, processes and instruments* | Co-Conception and teaching

2021W Project *Spatial Development Planning Triester Straße* | Co-Lecturer

2018W Lecture and Exercise *Urban development planning in practice – Digitalisation & new challenges in urban planning* | Co-Conception and teaching

2018S Design Studio *Designing urban transformation processes – Learning from Broadacre City* | Co-Conception and teaching

2017W Lecture and Exercise *future.lab. Was kommt da auf uns zu? Digitalisierung und Automatisierung in der europäischen Stadt* | Co-Conception and teaching

Board memberships

Since 2022 Member of the Working Group *"Use of Artificial Intelligence in Spatial Development"* by the Academy for Territorial Development in the Leibniz Association (ARL)

2020 – 2022 Member of the Scientific Board, *„Konzepte zur Integration des Radverkehrs in zukünftige urbane Verkehrsstrukturen mit autonomen Fahrzeugen" (RAD-AUTO-NOM)*, Technical University Kaiserslautern, DE

2019 – 2021 Member of the Program Committee, *"European Urbanism Next Conference 2021"*, June 9-11, 2021, Rotterdam, NL

2012 – 2014 Editorial Member, Atlantis Magazine, Polis Platform of Urbanism, TU Delft, NL

Awards

2021 Best Student-Led Paper Award 2021, World Society for Transport and Land Use Research

Grants/ Scholarships

07/2022 Fund for PhD students participating in conferences, TU Wien

05/2019 Grant for PhD theses and specialist courses abroad, TU Wien

04/2019 Fund for PhD students participating in conferences, TU Wien

2018 Fee Waiver Program for PHD, European Forum Alpbach

2012 Scholarship for Bilateral Agreement, Austrian Ministry of Culture