# INTEGRATED MOBILITY AND THE GOVERNANCE OF URBAN TRANSIT

Elena Goracinova, Lisa Huh and David A. Wolfe

INNOVATION POLICY LAB
MUNK SCHOOL OF GLOBAL AFFAIRS AND PUBLIC POLICY
UNIVERSITY OF TORONTO

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# Executive Summary

## Background

Smart mobility encompasses the development of self-driving, connected vehicles (C/AVs) and new forms of shared mobility. This rapid development is primarily driven by industry, promising that new technologies will increase road safety and reduce emissions (Mukhtar-Landgren & Paulsson, 2020; Council of Canadian Academies 2021). But new technologies are also associated with risks such as increased congestion and inequality (Ferreira et al., 2020; Groth, 2019; Pangbourne et al., 2020). For example, self-driving may increase the car's attractiveness and lead to mode shifts from more sustainable modes such as public transit to autonomous vehicles (Pakusch et al., 2018). Mobility data produced can support more effective traffic operations. However, government data strategies are fragmented and there is a lack of investment in building out strong digital infrastructures. And finally, shared mobility solutions (e.g., mobility as a service or mobility on demand services like Uber), portrayed as a tool to reduce dependence on personal vehicles, can exacerbate traffic and undermine public transport providers.

Most Canadian cities have been implementing new mobility technologies in increments and through pilot projects. However, the piecemeal adoption of technologies often occurs quietly and without robust public debate. These initiatives lack proper attention paid to governance issues such as data ownership or the commodification of mobility as the public sector recruits private technology partners to provide mobility services. Yet, questions about how governments should steer these changing networks of actors, resources and power are essential. A failure to address both the short and longer-term governance issues risks a lock-in to a mobility system that exacerbates the social and environmental problems that have challenged Canadian planners throughout the automobility transition. This synthesis report seeks to bring clarity and urgency to the debate about the impacts of new technologies by synthesizing our existing knowledge on the state's critical role in managing the transition to a 'smart' transport future.

## Objectives

The report's broader objective is to examine how authorities in the five case studies (US, Canada, UK, Finland, and Germany) manage connected mobility marketplaces. Two specific objectives are contained within this broader goal: the first is to understand how authorities a) govern their digital infrastructure, b) MaaS solutions, and c) C/AVs and to identify gaps in our knowledge of these processes. In doing so, we compare the extent to which initiatives in the five case studies meet the governance objectives set out in the literature (i.e., serve to expand governance capacity as it concerns each set of technologies), as well as the positive outcomes the literature associates with them (i.e., decreased use of automobiles and increased accessibility to transit). In other words, we want to understand if stakeholders in the case studies assume a leadership, enabling, or laissez faire role as they are faced with these innovative modes of transit provision, and how existing multi-level governance arrangements can account for these outcomes. Our second objective is to draw policy implications relevant to the Canadian context, specifically with respect to the governance arrangements most suited to the Canadian context.

## Results

The report finds that there is significant variation in cross-country adoption of smart mobility technologies, which is shaped by pre-existing governance structures and motivations. At the same time, there is a common underlying motivation that is shared across the case studies, that of enabling economic development. There are some exceptions to this trend, especially in cases like Seattle and Los Angeles in the US, where regulation of shared mobility providers is more proactive and strongly aligned with the cites' transit goals. This shows that more proactive regulation, or a leadership role on the part of public stakeholders, is necessary to ensure new smart mobility technologies are used to help strengthen and better integrate, rather than weaken, public transport. At the same time, however, it is not always the case that local or regional authorities have the authority to regulate mobility on demand and mobility as a service provider.[1] It is because of this that national or supranational regulation and intervention are necessary to ensure cities across the board have the power to control smart mobility provision in a manner that supports public transportation. National and/or supranational (e.g., EU) intervention is also necessary considering many local and regional authorities simply lack the funding or human capital and resources to dedicate time to long-term smart mobility planning.

## Key messages

This knowledge synthesis report argues the need for active public intervention and regulation of smart mobility providers instead of efforts to enable private innovation alone. This would mean clearly distinguishing economic development from transportation related objectives and prioritizing the latter in projects going forward or at least ensuring they are aligned. Further, we find there is limited consensus in the literature on the specific governance structures that national or sub-national governments need to adopt transportation technologies. Considering this, we recommend a more systematic analysis of existing initiatives, especially in the case of Canada where existing literature is mostly descriptive.

## Methodology

The literature on the governance of mobility innovations is case study based and often focused on large cities and urban environments within each country (e.g., Munich, Berlin and Hamburg in Germany). Because of this, the case study comparison is largely based on available literature on mobility innovation efforts in vibrant urban environments. After identifying literature on mobility innovation in each case study, we input the papers into the NVIVO software and categorized them according to whether: a) they tackle issues of governance and b) the technology they are examining. From the start, this analysis indicated that much of the literature on transit innovation is technical and/or does not deal with governance issues in any substantive fashion (Marsden & Reardon, 2017). After this, we analyzed the relevant literature in NVIVO and compiled our findings. The report is based on a qualitative assessment of public-policy approaches that deal with the present reality of transportation technology testing and initial service, as well as the longer-term implications of their possible broader adoption, rather than an exhaustive list of C/AV, shared mobility and digital infrastructure policies or testing and pilots in the case studies, but. For each case study, we tackle both efforts underway at the national and sub-national level, given the multi-level structure of governance networks, which impacts the capacity, accountability and efficiency of transportation systems (Marcucci & Stathopoulos, 2012). We begin the results section with an outline of each country's history of transportation governance for context and postulate a number of hypotheses as to how they may shape future developments.

[1] Including mandating data sharing on their part

# Background

Smart mobility encompasses the development of self-driving, connected vehicles (C/AVs) and new forms of shared mobility. This rapid development is primarily driven by industry, promising that new technologies will increase road safety and reduce emissions (Mukhtar-Landgren & Paulsson, 2020; Council of Canadian Academies 2021). But new technologies are also associated with risks such as increased congestion and inequality (Ferreira et al., 2020; Groth, 2019; Pangbourne et al., 2020). For example, self-driving may increase the car's attractiveness and lead to mode shifts from more sustainable modes such as public transit to autonomous vehicles (Pakusch et al., 2018). Mobility data produced can support more effective traffic operations. However, government data strategies are fragmented and there is a lack of investment in building out strong digital infrastructures. And finally, shared mobility solutions (e.g., mobility as a service or mobility on demand services like Uber), presented as a tool to help reduce dependence on personal vehicles, can exacerbate traffic and undermine public transport providers.

These threats are particularly acute given a governance environment that struggles to understand the distribution of roles and responsibilities in these possible mobility futures. One set of arguments suggests that the public sector's role is to enable change by providing favourable operating conditions, while the responsibility for innovation and service development rests with the private sector (Biuk-Aghai et al., 2016; Pangbourne et al., 2020). Alternative perspectives suggest that the public sector should innovate alongside the private sector to capture the benefits of new technologies and mitigate their risks (Docherty, 2018, 2020). They also argue that, while cities are essential in governing transitions, they do not act alone and require regional and national governments' support (Cardullo & Kitchin, 2019; Smith et al., 2019). Ultimately, this is a question about multi-level governance in the 21st-century city and public authorities' role in an era marked by transport disruptions.

Given this uncertainty, this knowledge synthesis report draws on a range of governance concepts to examine and unlock the social organization of new mobility solutions (across our five case studies including Canada, the US, the UK, Finland and Germany). By analyzing the existing knowledge on smart mobility policy instruments (and associated policy approaches), we hope to guide Canadian local governments in using new technologies to provide a higher quality integrated transit service. The following section outlines the potential roles that authorities can play when faced with new technologies and the policy instruments associated with each of these roles.

## Governance approaches

Researchers and practitioners have argued that many of the challenges for cities to adopt new mobility technologies, or to become smart cities, exceed the scope and capabilities of their current organizations, institutional arrangements and governance structures (e.g., Bolivar 2016, Gil-Garcia et al, 2015, Caragliu and Del Bo 2012).

However, this question has rarely been tackled in the context of transportation and/or smart mobility governance. In their review of contemporary scholarship on governance of transport, Marsden and Reardon found that only 13% of research papers from two leading transportation policy journals consider specific aspects of the policy process and that two-third of papers did not engage with real-world policy examples or policy makers but focused on quantitative analysis alone (2017). Focusing on the U.S. context, Lowe identifies a substantial gap in competitive National Science Foundation research funding for urban transportation between the engineering and computer systems directorates (75 awards in 2017) versus the social, behavioral and economics directorates (7 awards in 2017), further illustrating the technical orientation of the field (Fischer et al., 2020).

Instead, insights regarding the governance of new technologies in cities have often been presented in the broader context of smart cities. Much attention has rightly been focused, for example, on governance implications of smart city investments (Barns, 2018). There continues to be an open discussion regarding what smart city governance entails and how it is to be defined. In this review, we draw on the smart city literature to unpack the governance structure and implications of smart mobility investments.

The smart city literature recognizes the multi-faceted and multi-level ecosystem of various agencies and stakeholder groups (e.g., local governments, citizens, urban planners, vendors) that are often driven by conflicting interests in their efforts to introduce new technologies (Axelsson & Granath, 2018). Due to this complexity, authors argue smart cities require a proper governance system for connecting all forces at work, allowing knowledge transfers and facilitating decision-making to maximize their socio-economic and environmental performance.

The literature examines each of the smart city's components, from stakeholders, to structure, organizations and processes, as well as the contextual factors that affect them. Each combination of components, in turn, results in a different allocation of roles and responsibilities between the public and private sector and a strengthening or weakening of the public sector's governance capabilities. This review investigates these components to see how they can result in an increase or decrease of governance capacity.

The smart city literature identifies a range of novel policy instruments and initiatives (e.g., urban labs, transport innovation zones), but also traditional ones, to address the emerging complex urban realities. In each, stakeholders that can be involved in initiatives, including public (e.g., government agencies, political leadership), private (firms and/or private enterprises), academic (universities or research labs) or civic (citizens, civic groups, nongovernmental organizations). Intergovernmental relations get extensive treatment in the literature as studies point out the they are becoming more negotiated, with cities and regions expected to be more self-reliant and less dependent on central government support, and top-down hierarchical control evolving into a division of labor and partnerships between cities, regions, and the central government (Bache & Flinders, 2004; Hooghe & Marks, 2003; Le Galès & Lequesne, 1998; Piattoni, 2010; Pierre & Stoker, 2000).

The interaction between these stakeholders, in turn, is facilitated or impeded by a range of structures and organizations. For instance, authors like Scholl and AlAwadhy (2016) argue that the "*dismantling of existing departmental silos is a key element of any sustainable change*" while focusing on a city-wide ICT program implementation. Overall, there is consensus that increased, often multi-level, collaboration between stakeholders (through intergovernmental, interagency and inter-sectoral networks) is an imperative for successful smart city implementation that can help meet longstanding city goals.

The nature of this collaboration can be affected by a range of institutional factors, including the degree of autonomy and/or resources municipalities have to make decisions and/or other local factors (conditions such as geographical context, population, institutional conditions) related to the introduction of new technologies (Ruhlandt, 2018). Some suggest that municipalities can also use tests, pilots and demonstration projects as arenas where they can allow themselves to bend some rules, engage in experimental activities and set requirements for configurations under test.[2] At the same time, however, institutional capacity can be a collective resource that can be shared between different governing levels (Wallsten et al., 2020).[3] Overall, smart mobility contains major and important political issues that require a new type of political discussion about the role of public actors in the sustainability transition.

Findings about which component or combinations of components determine whether, or how well, a city pursues smart cities strategies in general (or smart mobility ones in particular), or offers a model of the underlying causal relationships are rarer, but growing, as authors undertake more comparative studies (Ruhlandt, 2018).

A significant body of literature suggests the best way to evaluate these partnerships is to discern whether the interests of public and private actors are effectively balanced. And to do so, they argue, is not just a matter of analyzing the policy itself, but also the manner in which it is implemented (or the process that lies behind it) (Davis, 2018). Authors categorize the nature of public-private exchanges into market-driven or contractual arrangements and more network-driven or relational arrangements. Wallsten et al. (2021) expand on this distinction to identify three distinct roles governments can play in this emerging space, the first of which is a leadership role, where authorities not only partake in network or relational arrangements, but also set the objectives technologies need to meet. The enabling and laissez faire approaches without government steering, they argue, are more market oriented. In the enabling one, government facilitates private sector innovation through its support of network and partnership initiatives, while in the laissez faire approach it sits on the sidelines. Both governance strategies assume that government is not well equipped to innovate and that the market can ensure that new technologies will be implemented in a way that meets public goals of affordable and sustainable transit. Each approach is also attached to a different public-private split of transit provision going forward. In the leadership approach, the public sector would retain a significant share and serve to orchestrate these new mobility systems. In the enabling and hands off governance approaches, the relevance of public actors in the transit system may decline and some suggest this will have detrimental effects on the sustainability and affordability of transit in the future.

Overall, there is a concern that if agreements are market driven or contractual, with government sitting on the sidelines, the public interest will be neglected because commercial actors are most likely to drive the development toward their own goals, where a primary focus will be on finding

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[2] Gather information to nudge decisions in a particular direction.

[3] Another, and partly correlated, lesson concerns that other public actors at regional and national level need to acknowledge the differences between municipalities.

paying customers. Authors are concerned that public actors at the municipal level do not always understand private actors and their goals well enough (or have the leverage to) to relate them to their own long-term sustainability (public transport promoting) goals (Isaksson *et al*., 2019; Lyons, 2018).

On the other hand, studies argue that ensuring transparent implementation processes involving multiple stakeholders through relational or network driven arrangements can lead to more positive outcomes (Davis, 2018). As part of these arrangements, they see a more significant role for government (in terms of leadership) but argue the goals and strategies of projects should be debated in the public eye and with ample citizen input. Overall, authors see the process of implementing these policies as a way to strengthen municipalities' governance capabilities (Davis, 2018; Pierre, 2019).

With respect to the substantive outcomes that may emerge from such "pro-active and open-minded governance structures," they describe the maximization of "the socio-economic and ecological performance of cities" as an envisaged outcome. In the context of smart mobility, this would mean challenging the primacy of the automobile and expanding non-motorized mobility alternatives, while reducing vehicle congestion in whatever way possible (Davis, 2018).

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# Methods

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The report is based not on an exhaustive list of C/AV, MaaS and digital infrastructure policies or testing and pilots in the case studies, but also on a qualitative assessment of public-policy approaches that deal with the present reality of transportation technology testing and initial service, as well as the longer-term implications of their possible broader adoption. For each case study, we review efforts both at the national and sub-national level, given the multi-level structure of governance networks that impacts the capacity, accountability and efficiency of transportation systems (Marcucci & Stathopoulos, 2012). We begin the results section with an outline of each country's history of transportation governance to set the context and postulate several hypotheses as to how they may shape current developments.

Overall, we find there is often limited consensus in terms of what national or sub-national governments should do regarding new transportation technologies. This is in part since the majority of governments have not carried out planning that considers these emerging challenges. Thus, this report focuses on a minority of public agencies that have proceeded with transportation innovation policy, who can be thought of as "early adopters."

# Results

As mentioned above, it is important to understand the current challenges in governing smart mobility in the context of the histories of transportation governance in each of the case studies. Below, we examine existing governance structures in Canada, the US, Finland, Germany and UK and hypothesize how they may influence ongoing developments in each of the three technological areas this report examines – digital infrastructure, autonomous vehicles and mobility as a service/mobility on demand.

## Canada

Transportation in Canada is a shared responsibility among the federal, provincial, and municipal levels of government. However, the Federal Government has no operational responsibility for the road network nor any authority over driver and vehicle licensing or rules of the road or urban transit. It may, however, use its extensive funding powers, and revenue sources of national direct and indirect taxes, to make financial transfers to all Provinces/Territories for highway infrastructure investments (Lawson, 2015). Provinces are responsible for highway networks and may also use their revenue sources to provide transfers to municipalities, notably for urban transit operations. However, federal contributions are ad hoc, and funding formulas are arbitrary or per capita based, hindering strategic planning.

In this context, many jurisdictions have poorly integrated regional transportation networks, with networks and services often provided by the private sector (rather than Governments) and marked by limited intergovernmental collaboration. Consequently, public transit agencies grapple with complex technological developments individually and with limited funding. The Ontario Chamber of Commerce has observed that transit services in regions such as the Greater Toronto and Hamilton Area (GTHA) are congested, poorly integrated, and have not expanded quickly enough to meet population growth (Kronfli, 2018).

In response, Canadian governments have embraced transit-led planning strategies to solve unsustainable urbanism (Steinberg, 2020). Key planning documents have identified new technologies as part of the solution. In Toronto, the 2041 Regional Transportation Plan (RTP) for the GTHA identified Mobility as a Service as key for optimizing the transportation system (*2041 RTP*, 2017, 37). Similarly, the Montreal Transportation Plan from 2008 encouraged using real-time public transit information to increase mobility (Bista et al., 2020).However, these strategies are frequently adopted in a current political context with a tendency to neglect long-term investment until eco nomic, social, and environmental problems become critical (Bakvis et al., 2009, 226).

### US

In the US, actors at different levels of governance are all working to better understand the opportunities and challenges around the sharing, analysis, and use of data collected as part of on-demand and shared mobility and autonomous vehicle services.[4] At the same time, and similarly to the case of Canada, there are governance obstacles stemming from historical challenges determining the optimal mix of public and private provision[5] as well as long-standing fragmentation in public sector decision making (Winston, 2013).

There is limited, recent literature or analysis of governance within public transit systems in the US (Sciara, 2017). The literature that does exist, focuses on the role of Metropolitan Planning Organizations, which are one of the most prevalent forums for regional planning in the United States, responsible for planning and implementing federal transportation policy at the regional level (Gerber & Gibson, 2009). More than 400 MPOs operate across the country in urbanized areas with populations greater than 50,000 (Sciara, 2017). An MPO's board—composed of city and county officials; federal, state, and local transportation agencies; and other regional stakeholders—approves plans and funding for regionally significant and federally supported transportation improvements. Contemporary MPOs, however, face a range of problems in practice. Their members must approve regionally scoped plans and investments, yet individual agencies and local governments control expenditures and projects, leading to challenges with fragmented governance like those present in Canada. Increasingly, MPOs support less car-dependent and more walkable and bikeable communities, but MPOs cannot control the land use decisions needed to create those communities.

In this context, city governments are taking responsibility for the success of transit operations within their borders (Fischer et al., 2020; Sciara, 2017). Although few, if any, cities have taken direct control of transit operations from authorities, a growing number are making standalone transit plans, adding transit sections to larger transportation plans, taking ownership of new

[4] https://www.fhwa.dot.gov/datagov/dgpfactsheet.pdf

[5] https://www.vox.com/2015/8/10/9118199/public-transportation-subway-buses

modes like streetcars, and entering into joint funding relationships with regional agencies to increase service.

Another emerging trend is toward decision-making processes based at the neighborhood or sub-municipal level given that urban transport, including public transit, has been increasingly relying on decentralized forms of financing, including local option transportation taxes and value capture[6], as illustrated by the Federal TIGER (Transportation Investment Generating Economic Recovery) and the popularity of modern streetcar projects. These forms of sub-municipal financing correlate with sub-municipal governance structures in the form of non-profit organizations and business improvement districts, representing a hyper-localized approach that contrasts with the decades long efforts to develop regional level structures that cross municipal boundaries.

With all these changes ongoing another aspect that has been evolving or been question is the appropriate division of responsibility between the federal and state or local governments in the transportation space. While some state that the "federal government must not encroach into this space as it could inadvertently create significant roadblocks for the deployment of new transportation technologies and erode the agency's spirit of cooperative federalism", others expect a more active role on the part of federal authorities.

## Finland

National policymaking influencing transport in Finland falls under five ministries: Transport and Communications, Environment, Finance, Employment and the Economy, and Education and Culture(Kivimaa, 2014). According to Kivimaa (2014), the Ministry of Transport and Communications is largely responsible for transport systems and networks, the transport of people and goods, traffic safety and issues relating to the environment, giving it significant power of the direction of new technologies.[7]

Municipalities are also important policymakers, having an independent role in land-use and regional transport planning. For example, metro and tram services are municipally owned in Helsinki (Hirschhorn et al., 2019). However, unlike the US and Canadian cases, there is more significant regional coordination. For instance, ticketing for public transport has been fully integrated in the Helsinki metropolitan area since the 1980s (Hirschhorn et al., 2019). Since 2010, the Helsinki Regional Transport Authority (HSL) has been responsible for planning and overseeing PT in the Helsinki metropolitan area, which includes the city of Helsinki, Espoo, Vantaa, Kauniainen, Vantaa, Kerava, Sipoo, Kirkkonummi, Siuntio and Tuusula (Hirschhorn et al., 2019). HSL is also responsible for determining PT fares, developing service plans, and setting routes and timetables (Hirschhorn et al., 2019). Helsinki's integrated PT system has enabled the development of smartcard and mobile app ticketing system across the Helsinki

[6] This trend has coincided with an increased focus on the local economic development benefits of public transit

[7] The Ministry of Employment and the Economy oversees competitiveness and vehicle-related energy issues, the Ministry of Finance of taxation, the Ministry of the Environment of regulation of transport fuels and the Ministry of Education and Culture of training of professional heavy-duty vehicle drivers.

metropolitan area (Hirschhorn et al., 2019). There are both public and private public transport providers across Finland—with Finland's railway being controlled by the national government and the state-owned company VR Group, while the bus market is liberalized, with around 84 privately-owned bus operators (Lakatos & Mándoki, 2020).

Although HSL manages an expansive transit network, they have had a lesser role in steering the future of Helsinki's transport sector. Instead, public actors at the national level have taken a top-down approach to steering the future of transport and have clearly identified the role for private sector innovation. The Finnish Ministry of Transport and Communications (LVM) and the Finnish Transport Agency (FTA) have been the primary advocates for deregulating transport markets and creating an enabling environment for private sector innovation in the transport sector. Additionally, Business Finland has provided numerous funding opportunities for private actors seeking to innovate in the transport sector. Following the enactment of the Act on Transport Services in 2018, transport operators have been required to provide timetable data and an API is available for third-party use (Pangbourne et al., 2020). However, it is evident that HSL's existing scope of governance (since 2010) has been an ideal foundation for enabling innovation in niche sectors like MaaS.

### Germany

Unlike countries such as Canada, which lack dedicated federal public monies for transportation projects, the German federal government has provided dedicated funds to state and local governments for public transportation capital investments since the passage of the Federal Municipal Transport Finance Law (GFVG) in 1967. Originally, 60 per cent of GVFG monies were used for local road projects, but over time the ratio shifted in favor of public transportation as more road funds became eligible for public transportation and local governments gained more flexibility to decide how to use the money.

In Germany, governance arrangements for transportation vary according to the mode of transport. For instance, federal railways and air transport fall under the scope of federal jurisdiction, while regional and local public transport (e.g., bus, trams, metro, regional rail) fall under the scope of the provinces or Laenders' jurisdiction (Fichert, 2017). In German cities, most forms of public transport are state-owned—this is the case in Berlin, Hamburg, Leipzig, and Munich (Fiorio et al., 2013). Although there are many different public transport providers and modes of transport within cities, regional public transport associations, called Verkehrsverbund (VVs), allow for coordination and integration of regional PT networks. Hamburg (HVV) was the first region to trial the VV model in 1967, and the success of HVV quickly led to the emergence of VVs across Germany (Buehler et al., 2018). Stakeholders in VVs include PT operators and government representatives, who cooperate and collaborate on decisions. In large VVs such as in Berlin-Brandenburg (VBB), Munich (MVV), and Hamburg (HVV), governmental jurisdictions have a leading role on the governing boards of the VVs (Buehler et al., 2018).

Unlike public transport authorities in Helsinki (HSL) or London (TfL), VVs are responsible for coordinating collaboration between public transport operators (Buehler et al., 2018). Additionally, VVs integrate all public transport modes and operators so that fares, schedules, and ticketing schemes are coordinated under a unified system (Buehler et al., 2018). In addition, many large VVs often have car-sharing or bike-sharing stations (publicly and privately operated schemes) adjacent to their U-Bahn or S-Bahn station, which allow for seamless multimodal mobility (Buehler et al., 2018). Further, many VVs have partnered with private mobility providers to offer discounted user fees—this pre-existing system of collaboration may have enabled PT operators to introduce new mobility schemes like MaaS in Germany.

### UK

Scholars have noted that the decentralized decision-making process has led to challenges in transport policymaking and data collaboration (Akyelken et al., 2018; Gupta et al., 2020). In the UK, transport markets have been deregulated since the enactment of the Transport Act in 1985, except for the metropolitan regions of London and Belfast (Fiorio et al., 2013). Public transport is highly deregulated in cities like Cardiff, Glasgow, and Newcastle, with many PT providers across the public and private sectors (Fiorio et al., 2013). In London and Belfast, public transport is partially deregulated—there is just one PT provider in Belfast, and one transport authority in London (Transport for London) overseeing many PT providers across the public and private sectors Fiorio et al., 2013). In the case of London, full deregulation was avoided in order to avoid increased traffic congestion, and to better enable coordination across different modes of transport (Fiorio et al., 2013). As a result, transport planning in London is distinct from the rest of the UK.

### Implications

The literature would suggest that decentralized governance structures in Anglo-Saxon countries, with limited inter-governmental coordination and collaboration, may be less likely to successful implement new technologies on a larger scale given more adversarial relationships between public and private actors and siloed transportation organization. On the other hand, Finland and Germany may be better positioned to define the goals of and facilitate partnerships, which the literature suggests is necessary for the implementation of new technologies in a way which benefits public transport goals. Finally, Finland and Germany also have more favorable land use and automobile-restrictive policies that make car use less attractive and encourage public transportation ridership, making it more likely that new transit technologies will make car use less appealing (Buehler, 2009).

# Digital Infrastructure Governance

Developing a robust data infrastructure is key to regulating new C/AV or MaaS mobility options to ensure they help meet public goals (e.g., integrated transport). In the words of Seleta Reynolds, general manager of the Los Angeles Department of Transportation, governments must "put rules in place to prevent walled gardens or monopolies - where providers create their own closed ecosystem and don't share data and information with others . . . and ensure that there is some public accountability once people grow dependent on those services" (Goldsmith & Leger, 2020). In the absence of these measures, cities lose control of traffic in their cities. For instance, Waze can decide where to route vehicles and overrun some neighborhoods with rush hour traffic, damaging street infrastructure and disrupting livelihoods.

Governmental authorities can explicitly adapt a broad range of regulatory levers to manage connected mobility marketplaces more effectively, while at the same time leveraging the data from these modes to inform public service delivery and improve public outcomes (e.g., using trip data from dockless scooters to inform bus route planning and improve transit access). This is a challenging task because many governments are not accustomed to data-oriented planning (i.e., data across departments/municipalities is not synchronized or regularly shared to enable region wide transportation coordination).

At the same time, however, the introduction of deep neural networks – or black boxes – in transportation planning makes the need for including civic organizations and individual citizens early in the process particularly acute. In the absence of civic participation, the accountability structures that surround data platforms in cities (e.g. MDS in LA) may become unclear. This might make it uncertain who has power in this new, quasi-open environment, and whether that individual is responsive to community needs. In other words, as new technologies are deployed in a context of structural inequality, it is not at all certain that, absent community participation, 'smart mobility' tech will, in fact, produce the equitable cities they propose to.

The following sections reviews the level of preparedness in the five comparator countries. We examine the extent to which governments have been able to build up governance capacity (e.g., the introduction of laws and regulations that “integrate detailed location data on roads, signs, traffic lights, and other control mechanisms for C/AV or MaaS operators to use).

## Canada

The academic literature on digital infrastructure governance in Canada is limited. Most insights presented in this knowledge synthesis report come from national and municipal digital infrastructure plans or reports, as well as a limited number of interviews conducted with relevant officials.

### National Level Actors

Research on digital government in Canada has focused on how the public sector should be reimagined for a digital age—by becoming more “horizontal, entrepreneurial, data-driven, and user focused” (Clarke, 2020). According to Clarke (2020), the literature has examined the “barriers that prevent these digital era reforms from being implemented and laments the bureaucratic risk aversion, dated legal and policy instruments, and skills gaps that prevent governments from modernizing into competent, digital-ready organizations that satisfy the expectations of their digital citizenry” (p.100). In line with this, the federal government has established new senior leadership roles, such as deputy minister-level chief digital officers and ministers of digital government and started initiatives such as the Smart Cities challenges (some of which are focused on mobility).

However, questions of data governance, including those covering how such data would be used by governments or private actors and/or privacy infringements (especially in the context of transportation) have not been covered in any detail in the literature (Clarke, 2020, 2021). As a result, this review relies on information from white papers, presentation, and interviews with federal government officials.

The most relevant national level program dealing with mobility-related data governance in the Canadian context is the Program to Advance Connectivity and Automation in the Transportation System (ACATS). Initiated in 2015, ACATS is a five year initiative launched to help Canadian jurisdictions prepare for the technical, regulatory and policy issues emerging as a result of connected and autonomous vehicles (C/AVs), a significant part of which are issues of data governance (*ACATS Funded Projects 2018 -2021*, 2021). The program is three pronged: of the $10 million total about $3 million was allocated to grants and contributions for 15 C/AV demonstration and research projects, another $2 million to contracts with companies that help government understand new technologies and their potential, and the remaining $5 million to hiring new staff as part of ACATS to be able to build up some new capacity in the space (meaning for salaries).

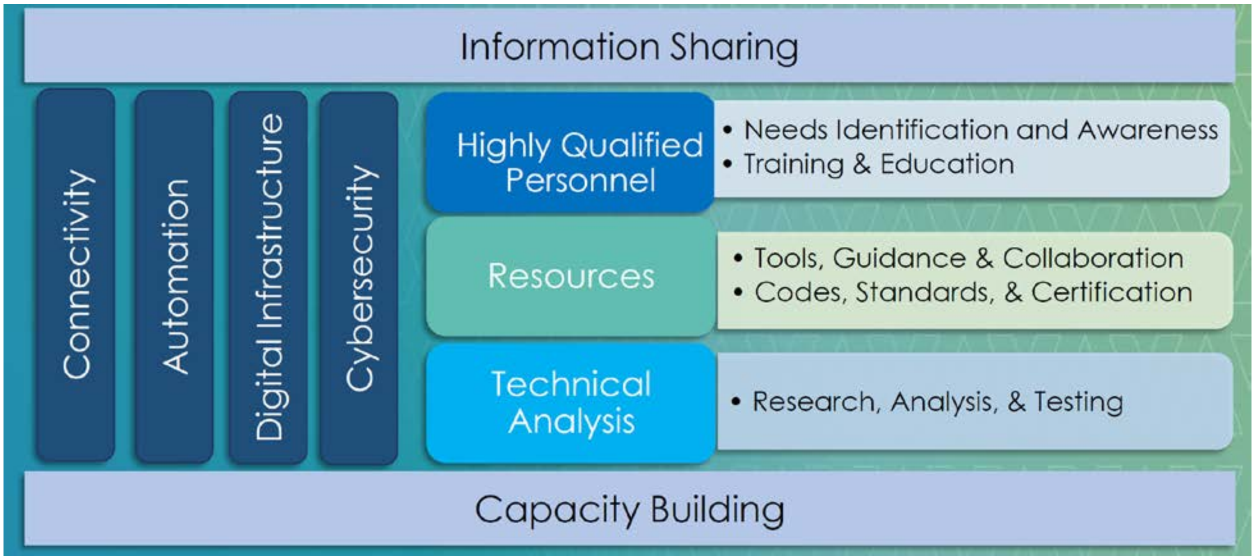


**Figure 1**. ACATS Program Overview (as shown in an ACATS report)

This program represents a continuation of Transport Canada's (TC) role in transportation, which has historically been around vehicle safety (e.g., vehicle safety systems, hours of service, inspection, infrastructure), which they now see as potentially compromised. In line with this focus on safety, one of the main pillars of ACATS activity is developing capabilities (both at the national and sub-national levels) related to digital infrastructure and specifically helping municipalities determine how to integrate or share new data without compromising its integrity or introducing a privacy risk. The focus is on working to better understand the opportunities and challenges surrounding the sharing, analysis and use of data generated by AVs.

In TC's view, new forms of data sharing with private entities open significant challenges or cybersecurity risks because legacy systems at the local, municipal and provincial level were built to be closed. Because of this, TC has made efforts to build expertise in the digital infrastructure space through contracts with companies. For example, ACATS contracted ESCRYPT to develop the SCSM[8] standard for cybersecurity, meant to help ensure that connected vehicle communications are secure and can be trusted by incorporating privacy-by-design principles, and enabling communication without revealing personal information about the vehicle or the driver. At the same time, however, ACATS doesn't provide guidance as to who should be implementing this standard in the Canadian context. ACATS also partners with non-profit organizations like the Transportation Association of Canada (TAC) to identify digital (and other skills gaps) in

[8] https://www.canada.ca/en/transport-canada/news/2019/03/transport-canada-awards-contract-to-escrypt-to-enhance-the-privacy-and-security-of-connected-vehicles.html

highway authorities, which can then be used to build a program that connects university grads with positions in government.

Further, there is little to no focus on issues of data sharing between public and private stakeholders, in part because of limited resources and no plans to extend the program once its five-year term ends in 2021. This leaves provinces and municipalities on their own when it comes to issues of data governance beyond cybersecurity. Other actors that operate on a national level include some non-profit organizations, such as the TAC. However, they are a voluntary organization that depends on members for funding and are only now beginning to consider the role of new technologies in evolving mobility systems.

### Regional/Local Actors

Individual provinces have all taken somewhat unique approaches to the issue of digital governance, with a first step often being launching a digital strategy—to guide the work of public servants and contractors who are designing, developing, and delivering digital services (e.g., Simpler, Faster, Better Services Act (2019) in Ontario). In some cases, the strategy is implemented by newly established government organizations (e.g., Ontario Digital Service), while in other provinces existing Ministries (e.g., BC's Ministry of Citizens' Services) assume the role.

As in the case of the federal government, the focus remains on open data, with less attention paid to data governance challenges. Oftentimes, strategies have multifaceted goals, but at the core of each is to encourage actors across government ministries to collaborate to share and procure data. In other words, the goal is to try to encourage organizational innovation by working across existing silos. These digital units often help provincial ministries of transportation as they consider how to manage and share data both internally, and with external stakeholders (interview). There is limited work exploring the internal operation of these digital units, but interviews suggest they are often overstretched as they try to work across ministries and develop whole of government strategies for non-transport related challenges.

Ministries of Transportation at the provincial level are also working on their own to develop new approaches for data governance. For instance, the Ministry of Transportation in Ontario developed a new governance committee that brings actors from across the ministry to work together on how to share data between departments,[9] procure data jointly rather than independently and share it with the public (i.e., open data). More fundamentally, however, interviews suggest establishing a data role for the Ministry would require developing data literacy across the board and an understanding among officials about why they should care about data. Because of this lack of awareness or purpose when dealing with data, open data policies are often supply-driven and not based on the wishes and needs of users, at least, not citizen users. Another barrier to overcome is the Transportation Ministries' historical role, which has always been to pay attention to data generated from highways (and not on municipal roads). It is not clear whether going forward provincial ministries will take on new responsibilities (e.g., helping

[9] Which would require them to put in place core capabilities to catalogue data in information platforms and ensure access (through self-serve analytics) and quality across departments.

with data standardization on municipal roles) or whether data governance will continue in a decentralized fashion.

Municipalities and regions have also been active in publishing reports that outline their role in the evolving transportation ecosystem.[10] As in the case of the provinces, there are challenges in aligning open data policies with the needs of citizens or even establishing a clear transport-related goal for their sharing. However, municipalities, particularly Toronto, have been more involved with data governance issues, partly due to the controversy that emerged around Sidewalk Labs. Over the two and a half years of its existence, the project was at the center of successive controversies relating to its proprietary approach to personal data (Artyushina, 2020). Following the project's cancellation, the City of Toronto continues to develop the city's digital infrastructure plan, although it is unclear how it sees its role in the emerging digital mobility ecosystem.

It is only in the case of Translink, the regional transit authority in Vancouver, where the organization seeks to open up data with an express public goal of providing cities with information for setting policy, instead of simply enabling innovation among businesses (Wolff et al., 2019). In the case of Ontario, open data is driven by municipalities themselves, without an overarching shared goal among them. One example is York Region's efforts to establish a data co-op, comprised of 9 municipalities, to share data and benefit from the collective investment in GIS technology, data, and people.[11] However, they have not been able to get other municipalities or regional transportation agencies (e.g., Metrolinx) on board. This is partly due to a lack of provincial and federal guidelines as to how cities should be sharing their data to integrate public and private transportation modes more accurately.

This difference could be a result of the variation in transportation governance structures between provinces in Canada. For example, while in the case of Vancouver's Translink, the board responds to a council of mayors for the region, Ontario's regional transit body, or Metrolinx reports to the province. Although it serves as a valuable resource, it does not drive collaboration between municipalities in a meaningful way. Nonetheless, it is still not clear whether Translink will go about implementing these plans.

Overall, there is limited to no academic writing on the emerging data governance structures across different levels of governance capacity. However, white papers, city reports, and interviews provide some insights into emerging governance changes across provinces in Canada. Efforts at multi-level governance, which would be necessary for the development of a comprehensive data strategy are limited, with provinces and municipalities often being left to their own devices to serve an enabling role for private innovation. Further, subnational authorities (including transit agencies) are often focused on issues of open data, with active efforts at data governance being more limited.

[10] https://www.toronto.ca/city-government/accountability-operations-customer-service/long-term-vision-plans-and-strategies/smart-cityto/digital-infrastructure-plan/

[11] Link to York region's Data Analytics Master Plan and other data: https://www.arcgis.com/home/group.html?id=65ccd969ecd34ad48baeefe5e3ab1183&view=list&start=1&searchTerm=Reports#content

## US

### National level actors

As of yet, the US has not established a comprehensive national strategy tackling issues of privacy or data use concerns. Like in the case of Canada, the focus has been on digital government transportation. Congress has directed the federal highway administration (FHWA) to improve data collection, management, and transparency.[12] However, the data collection standards developed at the national level primarily concerns actions within public organizations and have little to do with establishing data-sharing guidelines for private actors. For example, Section 1203 of the Moving Ahead for Progress in the 21st Century Act (MAP-21) calls on FHWA to collect and maintain standardized data to carry out performance-based assessments of transportation projects. FHWA senior leadership created the Data Governance Advisory Council to develop a corporate data management approach to address these internal and external concerns.

To inform its role, the Federal Highway Administration (FHWA) is working with the State Departments of Transportation (DOTs) and the National Academies of Sciences, Engineering, and Medicine (NASEM) to conduct research and direct the implementation of technologies and innovations. As a product of these interactions, the FHWA developed the informational Guide for State, Tribal, and Local Safety Data Integration, which recommends a nine-step process to help public transportation agencies improve their data safety capabilities through strong communication and partnerships (Scopatz et al., 2016). A voluntary data specification has also emerged out of NASEM's Transportation Research Board.[13] The specification is meant to enable multiple organizations to manage a passenger's entire trip cycle, from trip request to trip delivery, with all necessary data— assuring access to all the details that successful coordination among organizations depends on. At the same time, however, there is no clear information regarding how a state-level department of transportation or MPO should be funding or implementing these guidelines (Green & Lucivero, 2018).

### Regional/Local[14]

Despite lack of guidance from federal level authorities, reports suggest some states in the US are creating data governance policies that mandate all transportation agencies to create a chief data officer position not within their IT departments to reduce data silos across the organizations (*Data Governance: Ohio's People, Processes, and Technology*, 2020). However, there is often a lack of coordination between transportation agencies, making it difficult to use data to optimize transportation system performance in a meaningful way. While MPOs are supposed to serve as a hub for local political and administrative authorities to develop a unified regional vision and plan, they often lack the funds or power to do so. State DOTs, cities, counties, and transportation

[12] https://www.fhwa.dot.gov/datagov/

[13] The Transportation Research Board (TRB) is one of seven program units of the NASEM; and one of the key agency that provides independent and objective analysis and advice to regarding the implementation of new technologies

[14] https://rosap.ntl.bts.gov/gsearch?collection=&terms=data+governance

agencies largely control federal, state, and local funds for regional projects, shaping project scope, location, and implementation. Local officials may favor projects delivering local benefits (Bond & Kramer, 2010; Gerber & Gibson, 2009), and cities with local transportation tax funds have still more room to advance local projects (Crabbe, Hiatt, Poliwka, & Wachs, 2005).

However, unlike in the case of Canada, we see more multi-level governance efforts to standardize and share transit data both between public, but also between public and private actors. Studies document efforts on the part of some regional transit agencies to set up data fusion efforts across counties, as in the case of the Central Ohio Transit Authority.[15] In other cases, and specifically, when it comes to the development of new public-private governance forms, it has been the state leading the efforts, along with cities. For example, the Los Angeles Department of Transportation (LADOT) has developed the MDS, which is the open-source data specification for digital communication between the public entities that manage streets and sidewalks and the organizations that use them to provide transportation services (including private operators). In turn, the standard is managed by the Open Mobility Foundation created by the City of Los Angeles, Austin, Chicago, New York, and San Francisco.[16] Uber launched a suit against MDS (in June of 2020) on privacy grounds. The federal suit sought to end the use of the Mobility Data Specification (MDS) to regulate private mobility companies and manage the public right-of-way in Los Angeles. However, courts dismissed the suit, underscoring the legal validity of both the MDS and the role the LA Department of Transportation and cities across the US play in managing the public right of way.[17]

## Finland

### National

At the national level, public sector actors in Finland recognized the need to broaden the scope of transport governance and pursue data-oriented planning as early as 2009 (Lajas & Macario, 2020). Studies have suggested that Finland's national government is taking a "Promoter" role, actively using hard policy instruments to create an enabling environment for smart mobility innovations (Mukhtar-Landgren & Smith, 2019). An institution that stands out in the literature is the Finnish Ministry of Transport and Communications (LVM), a key driver of Finland's Intelligent Transport Strategies (Lajas & Macario, 2020). In terms of privacy legislation, Finland relies on the EU General Data Protection Regulation (GDPR), which is the central regulatory framework that guides how personal data must be handled across all EU member states (Ellner et al., 2018).

[15] The data would run on a platform set up by the startup Waycare, which made a name for itself in the Las Vegas area helping transportation officials predict when and where traffic collisions were likely to occur.
[16] It is used by more than 120 cities around the world to plan transportation infrastructure, support and regulate shared mobility services, and advance the goal of a safe, equitable, sustainable transportation system.

[17] https://cities-today.com/us-court-dismisses-lawsuit-against-las-mobility-data-sharing-requirement/

In 2009, LVM introduced the 1st Intelligent Transport Strategy, leading an administrative reform of transport. This strategy transformed the common narrative of transport by expanding the scope of transport administration from individual modes of transport to a more holistic and customer-oriented approach to transport (Lajas & Macario, 2020). In 2013, LVM unveiled the second Intelligent Transport Strategy, advancing projects in real-time data collection, processing and distribution, open data, and integrated public transport (Lajas & Macario, 2020).

LVM's efforts to expand the scope of transport governance and mandate data sharing across actors in the transport sector was realized in 2018, following the enactment of the Act on Transport Services (Pangbourne et al., 2020).[18] Under the Act, incumbents and new entrants to the transportation market are required to provide their operational data and single tickets for third-party resale (Lajas & Macario, 2020). The Act on Transport Services has two key objectives: the first is to "lower permit requirements and tear down silos between transport markets through deregulation (e.g., lowering taxi permit requirements)"; and the second is to "enhance the use of open and interoperable data interfaces by making the provision of open data and single tickets from APIs from transport service providers to third party operators mandatory" (Lajas & Macario, 2020).

### Regional/Local

At the regional level, it is unclear whether the Act on Transport Services enhances governance capacity for municipal authorities. Following the enactment of the Act on Transport Services, the Helsinki Regional Transport Agency (HSL) developed an operational contract that enables MaaS operators like MaaS Global (creator of the mobile application, Whim) to freely use HSL's timetable and real-time data, route and disturbance information, and an open interface journey planner (Mukhtar-Landgren & Smith, 2019). The contract also enables MaaS operators to resell HSL's single adult tickets (Mukhtar-Landgren & Smith, 2019). However, individual MaaS operators are responsible for determining their own pricing scheme and controlling the data that is processed through their services (Mukhtar-Landgren & Smith, 2019). While the contract indicates that MaaS operators *should* share non-personal travel data with HSL, the extent to which MaaS operators share their data with HSL has not been specified in the literature.

Despite efforts at the national level to facilitate data sharing, the long-term effect of the Act on Transport Services remains unclear. Finnish policy documents suggest that encouraging data sharing and utilization is a priority for Finland, and highlights opportunities for private sector innovation. However, there is a gap in the literature that examines the effect of the Act on Transport Services has on public sector authorities at the municipal level. While HSL's operational contract provides an opportunity to increase transparency across local PT operators and private MaaS operators, it remains unclear whether municipal authorities are benefitting from this partnership. There is a lack of follow-up studies examining whether how national-level efforts to enable private sector innovation are impacting the governance capacity of municipal-level authorities.

[18] First called the "Transport Code" in 2017.

## Germany

### National

At the national level, Germany has taken a leadership approach to data regulation and has gone further than Finland and the UK to ensure individual autonomy over personal data, and to expand the scope of data governance. In addition to the GDPR, Germany's Federal Data Protection Act (BDSG-new), enacted in 2018, goes further to specify rules for data processing that apply to both the public and private sectors (Hilberg, 2017). In 2017, Germany revised its Road Transportation Act (StVG) to enable C/AV testing in real traffic (Kouroutakis, 2019). The StVG outlines legal liability in the case of accidents and defines the characteristics of autonomous vehicles. Kouroutakis (2019) writes that the StVG defines autonomous vehicles as vehicles that are equipped with the following characteristics:

> [F]irst with full control of the driving task, second capable of conforming to traffic regulations in full automation, third that allow the driver to manually override or deactivate the automation at any time, fourth with the capacity to recognize that it is necessary for the driver to take full control and deactivate the automation, and finally with the visual and acoustic tactual indication that the driver shall take control with sufficient time for the driver to take control, and finally with the capacity to indicate wrong use to one of the system descriptions. (p. 11, 12)

The StVG also mandates all manufacturers to equip all C/AVs with black box recording systems to gather data and help determine liability in the case of collisions (Kouroutakis, 2019). Regarding data protection measures, the StVG limits the duration of data storage on black box recording systems to up to six months (Kouroutakis, 2019).

Furthermore, Germany was the first country of the European Union to develop a national Ethics Commission in 2016 to guide the ethical development of autonomous vehicle technology (Herrmann et al., 2018). In 2017, the Ethics Commission released 20 ethical guidelines for AV development (Mladenović et al., 2020). For instance, ethical guidelines state that algorithms used in C/AV technology may not determine the value of lives based on individuals' data in the chance of an unavoidable accident (Mladenović et al., 2020).

### Regional/Local

In Germany, municipalities are largely responsible for managing and governing open data. Individual provinces have a broad scope of governance and lead large-scale smart-mobility initiatives, which clearly indicates that municipalities in Germany have a greater scope and capacity for governance than municipalities in Finland.

In the case of Berlin, open data has been a municipal-level responsibility since the enactment of the Berlin E-Government Act (EGovG Bln) in June 2016 (State of Berlin, Senate Department for Economics, Energy and Public Enterprises, 2021). Prior to the Berlin E-Government Act, publishing data on the Berlin Open Data portal was voluntary (State of Berlin, Senate Department for Economics, Energy and Public Enterprises, 2021). The ordinance on §13 EGovG Bln mandates that all authorities of the Berlin administration publish the data they collect or process in machine-readable formats onto the data portal. Additionally, §13 EGovG Bln outlines detailed information such as: authorities that are obligated to publish data; types of data authorities are required to publish (e.g., statistics, Geodata, budgets); restrictions to publishing data (e.g., personal data, publication that would violate copyrights); and which format data should be published in.

Public authorities that publish data to the portal include the Verkehrsverbund Berlin-Brandenburg (VBB)[19], a transport association consisting of PT providers in Berlin and Brandenburg (Berlin Open Data, 2021). The VBB regularly provides bus and train timetable data in GTFS ("General Transport Feed Specification") format which can be accessed through the Berlin Open Data portal. The data sets include timetable data, stop information, and color values of the lines from Berlin and Brandenburg. The VBB also provides API with timetable information, which can be accessed upon request from VBB.

Similarly, the City of Hamburg has taken its own initiatives to develop digital infrastructure and determine standards for data management and sharing. In April 2016, Hamburg's Senate passed the Intelligent Transportation Strategy for Hamburg (ITS-HH) which aimed to coordinate the development of infrastructure and determine standards for data management and sharing (Späth & Knieling, 2019). The objectives of the strategy were to "improve transport safety; reduce environmental impacts of transportation; improve reliability and efficiency; support good and safe data collection and exchange of information, foster innovations". The strategy promoted an experimental approach to governance, emphasizing the need for close public-private collaboration, and supporting the implementation of pilot projects to test the viability of innovative developments in broader applications. The Senate invested €1.85 million for the testing phase of ITS-HH. The strategy identifies eight fields of action: data, innovation, information, intelligent traffic control, intelligent infrastructure, intelligent parking, MaaS, and intelligent vehicles.

In 2018, Hamburg launched its open data platform called the Urban Data Platform Hamburg (European Union's Horizon 2020, 2020). The Urban Data Platform integrates spatial data from different domains such as social, energy, mobility infrastructure, mobility, logistics, transportation, and economy. In contrast to public entities, however, private sector companies or individuals are not obliged to share or publish their data (Wagner et al., 2021). Instead, they negotiate data sharing arrangements via contractual agreements based on the GDPR. Those sharing arrangements are then assessed via public data protection agencies such as the Berliner Commission for Data Protection and Freedom of Information (2020) (DPA) to ensure individual data protection.

## United Kingdom

### National

At the national level, the UK has been taking a combination of leadership and enabling approaches to governing digital infrastructure. The DfT is the main national-level government

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[19] In Germany, regional public transport associations, called Verkehrsverbund (VVs), are responsible for coordinating collaboration between public transport operators with various levels of state jurisdictions (Buehler et al., 2018). Unlike regional public transport organizations in other countries, VVs integrate all public transport modes and operators so that fares, schedules, and ticketing schemes are coordinated under a unified system. In large VVs such as in Berlin-Brandenburg (VBB), Munich (MVV), and Hamburg (HVV), governmental jurisdictions have a leading role on the governing boards of the VVs (Buehler et al., 2018).

agency responsible for delivering transport-related policy and funding (GOV.UK, 2014). Numerous government institutions have developed standards for smart cities addressing issues such as data and information security, including the British Standards Institution (BSI) and the Centre for the Protection of National Infrastructure (CPNI) (POST, 2021). In 2018, BSI published a publicly available specification (PAS) to provide a framework for a security-focused approach to smart city development called PAS 185:2017 (BSI, 2018). Commissioned by the CPNI, PAS 185:2017 was developed for use by public and private actors involved in smart city initiatives, with details on how stakeholders can develop and operate smart city initiatives while ensuring the security of citizen data and information (CPNI, 2021). In 2016, the UK created the National Cyber Security Centre (NCSC), which is a government agency that shares cybersecurity knowledge with SMEs. NCSC has also published various documents that complement the smart city and cyber security guidelines produced by CPNI and BSI, such as the Connected Places Cyber Security Principles, Cloud security guidance, and the Cyber Assessment Framework (NCSC, 2021).

In addition to setting standards and guidelines, Innovate UK, the UK's innovation agency, has funded numerous smart city initiatives across the UK since 2012, which include feasibility studies and pilot projects (POST, 2021). In 2012, Innovate UK invested a total of £34.5 million towards feasibility studies across 30 cities in the UK and a pilot project in Glasgow for the smart cities' competition. In 2013, Innovate UK created the Connected Places Catapult, which is a state-owned innovation accelerator that supports public and private innovation in the transport and smart city sector (POST 2021; Catapult, 2021). In 2015, Innovate UK delivered £10 million to Manchester for its smart city project called CityVerve (POST, 2021).

Like Germany, the UK has supported smart city projects across the country through public investment and the development of guiding principles. While the UK is taking an experimental approach to smart city initiatives, guidelines and principles published by various government institutions highlight greater emphasis on security and efforts to steer private sector innovation, which is less evident in Finland.

### Municipal/Regional

In many regions across the UK, a common goal of municipal authorities has been to promote public sector data sharing and remove sectoral silos. Many metropolitan regions have received funding from Innovate UK to pursue large-scale smart city pilots, and data sharing and collaboration have been a central theme across numerous projects. Like municipalities in Germany, many municipalities in the UK have developed their own city-wide data platforms.

#### London

At the municipal level, the Greater London Authority (GLA) has taken a leadership approach in its efforts to encourage city-wide, cross-sectoral data collaboration. The GLA is London's main administrative body that oversees 33 local government bodies of the London Boroughs, as well as functional bodies like Transport for London (TfL) (Gupta et al., 2020). The GLA runs the London Datastore, which is an open government data portal, and a key data asset in London's data ecosystem. Initially launched in 2010 and revamped in 2014, the datastore publishes datasets that are specific to London and summary statistics that inform policymaking at the GLA (Gupta et al., 2020). Additionally, the GLA has been creating strategies, roadmaps, and pilot projects to coordinate city-wide data collaboration.

Further, cyber security has been an important topic at the municipal level. In 2015, the Mayor of London, the City of London Police, and the Metropolitan Police Service, launched a joint venture called the London Digital Security Centre (LDSC) (Greater London Authority, 2018). The LDSC was created in order to aid small and medium-sized enterprises (SMEs) against cyber threats (PDSC, 2021). In 2018, the LDSC became the Police Digital Security Centre (PDSC) and broadened its scope to take on a national lens. Nevertheless, the creation of the LDSC highlight the proactive approach municipalities in London have taken to improve cyber security among SMEs (PDSC, 2021).

Manchester

Municipal actors in Manchester have also been working towards breaking down sectoral and national silos. In 2016, the Manchester Combined Authority launched a data sharing authority called GM-Connect in order to promote public sector data sharing (RAENG, n.d.). Additionally, between July 2016 and July 2018, Manchester took part in a smart city project funded by Innovate UK called CityVerve (RAENG, n.d.). The central objective of CityVerve was to remove silos by creating an overarching platform to unify existing data platforms. The project was led by the Manchester City Council, along with Cisco, the leading private partner responsible for working with other technology firms. The University of Manchester was also an important stakeholder, responsible for project evaluation. The four pillars of the project were: "transport and travel, health and social care, energy and the environment, and culture and the public realm" (Gledson et al., 2018). Cisco developed an overarching platform that connects data from numerous data platforms (e.g., transport data and environmental data from the BT CityVerve Data Hub, anonymised health data from the DataWell hub, and data on physical assets from the Asset Mapping hub) (Gledson et al., 2018).

Glasgow

Authorities in Glasgow have also been actively engaged in smart city projects, taking a leadership approach to create the digital infrastructure required to enable private sector innovation. In 2012, Innovate UK awarded the Glasgow City Council (GCC) with £24 million from to carry out its proposed city demonstrator project (POST, 2021). The 'Future City Glasgow' programme took place between February 2013 to August 2015 and was led by the GCC (Leleux & Webster, 2018). The project included various components such as: the development of the Glasgow Operations Centre, an integrated traffic management system that bridges public space CCTV, traffic management, and police intelligence; the creation of a City Data Hub, a big data platform that gathers open datasets across sectors; and support for various pilot projects in the areas of active travel (e.g., the development of cycling and walking travel apps), social transport, intelligent street lighting, and energy (Future City Glasgow, 2021; POST, 2021; Leleux & Webster, 2018). While Future City Glasgow was led by the GCC, there were numerous stakeholders engaged in the project, including the University of Glasgow, Microsoft, and other SMEs (TSP, 2014).

Despite increasing efforts by the national government to develop standards for smart city initiatives, a research briefing published by the Parliamentary Office of Science and Technology in 2021, explains that many smart city pilots are unable to scale in real-world settings (POST, 2021). One reason is that pilots are often receive temporary exemptions from legal regulations but must comply with real-world regulations following their initial pilot phases (POST, 2021). There is a gap in the literature covering the types of pilot projects that have successfully carried over into real-world settings, and specific policy or regulatory challenges firms face in scaling up.

### Cross-country comparison

When it comes to AVs, issues of data governance seem to be more comprehensively tackled in Germany compared to the cases of Finland, Canada, the US, and UK, where the focus is largely on cybersecurity, recognizing challenges related to data theft and hacking. Contrary to the Finnish, UK, US and Canadian approaches, German governance culture has taken a more "control-oriented approach regarding data access and processing"(Mladenović et al., 2020). Despite the acknowledgment that a federated structure might spur innovation, German authorities are introducing legislation to ensure consistency across the board. Like the GDPR legislation, German authorities define personal data as any information with the slightest relation to an individual. As such, their regulation emphasizes complete transparency and drivers' full authority when it comes to data (Mladenović et al., 2020).

However, when it comes to data generated from mobility on demand and 'mobility as a service' solutions, there is a governance void across the board, with some exceptions.[20] The focus is on public entities opening their data sets, while the same onus isn't placed or strictly enforced when it comes to private entities. These consequences include the data subject neither understanding where their individual data is located, processed, and used, nor having any control over it.

According to Wagner (2021), the only reasonable reaction to this state of vulnerability is "either resignation (in the form of giving consent without reading data privacy statements) or to mistrust the institutions involved in providing smart mobility solutions and to minimize further data availability." The work argues that in Europe, this mistrust is amplified because US-based institutions provide many building blocks of smart mobility, and their usage requires personal data to be transferred to the US—a country with far less protective regulation on data privacy. Overall, there is a need for the academic literature to examine how private actors can be better regulated across the case studies.

# C/AVs

Across the board, authorities have taken an enabling approach to governing C/AVs, meaning they've created opportunities for the private sector to take the lead and innovate (often framing it as an economic development policy). Nonetheless, there are efforts to take more of a leadership (or mediating role) as cities have experienced backlash to their economic-development oriented strategy. Even though there are initial signs of reflection on unanticipated and undesired consequences, there is less experimentation or discussion about the political obstacles to policies that would be necessary to regulate the impact of C/AVs, or ensure they do not further car-dependence and undermine transit on the long run such as: 1) reducing minimum parking required for new developments (with exception of states like Arizona, which have mandated reducing parking requirements by up to forty percent and encouraged passenger loading zones as drop off and pick up locations for autonomous vehicles and ridesharing (Shao, 2020) or 2)

[20] This is the case with the Transport Act in Finland, for example, which sets clear rules for data sensing and sharing in the mobility sector (Ministry of Transport and Communication, 2018).

reducing curbside parking and 3) Transforming car lanes into space for pedestrians and bicyclists,

Further, the dearth of rules regarding the collection of data from AV companies (in cases other than Germany) also prevents policy makers (at different levels of governance) from having a much more nuanced understanding of how the technology works or better comparing AVs from different firms. This is problematic because it puts the automotive industry in the front seat, and the car industry is presenting driving automation as an innovation with the potential to restore the vitality of the private vehicles market while creating effective means to dismiss alternatives to car dominance. This is a particular challenge for the US and Canada where land use is planned around the car.

## Canada

### National level actors

In 2018, Canada was ranked 7th behind the Netherlands, Singapore, United States, Sweden, United Kingdom, and Germany on KPMGs autonomous vehicle readiness index. In 2019, it slipped five places to 12th place (and stayed there in 2020), behind the Netherlands, Singapore (these two countries retained their top-ranking positions in the second year), Norway, the United States, Sweden, Finland, the Unite Kingdom, Germany, the United Arab Emirates, Japan, and New Zealand.[21] Canada's ranking drop is partly due to the low score on infrastructure, particularly the lack of 4G coverage and electric vehicle charging stations across the country.

At the same time, however, Canada is one of the countries assessed by this research as having the highest ratings for government-funded AV pilots and industry partnerships, with much of its significant work focused on collaboration. Further, the country shares the Great Lakes vehicle manufacturing cluster with the US — Detroit faces the city of Windsor in Ontario — with the industry employing more than 125,000 people nationally and assembling more than two million vehicles a year (Council of Canadian Academies 2021).

The Canadian federal government has enabled these testing and pilot projects in part through the release of the guidelines for testing automated driving systems.[22] The Guidelines seek to clarify the different roles and responsibilities of federal, provincial, territorial, and municipal governments in approving and facilitating testing of autonomous vehicles as well as explaining the process for organizations to obtain approvals from different levels of government prior to conducting testing.[63]According to this document, the federal government: 1) leads the harmonization of regulations across Canadian jurisdictions, including regulations for pilot testing systems, 2) facilitates collaboration among all levels of government and industry; and 3) holds vehicle manufacturers accountable for safety standards compliance, technology standards internationally, particularly in the United States and Mexico.

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[21] https://www.ictc-ctic.ca/wp-content/uploads/2020/04/CAVs-ENG.Final_.0423.pdf

[22] https://www.mondaq.com/canada/rail-road-cycling/1119282/autonomous-vehicles-cross-jurisdictional-regulatory-perspectives

On the other hand, the role of the provinces is to create a legislative framework for AV/CV testing and deployment in their own jurisdictions, create legislation that incorporates federal vehicle safety requirements; and manage driver licensing, vehicle registration and insurance, rules of the road; and changes to highway infrastructure that might be necessary to support AV/CV deployment. Finally, municipalities are meant to execute the legislative and regulatory framework created by provinces and territories, including for AV/CV safety enforcement; make land use planning decisions; and operate transit systems.

The federal government's ACATS program also looks to enable C/AV pilot projects to aid municipalities in fulfilling their role. It has funded a series of multi-week demonstration projects in which a variety of C/AV shuttles manufactured by differing shuttle makers, such as Easy Mile and Olli, were deployed to test both user and client perceptions, as well as vehicle performance, seasonal performance, and other road-design factors that cities need to account for when attempting to deploy C/AVs within a shared mobility setting. Much work on AVs in Canada has also been embedded within larger foundational projects, an example being the Canadian Radio-television and Telecommunications Commission work in 2020 to review and revise legislation to enable connected vehicles (which includes AVs). Another was Infrastructure Canada's Smart Cities Challenge, for which the winners were announced in May 2019, where a third of the applications specifically focused on connected and autonomous vehicles. The City of Montréal, which was awarded the top C$50 million (US$37 million) prize in the competition, includes use of AVs in its plans to improve public transport and access to food.

That said, policy makers and industry actors have thus far not established specific regulations or governance structures when it comes to autonomous systems.[23] In other words, as automotive firms achieve higher levels of vehicle autonomy – where the active role of the driver falls back, and control shifts to the vehicle itself and the infrastructure supporting it – those decisions, and the preponderance of responsibility, will transfer to a different set of actors, and there is a lack of guidance in terms of how to make them (e.g., who live and who dies in a particular tricky situation) (Mordue et al., 2020).

### Local/Regional

On January 1, 2019, O. Reg. 517/18*: Pilot Project - Automated Vehicles* came into force in Ontario. Under this regulation, with authorization, level 3 automated vehicles can be driven on Ontario public roads (with the presence of a human driver on board).[64] Québec also has a similar legal regime. Further, Transport Canada's ACATS program has funded several C/AV pilot projects on the subnational level.[24] However, provinces themselves have also invested in developing and testing C/AVs. Provinces like Quebec have been more focused on funding research related to C/AVs, including the technical monitoring of demonstration projects), with

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[23] All vehicles coming into Canada still need to comply with Canada's Motor Vehicle Safety Act. Under the act, all vehicles in Canada have to comply with the country's motor vehicle safety regulations.

[24] https://cutric-crituc.org/wp-content/uploads/2021/03/New-Mobility-and-Autonomous-Vehicles-Impacts-on-Greenhouse-Gas-Emissions-in-Metro-Vancouver.pdf

some funding also allocated to support for pilot projects to help municipalities understand the potential of AVs (Kelly, 2021).[25]

Most initiatives, however, are motivated by the desire to strengthen the digital sector or renew the automotive industry. Transportation related goals are largely separated from the firm growth aspect. This is especially the case in Ontario, where much of the investment in C/AVs has been led by the Autonomous Vehicle Innovation Network (now the Ontario Vehicle Innovation Network) funded by the Ontario government (i.e., the Ministry of Economic Development, Job Creating and Trade and the Ministry of Transportation) and delivered in partnership with the Ontario Centre for Innovation (OCI) (Goracinova 2021).

OVIN has "uploaded" the C/AV policy field to a network of organizations—coordinated by OCI. It opened a competition for six C/AV regional technology development sites, including a demonstration zone to address the multiple dimensions of C/AVs. The program incentivized local level organizations—including cities, regional economic development agencies, regional innovation centers (RICs) and universities—to form alliances that would enable their respective regions to support companies as they advance their C/AV technologies. For example, in January 2020, AVIN/OVIN said it would be working with Canada's Automotive Parts Manufacturer's Association to develop Project Arrow, a concept vehicle that would use the domestic company's expertise in AVs, connectivity, electric and alternative fuels. However, the projects funded by the organizations do not always go hand in hand with city transportation goals and instead are largely motivated by efforts to make cities appear to be appealing locations for economic investment and experimentation (Goracinova 2021).

Further, interviews suggest that cities, like Toronto, must rely on AVIN for funding and cannot independently support companies they find aligned with their long-term transportation goals. For example, while the City of Toronto has established transportation innovation zones[26] (i.e., geographic area that hosts testing of transportation and public realm approaches and technologies), actors interested in experimenting in the space must get funding through AVIN or federal level organizations like Sustainable Development Technology Canada instead of from the city.

**Table 1.** Sample C/AV Projects in Canada

| Year(s) | Description |
|---|---|
| 2020-2022<br>(City Reports) | **Title:** Minding the Gap: An Automated Shuttle Trial<br>**Funding:** ACATS<br>**Lead Organization:** City of Toronto<br>**Stakeholders:** City of Toronto, University of Toronto |

[25] The provincial Ministère des Affaires Municipales, provided a grant of $5 million over five years to help realize Montreal's plans to launch an electric self-driving shuttle bus service in the Plaza St-Hubert area . The total cost of the project on St-Hubert is $1.14 million.

[26] https://www.toronto.ca/services-payments/streets-parking-transportation/transportation-projects/transportation-innovation-zones/

| | |
|---|---|
| | **Description:** Autonomous minibus/shuttle pilot. |
| 2018<br><br>(City Report to ACATS) | **Title:** Calgary Autonomous Shuttle<br><br>**Funding:** ACATS<br><br>**Lead Organization:** City of Calgary<br><br>**Stakeholders:** City of Calgary, University of Calgary<br><br>**Description:** Calgary was selected as one of the autonomous shuttle pilot programs funded by ACATS. |
| 2018-2019 | **Title:** City of Beaumont Autonomous Shuttle Pilot Project<br><br>**Funding:** Tax Rate Stabilization Reserve Fund + municipal budget<br><br>**Lead Organization:** City of Calgary<br><br>**Stakeholders:** Pacific Western Transportation (ELA maintenance and repair costs), ATS Traffic (Contributed to route signage, lane markings), Can-Traffic Services Ltd.(Traffic signaling, vehicle-to-infrastructure hardware, installation), Lafarge<br><br>Concrete lane dividers<br><br>**Description:** Showcasing willingness to invest in new technology |
| 2020- | **Title:** Autonomous Shuttle Project in Whitby<br><br>**Funding:** AVIN<br><br>**Lead Organization:** AVIN<br><br>**Stakeholders:** SmartCone Technologies, AutoGuardian By SmartCone, the Town of Whitby, Region of Durham, Durham Region Transit (DRT), Metrolinx and other partners are working to make this idea a reality.<br><br>**Objectives:** First autonomous shuttle project integrated into existing transit route (DRT 300) |

Thus far, discussions of AV pilots, policy, and planning efforts in Canada have focused on research that has tended to be more empirical and descriptive—focusing on policy developments, cases, and typologies. These studies and many of the planning approaches they examine, rarely question the social and political assumptions embedded into AV projects. For example, how will AVs impact a municipality's carbon goals? Will AVs further entrench transportation inequalities? Specifically, much of this work and many pilot projects are often framed as purely technical endeavors—focusing on technological feasibility, operations, and interoperability. Such narrow framing closes out questions about social values and alternative goals and priorities that may shape how AVs are used in different ways.

## US

### National level actors

A comprehensive C/AV specific regulatory structure has not yet emerged at either the federal or state level in the United States. Studies suggest there are no comprehensive federal requirements for roadway testing protocols, minimum safety criteria, or vehicle design to provide definitive guidance to high automated vehicle (HAV) manufacturers or suppliers. Developers and investors remain free to back their preferred technologies and seek permission to test and prove those technologies on the nation's roads.

While early guidelines foregrounded the role that state and local governments can play, the most recent publications by the US Department of Transportation (USDOT), "Automated Vehicles 4.0" and "Automated Vehicles: Comprehensive Plan," call for a "consistent federal approach (*Autonomous Vehicles: Legal and Regulatory Developments in the United States*, 2021). In light of this, NHTSA has also taken preliminary steps to centralize governance by seeking industry and stakeholder comment for how HAV testing, and safety should be regulated. In addition, the U.S. Department of Transportation's National Highway Traffic Safety Administration (NHTSA) has also released voluntary safety guidelines for the safe development and deployment of AV/CVs (SAE Automation Levels 3 through 5) (Babak et al., 2017; *The Administration's Priorities for Transportation Infrastructure*, 2021; Fraade-Blanar & Kalra, 2017).

### Regional/local

Given that the federal government has been slow to enact any regulation or policy for C/AVs (even around basic safety), states and cities in the US are taking amore active role (J. Brown et al., 2018). Even so, to date not all states and only a few cities in the U.S. have incorporated C/AVs into their long-range planning efforts due to uncertainty about the technology's potential going forward (Freemark et al., 2020). Unlike the more descriptive literature in the Canadian context, studies in the US investigate the extent to which ongoing C/AV initiatives help US states, cities and municipalities meet transportation goals and priorities (McAslan et al., 2021). Papers show that the most common type of initiative in the US context are C/AV pilot projects, while regulation and rules related to testing are rarer but still growing in number.

At the forefront of regulatory efforts have been state and local governments, which have taken a generally permissive approach to driverless vehicle safety and testing, but numerous state-specific regulations have emerged, creating a patchwork regulatory scheme that differs state to state and changes nearly every month. Currently, 37 states and D.C. have enacted some sort of HAV related legislation. Several governors have issued related executive orders as well. Some of these regulations are minimal, simply authorizing platooning or establishing advisory councils to conduct research, while others are more stringent. For example, California regulates extensively (*Autonomous Vehicles: Legal and Regulatory Developments in the United States*, 2021).[27]

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[27] In California, any testing permit requires the manufacturer, among other requirements, to demonstrate substantial collateral against potential liability judgments. Additionally, drivers must complete a training program before certain types of HAV testing, and if a vehicle manufacturer desires a driverless test, the company must adhere to further specific procedural requirements

When it comes to pilot projects, studies indicate that that the approaches cities take toward C/AV pilot projects differ significantly, and often lack coherent policy goals (Chatman & Moran, 2019; McAslan et al., 2021). In other words, they suggest there is a disconnect between the goals of the pilot projects and the city's transportation goals, and a lack of vision for how the pilot project's findings can be used to formulate a long-term vision for how C/AVs fit into their mobility systems. Instead, they argue that C/AV pilot goals, focused on introducing C/AV technology to the public, and promoting economic development, may benefit C/AV companies more than they benefit cities. McAslan et al. (2021) postulate that this in part due to the lack of available funding, which is a major constraint on long-term transportation-related planning for C/AVs.

Articles also examine private flexible-route C/AV Testing and passenger service pilots in the US, led by companies such as Waymo (owned by Alphabet), Cruise (owned by General Motors), Uber, and Lyft. For example, Waymo has begun its "Waymo One" service in Arizona which provides rides in C/AVs to members of the public that are part of the company's "early rider program" (Korosec, 2018; Krafcik, 2018). In Las Vegas, Lyft has partnered with the company Aptiv to pilot a small fleet of C/AV sedans (Ackers, 2019). However, academic research suggests public-sector staff in US cities believes there is inadequate coordination taking place between cities and C/AV companies regarding testing and pilot C/AV ride hailing services. In other words, authors argue the information shared by C/AV companies on their operations was inadequate for their planning purposes, even in cases where explicit partnerships had been established.

## Finland

### National

In Finland, national authorities have been enabling C/AV governance, using legislative changes to create more favourable conditions for C/AV testing on public roads. However, it is unclear whether the increased *scope* of governance has translated to increased governance *capacity*. In relation to regulations in Germany and the UK, Finland's regulations surrounding C/AVs are less extensive and C/AV (SAE 0-5) testing in real traffic is permitted upon acquiring a test plate certificate for the vehicle by Trafi (Ellner et al., 2018).[28] Rather than governing new mobility, efforts at the national level seem geared towards creating an enabling environment for private actors, rather than steering the development of new mobility options. For instance, in 2017, Finland's Road Traffic Act called for the change in the colour of road markings (from yellow lines to white) to provide better for machine vision detection (Mladenović et al., 2020). The Road Traffic Act also suggests that road data (e.g., signs, traffic lights, control devices) should be available for use by C/AV operators.

Unlike in Germany and the UK where C/AV pilots range in use cases, the literature surrounding C/AV pilots in Finland is focused on C/AV pilots for shared-use cases (e.g., connected bus pilots or autonomous shuttle pilots). Main actors at the national level include the Finnish Transport and Communications Agency (Traficom), Business Finland, Forum Virium Helsinki, and the VTT

[28] Now Traficom, following the consolidation of Trafi and the Finnish Communications Regulatory Authority (FICORA) (Traficom, 2019).

Technical Research Centre of Finland. Business Finland has jointly funded pilot projects with municipalities and private actors like the Living Lab Bus (Living Lab Bus, 2019). The Living Lab Bus pilot was operated by VTT Technical Research Centre of Finland and tested a fleet of ten electric buses owned by HSL (Heino et al., 2018).

Between 2016-2018, Finland participated in an EU-funded Interreg project Sohjoa Baltic (Ainsalu et al., 2018). In Finland, trials took place on three routes in Espoo, Helsinki, and Tampere, and was led by the Metropolia University of Applied Sciences, and Forum Virium Helsinki (Ainsalu et al., 2018). The objective of the study was to test how autonomous shuttles would adapt in winter conditions, as well as to study how C/AVs were perceived by the public. Findings have found that C/AV technology was not yet advanced enough to adapt to winter conditions, and that the slow speed of buses (12 km/h) made shuttles more suitable to travel on pedestrian and bicycle lanes (Ainsalu et al., 2018).

### Regional/Local

At the municipal level, authorities have taken an enabling role to C/AV governance, initiating smaller-scale pilots and participating in larger-scale EU-led pilot projects. Main actors at the regional level include cities responsible for granting special permissions for pilot routes. Local transport authorities at Helsinki Regional Transport Agency (HSL) have led small-scale pilot programs to test MoD services. For instance, between 2013 and 2015, HSL conducted the Kutsuplus pilot program, a transit service of autonomous, wifi-equipped minibuses that serviced users between city bus stops. The project operated from the spring of 2013 to the end of 2015 but was ultimately canceled due to a lack of funding and scalability (Hensher, 2017; Heikkila, 2014).

Between July 2015 to August 2015, Vantaa participated in an EU-funded C/AV pilot organized by CityMobil2 (Hunter, 2018). The objective of CityMobil2 was to assess how C/AVs could be integrated into public transportation (Ainsalu, et al., 2015). The pilot project took place in a recreational district in Vantaa, transporting riders from the Kivisto Railway Station to the location of the 2015 Housing Fair, the autonomous shuttle system transported a total of 19,021 riders over the duration of the pilot. The Vantaa pilot project had the highest ridership amongst the nine EU cities participating in the pilot programs, and the authors attribute Vantaa's high ridership to the Housing Fair and the system's connection to a metro transit station.

Helsinki is often selected as a demo site for EU-led smart city initiatives. There appears to be a gap in the literature in terms of the role of Finnish actors (state, municipal, and local) in EU-led projects conducted in Finland. For instance, Vantaa, Finland, was one of nine European cities selected for the EU-led CityMobil2 autonomous shuttle pilot project (Hunter, 2018). However, there is a gap in the literature with regards to the role of local authorities and their degree of involvement in the pilot. It is likely that more EU-led/EU-funded studies will take place in Finland, and it is crucial to understand how Finnish authorities are contributing to the EU pilot projects. Moving forward, it is important to study the contribution of Finnish actors in shaping both the local mobility landscape as well as the greater EU mobility community. It may be helpful to study how governance arrangements in EU-led pilots vary from municipally- or nationally led pilots.

## Germany

### National

In Germany, national policies supporting C/AV technology are focused on upholding Germany's position as a leader in the automotive industry, as well as increasing general road safety and energy efficiency (Mladenović et al., 2020; Fraedrich et al., 2019). Germany has taken a combination of leadership and enablement approaches to guide and support private sector development in C/AVs at the national level. The Federal Ministry of Transport and Digital Infrastructure (BMVI) is the primary national actor responsible for guiding and evaluating C/AV legislation (e.g., StVG) and funding digital test bed initiatives across Germany. The Federal Ministry of Education and Research (BMBF) is also an important actor and has funded various C/AV research and development projects led by private corporations. Policy instruments used at the national level include changes to legislation surrounding C/AVs, the development of data protection regulations, the development of an Ethics Commission, the development of digital test beds, as well as funding for C/AV pilots (Mladenović et al., 2020).

German legislation is much more specific in setting out standards for C/AVs and outlining liability in crashes in relation to Finnish legislation. In 2017, Germany revised its Road Transportation Act (StVG) to enable C/AV testing in real traffic (Kouroutakis, 2019). The StVG outlines legal liability in the case of accidents and defines the characteristics of autonomous vehicles. Kouroutakis (2019) writes that the StVG defines autonomous vehicles as vehicles that are equipped with the following characteristics:

> [F]irst with full control of the driving task, second capable of conforming to traffic regulations in full automation, third that allow the driver to manually override or deactivate the automation at any time, fourth with the capacity to recognize that it is necessary for the driver to take full control and deactivate the automation, and finally with the visual and acoustic tactual indication that the driver shall take control with sufficient time for the driver to take control, and finally with the capacity to indicate wrong use to one of the system descriptions. (p. 11, 12)

In determining liability, the StVG clarifies that drivers of AVs are primarily responsible for collisions under their control and are expected to be insured like any other driver. However, in the case of accidents due to vehicle malfunctions, liability will fall upon the manufacturer (Kouroutakis, 2019). The StVG also mandates all manufacturers to equip all C/AVs with black box recording systems to gather data and help determine liability in the case of collisions. Regarding data protection measures, the StVG limits the duration of data storage on black box recording systems to up to six months (Kouroutakis, 2019).

Additionally, the Federal Ministry of Transport and Digital Infrastructure (BMVI) has initiated and funded numerous digital test beds in motorways and urban areas across Germany to enable C/AV testing in real traffic (Mladenović et al., 2020). Roads in digital test beds are equipped with intelligent infrastructure, which allows for communication between vehicles and roads in real traffic.

In 2015, BMVI initiated the Digital Motorway Test Bed (DTA) on the A9 federal motorway in Bavaria (BASt, 2021; BMVI, 2020). While the DTA is operated by the BMVI and the Free State of Bavaria, there are numerous stakeholders supporting the DTA, and private stakeholders (e.g., Audi, Volkswagen, BMW, and Mercedes) who test their C/AVs or related technologies (e.g., lasers, radars, and cameras) on the DTA (BMVI, 2020). According to Germany's Federal Highway Research Institute (BASt), tests for C/AVs on the DTA are primarily conducted by private firms and research institutes, while tests for intelligent infrastructure are primarily conducted collaboratively by the BASt and responsible motorway authorities (BASt, 2021). The BMVI is also involved in a cross-border digital test bed that runs through Germany, France, and Luxemburg. Other German actors involved in the cross-border test bed include the city of Merzig, and the Saarland University of Applied Sciences (BMVI, 2020).

### Regional/Local

Broadly speaking, actors at the regional level are taking an enabling role in C/AV governance. Main actors at the regional level include municipal authorities in cities where C/AV pilots are conducted, public transport authorities conducting autonomous shuttle pilots. A range of C/AV pilots for different use cases are being conducted throughout Germany, from large-scale digital test bed pilots to smaller-scale autonomous shuttle pilots. While C/AVs are permitted to test in real traffic across Germany, there are legal restrictions (e.g., speed limits) that autonomous vehicles are required to follow (Ainsalu et al., 2018). Thus, local authorities are responsible for granting special permission for C/AV pilots testing SAE level 4 and level 5 autonomous vehicles on public roads (Ainsalu et al., 2018). This arrangement varies from Finland, where SAE level 0-5 vehicles may test on public roads with a permit from Traficom, an actor at the national level.

There has been an increasing number of autonomous shuttle pilots conducted across Germany in recent years. In March 2018, Berliner Verkehrsbetriebe (BVG), Berlin's largest public transport authority (and a member of the VBB), and the Charité - Universitätsmedizin Berlin initiated a joint autonomous shuttle pilot funded by Germany's Federal Ministry for the Environment, Nature Conservation, Nuclear Safety and Consumer Protection (BMU) (Charité - Universitätsmedizin Berlin, 2021). During the first year of the pilot phase, a BVG operator was on board the shuttles, and traveled three fixed routes in the Charité university campus, transporting students, patients, and workers (Charité - Universitätsmedizin Berlin, 2021; Ainsalu et al., 2018). The project's main goals were to gather information on passengers' AV acceptance (Ainsalu et al., 2018).

In Germany, efforts to enable the development of C/AVs largely take place among public actors at the national level and private actors in the automotive sector. On the other hand, the current literature suggests that urban transport and city planning authorities have a limited role in steering the development of C/AVs. A study from 2019 found that local governments in Germany are not actively engaged in discussions surrounding C/AVs, and surveys and interviews with members from the Association of German Cities' expert commission on transport indicate that planners are more hopeful that shared C/AVs could complement their planning goals (Fraedrich et al., 2019). There is a gap in the literature on how municipal authorities seek to steer C/AV governance, and their degree of involvement in current discussions. While digital test beds are crucial testing sites for German auto and intelligent infrastructure manufacturers, a narrow focus on C/AV development could result in long-term sustainability challenges.

## United Kingdom

### National

In general, there seems to be a shared sentiment across public and private actors in the UK that policymakers should take an active approach to C/AV governance. The UK government has taken a leadership and enablement approach at the national level, commissioning workshops, investing in large-scale pilot projects, and developing regulations. In 2015, the DfT, along with the Department for Business, Energy & Industrial Strategy (BEIS), established an expert C/AV unit called the Centre for Connected and Autonomous Vehicles (CCAV) (GOV.UK, 2017).

As in Germany, the UK's legal framework goes further than Finland's legal framework in setting out standards for C/AVs and in outlining liability in collisions. In 2018, the UK enacted the Automated and Electric Vehicles Act (AEVA), which outlines liability in the case of an accident. Unlike Germany's StVG where drivers are liable for most collisions, the UK's AEVA states that insurers are responsible for accidents that occur while vehicles are in self-driving mode (Kouroutakis, 2019). Like national authorities in Germany, national authorities in the UK have been actively supporting private stakeholders by supporting various C/AV pilots across the country. However, the UK seems to have a greater variety of C/AV pilots including autonomous pods, while digital test bed pilots tend to be more popular in Germany.

The DfT in the UK has had an active role in leading discussions about how C/AVs should be governed in the UK. In 2016, the DfT commissioned two workshops with stakeholders from the public and private sectors to explore the role policymakers should take in C/AV governance. The findings highlighted a shared view among stakeholders that an active governance approach is needed at all levels of governance (Cohen et al., 2018).

As in Germany, the UK has many private stakeholders in the C/AV industry, and private organizations lead the majority of the government-funded C/AV pilot projects. The DfT, along with the CCAV has hosted various competitions throughout the years to fund C/AV projects. Innovate UK, the UK's innovation agency, has been responsible for delivering most of the funding for C/AV pilots across the UK. In 2015, Innovate UK delivered funding for three successful proposals to the 'Introducing Driverless Cars to UK Roads' competition. Winning proposals were GATEway project, an autonomous pod shuttle service trial in Greenwich Park, London (Cohen et al., 2020); The UK Autodrive project, a trial for C/AV testing in Milton Keynes and Coventry (UK Autodrive, n.d.); and the Venturer project, a trial for C/AV testing and research in Bristol (Venturer, 2020).

### Regional/Local

At the regional level, municipal authorities seem to be enabling C/AV governance, partnering with private actors to enable trials in their cities. While private firms led most of the C/AV pilots funded by Innovate UK, few projects were managed by public actors. For instance, the Project Synergy pilot, which ran between 2017-2020, was operated by Transport for Greater Manchester. The shuttles were developed by Westfield Sportscars and traveled around Manchester airport. The main objective of the pilot was to determine how autonomous shuttles could be integrated into public transport and fill complement a passenger's journey (SPACE, 2020). However, in the case of pilots led by private actors, there seems to be a gap in the literature regarding municipal authorities' role and their degree of involvement.

At the same time, cities like London have implemented congestion charges meant to get people out of their cars to reduce traffic. According to some authors, this may help lower the risks of gridlock, which are so great with autonomous vehicles (Hawkins, 2020). However, other have found that while congestion charging initially helps to reduce traffic, it eventually encouraged on to the road other drivers who had previously been deterred by the prospect of delays (Hawkins, 2020; Metz, 2018).

### Cross country comparison

The mobility transition and the emergence of the C/AV industry are prompting cities to operate in a more multi-scalar governance context. They attempt to mediate across multiple stakeholders, ranging from non-profit organizations to universities (Aoyama & Alvarez Leon, 2021). The roles that they adopt are dependent on political economic relations between the public, private corporations, urban institutions, and other scales of governance. It is not clear at this point if C/AVs in any of the case studies are envisioned to reduce the usage of cars, with some studies showing they will mostly absorb walking and cycling practices. Another aspect shared across the case studies is the focus on technological solutions in autonomous transport as a path toward generating new export activities.

# Shared Mobility

A growing number of public transportation agencies are partnering with Mobility on Demand (MOD) or Mobility as a Service (MaaS) companies, raising the question of what role MOD companies can, should, and currently play in public transport provision. By mobility on demand, authors usually refer to an innovative transportation concept where consumers can access mobility, goods, and services on-demand by dispatching or using shared mobility.[29] MOD passenger mobility can include bike sharing, carsharing, microtransit, ridesharing (i.e., carpooling and vanpooling), TNCs, scooter sharing, shuttle services, urban air mobility, and public transportation. MOD courier services can include app-based delivery services (known as courier network services (CNS)), robotic delivery, and aerial delivery (e.g., drones).

In Europe, another model of multimodal transportation known as MaaS is emerging. Although MOD and MaaS share a number of similarities, such as an emphasis on multimodal integration (physical co-location of services, fare payment, and digital integration), the concepts are fundamentally different. MaaS focuses on mobility aggregation and subscription services, often facilitated through a smartphone application or website (Shaheen & Cohen, 2020b, 2020a).The assumption inherent in the introduction of these services is that as consumers gain access to more shared modes of mobility, they will be more inclined to accept and transition to a car-free lifestyle (at least in urban areas).

[29] Transportation services and resources that are shared among users, instead of privately owned.

## Canada

### National level actors

In Canada, on the federal level, the government has not played a major role in regulating different forms of shared mobility, such as carsharing, microtransit or bike sharing. The only exception is ride sourcing on the tax front, where the federal government requires ride sourced drivers to register for, charge and remit the HST/GST on the fares they collect (Uber, 2020; Canada Revenue Agency, 2017). It does, however, control funds that the provinces and municipalities can apply for to invest in MOD or MaaS transportation. Nonetheless, municipal government staff have noted that currently, it is difficult for cities to obtain funding to support shared mobility initiatives, such as a car-sharing pilots or infrastructure to encourage shared parking (Ditta et al., 2016).[30]

### Regional/Local

Demand-responsive transit in Canada is growing. Municipalities are interested in new ways to serve customers in areas that would traditionally be excluded from transit service (Klumpenhouwer, 2020). While land-use, the prioritization of the automobile, and the lack of walkability in neighbourhoods plays a significant role in the ability of municipalities to provide transit service, demand-responsive transit may provide an increasingly feasible way to shift the conversation toward more shared, greener, and connected communities.

As mentioned above, it has fallen to the thirteen provinces and territories and over 3,500 municipalities to regulate mobility on demand and mobility as a service transportation models. Studies have shown there is significant variation between provinces when it comes to regulating MOD services like ride hailing, given variation in pre-existing regulatory and governance structures. For instance, while Toronto treats ground transportation regulation as a local responsibility, in Montreal and Vancouver, ride hailing is primarily regulated at the provincial level (Tabascio & Brail, 2021). Across the board, however, studies indicate that "decisions around ride-hailing are often political and decoupled from ridership and other transportation concerns" (Tabascio & Brail, 2021, p.1). Instead, ride-hailing regulation, they argue, is driven by a desire to attract and retain innovative firms (Brail, 2018).

In addition to ride hailing, studies also investigate the adoption of various types of on-demand services like bike sharing, and car sharing in Canadian municipalities, although they do not delve into the politics of these processes (Sweet & Scott, 2021). Reports suggest that regional transportation agencies (e.g., Metrolinx in Ontario) have played a key role in the growth of some of these services, including Bike Share Toronto – which received $4.9 million from Metrolinx to double the size of its network by adding 1,000 bikes and 120 stations and to extend its reach into new parts of the city (Ditta et al., 2016).

Despite the prioritization of economic development motives, municipalities have also tried to experiment with MOD technologies and platforms to improve their responsiveness to citizen needs (compared to fixed-transit routes). Dozens of Canadian municipalities have turned to new

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[30] Tool through which adjacent property owners share their parking lots and reduce the number of parking spaces that each would provide on their individual properties.

on-demand transit technology companies, many of whom are headquartered in Canada, offering a new, more personalized form of transit (i.e., on-demand transit). Klumpenhouwer (2020) describes on-demand transit in the following way: "in times and areas with lower demand for transit, transit agencies serve stops more efficiently if they go directly to where and when people are waiting, instead of following a pre-planned route and schedule through requests made on a smartphone." Accordingly, on-demand transit has been essential to helping some municipalities adjust their service during the pandemic. Cities, like Montreal have also used on-demand transit to expand their reach into low-density areas. In other cases, however, municipalities have used MOD services to replace public transit altogether. In the case of Innisfil, instead of buses or trains plying regular routes, it is Uber's roving cars that function as the transit fleet, with the city subsidizing the rides.

Despite attempts to integrate MOD services with the transit system, users often have to pay separately for each of these, making MaaS more difficult to utlize. A Montreal example would be booking a ride-sourced trip via Téo Taxi, then paying transit fare via an Opus card, then using a BIXI key to unlock a bike (Underhill & Knowles, 2020). Another challenge is the lack of regional payment integration, which makes it difficult for services to be integrated across the region. In the case of the Greater Toronto and Hamilton Area, having 10 autonomous transit agencies, one provincial agency and one regional transit service makes it challenging for organizations to coordinate in a way that enables integrated payment.

## US

### National Actors

Recognizing the importance of multimodal transportation, the Federal Transportation Agency (FTA) in the US has been funding and researching innovative MOD and public transit partnerships. FTA developed the MOD Sandbox Demonstration program in 2016.[31] The aim of the MOD Sandbox demonstration is to explore opportunities and challenges for public transportation related to technology-enabled mobility services including: ways that public transit can learn from, build on, and interface with innovative transportation modes from a user, business model, technology, and policy perspective. Each demonstration pilots a variety of concepts such as: smartphone applications and trip planners, integrated fare payment, first-and-last mile connections to public transportation, and paratransit. In addition to these efforts, all vehicles (used as part of shared mobility services) must comply with safety standards established by the Consumer Product Safety Commission and all other federal, state, and city safety standards (*Guidelines for Regulating Shared Micromobility*, 2019).

[31] Key objectives of the sandbox include: enhancing public transit industry preparedness for MOD; assisting the public transit industry to develop the ability to integrate MOD practices with existing transit services; validating the technical and institutional feasibility of innovative MOD business models and documenting MOD best practices that may emerge from the demonstrations; measuring the impacts of MOD on travelers and transportation systems; and examining relevant public sector and federal requirements, regulations, and policies that may support or impede transit sector adoption of MOD.

### Regional/Local

As on-demand mobility providers like Uber and other TNCs were launched in cities across the US, articles suggest they first flouted existing regulations before public officials were able to implement measures to regulate them. At this point, most U.S. states have enacted legislation or regulations for TNCs. As of August 2016, 39 states and the District of Columbia have successfully implemented such measures, although city regulation of Uber thus varies substantially (Ditta et al., 2016).

At the same time, however, the literature suggests the introduction of these new technologies has largely been driven by private actors, with public transportation goals often remaining secondary to their interests. According to Collier et al. 2018, Uber and other TNCs have accepted certain consumer protection and safety regulations that are consistent with its need to build customer trust. However, other regulations have been more contentious, and Uber has "vigorously opposed those it fears will restrict the easy entry of drivers and the supply of cars on the road, like fingerprint-based background checks, vehicle caps, and, in the most extreme case, full bans" (Collier et al., 2018).

And even regulations that do exist (e.g., in San Francisco) were approved with the involvement of a limited number of actors confined mainly to a small number of regulatory agencies (Davis, 2018). Debate over the purpose of the policy and its subsequent implementation was depoliticized, closed, narrow and technical, unfolding behind the scenes in meetings of state regulators. This meant that there was very little public discussion about the pros and cons of ride sourcing even generally, let alone in light of city's larger sustainability aims and its regional transit system (Davis, 2018).

At the same time, however, local authorities are experimenting with partnerships with mobility on demand companies to make transit more accessible to current or potential drivers. Authors identify six types of partnerships between public transportation and MOD service providers, including: 1) first and last mile partnerships where a public-sector partner subsidizes a MOD service operator to provide services to or from a public transit stop or station or low-density, 2) service and public transit replacement partnerships subsidize a MOD provider to offer service in a lower-density area, and 3) Paratransit partnerships leverage MOD services to supplement or replace an existing paratransit service (Shaheen & Cohen, 2020b). Out of all these different categories, there is most literature evaluating the success of first and last mile partnerships in terms of its ability to increase transit ridership and reduce vehicle use, especially among more marginalized populations. For example, authors have studied the Los Angeles MOD program (a demonstration project funded by the US Department of Transportation) to examine the impact of subsidized ride-hailing to and from transit. However, their findings suggest that the MOD program neither advanced nor undermined transit access among disadvantaged transportation populations and neighborhoods (A. Brown et al., 2021).

In some cases, regulations implemented by municipal governments (e.g., Seattle) has been more proactive when it comes to shared mobility (Moscholidou & Pangbourne, 2020). For example, the Seattle Department of Transportation (SDOT) has introduced detailed regulations or permit systems that are specifically related to bike sharing, carsharing and ridesharing services. In some cases, regulations are also limiting the number of permits, restricting the number of vehicles and operators allowed in the city. According to Moscholidou and Pangbourne (2020), Seattle's clear regulatory position can help cities and their public transportation systems deal with and manage the potential pressure from new market forces.[32]

The literature suggests that the fragmented nature of transportation organizations in the US also presents a challenge for introducing mobility as a service schemes (Schweiger, 2017). In terms of operational challenges, many transit agencies operate independently and may not coordinate their services with other private or public providers. Thus, participation in MaaS may require changes in the way agencies schedule and operate their services and in the role of each agency in the overall transportation network and MaaS scheme. Further, different governmental and regulatory agencies currently provide transportation services under an array of policies and objectives while trying to satisfy travellers' needs simultaneously. Other operational challenges include addressing the changes that will be caused by the deployment of MaaS.

Despite these institutional challenges, however, cities are working on experimenting in the space. For instance, Pittsburgh just became the first U.S. community where every resident can feasibly and affordably trade their private cars for an app with the launch of its long-awaited Move PGH pilot. Touted as the first comprehensive 'mobility as a service" app in the United States, residents will be able to use it to pay their bus fares; rent micro-mobility vehicles such as electric bikes, mopeds (Scoobi), and scooters (Spin); find someone to carpool with (Waze); and, when absolutely necessary, rent an automobile for a few hours (Zipcar)—all under the umbrella of the Transit app.[33] Despite private involvement, articles suggest the city itself will manage the program, and resolve any problems that may emerge between transit providers.

The literature points to some issues that may emerge as part of these public-private arrangements. Studies of smaller-scale mobility on-demand demonstration projects funded by the FTA showcase some of the challenges that may emerge because of public-private partnership. For example, the Chicago MOD Sandbox demonstration encountered a problem with the acquisition of a primary project partner/vendor by another company, which then delayed and created challenges for the pilot project (Cohen et al., 2021).

## Finland

### National

In the case of Finland, most of the academic literature is focused on the mobility as a service form of shared mobility. They find that Finland has been taking a top-down approach to mobility governance, with policies at the national level guiding actions taken at the municipal level. Public sector efforts to promote mobility have been geared towards creating an enabling environment for private sector innovation in MaaS. Authorities at the national level have been taking a leadership and enabling approach, utilizing hard policy instruments to lower or remove barriers to entry to the mobility market (e.g., Act on Transport Services), and soft policy instruments to promote market-driven MaaS (e.g., funding MaaS-related studies) (Smith et al.,

[32] The Director of SDOT can adopt whatever rule they deem useful for the conduct of the Department's business, and essentially has complete powers to regulate any service.

[33] https://usa.streetsblog.org/2021/07/09/u-s-finally-gets-first-mobility-as-a-service-platform/

2019). At the national level, the Finnish Funding Agency for Innovation (Tekes)[34] has directly supported MaaS Global by investing in the company in its early stages. Indirectly, the Finnish Ministry for Transport and Communication (LVM) has created an enabling environment for MaaS by proposing reforms to Finland's transport legislation (Smith, Sarasini, Karlsson, Mukhtar-Landgren & Sochor, 2019). Additionally, LVM's successful efforts led to the enactment of the Act on Transport Services in 2018.

These policy instruments tend to direct local and regional actors to comply with national-level objectives of promoting MaaS, rather than participate in steering the development of MaaS (Smith et al., 2019). Policy instruments used to promote MaaS include funding pilots and pre-studies for MaaS. Finnish Ministry of Transport and Communications (LVM) and Business Finland. Through 2015 and 2016, LVM and the Finnish Funding Agency for Technology and Innovation (Tekes) jointly funded 8 pre-studies for MaaS (Lajas & Macario, 2020). LVM has also promoted MaaS in Finland by participating in new mobility workshops led by ITS Finland (non-profit aimed at promoting intelligent transport in Finland), establishing a 'new mobility' think tank, and co-founding MaaS-Alliance (a public-private partnership aimed at facilitating the diffusion of MaaS) (Mukhtar-Landgren & Smith, 2019).

### Regional/Local

At the regional level, authorities have taken an enablement approach to MaaS governance, complying with national-level objectives of promoting MaaS. Authorities at the regional level have not been actively involved in planning for the long-term development of MaaS (Smith et al., 2019). The main actor at the regional level is the Helsinki Regional Transport Agency (HSL). At the regional level, the Helsinki Regional Transport Agency (HSL) has created operational contracts that enable platforms like Whim to purchase HSL's ticket and sell it for third-party resale. Despite state efforts to promote MaaS and to carve out a niche for the state in the international market, it is not guaranteed that Finland or Helsinki will benefit economically or socially from creating an enabling environment for private actors in the MaaS ecosystem. For instance, the majority of MaaS Global's shareholders are foreign actors (Veeneman et al., 2018).

Further, there has been ongoing conflict between Whim and the city-run HSL. With its own mobile ticketing app, HSL had little incentive to open the market to MaaS providers and was soon accused by MaaS Global of refusing to share easy access to its popular monthly transit passes. Furthermore, there is a lack of clear numbers showcasing how many people actually used the Whim service as those numbers remain available to Whim alone (Carey, 2021).

It is evident that private actors like MaaS Global have benefited from the enabling environment created by Finland's national government and the regional transport authorities. While HSL's generic contract may have been created as a response to top-down initiatives to enable innovations in MaaS, it is currently unclear whether HSL's operational contract allowed for increased collaboration between PT operators and MaaS providers, and whether the contract was effective at increasing transparency across public and private stakeholders. Consequently, a follow-up study should explore the effects of HSL's operational contract on the governance capacity of municipal actors. Questions to consider include: 1) Is HSL's contract mutually

[34] Now Business Finland

beneficial for PT providers and MaaS operators? 2) What mechanisms are in place to ensure that MaaS operators share their data with HSL? 3) How has the operational contract affected PT ticket sales?

Further, few articles have explored questions of the affordability of MaaS for users. While Whim offers different subscription packages, their monthly unlimited packages represent 18.3 percent of the average household disposable income in Helsinki (Pangbourne et al., 2020). In contrast, the current average individual transport expenditure in Finland is 15 per cent of an individual's monthly wage (Pangbourne et al.,2020). The issue of affordability may be overlooked in the existing literature, as MaaS platforms like Whim are not yet broadly diffused. Current data indicates that Whim's monthly subscription packages support 1.8 million out of 374 million trips made in Helsinki each month (Pangbourne et al.,2020). However, transport inequity could become a pressing concern once MaaS is widely adopted. Thus, more studies must be conducted to examine what role public sector actors can take to prevent issues of transport inequity before MaaS is widely adopted.

## Germany

### National

The articles examined for this literature review did not examine the role of the national authorities in depth. There are various types of MaaS schemes across Germany, varying in levels of integration. MaaS schemes that are partially integrated are characterized by partial integration of ticketing, payment, and ICT integration, while schemes that are fully integrated include all three features (Kamargianni et al., 2016). Although there are both public and private operators of MaaS schemes across Germany, there has been an increasing number of public transport operators in developing and operating fully integrated MaaS schemes across Germany. These trends suggest that transport operators are recognizing new mobility trends and making deliberate efforts to make public transport more attractive to riders by offering to integrate various modes of transport.

### Regional/Local

In the case of Germany, regional and municipal authorities have also been faced with former niche innovations in the form of car-sharing, bike-sharing, and e-scooter-sharing seeing remarkable growth in recent years. While some see these services as important elements of a "multioptional mobility system", others caution that they might draw consumers away from public transport, walking, and cycling without reducing car traffic. Further, against a background of uncertain legal conditions for regulation on the federal level, cities like Berlin have also hesitated to introduce formal regulation of shared mobility services (Ruhrort, 2020).

A second strand of research dealing with sub-national authorities focuses on the potential of on-demand services as part of an integrated mobility system. One of the core concepts is "mobility as a service" (MaaS). At the municipal level, large cities in Germany have been taking a leadership approach to governing MaaS, with Berlin and Munich leading the way by experimenting in large-scale trials. In 2019 BVG initiated a full-scale MaaS pilot called BVG Jelbi (Trafi, 2020). Jelbi is a fully integrated MaaS scheme operated by BVG. Jelbi's platform was built by Trafi, a Lithuanian technology start-up, using Trafi's MaaS API system, which is customized for BVG. BVG Jelbi integrates trip planning, booking, and payment, and provides real-time information for PT and vehicle availability. Jelbi was launched in September 2019, following six months of close collaboration between BVG and Trafi (Trafi, 2020). Jelbi offers a range of mobility services: VBB public transport tickets in zones Berlin A, B, and C; free-floating car sharing through from MILES; station-based car sharing from mobileeee; bike-sharing from nextbike; e-moped or e-scooter from emmy, TIER, Lime and Voi; ridesharing from BerlKonig; and taxi from Taxi Berlin (BVG Jelbi, 2021). According to Trafi, around 5 per cent of Berliners have used the BVG Jelbi app in the first year of its launch. The latest data indicates a modal share of 51per cent PT and 49 per cent shared mobility split (Trafi, 2020).

BVG's growing partnerships with private sector mobility service providers highlight BVG's ability to align private sector actors with their goal of reducing dependence on private motorized vehicles. Further, BVG's ability to initiate and execute a full-scale MaaS pilot, highlights the potential for public sector actors to increase their governance capacity with the emergence of new mobility services. However, there is a need for future studies to explore the long-term impacts of Jelbi and public-private dynamics. Jelbi is currently in its pilot phase, gathering trip data from riders and sharing general data with private companies. It is important to further explore how data is shared and stored should be explored further, and whether it is feasible for the long term.

Similarly, Münchner Verkehrsgesellschaft (MVG), Munich's public transport authority (and a member of the MVV) has followed in BVG's footsteps and launched a MaaS pilot called MVGo (Trafi, 2021). Like Jelbi, the MVGO platform was built by Trafi using its MaaS API system, and integrates trip planning, booking, and payment, and provides real-time information for PT and vehicle availability. MVGO was launched in February 2021, and services currently available for first and last mile transportation include: rental bikes from MVG Rad; and e-mopeds or e-scooters from emmy, TIER, and Voi (MVG, 2021). Pressured by grassroots initiatives, cities like Berlin have also recently decided to implement policy measures that redistribute space away from cars to other modes and other uses( Ruhrort, 2020).

As the first fully integrated MaaS schemes in the world to be owned and operated by public transport authorities, the success of Jelbi and MVGO pilots can demonstrate to municipalities around the world how MaaS can be used to achieve sustainability goals. However, as it is still early in the pilots, it remains unclear how successful these pilots are. Future studies should explore whether platforms like Jelbi and MVGo are viable in the long run, both from the perspective of public transport authorities operating these platforms, as well as from the perspective of private sector mobility providers partnering with the public sector operators.

Like Whim in Finland, there is a gap in the literature examining the dynamics between public and private actors in the MaaS ecosystem. Jelbi and MVGo are currently in their pilot stages, but if they are successful, these platforms have the potential to radically change the scope of governance for PT authorities. It remains unclear whether the public and private mobility providers are benefitting from these platforms enough to continue their partnerships. Many questions arise, such as: how is Jelbi received by VBB? is there potential for apps to be standardized across VVs or even nationally? how have PT sales been affected so far?iIs there a Will Jelbi hinder BVG ticket sales? is mobility data shared amongst all stakeholders?

## United Kingdom

### National

Transport Minister Trudy Harrison has maintained that shared mobility must become "the norm" across the UK as she outlined support for a system "fit for the future". In line with this, the UK Department for Transport published its *Future of Mobility: Urban Strategy* report in 2019. The report discusses possible initiatives that would be necessary to advance MaaS, including providing funding for four "future mobility zones" to test out new forms of mobility.[35] It also examines the possibility of encouraging transport companies to share their data to encourage Mobility-as-a-Service. Unlike Germany and Finland, public authorities in the UK seem to be approaching MaaS with more caution. While the DfT has held numerous funding competitions for MaaS, there is yet an absence of a fully integrated platform such as Whim in Finland or BVG Jelbi in Berlin.

### Regional/Local

In the UK, transport strategy and planning take place at the municipal level. TfL is London's main institution responsible for transport strategy and planning and delivers the Mayor's Transport Strategy. TfL has a broad scope of responsibilities, managing and regulating London Underground, London Buses, TfL Rail, London Trams, London River Services, and Santander Cycles (Moscholidou & Pangbourne, 2020). TfL is also the licensing authority for taxis and Private Hire Vehicles (PHVs), such as Uber (Moscholidou & Pangbourne, 2020). London Boroughs are also important actors at the regional level, largely responsible for decisions on land use (e.g., parking space) (Akyelken et al., 2018).

While London's progress in MaaS developments appears to be lagging in relation to Helsinki and Berlin, leadership approaches taken by public authorities in the past to develop and successfully promote broad public adoption of London's Oyster card, suggest to some authors that national and municipal authorities have the governance capacity to develop and deploy MaaS (Akyelken et al., 2018). Reducing traffic congestion has also been a central focus in London's policy documents since the early 2000s, and both hard and soft policy instruments have been carried out to deter the use of private motorized vehicles (Audouin, 2019).[36]

Considering this, Akyelken et al. (2018) argue public authorities may be reluctant to popularize services (e.g., ride hailing, ridesharing, carsharing) that could potentially reduce PT use and increase traffic congestion. On the other hand, authors like Moschodilou and Pangbourne (2020) argue that TfL cannot act because its powers to regulate are limited and not sufficiently

[35]The West Midlands Combined Authority has already claimed £20 million of this with a proposed scheme to incentivise people to give up their private car in favour of shared or public transport.

[36] Reducing traffic congestion has been a central focus in London's policy documents since the early 2000s, and both hard and soft policy instruments have been carried out to deter the use of private motorized vehicles. For instance, authorities have used policy instruments like congestion charging, parking limitations, and high parking costs have been implemented in hopes to reduce personal car ownership (Akyelken et al., 2018).

flexible to respond to rapid changes in the smart mobility arena.[37] In other words, there seems to be disagreement in the literature as to the reasons for loose regulation in the shared mobility space.

### Country Comparison

Across the board in our case studies, there is a fear that shared mobility services offered by private profit seeking companies may open the door to a weakening of public transit and the further privatization of the mobility sector. At the same time, however, the ability to regulate private providers seems to be dependent on the pre-existing governance capacity at the local level (e.g., higher in Seattle and lower in London). When the national level government intervenes, as in the case of Finland and encourages public actors to collaborate with private ones in the delivery of MaaS services, local stakeholders may feel threatened, and fear public transit may be in peril. Overall, it appears that local authorities are best positioned to plan for and integrate shared mobility services, and reforms may need to be put in place to give them the power to do so.

# Implications

This knowledge synthesis report underlines several governance principles authorities at different levels of government should consider going forward. First, the case studies highlight the need to consider issues of data governance, C/AVs and shared mobility as deeply interconnected and interdependent. Without close attention to data governance, neither C/AVs, nor shared mobility solutions can be fully leveraged to create an integrated public-transport system that decreases citizen dependence on cars. However, in the case of Canada, data governance is often limited or constrained to issues of cybersecurity without clear rules and regulations regarding how both public and private actors should share data in a manner that helps meet sustainability and affordability goals. Adopting smart mobility solutions in a comprehensive manner requires that both national and subnational governments collaborate to establish clearer data governance guidelines, instead of leaving the task to municipalities alone.

Second, the report demonstrates that economic development motives are not always aligned with transportation related goals. This means that public stakeholders should have more room to dedicate their efforts and time to transportation goals, rather than assuming economic development initiatives are conducive to green and affordable transit. This is a challenging goal, given the financial constrains faced by many public stakeholders, especially at the subnational level. In light of this, it is advisable that future funding programs at the federal or provincial level should have a clearer focus on transportation goals, rather than being an afterthought. The case of Finland shows that even in cases where governance is more comprehensive and centralized,

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[37] TfL's regulatory powers, “as defined in the Greater London Authority Act 1999, include the introduction of byelaws and the promotion of Bills in Parliament. Byelaws are usually related to specific locations (such as trains), meaning that they may not be appropriate means to regulate smart mobility services, and Bills need to go through a very lengthy process before they become Acts of Parliament, usually taking years”(Moscholidou & Pangbourne, 2020).

conflicts and uncertainties around mobility technologies (i.e., MaaS) may emerge when regulation is designed with economic development, rather than transportation goals in mind.

Further, despite the importance of multi-level governance, certain tasks and decisions (e.g., implementation and oversight of MaaS systems) may best be guided by local-level actors. When they don't have the governance capacity or funding to tackle these issues, it may be necessary to introduce institutional changes that empower them to do so. Finally, the case studies demonstrate some of the threats inherent in smart mobility technologies, especially when private actors provide solutions. In other words, transportation services may not be as reliable considering the often-volatile business cycles mobility companies go through in the current landscape.

Regarding knowledge gaps, the academic literature on smart mobility governance in the Canadian case is still quite limited. There is ample room to move beyond descriptive analysis and toward more critical treatment of existing governance structures and motivations driving different levels of government to invest in smart mobility.

# Conclusion

The comparative study of smart mobility initiatives in Canada, the US, UK, Finland, and Germany underlines that so far there are no definitive answers regarding the right combination of stakeholders necessary for the successful implementation of smart mobility technologies. Instead, there are general principles that could be followed (listed in the implications section) as public policy stakeholders consider next steps. Future research should critically examine whether and how economic development and transportation motives can be balanced without compromising the quality or robustness of public transportation. There should also be more in-depth investigation of how multi-level smart mobility governance takes place in Canada and analysis of how these relationships are evolving. Finally, there is a need to examine the numerous pilot projects across all three technology fields in a comparative and comprehensive way to determine how and whether they are building on each other. And as the above analysis illustrates, valuable insights about the evolving Canadian model can also be derived from a comprehensive comparative study that includes international cases.

In addition to bringing forward governance principles that are valuable to consider going forward, the knowledge synthesis report also urges caution. The smart mobility deployments thus far have not shown that they necessarily impact public transport positively, even when governance structures are robust. This is because as an increasing number of private actors enter the public realm of transit, more unforeseen obstacles may emerge and destabilize transit (e.g., a smart mobility provider going bankrupt).

# Knowledge mobilization activities

In addition to the presentation to SSHRC in January 2022, the authors will deliver the findings of this research to the Partnership for the Organization of Innovation and New Technologies (4POINT0), SSHRC Partnership Project, directed by Professor Catherine Beaudry at the Ecole Polytechnique Montréal. Further, the report will be posted to the Innovation Policy Lab website at the Munk School of Global Affairs and Public Policy and disseminated through the Innovation Policy Lab newsletter, which reaches both academic and non-academic stakeholders.

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