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Planning a 'race for automation'? A Social Science approach to Automated Vehicle experiments in Europe

Abstract

Descriptions of new technology as something that requires rapid adjustment and rapid capacity building in society's companies and institutions can be found across scientific and professional analyzes of modern society. In this article, we investigate how a specific technology - driverless vehicles - was institutionally framed as a race for automation and how this discursive framing subsequently served - in a Danish context - as the underlying premise for private and public actors' attempts to implement the technology. We show that this narrative of urgency functioned as a scattershot strategy, which left local partnerships and planners with the task of building societal capacity for automated vehicles on the basis of perceived competitive risk and postulated benefits but without access to substantiated facts about the concrete technology and the demands it places on physical and institutional infrastructure. Project participants were therefore unable to set realistic goals and adjust their resource consumption in a way that went beyond the needs of the individual actors to avoid losing their foothold in a postulated race for automation. Experiences from the Danish test trials reject the common notion that vehicle automation will by virtue of being without a driver be socially inclusive.

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Introduction

In these years, digital technologies are transforming society in virtually all spheres of human activity. This applies both in relation to how concrete tasks are solved and in relation to expectations and ideas about how cities and planners can and should prepare for the future. Technologies based on sensors, digital networks and data processing services are promoted as potential gamechangers in a number of public service contexts for example as means to streamline resource-intensive services related to for example mobility, buildings and energy[1]. Many of the prospective technologies and applications are in a development phase where end-state requirements for surrounding infrastructural and regulatory frameworks are undefined and

[1] Wlodarczak, P. (2017). Smart Cities – Enabling Technologies for Future Living. In: Karakitsiou, A., Migdalas, A., Rassia, S., Pardalos, P. (eds) City Networks. Springer Optimization and Its Applications, vol 128.

potential systemic effects unexplored. Several authors have pointed to the necessity of a critical approach to the ways in which implicit commercial interests and democratic deficits can be embedded in interventions that uncritically beat the drum for implementation of technology as an a priori solution in public services[2], while others focus on the risk of urban stagnation and bad management if digital innovation is not pursued[3].

Based on extensive fieldwork and interviews with actors who performed trials of automated vehicles in a Danish context, we argue that meaningful technological innovation in public services presupposes a conceptual preparedness among planners, innovators and decision-makers in order to navigating the complex field which arises when high-tech opportunities, commercial interests, pressured budgets and competitive considerations intersect in the management of the city's space; Such a conceptual preparedness could also inform development of particularly suitable collaborative frameworks for digital urban innovation, which takes seriously the institutional positions, commercial pressures and particular skills of the actors involved.

As a contribution to such a building of collective conceptual preparedness, we found that a deconstruction of the recent history around automated cars as well as the process surrounding the establishment of the first experiments with automated public transport in Denmark has the potential to provide a deeper understanding of some of the forces at play in implementation of potentially disruptive digital technologies. Planning involving new technologies is a dynamic and complex field that goes beyond specific projects and technologies and we suggest that the expectations, actions and reactions that characterized the introduction of automated cars are best understood in a historical and sociological light through partly a mobility-modernity lens and partly a technology-regulation lens.

The article begins with an overview of announcements from industry, central EU institutions and the daily press regarding automated vehicles between 2015 to 2019. Based on the characteristics of these announcement, theoretical perspectives on technology implementation and postmodernity are used to identify five different types of pressure, each of which, we argue, implies a distinct race within an overall framing of vehicle automation as a race. Then we present six key project actors in the Danish process of adopting new legislation for testing automated vehicles focusing on the individual actors' motivation and understanding of the perceived opportunities and risks that affected their choice to invest in tests of automated vehicles. We then describe how the lower-than-expected technological maturity and pace of improvement that the technology displayed in open traffic undermined project participants' goals and the economic viability of implementation, but preserved the capacity building effect of stimulating - even unsuccessful and costly – across the board project activity. Finally, we look at some of the concrete experiences form the trials. We find that Danish users' high acceptance of new technology and reservations regarding being perceived to stand in the way of new technology

[2] Luque-Ayala, A. & S. Marvin (2015). Developing c critical understanding of smart urbanism? Urban Studies. Vol.52.; Leclercq, E. M. & E. A. Rijshouwer (2022). Enabling citizens' Rights to the Smart City through the co-creation of digital platforms. Urban Transformations; Ehwi, R. J. (2022). The ethical underpinnings of Smart City governance: Decision-making in the Smart Cambridge Programme, UK. Urban Studies.

[3] Wlodarczak, P. (2017). Smart Cities – Enabling Technologies for Future Living. In: Karakitsiou, A., Migdalas, A., Rassia, S., Pardalos, P. (eds) City Networks. Springer Optimization and Its Applications, vol 128.; Manika, S. (2020). Mechanisms for Innovative-Driven Solutions in European Smart Cities. Smart Cities 3, no. 2: 527-540.

could - in the current situation where sparse independent knowledge about benefits and risks exists - impede an inclusive and sober debate about the risks and benefits of vehicle automation. Methodologically the paper builds on a multiple case study approach which involved surveys, fieldwork and interviews performed between 2018 and 2022.

A brief history of Autonomous vehicle announcements

automated driving is not a new obsession but has appeared in science fiction and in attempts to predict future societies and cities. Experiments that started in the mid-80s made it possible in 1994 for Ernst Dickmanns to drive prominent passengers around the streets of Paris in a computer-controlled car, before two years later he had to conclude that the available computing power was not yet sufficient to move the technology forward. Then the financing dried up and development was at a standstill for a decade. In the early 2000s, research gained renewed momentum when the US military research organization DARPA was authorized by the US Congress in 2004 and 2005 to offer multi-million dollar prizes in the now infamous DARPA challenges" with the goal of spurring on American ingenuity to accelerate the development of autonomous vehicle technologies that could be applied to military requirements". At the first challenge, none of the registered teams managed to get through the prescribed desert route, but the following year DARKA had doubled the prize money and set up a new route. This time several of the teams managed to get through the route and at the celebration the leader of the winning team could state: "A year ago, people said this couldn't be done [...] Now everything is possible". The success triggered large research investments and the winning researcher went on to found Google's Self-driving car team and in 2006 was the originator of the catchy statement: "The potential here is enormous. Autonomous vehicles will be as important as the Internet".

In 2015 Daniel Fagnant and Kara Kockelman published a highly quoted cost-benefit analysis paper titled "Preparing a Nation for autonomous vehicles"[4] in an influential transportation journal and within a year, renowned media outlets predicted that full autonomy would be available to citizens by 2020[5]. Over the next two years several large car manufacturers declared that they expected to market fully autonomous vehicles as soon as 2020[6].

Then, in 2018, Waymo announced the procurement of 20.000 vehicles from Jaguar intended for the company's autonomous hailing service that would be launched in 2020, a journalist at the Atlantic noted: "2020 is not some distant number. It's hardly even a projection. By laying out this time line yesterday, Waymo is telling the world: Get ready, this is really happening."[7]

In sync with announcements from universities and the automotive industry, economic analyzes from central European institutions were published. In 2015 the OECD published a report titled

[4] Fagnant, D. & K. Kockelman (2015). Preparing a nation for autonomous vehicles: opportunities, barriers and policy recommendations. Transportation Research Part A: Policy and Practice. Volume 77.
[5] The Guardian (2015). Self-driving cars: from 2020 you will become a permanent backseat driver; Insider (2016). 10 million self-driving cars will be on the road by 2020.
[6] Techrepublic (2016) Waymo (formerly Google's Self-Driving Car Project): The smart person's guide; wall street journal (2015). Toyota Aims to Make Self-Driving Cars by 2020; Autotrader (2017). Self-Driving Cars: Honda Sets 2020 as Target for Highly Automated Freeway Driving.
[7] The Atlantic (2018) The Most Important Self-Driving Car Announcement Yet.

Automated and Autonomous Driving - Regulation under uncertainty[8]where readers were warned about potential consequences of inaction: “Authorities will have to adapt - and possibly rethink - their approaches to regulating these activities in order to avoid conflicts. Failure to do so might even prevent the deployment of the urban mobility pathway for autonomous vehicles which would stifle innovative uses for this technology and potentially lead to welfare losses.”

ERTRAC, the European Road Transport Research Advisory Council, which convene representatives from “all the stakeholders of the Road Transport sector, including private and public organizations involved in Research, and gathering also administrations from both European and national levels” prepared an “Automated Driving Roadmap”[9] stating that: “Automated Driving must be considered as a key aspect for the European Transport policy, able to support several objectives and societal challenges, such as road safety, decarbonization, smart cities, social inclusiveness, etc.” Echoing the OECD, ERTRC found that action was needed to accommodate these benefits:

“The European community is nevertheless facing important challenges to enable or implement higher levels of Automated Driving in all environments. It is utmost important that these challenges and existing gaps (technology, legislation, regulatory, policy, etc.) are early recognized and appropriate measures are taken […] The whole industrial sector needs to evolve and adapt in a fast pace to stay ahead in global competitiveness while including all stakeholders and addressing societal needs.” (ERTRAC, p.4)

Following such dire warnings, the intuitional approach shifted from fascination to preparation and more funding was freed up through the European research and innovation programs. In the ensuing years the expectation of an imminent transformation of road transport sent decisionmakers, planners and civil servants scrambling to figure out how to pave the way for a technology that didn’t yet exist.

Consulting firms and specialist in strategic communication develop a new market by addressing automotive industry stakeholders with messages about the urgency of competitive positioning, e.g. FTI in 2019: “The Race is on for Autonomous Vehicles: Automated vehicles will be one of the big issues the EU will be addressing further, once the new Commission takes office in November. For industry, the time to position itself is now. The shaping of both national and international legislation has started. Getting involved sooner rather than later will give companies a head-start over their competition”[10]. Commentary from stakeholders is abundant and confliction perspectives on the status of European fitness and preparedness co-exist. In 2018 European industry news platform Fleeteurope posts a story promoted by VW that Europe is losing the race for autonomous vehicles because “Both the U.S. and China produce more and better research into autonomous driving technology than Europe, where EU regulations have a restrictive effect”[11] whereas Forbes’s 2018 analysis has Europe as a potential winner: Europe To Be The Tortoise In The Self-Driving Car Race: Europe’s budding entrepreneurship scene, legacy companies, focus on

[8] ITF (2015). Automated and Autonomous Driving: Regulation under Uncertainty. International Transport Forum Policy Papers, No. 7, p. 26. OECD Publishing. Paris.
[9] ERTRAC (2015). Automated Driving Roadmap. p. 4. ERTRAC Task Force - Connectivity and Automated Driving
[10] FTI Communications (june 4. 2019). The Race is on for Autonomous Vehicles.
[11] Fleeteurope (2018). Why Europe is losing the race for autonomous vehicles.

public transit, and integrated legal system set it up for a successful, yet different end-state of autonomy."[12]

While content and viewpoints differ among economists and business analysts the idea of autonomy as a race is ubiquitous. And while only limited independent facts regarding automated vehicles technological performance and progress is available, a surge of privately and publicly funded projects, aimed to build capacity in key sectors and gain hands-on experience, take off across Europe[13]. Research documents, news stories and policy papers prepared as part of this project frenzy repeat the prospect of valuabel social benefits (safety, inclusiveness and the environment) as motivations to pursue an automated transport future. These benefits are largely stated as scientific facts and they migrate into introductory sections of scientific papers in a variety of specialized fields without robust scientific validation[14]. The claimed benefits make superficial sense (people will not need at license to drive – ergo the elderly and disabled, who might not be able to drive today, can be better served; Human factors are responsible for 90% of the driving failures that result in road accidents – ergo a system where people don't drive will be 90% safer; new transport technologies tend to be less polluting than old technologies – ergo autonomous vehicle technology will be good for the environment) and gradually the claims reifiy as the hegemonic narrative of automation benefits. Research papers trying to substantiate the claims are largely unable to rigorously do so for the obvious reason that no technologically mature implementations exist and therefore systemic effects and user benefits can be hypothesized but not tested in any real sense[15].

A race? what is the rush… and who are the competing?

The notion of automation as a race implies urgency as well as winners and losers. But the fact that the technology in question has not yet been put to use anywhere or even had its functional capacity publicly scrutinized, reveals that the postulated urgency is based on something else than a concreate need to adjust policy and planning choices to accommodate a new technological reality. A look to technology regulation theory can help identify a number of reasons to frame automation as a race and a number of different races within the race.

A recognized theory to explain the relationship between technology and governance was formulated by David Collingridge in what is often referred to as the Collingridge dilemma:

> *"The root of the manifest difficulties with which the control of technology are beset is that our technical competence vastly exceeds our understanding of the social effects which follow from its exercise. For this reason, the social consequences of a technology cannot be predicted early in the life of a technology. By the time*

[12] Forbes (2018). Europe To Be The Tortoise In The Self-Driving Car Race
[13] ERTRAC, 2017. Automated Driving Roadmap.
[14] Littman, T., 2022. Autonomous Vehicle Implementation Predictions - Implications for Transport Planning. Victoria Transport Policy Institute; Lanng, D. B., Hougaard, I. B., & Villadsen, H. (2022). Could autonomous vehicles help cities tackle transport evils and accelerate the transition to sustainable mobility? Institut for Arkitektur og Medieteknologi.
[15] supra note 2; See also Norton, P., 2021. Autonorama – The illusory promise of high-tech driving. Island Press.

undesirable consequences are discovered, however, the technology is often so much part of the whole economic and social fabric that its control is extremely difficult"[16]

According to this perspective, there is a particular problem of synchronization that makes the interaction between social change and technological change particularly complex. Logically, the dilemma can either be resolved by placing limits on the way new technology is allowed to transform society or by relaxing expectations of the control that society has over unintended consequences of technology. Framed in this way, it becomes clear that there exists a natural field of tension between advocates of technological innovations that have the potential to disrupt the status quo and advocates of caution and predictability in social life; a field of tension which links to the fundamental and deeply political discussion about the role and legitimacy of state and governance in deciding how successful technological innovation is given or prohibited from unmitigated access to change society.

Social geographer David Harvey described how the risk of stagnation and overaccumulation in Fordism and the first era of mass production leads to the necessity of entering new markets and adopt more flexible forms of production and consumption. The transition, according to Harvey, was "accomplished through rapid deployment of new organizational forms and new technologies in production"(p.109). The ensuing acceleration in turnover times across many sectors can be understood as the historical backdrop of what has been labeled the pacing-problem. The pacing-problem can be understood as the societal effect of Collingridge's dilemma in conditions of societal acceleration and is defined as a "growing gap between the pace of science and technology and the lagging responsiveness of legal and ethical oversight society relies on to govern emerging technologies"[17].

The flip side of the pacing problem is by some technology libertarians labeled the pacing-benefit[18] which can be exploited by 'evasive entrepreneurism', a term that describes "entrepreneurial efforts aimed at avoiding the legal system and efforts aimed at minimizing losses associated with the formal legal structure by using innovations to exploit contradictions in that framework"[19]. One such strategy is the "too big to ban" strategy which is in essence an operationalizing of Collingridge's dilemma. One very aggressive example of this strategy was Ubers permissionless introduction of their ride hailing platform in cities. As court cases and regulators caught up with the new status quo and started to outlaw the service, Uber had in some places built a userbase that was willing to mobilize on the company's behalf and form a political lobby influential enough to force a change of rules"[20]

Based on the content of innovators announcements and the described historical challenges to the social control of digital technology, the prevalent framing of vehicle automation as a "race" can be

[16] Collingridge, D. (1981). The Social Control of Technology. P.11. Palgrave Macmillan

[17] Marchant, Gary & Allenby, Braden & Herkert, Joseph. (2011). The Growing Gap Between Emerging Technologies and Legal-Ethical Oversight: The Pacing Problem.

[18] Adam Thirer (2018) The Pacing Problem and the Future of Technology Regulation. Expert commentary. The Bridge – Mercatus Center.

[19] Hagemann, Ryan and Huddleston, Jennifer and Thierer, Adam D. (2018) Soft Law for Hard Problems: The Governance of Emerging Technologies in an Uncertain Future. p. 74. Colorado Technology Law Journal.

[20] Note 3; Rob Tracinski (April 12, 2017). Civil Disobedience as a Business Model. RealClearFuture.

understood to address at least three distinct but interdependent races – A race for individual manufactorers to be the first to marked useful AVs. A race for innovators to get AVs operating in the transport system while escaping stifling regulatory constraints. A race for regulators to maintain regulatory control of road vehicles and traffic safety.

Drawing again on David Harvey's description of post-Fordism time-space compression and the shift to flexible accumulation[21] of capital, it is possible to identify at least two further races within the race. According to Harvey a mayor consequence that has flowed from the general speed-up in the turnover times of capital has been to accentuate volatility and ephemerality as defining features of the operating conditions for businesses in postmodernity:

"The volatility, of course, makes it extremely difficult to engage in any long-term planning. Indeed, learning to play the volatility right is now just as important as accelerating turnover time. This means either being highly adaptable and fast-moving in response to market shifts, or masterminding the volatility."[22]

In response to this new condition of volatility and as digital technologies began to transform almost every field of human activity and destroyed old well managed compagnies dependent on business models that were no longer competitive, a new field within business and management theory took shape: disruptive innovation theory[23]. Even a superficial look at criteria for disruption clearly indicates that a successfully implemented autonomous ride hailing platform could disrupt large parts of the transport industry and supporting networks ranging from public transport operators, car retailers, drivers' unions, insurance compagnies to parking inspectors. Further, Spatial and inter-urban competition and urban entrepreneurialism[24] as means to attract investment ads a geographical backdrop to vehicle automation as a disruptive innovation. As countries, cities and municipalities are dealing with knock-on effects of flexible accumulation, (de)industrialization and globalization, volunteering as first-movers on automation may position them as "open for business" and reduce the risk of being bypassed in the rollout of new transport services and end up with a legacy transport system no longer supported by state-of-the-art technology.

In sum, the prospect of disruption of transport's support systems as a result of vehicle automation ads two further "races" integral to "the race for automation": A race for countries, cities and municipalities to attract innovators' attention and investment. A race for existing transport busineses to adjust to a new automated reality or risk obsolesce.

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[21] In a commentary Harvey reflects on his use of the term "flexible accumulation" rather than "neoliberalism" and points to a change of language in his later book *A Brief History of Neoliberalism*. (Harvey 2017, p.158)

[22] Harvey, D. (2017). Time-space Compression and the Postmodern Condition. In Harvey, D., Ways of the World p. 111

[23] Bower, J. L. and Christensen, C. M. (1995). Disruptive Technologies: Catching the Wave. Harvard Business Review, January–February 1995

[24] Harvey, D. (2017). From Managerialism to Entrepreneurialism. In The Ways of the World. Profile Books. London.

Actors and motivations driving automated transport innovation in Denmark 2017-2022

In 2017 legislation was put in place to allow tests of automated vehicles in Denmark and from the outset the legislation was criticized by local industry stakeholders as well as Danish representatives for international players like IBM and KPMG for being overly restrictive and putting Danish companies at a competitive disadvantage compared with Sweden and Norway where rules were reported by stakeholders to be more welcoming to innovation[25]. The legislation came under further attack from politicians who argued that Denmark was putting itself at a disadvantage and regulators were privately challenged by academics and automobile specialists who found that as a country with no mayor automotive industry Denmark lacked of relevant competences. These controversies set the scene for the five trials of public automated shuttles which became the first to file successful application for testing, all with years of delay compared to stakeholders' expectations at project conception[26].

From March 2020 to August 2022 autonomous shuttles where operated on five different testsites in Denmark as part of projects initiated and funded by five main actors (some of which were active in more than one test trial). This group of central actors consisted of an urban municipalitiy, two established transport companies that (for very different reasons) had branched out to specialize in operating driverless vehicles, a public transport authority tasked with ensuring basic mobility to citizens in rural and urban districts, and finally, in a less direct manner the European research and innovation funding scheme Horizon 2020 under the European Commission. A sixth main actor was the Danish Road Directorate who coordinated work to form a legislative framework for testing automated vehicles. In the following each actors' description of their motivation for engaging in the projects are presented drawing a picture of the different ways in which the 'race for automation' was interpreted.

Actor one: The municipality of Aalborg, Denmark's fourth largest city and third largest municipality with around 220.000 inhabitants.

Aalborg became the first Danish actor to ask the Ministry for Transport for permission to run autonomous vehicles on public roads and pushed for a change of the law to accommodate testing. The move was initiated from within the municipality's transport and urban planning unit, where a once abandoned idea to renovate both the public image and the worn-down infrastructure of a notoriously problematic suburban district had simmered for a few years. The original idea was to (among other things) insert a public transport service on the central path connecting different areas within the district. The idea had been judged to be economically unsustainable, but with the advent of autonomous shuttles the hope was that an unmanned solution could heighten the perceived sense of personal safety for people using the path, benefit vulnerable residents' mobility and position the embattled neighborhood as a first mover on the technology of the future.

The move coincided with in internal discussion within the transport planning unit regarding its role and strategy. Internal and external pressure to abandon a long-held methodology of predict and

[25] MobilityTech (28. october, 2020). Ny kritik af forsøgsordning med selvkørende busser: Minister vil dog afvente evaluering i 2022.

[26] Interviews Aalborg Municipality, Holo, Nobina, Movia.

provide for motor traffic in order to instead (or also) facilitate a future green transport system had raised difficult questions about employee competence in foretelling the future and plan under conditions of uncertainty. “How can we equip ourself to dare to embrace the future?”[27]

Actor two: Holo (Previously Autonomous Mobility), a subsidiary company of Denmark’s largest automobile importer.

Holo was founded in 2016 at a time when Uber’s app-driven hold on young urban transport customers and the prospect of automated taxis made the future for private automobility seem less curtain that it had done for the previous seventy years. Holo was founded as a start-up predicated to – in accordance with disruption theory – deploy technology and innovative disruption to challenge the established business model of its parent company from within and before the competition.

Like its parent company Holo occupies a position between vehicle producers and vehicle users. Operating in a market where only autonomous minibuses from a narrow range of start-up vendors are offered for sale Holo carved out a niche by specializing in vehicle implementation in real-life conditions, local regulation and negotiating its customers’ – mainly Public Transport authorities – hopes and requirements. When in 2020 we asked the acting CEO of the company what they needed most to understand about the other actors in the Danish automation network he answered that it would be helpful to understand the objectives of potential customers like for example Aalborg Municipality: "What do you really want with this field? Where would you like to go?”[28]

Actor three: Nobina Denmark, Danish branch of Nobina the Nordic region’s largest public transport operator headquartered in Sweden.

In Denmark Nobinas main business depends on winning public tenders for bus operation and on bus transport being prioritized politically and finacially by local administrations via the regional Public Transport Authorities. Unlike Holo, public transport service is Nobinas DNA and Nobina entered the field of autonomous operation to build capacity in order to sustain its role as provider of public transport in a squeezed bus market. As money for public transport was increasingly channeled towards light rail construction in cities, Nobina felt a risk of their market slipping and saw an opportunity in specializing in autonomous firsts and last mile feeder transport proposing to leverage the mobility impact of large investments in railed urban transport.

Confronted with an application process for testing automated vehicles which was new to both regulators and applicants, highly bureaucratic, manhour intensive and which dragged on for years, Nobina’s Head of Market & Business Development asked rhetorically: “what is the interest in making this work? Because everyone can see that it sounds super smart. You can do all sorts of things very cheaply. But I think the danger is that it ends up so far in the future that it's not relevant to anyone…”[29]

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[27] Interview Aalborg Municipality.
[28] Interview Holo
[29] Interview Nobina

Actor four: Movia, Seeland Public transport authority (PTA).

Movias main responsibility is to organize efficient operation of public buses and ensure good connections between different means of transport across eastern Denmark. As PTA Movia is in an asymmetrical relationship with the private operators who perform contractual tasks for them, but like them Movia rely on national and local political will and budgetary means to pay for public transport. Movias head of Mobility sums up the PTA's interest in automation as a matter of providing better public transport in a situation where means are strained: "If we can replace the [public transport] products, we have today with a similar product that is cheaper, then we will be able to offer a better service for the same money... [] Someone has to take it upon themselves to ensure basic mobility coverage. And that is what we are legally set up to do...".
Movie is a driving force in two of the five Danish Test Trials and when we ask what made it attractive for a PTA to take the risk of being first in an immature market, they reply:
"it is sometimes the role of a public institution to use effort, money and political capital to support a desired development."[30]

Actor five: European Commission

While all the Danish projects were eighter in part or in whole funded by project participants two projects were mainly funded through European Commission grants and two projects received minor support. Funding was given through the Horizon 2020 initiative and through the Urban Innovative Actions program. In 2017 when the two projects received funding concerns about vehicle automation and Europe's role in its implementation was a priority for the commission and within the transport part of the Horizon 2020 program a call on "Automated Road Transport" had a dedicated budget of 114 Mn € for the years 2016-2017[31]. In a 2018 factsheet the commission wrote of its strategy: "Cooperative, automated and connected driving could shape mobility in the years to come, the way motor vehicles did in the last century. It will make mobility safer, cleaner, more accessible and more efficient. It will contribute to a strong and competitive industry that creates jobs and gives an innovation boost to the entire economy. The Commission supports industry and public efforts to prepare now for an optimal roll-out.[32]"
The European Commission's approach was to stimulate activity and steer activity towards capacity building in member states. Some projects seemed to replicate earlier funded projects, which could seem counterproductive from a narrow research perspective, but from the perspective of capacity building repetitions across geographies and institutional networks could be seen as the point of the exercise rather than as a failure in dissemination of existing knowledge.

Actor six: The Danish Road Directorate

Pre 2017 when the legislation was passed, the road Directorate was coordinating with the police, the Dansh Transport Agency and legal departments to create a framework for testing of automated road vehicles that allowed research without compromising safety[33]. The defining role of the Road Directorate is to predict the use of roads and to form a factual basis for analysis and regulation the department studied written reports and visited car manufacturers in California.

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[30] Interview Movia
[31] ERTRAC, 2017. Automated Driving Roadmap. European Road Transport Research Advisory Council.
[32] European Commission, 2018. Europe on the Move - Connected & Automated Mobility: For A More Competitive Europe – Fact sheet.
[33] Interview Danish Road Directorate

Contrasting the bold prediction of the European Commission the Road Directorate found that reliable information was difficult to come by even as a national authority: "Sales departments made very ambitious announcements. [...] while research departments and R&D departments were partly very reticent about information in general and partly also somewhat more conservative [...] We could easily enter into a dialogue with authorities in other countries and hear what their experiences were, but they also did not know very much about how advanced this technology actually is... It has been quite difficult to get a handle on.[34]"

Actors 1-6

All actors were asked what other actor(s), interests or deliberations they were most interested in understanding if roles were reversed and they had the opportunity of interview any stakeholder in the field. Answers to this question draws a picture of the interdependencies involved in technological innovation. One operator would ask the national authority who had devised the very challenging regulatory regime if it was in fact important for folks at the national level to gain knowledge in this field[35]. At the national level it is acknowledged that this is a justifiable question and that the answer is yes, but that the safety concerns are paramount[36]. Private operators would like to understand exactly what transport buyers would like them to provide[37] and transport buyers would like to understand what the technology will offer in terms of integration with existing services and cost profiles before outlining specific plans[38].

Rubber hits the road

While each of the described actors respond to different and unique pressures, what they had in common is that they were activated by the announcements from competing tech and automotive industries as well as from leading political institutions claiming that full automation was only a few years away and would presumably cause a change so fundamental and with such momentous implications, that it was wise or even necessary to get the whole social, political and industrial system moving well in advance of their actual introduction.

While the actors were waiting for permission to test, they all found ways to gain experience with the procured shuttles (on test tracks, by operating inside buildings and by visiting partners abroad) and it became universally clear that the technology was far less mature and maturing slower than had been expected at the outset of the process of project planning[39]. At this point though, contracts had been signed between actors and too much had been invested for the central actors to further postpone the tests. Despite the fact that it was clear that the sine qua none criterium for commercial relevance – operation without a human fall-back driver – was not going to be achieved in any open traffic setting or for years to come[40], the projects proceed while budgets got strained by delays and lack of enthusiasm for throwing good money after bad. Actors sought access to other brands of autonomous vehicles than their original choice of technology, but

[34] Interview Danish Road Directorate
[35] Interview Nobina
[36] Interview Road Directorate
[37] Interview Nobina, Holo
[38] Interview Movia
[39] Interview Movia, Holo, Nobina, Aalborg Municipality
[40] Interview Movia, Holo, Nobina, Aalborg Municipality

repeatedly encountered the same challenge: Promotional videos and actual market ready technology are two very different things in vehicle automation[41].

While no actual disruption of the traditional transport business models had taken place, institutional capacity has been built within and beyond actors' organisations but without the benefits that had originally motivated participation, engagement and investment. Within each actors' organisations, multiple man-years had been invested in conceiving, rethinking, predicting and preparing automated transport. Beyond the participants in the testing projects, engineers at the Femern Belt connection had, for example, prepared plans for how to upgrade the tunnel for automated vehicles[42], municipal planners had widely taken part in workshops on future transport modes including automated varieties, and every recent national and regional white paper on the future of transport has contained a section on automation[43].

In other words: The expectation of market disruption and an upcoming Collingridgian gap between technological reality and societal capacity, created all the prognosed races within the race for automation, but the race itself became frozen in time by the fact that the status quo was not disrupted as predicted. It is debatable whether this situation is an anomaly or rather a typical expression of capitalist innovation. As David Harvey proposed regarding the unorderly development of markets:

"Capitalist development is always speculative – indeed, the whole history of capitalism can best be read as a whole series of miniscule and sometimes grandiose speculative thrusts piled historically and geographically one upon another. There is, for example, no exact prefiguration of how firms will adapt and behave in the face of market competition. Each will seek its own path to survival without any prior understanding of what will or will not succeed. Only after the event does the 'hidden hand' (Adam Smith's phrase) of the market assert itself as 'an a posteriori necessity imposed by nature, controlling the unregulated caprice of the producers´" (Harvey 2017, p. 154)

In a 2020 book technology historian Peter Norton takes this reflection a step further by documenting that recurring waves of strategic overpromising and underdelivering has been a successfully and consistently applied marketing strategy within the automotive industry. The counterintuitive idea being that vivid fantastical depictions of perfect frictionless automobility keeps the customer dissatisfied with the current state of technology, dazzled by the vibrancy of the presented utopia and willing to upgrade as soon as possible. While it is of cause most likely that developers and investors involved in autonomous vehicles development would prefer if the challenge of unconditioned automation had proven easier to overcome, the American automotive industry was one of the first businesses to realize that in the postmodern condition "supply must actively seek to create its corresponding demand"[44].

[41] Interview Holo, Movia.
[42] Femern Belt Development, 15. oktober 2018: "Femern-tunnelen klar til selvkørende fremtid"
[43] See e.g. Danske Regioner, 2017. Fremtidens transport - disruption kræver ny fleksibel planlægning; Transport-, Bygnings- og Boligministeriet, 2018. Mobilitet for fremtiden. Ekspertgruppens afrapportering.
[44] McIntosh, A., 2008. Hell and High Water, p.164. Birlinn. Edinburgh.

Public perception – product meets narrative

When the test trials were launched potential and actual users were surveyed in two of the projects. One project was serving students and staff at the campus of a technical university, the other was serving patients and staff at a hospital. In both settings users were predominantly positive about the technology's prospective uses in Denmark[45]. After riding in the automated shuttles (which had an on-board safety operator present) users at the technical university were generally unimpressed with the shuttles speed and some commented on shortcomings of the vehicles software when confronted with for example roadside obstacles or falling leaves disturbing sensors[46]. Users at the hospital were generally very unlikely to criticize the shuttles even if they had experienced abrupt braking or if the shuttle had in other ways underperformed in terms of comfort. In the ensuing evaluation of passengers' use of the hospital shuttle, evaluators found that the on-board safety operators played an essential role in assisting patients and their relatives while traveling on the shuttle[47]. Although the shuttle was in some cases an obvious nuisance in the hospital lobby and not always comfortable for users to stay in, there were very few instances of criticism. The users were generally accepting of the new technology and in particular did not want to be perceived as being against new technology

The social profile of digitalization of transport services is an under-researched topic and one that needs to be studied in ways that are suitable to understanding vulnerable citizens different types of needs[48]. Observations across the five tests fundamentally disputes the claim that automation will necessarily be accessible to vulnerable citizens, elderly and persons with walking difficulties. Also, social benefits that were recorded as resulting from the testing of the vehicles were mainly driven by the active presence of the on-board safety operator who made citizens in Aalborg feel safer by populating an otherwise desolated path after dark and in the hospital trial by assisting patients and families at the hospital. There is reason to be cautious not to underestimate the potentially detrimental effect of the misleading narrative about automated vehicles social benefits to vulnerable groups.

Conclusion

We have shown how a collective expectation of an imminent disruption to the business models of one of the words largest industrial value networks resulted in coordinated calls from political institutions for capacity building across all affected sectors. To legitimize a rapid societal shift to accommodate automated vehicles unproven benefits were stated and repeated as scientific facts, even though not even national governments had a reliable foundation for evaluating the time line or any of the practical and social implications of vehicle automation.

While vehicle automation is a spectacular technology that attracts public attention and imagination, a number of other data driven technologies are being proposed as solutions in many

[45] Villadsen, H., Christensen, T. B., Persson, D.R., Servizi, V. (2022) Self-driving shuttles – well on the way or slightly in the way? User perspectives and interactions with other road users. Department of People and Technology, RUC.; User survey results presented at Trafikdage light 2020.

[46] Villadsen, H., Christensen, T. B., Persson, D.R., Servizi, V. (2022) Self-driving shuttles – well on the way or slightly in the way? User perspectives and interactions with other road users. Department of People and Technology, RUC.

[47] Epinoin/Movia (2018). Evaluering af førerløse busser (unpublished external evaluators report)

[48] Durand, Anne & Zijlstra, Toon. (2020). The impact of digitalisation on the access to transport services: a literature review.

fields of public services and social life which highlights the need to not only build timely capacity to absorb technology but also to build a meta-capacity – a conceptual readiness - to preserve critical assessment of technology and critical assessment of the capacity building process itself.

The growing problem of social control of technology has been widely accepted as a direct result of acceleration in innovative capacity. This acceptance may risk to cause the second order problem of unreflective or rushed overcompensation. The past decade's struggles to adjust to a world which is increasingly run on data may have resulted in a shaken confidence in society's ability to absorb new technologies in an orderly and democratic manner, but as the case of vehicle automation projects in Denmark shows: Decision makers', innovators' and planners' ability to build capacity in a way that does not deplete potential project partners willingness to invest time, money and reputation depends on a system of high level intelligence and directed funding that does not run wild on industries' promotional announcements and does not prioritize just any preparative activity over meaningful preparative activity.

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