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Automated Mobility Transitions: Governing Processes in the UK

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Abstract: Contemporary systems of mobility are undergoing a transition towards automation. In the UK, this transition is being led by (often new) partnerships between incumbent manufacturers and new entrants, in collaboration with national governments, local/regional councils, and research institutions. This paper first offers a framework for analyzing the governance of the transition, adapting ideas from the Transition Management (TM) perspective, and then applies the framework to ongoing automated vehicle transition dynamics in the UK. The empirical analysis suggests that the UK has adopted a reasonably comprehensive approach to the governing of automated vehicle innovation but that this approach cannot be characterized as sufficiently inclusive, democratic, diverse and open. The lack of inclusivity, democracy, diversity and openness is symptomatic of the post-political character of how the UK's automated mobility transition is being governed. The paper ends with a call for a reconfiguration of the automated vehicle transition in the UK and beyond, so that much more space is created for dissent and for reflexive and comprehensive big picture thinking on (automated) mobility futures.

Keywords: automated vehicles; autonomous vehicles; governance; post-political; Transition Management; socio-technical transitions

1. Introduction

A transition towards automated mobility is underway [1–4]. Every day there are reports of new trials, demonstrations, and partnerships, with a multitude of news stories covering the developments in robotic and automated vehicle innovation. The technological escalation of automated vehicle innovation—also known as 'driverless', 'self-driving' and 'autonomous' vehicles—is playing out across multiple spatial scales from the local to the global, with incumbent and new entrant actors across domains. Governments have become important actors in this multi-scalar race for supremacy in the automation of transport, through a range of activities including the adaptation of policy and regulation and the funding of demonstrations and trials. Their interests lie as both producers and consumers: countries including the UK, Germany, South Korea, the USA, and Japan are seeking to attract finance for research and development, and domestic production of automated vehicles (AVs hereafter), but they are also making and/or supporting claims of the environmental, social, and economic benefits arising from the widespread adoption of these innovations through, for instance, official publications and funding regimes.

Advocates of AVs argue that these innovations have the potential to revolutionize contemporary systems of mobility, framing AVs as radical technologies that will disrupt how, where and when people and goods move. AVs, their argument goes, will be part of a transition away from the current systems of mobility that produce harmful emissions, and replicate social inequalities, to a so-called 'smart mobility' system that harnesses new innovations, and stimulates new practices of mobility.

While it is beyond the scope of this paper to assess the validity of such claims, counter-discourses point to the ethical, legal and adoption challenges of AVs (e.g., [3]). This paper critically examines the governance of the transition to automated mobility, and seeks to make two contributions to the existing literature on AVs, and mobility transitions, more generally. It first proposes an analytical framework building on the Transition Management approach that draws attention to the politics of transition, and second examines the transition dynamics around AVs in the UK within the context of the global race to automation. While the UK is not alone in its interest in AV innovation, it is relatively unique given its historical dismantling of domestic vehicle manufacturing, and the renewed attention to vehicle research, development and production in the guise of national economic policy and a national Industrial Strategy [5] in recent years.

To make the current system of mobility more environmentally sustainable and socially just, deep structural changes are required [6,7]. Such systemic changes are referred to as socio-technical transitions, as changes need to occur to the overall configuration of the system, including the technologies, regulation, consumer practices, infrastructures, and cultural meanings (e.g., [8]). Since the transformation of socio-technical systems involves a range of actors (businesses, policymakers, consultants, interest groups, consumers, and civil society), is characterized by uncertainty, and occurs over long timeframes, traditional governance processes are often unsuitable [9]. Reflexive governance approaches are required as they more usefully balance interests of state, market and societal actors. Transition Management (TM, hereafter), is one such reflexive approach, which provides an analytical framework to examine the ways through which transitions can be guided. The TM cycle focuses on four types of practical activity—strategic, tactical, operational, and reflexive—and suggests that by better understanding 'the origin, nature and dynamics' of transition processes, actors will be able to both anticipate and adapt, with potential to influence the speed and direction of transition ([9], p. 49). Yet, the thinking on transition has still to develop comprehensive understandings of the multiple and intersecting role(s) of power and politics of/in TM [10–12].

With some important modifications pertaining to the politics of transition dynamics, the concepts and ideas arising from TM can be used as a heuristic framework for the interpretation and evaluation of currently unfolding governance processes in automated mobility. The ability of automated vehicles to contribute to a systemic sustainability transition is as yet unclear and can easily be contested, but the complexities and uncertainties arising from these technologies can still fruitfully be analyzed using TM. Accordingly, in this paper, we draw on TM and writing on what has become known as the post-political condition [13,14] to analyze automation transition dynamics. After introducing some key debates in TM and post-political literature, we draw from TM concepts (strategic, tactical, operational, reflexive) to examine the governance of vehicle automation in the UK. We point to the lack of inclusivity, democracy, diversity and openness in the AV transition, which is symptomatic of its post-political character. We conclude by calling for greater consideration of the political dimensions of innovation and transition processes, including in AV innovation in the UK.

2. Transition Management

The balancing of state, market, and societal interests is important in the reflexive governance of societal change [15]. While articulated goals, knowledge and power differ between approaches to reflexive governance, it is broadly agreed that participation, experimentation, and collective learning need to be central features of all governance processes because of their diversity, uncertainty, and societal heterogeneity [15,16]. From this perspective, societal change results from a range of different forces, and reflexive governance approaches seek to embrace the heterogeneity and multi-dimensionality of problems, and the range of possible futures. TM is a consensus-driven, multi-actor model [17]. It shapes innovation processes and structural transitions within socio-technical systems, such as mobility [18]. TM is not, however, focused on achieving predefined outcomes through processes of planning and control but rather at goal-oriented modulation [19]. Management in this sense draws its

meaning from complexity theory and refers to efforts to influence processes of change in a desirable direction [20].

The TM literature suggests that, by studying past transitions, insights on how to steer future transitions can be gathered and used to realize sustainable change [21]. Proponents of TM argue that change is not revolutionary but occurs by way of incremental steps that lead to lasting, systemic and 'evolutionary' change [22]. Transitions are not the result of a single modification (e.g., to policy or technology) but emerge from developments across domains including, but not limited to, technologies, infrastructure, user practices, cultural values and meanings, markets, business models, regulation, and knowledge. In practice, the transition process begins with selected innovators and visionaries brought together as a small network of frontrunners, referred to as the 'transition arena'. Following this, a long-term guiding vision is sought, and a number of possible transition pathways are defined. Transition experiments are designed to contribute to desired transition trajectories and to develop into 'niches'. TM suggests that a multiplicity of experiments form a portfolio in which they reinforce one another [9], and develop shared learning, contributing to a predetermined sustainability objective in detectable and measurable ways.

The TM cycle (Figure 1) translates the basic principles of the management of transitions into four types of practical governance activities that exhibit distinct characteristics, including the actors involved and the levels at which they operate [23]:

Figure 1. The Transition Management Cycle. Adapted from: Loorbach, 2010 [15].

Strategic: Strategic activities operate at the societal system level, with long time horizons. They involve processes of vision development, and the formulation of long-term collective goal and norm setting. During this time, uncertainty is high, and opinion leaders have space to voice alternatives and potentially influence societal and political discourse. Actions relate to the 'culture' of a societal system, and activities include debates on norms, values, identities, sustainability and societal importance.

Tactical: Tactical activities operate at the sub-system (e.g., sectors or themes) level and focus on achieving goals within their specific context, rather than on overarching change to the entire societal system. Activities include the development of coalitions, transition agendas and images, negotiations between key stakeholders and actors, and transformations of existing structures and institutions in line with articulated strategic goals. The development of networks and coalitions is important to activities at this level as the resulting linkages can provide mechanisms for change.

Operational: At the operational level, TM activities are inclusive of short term and everyday decisions, and actions including trials and experimentations with innovative potential. The focus at this level is on practices and their implementation, including the mobilization of actors. Actors explore solutions and create innovations that include technologies, rules, and organizations, some of which

may fail. Action will be driven by the ambition, skills and/or promising innovations of actors involved in the operational activities.

Experimentation is a critical feature of the pre-development phase of transition [22]. Transition experiments require both time and resources to establish within niches before becoming embedded in existing regimes. Strategies to achieve embedding consist of learning from the experiment (deepening), repeating based on earlier learning, experimenting in a different context (broadening) and applying the successful experiment at a wider scale (scaling up). Demonstration projects can be practiced in different ways, for instance, by presenting a (near) completed artefact, or as part of the developmental process.

Reflexive: Reflexive TM activities include monitoring, evaluation and learning, gained through debate, research and assessment. The reflexive process operates across and within the strategic, tactical and operational levels, and consistently evaluates and, where necessary, adapts the goals, strategies and actions based on developments that may be expected and unexpected, with desirable or undesirable effects.

TM plays out over the four levels (Figure 1) and across time scales. From experimental applications of TM, guiding principles have emerged that can help to develop context sensitive implementation across different circumstances (e.g., urban to rural, local to national, energy, mobility, education and welfare) [9]. Of particular relevance to the case analyzed in this paper are:

Inclusivity— the need for marginalized perspectives to be included in the TM process, exposing questions on how to involve 'outside' perspectives and interests. Tensions between inclusivity and exclusion are often reported in case studies of sustainability transitions (e.g., [24]) which point to the inclusion of certain actors, issues, and future visions at the expense of others. As well as actor groups included, the TM approach calls for inclusive and open dialogue between actor groups.

Democracy— the need to engage with all sectors of society. The importance of democracy raises multiple questions about legitimacy and accountability, including how these terms should be understood.

Diversity— the importance of not only diverse actors (i.e., inclusivity) but also sites of experiments and ways of organizing and practicing governance. Those ways should both aid innovation and expose contestation and conflict.

Openness— the need for multiple pathways and avoidance of homogenization (uniformity and standardization) throughout the transition process, including the acceleration phase. This theme underscores the need for long-term reflexivity with sensitivity to local context. For instance, keeping the start of a transition process as open as possible will create space for different visions of the future and allow different transition pathways to coexist.

A range of criticisms of TM have emerged relating, for instance, to the role(s) of empowerment [25] and democracy [26]. Avelino [25] discusses the micro-politics of policy design, and the aim of TM to 'empower civil society' ([27], p. 284), pointing to issues of disempowerment which can occur at the operational TM level. The meaning of democracy for the practice of TM is examined by Hendriks [26] who argues that there is a complex relationship between democracy and long-term policy design. Yet, a reoccurring criticism relates to something implicit in the empowerment and democracy debates—the politics of TM (e.g., [11,26,28,29]), with the transitions literature falling short in conceptualizations of power [30], which will be developed further below.

3. Politics and the (Post-)Political

Templates for transition are political statements [11], which are contingent, only partially inclusive, and often unstable over time. This suggests that there is a politics to TM, through which power struggles emerge over "when and how to decide and when and how to intervene" ([11], p. 766). Concerns about the political implications of reflexive governance and TM have included observations

that interactions between reflexive governance designs and real-world political contexts may impair effectiveness, and that application of the approach in the context of representative democracy may marginalize particular groups and reinforce an incumbent, capitalist political economy [16]. Moreover, Voß and Bornemann [16] argue that politics should be viewed as a 'constitutive element of reflexive governance' (p. 2) and that its roles in the practice of participatory experimentation and learning must be considered carefully.

To this end, we follow Mouffe [13] in distinguishing the political from politics. She defines the former as "the dimension of antagonism which I take to be constitutive of human societies" and the latter as "the set of practices and institutions through which an order is created, organizing human coexistence in the context of conflictuality provided by the political" ([13], p. 9). Building on these ideas, Swyngedouw [14,31] has proposed that, in a post-political scenario, the governing of change is reduced to consensus formation, technocratic management and problem-focused governance, all of which are maintained by both populist discourse and post-democratic institutional configurations. For him and others, the rise of the post-political condition is inextricably linked to the diffusion and evolution of neoliberalism. This, they argue, has led to the dominance of a mode of governing based on an ethos of efficiency, instrumentality and economic rationality, and grounded in techniques of economic administration and markets (see [32] for similar arguments within a different philosophical framework). This has meant that participation and buy-in of the private sector into policy processes and (economic) development are now widely seen as essential. Governments seek to create a more certain investment environment to gain greater private sector participation and managerial, expert-driven governance [33]. As a corollary, engagement with citizens is often limited to narrow, 'rubber-stamping' consultation in which big-picture and value-oriented questions are rarely discussed or evaluated [33]. The consequences of this approach are 'good governance' achieved by means of stakeholder-based (negotiated) consensus and a marginalization of the political as understood by Mouffe [13].

Before exploring the claim that TM discourse "seems to bear the hallmark of what is considered 'post-political'" ([12], p. 572), we note that the above claims about the post-political condition have not remained unchallenged. The shift towards the post-political is spatially divergent and is resisted in numerous spaces and times (e.g., [34–36]). For instance, Beveridge and Koch ([35], p. 39) call for "a more open view of . . . the city as a place of struggle and a site of (radical) political agency," and thus for more detailed, nuanced and contingent understandings of the political because cities continue to be sites of resistance and emancipation. Highlighting that neoliberalism is neither monolithic nor coherent, Larner [36] suggests that certain experiments (typically in cities) do generate politicized formations and ways of anticipating the future that cherish dissent, ask fundamental questions about value systems, and are radically different from the present. The points by Beveridge and Koch, and Larner are germane to automated mobility, given the strong desire of many AV protagonists to undertake experimentation with urban traffic in city settings, as well as the interest of incumbent vehicle manufacturers and the privileging of expert management in AV experiments.

Transition Management and the Post-Political

Notwithstanding its critiques, the thinking by Swyngedouw, Mouffe and others highlights the need for further theorization of TM's political dimensions. Previous texts considering conceptualizations of TM through a post-political lens have identified various gaps that can obscure conflict, exclusions, and inequalities and increase the risk of co-optation by vested interests [30,37]. Kenis et al. [12] identify five points of entry for critiquing the TM process:

Consensus, dissensus, and diversity: Openness shifts across temporalities in TM since dissensus is allowed to exist in the short-term "to the extent that it is instrumental to consensus" in the long run ([12], p. 575). The framing of disagreement as temporary has implications for diversity as choice occurs within boundaries and is framed in a structured setting. Constraints on diversity may be inevitable, but Kenis and colleagues contend these needs to be acknowledged explicitly in TM processes.

Conflict: In TM, conflict "acquires a very specific meaning and aim" ([12], p. 576) that is economic rather than political. As a result, conflict is often seen as a deficiency to be overcome or rather as something to trigger creativity and/or innovation.

Actor representation: TM focuses on the participation of four main actor-groups: governmental bodies, business, non-governmental organizations, and knowledge institutes and 'recognized experts'—meaning that transition arenas are frequently centered on very specific interests and tend to reflect and reproduce the hegemonic framework of a growth-based, market-led economy. Publics in their various guises are often not included and it is often assumed that the images and visions that appear from the transition arena will be accepted by the public(s). Insofar as publics are involved in TM, their role is often that of 'the consumer' rather than as "citizens and active agents in transition processes" ([26], p. 579).

Power in transition arenas: Actors in the transition arena are thought to put their common interests before personal interests, but this assumption fails to recognize the power struggles and possibly conflicting interests among actor groups as well as the resulting exclusions. The interests of innovators, researchers and government officials need to be better understood as part of the process of co-constructing futures which are embedded in individual and collective interests and priorities.

Markets: Common configurations of transition arenas and the ways of handling dissensus and conflict mean that TM processes tend to reflect, and reproduce, the hegemonic framework of a growth-based, market-led economy.

Just like authors such as Swyngedouw and Mouffe producing overly universal and monolithic representations of the post-political condition with "little room for nuance" ([36], p. 193), Kenis et al. tend to homogenize TM. They thereby risk exhausting TM's potential to foster political alternatives configured around justice, an ethics of care or the generation of the (urban) commons (cf. [38]), for instance, by letting different actors participate in the transition arena.

Nevertheless, Kenis et al.'s critique draws attention to various issues that need to be considered if TM is used as a heuristic framework for analyzing how the transition towards automated mobility is governed. It is, for instance, critically important to consider how open the governance of the AV transition process is to different actor groups. This will shed light on the intersecting roles of various groups, shifting focus to not only the knowledges which are privileged but also those which are excluded from dominant discourse. Likewise, special attention needs to be directed towards the space-times for and of conflict, disagreement and dissensus that exist and what effects they generate. It is also important to consider the role(s) and configurations of markets within the TM process. In fact, the focus on markets can be generalized into a broader orientation towards the techniques and procedures that are used to govern the innovation process, of which markets are only one subset. Integration of these sensibilities into a TM-oriented analysis will enable a comprehensive interrogation of the AV transition processes taking place in the UK.

4. Development of Automated Vehicles

Research into the development of so-called 'driverless' vehicles dates back to at least the 1920s. Predicated on transport problems such as anticipated road congestion [39], the perceived limits to human capacities to drive safely [40], and Sci-Fi and engineering optimism and capabilities, a range of vehicles were retrofitted with different types of automated technologies including antennae, circuit breakers and electric motors [41], and "drive-by-wire" [39]. With names like "American Wonder" and "Phantom Auto", early AV innovation leveraged upon the economies of the so-called 'roaring twenties' and associated post-war techno-optimism. In the UK, government-funded projects in the 1960s demonstrated AVs on private and public roads including a section of the newly constructed M4 motorway, with retrofitted vehicles (Citroen DS19 saloon, Standard Vanguard estate, and Austin Mini). However, funding for the research was withdrawn in the mid-1970s when, in the context of economic recession, the technologies were deemed "unnecessary and unaffordable" [39].

While the research, testing and demonstration of 'fully' driverless/automated vehicles was temporarily halted, automation of discrete driving tasks, and specific types of vehicles continued apace. Modern passenger and freight vehicles now utilize a range of automated innovations from cruise control, to automatic gear functions and automated breaking. These automated technologies have slowly emerged in vehicles and become normalized through use. Likewise, the value of using automated vehicles in factory sites and ports and by the armed forces has stimulated continued attention to the development and application of AVs. The current wave of interest into AVs is novel in that heterogeneous technologies (passenger vehicles, pods, etc.) are being tested on public roads, and in some contexts used by the public, with technologies progressing towards being 'fully driverless'. But importantly, for the first-time innovation around AVs is systemic; it is not limited to the way a vehicle is driven but to a much wider range of innovations within the vehicle as well as beyond including propulsion, traffic management, mobility-as-a-service, and IT applications for transport in the smart city [42]. Moreover, there are important interactions between automation and other innovations in fuels (e.g., electrification) and ownership models (e.g., sharing), which together may offer greater potential for emission reductions and sustainability of the transport system (e.g., [43]).

The resurgence of interest in fully-automated vehicles has been motivated by advances in deep machine learning by ICT providers and software companies. Google's self-driving car project Waymo was launched in 2009 with the objective of developing a fully automated ('driverless') vehicle by 2020. Similar claims have been made by incumbent vehicle manufacturers (e.g., Volvo) and ICT companies (e.g., Apple) and others (e.g., Uber). While much attention is being paid to the technological, socio-cultural, ethical and policy implications of automating passenger transport, progress has also been made in the development of automated freight vehicles. A range of driverless goods vehicles are emerging, from articulated trucks (a.k.a. 'big rigs' or 'semi-trailers') to delivery vans and ground drone 'delivery bots'. These innovations are being led by both incumbent vehicle manufacturers—e.g., Daimler's Freightliner Trucks—and start-ups such as TuSimple (China), Otto (USA), and Starship Technologies (Estonia). Partnerships and collaborations between vehicle manufacturers and start-ups share expertise, know-how, and capabilities in vehicle manufacturing and software, respectively.

Partnerships have been important for both incumbents and start-ups across passenger and freight, as incumbents "didn't want to simply bend metal for what would inevitably become seen as the Google or Uber car" [44], while start-ups benefit from the large economies-of-scale and established funding, system and networks of the incumbents. Innovation for heavy freight vehicles have focused on retrofitting technologies, which may offer opportunities for a faster transition due to lower up-front costs and barriers to adoption. In the light goods and micro delivery vehicle sectors, innovations include design-led vehicles (e.g., Arrival) which have been manufactured from the ground up (e.g., StarShip Technologies).

5. A Transition Management Perspective on Automated Vehicles

To understand the current interest in AVs among industry, government and the mass media in the UK, this and the subsequent sections of the paper draw on the analysis of existing documents and primary data. Forty-one qualitative interviews with a diverse set of stakeholders including government departments, industry organizations, entrepreneurs and start-up businesses, NGOs and charities were conducted over the course of 2017, and a workshop with stakeholders focused on automation in freight transport was held in March 2017 in London. These empirical materials are coupled with an analysis of industry, government and mass media documents to gain insights into the current framing of the AV transition, discussed below.

In this paper, we draw from the collective insights gained from these various empirical activities. The industry workshop was convened by both authors and used to gain detailed insights into the various perspectives of stakeholder groups on the UK's newly introduced Industrial Strategy, and the expectations, desirability, diffusion of vehicle automation, including the UK's role in the global market. The interviews were designed by both authors and conducted by DH. The interviews

included participants from national organizations, and urban stakeholders engaged in experimentation. Thematic coding of the workshop, interviews and documents offered detailed insights to the way the transition to AVs is being governed in the UK, which we consider through the heuristic of our modified TM approach.

Robotics, Artificial Intelligence and automation have been envisaged by the UK government as a centerpiece of the post-Brexit, new 'industrialized' economy [5]. The focus on automation including research and development, manufacturing and adoption is also a response to the UK economy since the Global Financial Crisis, domestic regional inequalities particularly between northern and southern England, and the dismantling of indigenous vehicle manufacturing during the 1980s [45]. The degree to which developments in AV technology will respond to these problems is not clear; however, the government has been actively involved in wide-ranging activities, including:

- Future visioning and the creation of positive discourses around automation;
- Facilitation of network building between incumbents, start-ups and other actors;
- (Part) Funding technology trials and demonstration projects;
- Creation or amendment of domestic legislation (e.g., licensing and insurance);
- Development of a Code of Practice for testing of AV technologies; and
- Engagement with international agencies to create or amend international standards and/or legislation.

Thus, the UK government has adopted a relatively comprehensive approach to AV innovation (Figure 2), with activities emerging in multiple domains.

The four levels of the TM cycle offer an opportunity to conduct a more detailed examination of the practices and processes being adopted for AV innovation in the UK, but also expose the gaps in both TM and the governance of AV innovation. Below we provide a brief discussion of the current state-of-play in the governance of AV innovation in the UK, pointing to the activities, institutions and actor groups that have been involved, and analyze these using the TM concepts as a heuristic device. This discussion is a summary and update from a more detailed analysis published elsewhere [46].

Figure 2. Timeline of key policy and regulatory responses, and demonstration projects in the UK, 1960–2017.

5.1. Strategic

At a strategic level, the UK has positioned itself as both an interested consumer and an active producer of AV technologies. High profile, public proclamations of the transition to robotic and automated technologies across all spheres of daily life have ushered a sense of inevitability to the rise of AV technology. For instance, in June 2017, the Queen announced the Autonomous and Electric Vehicles Bill, which was designed to "allow innovation to flourish and ensure the next wave of self-driving technology is invented, designed and operated safely in the UK" [47]. While the Bill itself offers tactical and operational outcomes, there are strategic imperatives to its high profile announcement and subsequent media attention. Such moves have been coupled with the post-Brexit 2017 Industrial Strategy Green Paper [5], a consultation document which outlined ten pillars to drive productivity and growth across the UK. Artificial Intelligence, robotics and automation were noted within the Strategy as areas of strategic importance for post-Brexit Britain. This was reiterated in the 2017 Autumn Budget, with Chancellor of the Exchequer, Hon Philip Hammond MP asserting that "the world is on the brink of a technological revolution" and that "Britain is genuinely at the forefront of this technology revolution" [48]. Driverless vehicles were acknowledged as the technology most symbolic of the revolution "gathering pace around us" [48].

The UK government has also focused on activities such as problem definition, the establishment of (an equivalent to) a transition arena, and vision building. These activities have been articulated in key publications (e.g., [5,49,50]), which communicate the government's position in harnessing benefits from automation technologies as both producers and consumers, and the various roles the government has taken, and intends to take to this end. In 2015, the government released two reports outlining the "Pathway to Driverless Cars" [49,50]. These documents serve as action plans: one report is a more general summary characterizing the technology and identifying challenges and the opportunities to development and adoption [49], while the other is a detailed report examining regulatory frameworks [50]. Both reports are focused on overcoming barriers and situating the UK as a center of technology development, testing and demonstration. This is largely achieved by way of (favorable) comparison with other regions, countries and states competing in the global race for supremacy in AV innovation (e.g., the USA—particularly, Nevada and California; Germany; Sweden; Japan; and South Korea).

5.2. Tactical

Government funded organizations *Innovate UK*—the government innovation agency—and the *Transport System Catapult*, which promotes UK innovation in Intelligent Mobility, play a key role as intermediaries [51–53] in AV developments in the UK. They have helped to bring together key industry actors. Processes of agenda building, negotiating, networking, and coalition building are also within the remit of the *Centre on Connected and Autonomous Vehicles (CCAV)*, which is part of the Department for Transport and the Department for Business, Energy and Industrial Strategy and was established in 2015 to work across government to aid early market entry for AV technologies. This partnership somewhat tellingly points to the intention of the UK government to be active in the business development and innovation of AV technologies. Indeed, the remit of the Center is to "help ensure that the UK *remains* a world leader in developing and testing connected and autonomous vehicles" ([54], emphasis added).

5.3. Operational

Experimentation is a key part of the race to automation, evidenced in the UK and internationally not only by industry actors but also governmental approaches to AV development. The operational phase of TM, through the mobilization of actors, and the execution of projects and experimentation is underpinned by the funding rounds provided by the UK government (e.g., Figure 2) used to stimulate domestic innovation, including three rounds of Connected and Autonomous Vehicle

(CAV) competitions (2016, 2017, 2018) offering matched industry funding. In 2014, Innovate UK led a competition for £19 million funding, and identified four sites of demonstration constituting partnerships between private companies, consultancies, universities and local authorities, and culminating in three trials lasting between 18 and 36 months. Bristol, the Royal Borough of Greenwich (South-East London, Figure 3), Coventry and Milton Keynes were selected as sites for (AV) learning and experimentation.

Figure 3. GATEway driverless vehicle demonstration, Greenwich, London. Source: Creative Commons CC0 1.0 Universal Public Domain Dedication. WikiMedia. Available from: https://commons.wikimedia.org/wiki/File:GATEway-Podcar-NthGreenwich-London-P1400388.jpg.

Government funded demonstrations have been primarily trialing passenger vehicle technologies, with most automated freight vehicle trials led by industry, such as Starship Technology's demonstrations in London. Interest in trialing HGV platooning technologies on UK motorways has waxed and waned, with the application gaining little traction as part of the broader hype around AV technologies. Nevertheless, there are reports of on-the-road 'real-world' trials for platooning technologies in the UK in 2019, funded by the Department for Transport and Highways England, and run by the Transport Research Laboratory.

The use of geographically dispersed and diverse demonstrations fits with the TM philosophy. However, while multiple technologies are tested in experiments involving different actor constellations, it is notable that to date, all government-funded demonstrations are located in southern England, which may reinforce the asymmetric economies of the south of England and the remainder of the UK and which runs counter to the stated goals of the new Industrial Strategy [5]. The places of experimentation also expose a concern at the operational level of TM since there has been a focus to date on urban experimentation of AV technologies. Yet, while urban traffic may well be the most difficult to automate [55], urban trials are often configured in specific parts of the city—with low(er) traffic flows, less complex road configurations, and often on sites of new residential and/or commercial developments (e.g., Greenwich Peninsula). There have, however, been steps towards experimentation on motorways for both passenger vehicles (e.g., DRIVEN consortium) and the aforementioned platooning of freight vehicles.

5.4. Reflexive

The reflexive stage in the cycle is not yet well articulated for AV innovation in the UK, with learning appearing to relate to international government policy and regulation, and industry developments. For instance, the UK Government's Pathway to Driverless Cars regulatory review [50] provides a detailed examination of international government regulations to driverless vehicle technologies, to aid the development of domestic policy. This provides some evidence of the competitive stance taken by the Government with relation to gaining domestic innovation, research and development, and demonstration projects. It appears that discourses of international competition and economic

significance and the frame of a race towards automation have created a sense of urgency that results in a privileging of the implementation of legislation and cutting of 'red tape' over public participation in the innovation trajectory.

According to the TM literature, part of the learning achieved in this process is an evaluation of whether the transition objectives have been realized. This critical and self-reflexive process offers opportunities for restructuring the problem framing [16,29]. The diversity of private sector actors and overlap between demonstration projects in terms of technologies (e.g., vehicles, sensors) used, and consortium partners (Figure 4), may suggest learnings between projects and collaborative development of technologies. Insofar as lessons have been learnt, these are not widely circulated and not in the public domain, no doubt in part because of commercial sensitivities and the perceived importance to not advance the position of perceived competitors.

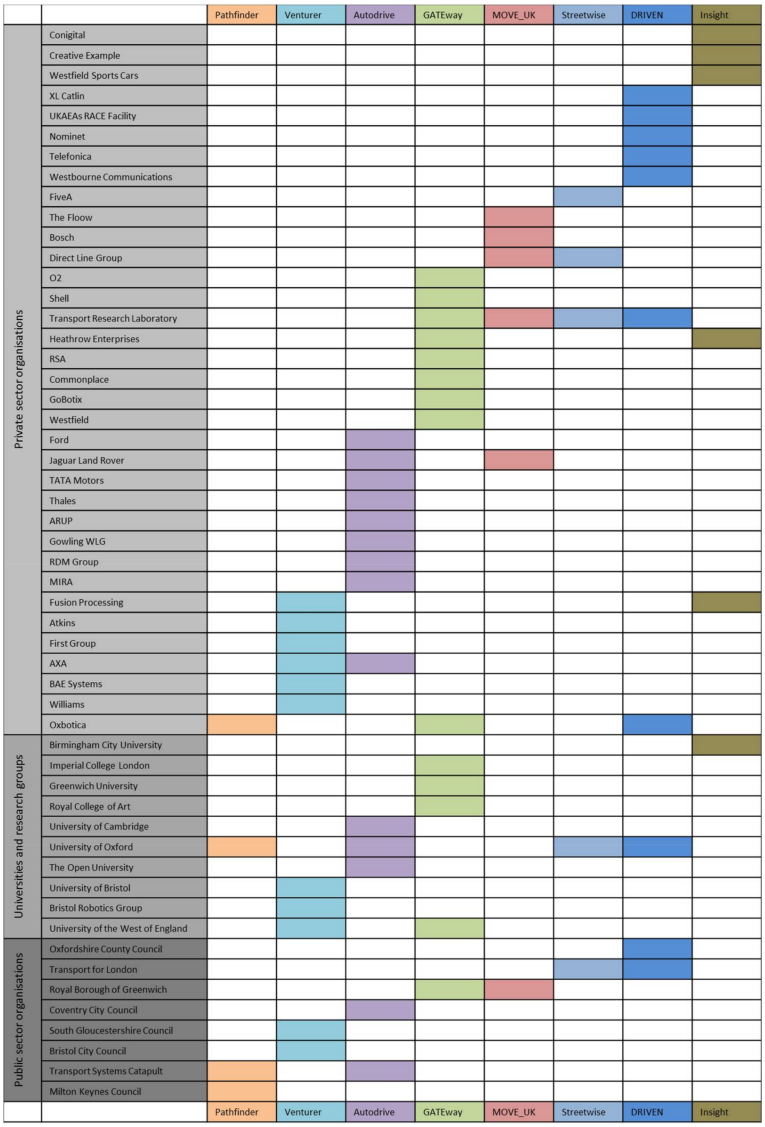

Figure 4. Actor Groups Involved in Eight UK Government Funded Connected and Autonomous Vehicle (CAV) Demonstration Projects: Lutz Pathfinder Project, 2014; Venturer consortium, 2015; Autodrive consortium, 2015; GATEway consortium, 2015; MOVE_UK, 2016; Streetwise consortium, 2017; DRIVEN consortium, 2017; Insight consortium, 2017.

5.5. Interconnections

There are multi-level dynamics, whereby strategic activities can influence tactical, operational, and reflexive activities through top-down processes, yet experimentation and learning from the operational and reflexive levels can also put pressure on the strategic level by way of bottom-up forces [56]. When the TM cycle is used to evaluate AV innovation in the UK, it shows that the levels are not well aligned and integrated. It is not immediately clear how the monitoring and evaluation of the demonstration projects will contribute to wider learnings and reflexive governance. It might be that this role is adopted by CCAV or Innovate UK, particularly where there are commercialization opportunities, but the materials used for this paper neither confirm nor refute this conjecture. These insights signal the need for multi-level coordination with local experimentation informing the development of national policy and coordination across scales, including with international policies.

6. A Post-Political Race to Automation

Working through the levels of the TM cycle, the previous section has discussed the various activities of the UK Government and other actors as part of what it widely framed as a global race toward automated vehicles. Yet, both this framing and the wider activities of the government and others can be considered post-political. The issues identified at the end of Section 3 will be explored in support of this claim.

6.1. Openness and Inclusion

At first sight, the eight (partially) publicly funded demonstration projects presented in Figure 4 harness diversity in partners and technologies. There are no less than 50 partners, across university-industry-government configurations. This is not only consistent with the principles of TM (Section 2) but also fits with the Triple Helix concept of innovation dynamics [57]. According to the latter, governments act as public entrepreneurs and venture capitalists, universities capitalize knowledge and stimulate spin-offs and the development of new firms, and industry engages in research and knowledge sharing—thus each "take(s) the role of the other" ([58], p. 1). This process encourages hybridization across and between the three spheres [59] and is visible in the collaborations and demonstrations utilized in the AV innovation process. For instance, Oxbotica emerged from the University of Oxford's Mobile Robotics Group, centered largely on their autonomous control system, Selenium – but also extending into fleet management systems (Caesium) utilized across passenger and goods mobility. Oxbotica has partnered with Milton Keynes Council (Pathfinder), Royal Borough of Greenwich (GATEway) and the Oxfordshire County Council (DRIVEN), as well as numerous private sector partners (Figure 4) to drive innovation.

Nevertheless, openness between partners, across demonstration projects, and beyond will be mediated by commercial sensitivities and willingness to share commercial information, particularly at an early stage in the AV race. It is not clear if and how intermediaries such as Innovate UK, the Transport System Catapult and CCAV negotiate those sensitivities and encourage sharing. However, there is clear overlap in partners between the (partially) funded projects given that the Transport Research Laboratory, Oxbotica, and the Royal Borough of Greenwich council are contributing to multiple projects. This would suggest at least some learning across the projects. At the same time, their prominent role also indicates selectivity in coalition building and may work against the principles of inclusivity, democracy, diversity, and openness [9].

A clear absence in experimentation is the active participation of mediated and emergent publics and their proxies (e.g., public opinion, values, sentiments); publics are predominantly configured in dominant discourse as "future technology adopters" [60]. As the trials have progressed through time, there has been more recognition of "users" as part of the innovation pathway, and thus the potential for a broadening of learning and opportunities for greater inclusivity. For instance, the Insight consortium is conducting research on accessibility for independent travel, and other user-centered projects funded

through the "Intelligent Mobility Fund" mechanism (e.g., Flourish, http://flourishmobility.com/) are highlighting the need to better understand the social equity dimension of AV innovations.

There are, however, two immediate problems with this framing. Not only is the conceptualization of heterogeneous publics as 'user' limited and limiting; there also remains a clear prioritization of experts from government, industry and academia in discourse relating to robotics and automation. There has so far been little public engagement beyond public perception surveys [61,62], consultation on the Industrial Strategy Green Paper [5], and exposure to the technologies through public trials. As previously reported with electric vehicles [63], a wider range of roles, including as citizens, is not currently envisaged in AV governance and experimentation. This means that the creation of visions about possible futures and the construction of a socio-technical discourse or vision will include certain elements and exclude others, and for AV innovation in the UK, will remain strongly dominated by a market driven, expert focused discourses thereby potentially limiting the range of alternative AV futures that are imagined.

6.2. Disagreement, Conflict and Dissensus

The discourse about AVs propagated by the UK Government; publicly funded intermediaries such as Innovate UK, the Transport Catapult and CCAV; and industry is, or tries to be, strongly performative. Not only does this discourse seek to generate or strengthen positive attitudes and buy-in from relevant stakeholders in industry, the mass media and wider publics by presenting automation in vehicles as a highly desirable and inevitable future; it also tends to reinforce a market-centered logic that prioritizes economic stimulation and understands the role of the public sector as enabling and speeding up innovation by industry.

Given that government departments and organizations (e.g., CCAV) have played a leading role in activities that for TM scholars would encompass all levels of the TM cycle, the discourse has had effect not only in strategic problem definition and vision building but also in the setting of funding regimes and priorities (operational level), the putting together and selection of consortia for funding and support (tactical level), and the setting key parameters for monitoring and evaluation. As a result, there is neither much space for (open) disagreement nor clear evidence of (open) conflict between actors involved in AV experimentation in the UK; consensus building seems to have been a guiding principle in strategic, operational, tactical as well as reflexive activities, and no clear distribution in terms of consensus and dissensus can be identified. It is quite possible—albeit extremely difficult to prove—that actors have been selected on the basis of their support of the dominant vision, which in many ways reinforces the incumbent regime of automobility [6,63]. It would seem, then, that insofar as dissensus is harnessed in the management of the UK's AV transition, it is understood as temporary—i.e., as a deficiency to be overcome, or as something arising from competition within the innovation race that can stimulate creativity and thereby speed up the transition process.

There have been several episodes of specific actors articulating disagreement, but to date these have not had much impact on long term strategic visions, and to a lesser extent, the various rounds of government funding. One of the most high-profile episodes was the House of Lords Science and Technology Select Committee [64] assessment review of CAVs which gave voice to a range of alternative perspectives and visions. It thus provided (limited) space for dissent but it is unclear the impact this has had or will have on AV discourse, or the openness of TM to alternative futures.

More explicit forms of dissensus have been vocalized with reference to AV innovation and demonstration in freight transport. The emergence of last mile delivery pods has exposed questions of the use of pedestrian space, the final five meters of delivery, safety and security, and the ability to scale up and respond to urban transport problems in a meaningful way. In the case of heavy goods vehicles, testing and experimenting with platooning technologies on UK motorways (convoying two or more trucks) has led to the rail freight industry advocating multi-modal solutions that do not continue dependence on road-based modes, and some broader industry and public discomfort with the concept of platooning. As with the House of Lords enquiry, these alternative voices are not (yet)

impacting upon dominant discourse. One reason for this seems to lie in the economic stakes: as previously noted, the Government has identified autonomous (and electric) vehicle technology as one of the core constituents of the UK's future manufacturing base.

Perhaps this is also why discussion and acceptance of the possibility of failure is almost entirely absent from UK discourse around AV innovation. Demonstration projects and government funded research and development have no clear mechanism for failure, instead fitting within a narrowly focused future vision and contributing to the expert-led pathway. However, signs of skepticism from mass media and other actor groups are slowly appearing in broader discourse. These signs relate to labor implications (e.g., professional driver workforce), timescales of diffusion, future expectations (e.g., dystopian futures), and the selectivity of the Government's attention and funding priorities, with critics pointing to the privileging of AV technology demonstrations over other innovations in funding decisions. Since AV innovation has been framed in terms of economic opportunity post-Brexit, it remains to be seen what the effect on policy may be and/or whether the skepticism turns into full-fledged dissent, disappointment and temporary or permanent termination of government funded experimentation with automation, as previously occurred in the 1970s. For now, at least, the dominant discourse tends to foreclose dissent and narrow possible futures.

6.3. Knowledges, Techniques and Procedures

A central element of the discourse underpinning the creation of niches for experimentation with AV technology is the idea that the race to automation can be 'won' by means of technological innovation, a focus on market processes, and changes to rules and regulations that 'cut red tape' and are supposed to enable AV innovations to flourish. This thinking is heavily influenced and framed by path dependent and context specific processes in which national level policy making is situated. First, rather narrow and heavily history-dependent definitions of expertise and experts in the UK's transport debates and governance have reinforced the prioritization of technical input from engineering, economics and business studies, with fewer insights from critical social sciences or the creative arts, with due implications for the (types of) questions asked and responses gained. Second, as in other countries, the governance of AV technologies is heavily influenced by discourses of competition and the race to a (fully) driverless vehicle future, which is informed by previous high-profile innovation races (e.g., space race, arms race) but also vehicle technology races (e.g., EVs; [65]).

Third, the dominance of the regime of private, motorized mobility remains pervasive in the UK (e.g., [6,63]), while policy, visioning and decision making in relation to transport are myopic in the sense that they are strongly shaped by current political agendas, particularly at the national level. There is a strong focus on 'fixing' the problems of sluggish growth and stalling productivity in an economy deeply affected by the Global Finance Crisis and facing deep uncertainties relating to Brexit. This is perhaps most evident at the strategic level in the Industrial Strategy Green Paper [5] which views AV produced and consumed within well-functioning and (therefore) efficient markets as a key means to tackle the productivity gap and drive growth. At the same time, there is increasing realization that the dominant system of mobility generates many negative externalities—alongside congestion, air pollution in urban areas is currently attracting most attention. In this context, technologically deterministic reasoning which posits new technology—including AVs—as a neutral, effective and efficient solution to problems is not simply an attractive proposition but a habit of thought that is deeply institutionalized in policy and governance.

Technological determinism is also common at the local level of cities and city-regions, but is often also complemented by knowledges and discourses that are not predominantly focused on efficiency, quantitative growth and markets (e.g., [7]). This may be why local authorities known to experiment extensively with sustainable transport—examples include London, Milton Keynes, Bristol and Oxford—are equally keen to play a leadership role in AV experimentation, without always recognizing the full range of tensions between hosting and organizing AV demonstrations and a commitment to sustainable mobility. It is partly for these reasons that the post-political condition is shaping AV

innovation and transition processes also in important ways at the city level. It may not be as pervasive as on the national level but there has so far been no evidence to suggest that cities and experiments in urban settings are sites of resistance to the processes described by the likes of Mouffe and Swyngedouw as far as automation in transport is concerned.

7. Discussion and Conclusions

Much has happened around AV innovation over the last five years in the UK. The Government has played a strong role as coordinator, enabler and risk taker in a way that resembles the prescriptions of the Transition Management (TM) approach. Moreover, there have been activities at all levels of the TM cycle (Figure 1), although there could have been more integration across them. The UK government's response has been centered on creating conditions for AV technology emergence and diffusion, rather than system-wide, long-term visioning, and a critical analysis of the role automation may play in future mobility.

As far as TM's guiding principles of inclusivity, democracy, diversity, and openness are concerned, there has been a reasonable level of diversity in terms of private sector actors involved, partnerships constituted, and technological innovations pursued. This should at least in theory offer good opportunities for social learning about AV innovation processes. Nonetheless, those processes have so far not exhibited high levels of inclusivity, democracy and openness. This is primarily because civic society and publics have not been involved in an active and meaningful manner, and the transition towards automation is imagined and framed as a series of technical problems that need to be solved as fast as possible if the UK is to come out on top in the global race for supremacy in AV innovation.

Depoliticization of changes has a long history in UK transport planning and governance more widely, in part because the sector is historically dominated by (male) professionals with training in engineering, economics, or physics. While this means that the governance of innovations in transport has always had an inclination to be anti-political in the sense of "suppressing potential spaces of contestation and placing limits on the possibilities for debate and confrontation" ([66], p. 270), it is still valid to describe developments around AVs in the UK as post-political in the manner that Mouffe [13] and Swyngedouw [14,31] understand this term. This is because of the way AV developments have discursively and institutionally been linked to the problematics of:

- the UK's economic development trajectory since the Global Financial Crisis and with the prospect of Brexit;
- a global competition between countries and cities which apparently are in a race for supremacy in R&D and manufacturing; and
- market formations as the only efficient manner in which AVs can be improved and diffused.

It is in this context that questioning the wisdom of the UK's approach to encouraging AV developments becomes very difficult and for certain actors almost unpatriotic even though developments in AV innovation in countries such as China, the USA, Germany and Israel raise doubts about the UK's strategy, and the whole idea that it is cities and countries that are in competition is problematic when (AV) technology development takes places in complex, transnational networks. In other words, dissent is foreclosed and certain claims valorized. If and when dissent is articulated as in the House of Lords enquiry referenced above, or the complaints about automation in freight transport by the rail sector, then it does not appear to have profound influence on dominant discourse.

We draw two conclusions from the above reflections, which have relevance for the UK and beyond. In terms of theorizing transition dynamics in transport, technological changes like those around automation cannot be understood by focusing on technology alone. How the political and politics are configured and enabled within the processes of governing innovations must be considered as well. This means that potentially useful analytical frameworks may need to be revised to highlight the political dimensions of innovation and transition processes. Integrating elements from theorizing of

the post-political condition into the TM approach is one way in which this might be done, but other analytical perspectives should be explored as well.

In addition, there is a need to fundamentally rethink and reconfigure the AV transition in the UK and beyond. Numerous researchers from different hues have shown that public participation is no panacea and can indeed be co-opted by particular vested interests (e.g., [67]). Yet, it is clear that greater openness, democracy and participation from currently marginalized groups will be needed to harness the generative capacities of reflexivity regarding the assumptions underpinning mainstream discourse, big picture thinking about the future, and reflection on values and the desirability of different forms of provision (e.g., market, community, commons) in relation to transport in general and AVs in particular. The political nature of automation cannot, and should not, be marginalized but at the heart of attempts to govern (automated) mobility futures in the UK and beyond.

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