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Promise of the obsolete: expectations for and experiments with self-driving vehicles in Norway

Bård Torvetjønn Haugland and Tomas Moe Skjølsvold

Department of Interdisciplinary Studies of Culture, Norwegian University of Science and Technology (NTNU), Trondheim, Norway

ABSTRACT

This article explores the expectations associated with self-driving vehicles and the role of public trials in testing and upscaling this technology. Using a two-pronged empirical approach, we first analyze public responses to draft legislation circulated in preparation for Norway's 2017 Act Relating to Testing of Self-Driving Vehicles. Drawing on the sociology of expectations, we investigate the anticipated benefits of self-driving technology and identify a possible tension between calls for a flexible legal framework and concerns regarding the thoroughness and purpose of testing. Thereafter, the article analyzes interviews with actors conducting the first public trial under the new law, drawing on literature on upscaling and public experimentation to investigate the effects of societally embedded testbeds. We argue that public testing influences the understanding of self-driving technology and its relation to traffic. Additionally, the analysis shows how these understandings enter processes of policymaking, lawmaking, and technology development, indicating that actors conducting testing have been granted significant influence over current institutional understandings and future technical requirements for self-driving vehicles. We conclude that as trial experiences mold current understandings of autonomous transport, companies conducting testing guide expectations toward specific self-driving futures, thus rendering these futures more probable than others.

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Self-driving vehicles; public experimentation; socio-technical transitions; transport systems; sociology of expectations

Introduction

In this article, we explore visions and expectations for self-driving vehicles and the relationships between such visions and practical innovation aimed at materializing a self-driving future in Norway.[1] Ranging from car manufacturers, software companies, and tech startups to researchers, politicians, and lawmakers, a plethora of actors envision that autonomous transport will reshape transport systems in the years to come (Gandia et al. 2019; Hopkins and Schwanen 2018; Stilgoe 2018). Still, questions relating to the development and implementation of such technology remains. Examples of uncertainties include whether, when, and where self-driving vehicles will come into use; their effect on traffic safety, congestion problems, and climate change; their organization in terms of ownership and business models; and the handling of the data that they gather and produce. Norway's most recent National Transport Plan (NTP) disregards such uncertainties and emphasizes the prospective benefits of autonomous transport (Ministry of Transport 2017). The NTP, which cites supporting international studies, lists benefits such as increased traffic safety and mobility to highlight the importance of launching trials and demonstration projects which explore current technological capabilities. The Norwegian Parliament passed an act facilitating such testing in 2017 (Act Relating to Testing of Self-Driving Vehicles 2017), and since its implementation in 2018, the country has seen a surge of projects to study self-driving buses on public roads.

Writing from a socio-technical perspective rooted in science and technology studies, we consider a shift toward autonomous transport as entailing more than exchanging drivers for computers. Rather, we see the shift as a process that (1) necessitates systemic change, (2) encompasses the implementation of new materials, technologies, practices, roles, business models, and policies, and (3) represents a potential shift in what some call the system of automobility (Sheller and Urry 2000; Urry 2004). Our interest lies in how actors in and around the transport sector strategize and act to enable the emergence of a new transport system. Two key

CONTACT Bård Torvetjønn Haugland bard.t.haugland@ntnu.no Department of Interdisciplinary Studies of Culture, Norwegian University of Science and Technology (NTNU), Trondheim 7491, Norway
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aspects of the process are the production of expectations and pilot projects. Expectations are often instrumental in providing direction for experimentation, whereas pilot projects facilitate learning about experimental technologies. This learning, in turn, may influence further expectations, but also facilitate the upscaling of niche technologies. In this article, we explore the interaction between expectations and pilot projects.

Empirically, our approach was twofold. First, we studied responses to the draft legislation on opening public roads for testing self-driving vehicles. The feedback from a broad range of actors highlighted both the issues at stake related to the testing of self-driving vehicles and existing visions of self-driving futures. Second, we conducted an in-depth case study of the first Norwegian pilot project to test a self-driving vehicle on a public road, allowing us to explore how autonomous transport is understood and performed today. This dual approach enabled us to probe the relationship between pilot-project activities and the potential future of self-driving vehicles. In this article, we address the following research questions: What expectations and visions do key actors within the Norwegian transport sector have for self-driving vehicles, and what issues do they anticipate? How do companies involved in pilot project activities currently understand and perform self-driving?

The remaining parts of this article are structured as follows. We start by establishing a framework for approaching the expectations and work underpinning attempts at systemic innovation and then outline our methods. Thereafter, we present our empirical findings, focusing first on responses to the draft Act Relating to Testing of Self-Driving Vehicles (*Lov omutprøving av selvkjørende kjøretøy*) and second on our case study. Finally, we provide an analysis of our findings and our main conclusions.

Studying systemic innovation

We approach the potential introduction of self-driving vehicles as an attempt at systemic change, entailing the introduction of multiple technologies, practices, and cultural elements that will form a new socio-technical transportation regime (Geels 2012). The literature on large-scale socio-technical change and transitions has long considered the production of visions and expectations as key to processes of systemic innovation, as emphasized by the importance ascribed to such activities within the fields of transition management and strategic niche management (Kemp, Schot, and Hoogma 1998; Rotmans, Kemp, and van Asselt 2001; Berkhout 2006). In this regard, the articulation of shared expectations has been considered central for providing directionality to processes of learning, attracting attention and enrolling new actors, providing legitimacy for new technologies, and establishing their competitiveness vis-à-vis other technologies (Geels and Raven 2006; Schot and Geels 2008).

The role of visions and expectations in technology development processes has been further explicated within the sociology of expectations (Borup et al. 2006; Brown and Michael 2003; Brown, Rappert, and Webster 2000; van Lente 2012). This conceptual framework highlights the performativity of visions and how expectations for the future influence contemporary actions. This literature draws on classical insights from science and technology studies, such as how technology designers have envisioned future technology use and mobilized these visions in their design strategies (e.g., Akrich 1995; Woolgar 1991). Numerous studies have probed contemporary expectations with the goal of understanding the strategies of actors within fields such as transport (Wentland 2016, 2017) and energy (e.g., Ballo 2015; Skjølsvold and Lindkvist 2015). This work has shown how innovators' visions of large-scale technological change tend to be accompanied by expectations of wider societal change (e.g., Skjølsvold 2014). The effort to generate such visions and to engage in associated societal issues has been highlighted as key to establishing new pilot-project activities (Engels and Münch 2015).

As visions of self-driving vehicles often include broader societal and systemic change, we also explore the strategies used in a pilot project to materialize one such vision and, by extension, to advance a transport system which includes this technology. We take inspiration from Naber et al. (2017), who have developed a typology describing four patterns of upscaling:

1. *Growth*: the continuation of an experiment with more actors involved, and/or an increase in experimental scale
2. *Replication*: the reproduction of the experiment's main concept at another site or in another context
3. *Accumulation*: the linking of an experiment to other initiatives, providing potential synergies.
4. *Transformation*: the experiment prompts or shapes wider institutional change.

Additionally, Naber et al. (2017) highlight three important aspects for successful upscaling. First, they describe the establishment of social networks consisting of a diverse set of actors (e.g., companies, scientists, users, policymakers). Second, they discuss

Table 1. Overview of interviewees' affiliations.

Institution/company	Function	Interviews
Kolumbus	Regional public transport company/"mobility provider" for Rogaland County	5
Forus PRT	Project leader for the pilot project; interviewee also had experience in operating the self-driving shuttle bus.	1
Forus næringspark	Manager of the properties in the business park; provided a stretch of road for testing	1
Department of Transport, Rogaland County	Authority over Kolumbus; shared their responsibilities with the Norwegian Public Roads Administration.	1
Smart City Office, Stavanger Municipality	Produced Stavanger's smart city strategy, including elements for energy, climate, and environment	1 (2 interviewees)
Norgesbuss	Provided the bus drivers for Kolumbus in the Stavanger region; interviewee operated the self-driving bus.	2 (1 interviewee)

involvement in learning processes that are broad (encompassing both technical and social learning) and reflexive (showing a willingness to change direction). Finally, they highlight the importance of articulating shared visions and expectations, with emphasis on the substantiation of these visions through experimental data.

Traditionally, pilot projects have been confined to research institutions and research and development departments, but in recent decades there has been an increase in real-world testing (Marvin et al. 2018). This has sparked a debate on whether public testbeds are a prerequisite for attaining urban sustainability or whether they represent a corporate colonization of public spaces (Bulkeley, Broto, and Edwards 2014). While societally embedded testbeds are well suited for facilitating broad learning processes, Engels, Wentland, and Pfotenhauer (2019) identify three prominent issues associated with such embeddedness. First, experimentation has traditionally entailed surveying the effect of changes on different variables, a controlled environment that is hard to reproduce in a real-world setting. Second, there is the question of whether testbeds are merely embellished test sites for companies, merely serving as public demonstrations of viability rather than scientific experimentation. Finally, there is the question of whether the knowledge produced in a specific context is scalable or transferrable to other sites. These issues are pertinent, as our second set of empirical materials relates to public testing.

Methods

In the study on which this article is based, our method was twofold. First, we analyzed 62 consultation responses to a draft version of the Norwegian Act Relating to Testing of Self-driving Vehicles (2017).[2] The responses were written by a variety of actors who self-identified as affected by the Act, thus providing us with an overview of key positions regarding autonomous transport among actors associated with the Norwegian transport sector. The statements differed in length and character, ranging from a few lines expressing support for the legislation to several pages of discussion. Our reading of the statements focused on two matters. First, we searched for societal aspects that self-driving vehicles were expected to affect, with the aim of understanding the broad implications of systemic innovation within transport. Second, we identified statements concerning autonomous transport in the future, which opened up space for the inclusion of differing expectations in our analysis.

The second part of our analysis was based on interviews and observational data relating to a pilot project testing a self-driving shuttle bus outside of the city of Stavanger, located on the west coast of Norway. We conducted our interviews and made our observations during November and December 2018. As the pilot project ended in December 2018, it provided a good opportunity to engage with actors regarding their experiences and lessons learned over the course of the project. Barring one interview carried out over the telephone, we conducted all of our interviews in person. The respondents were chosen strategically, initially by focusing on actors who were managing the project, and then by "snowballing" to find new interviewees (Atkinson and Flint 2004), in order to gain a broader understanding of regional approaches to the future of transport. An overview of the interviewed representatives of institutions and companies is provided in Table 1.

All but two interviews were semi-structured, conducted with an interview guide created to explore a set of pre-defined themes (e.g., Rapley 2004). The exceptions were interviews held with the operator of the bus.[3] As we wanted to see the bus performing in its natural setting, we made four trips as ordinary passengers. During these excursions, we conducted open interviews with the operator while simultaneously paying attention to the operator's actions and the surrounding traffic. We audio-recorded all interviews and subsequently transcribed them verbatim. The quotes used in this article have been translated from Norwegian by the authors, and the interviewees have been given pseudonyms. The transcriptions have since been analyzed using an open coding process (Charmaz 2006), during which certain themes and topics accumulated. Our subsequent analytical approach focused on the themes and topics as points of interest, both in terms of their potential for comparison and based on our assumption that they were important issues for the interviewees.

Public hearing: expectations and issues of self-driving vehicles in a process of policymaking[4]

Norway's National Transport Plan for 2018–2029 claims that self-driving vehicles have the potential to improve road safety, to enhance mobility, and to reduce the environmental impact of the road sector (Ministry of Transport 2017). The plan presents multiple scenarios, ranging from options in which autonomous transport is "clean and shared" to alternatives in which "private autonomy" dominates. Rather than identify a preferable scenario, the plan emphasizes that the realization of any particular scenario depends on contemporary societal choices. Accordingly, it is necessary to "investigate the potential of new technological solutions through trials and demonstration projects" (Ministry of Transport 2017, 35, authors' translation). Such investigations are facilitated by the Act Relating to Testing of Self-Driving Vehicles (2017).

When preparing the 2017 Act, the Ministry of Transport convened a public consultation on the draft legislation. The draft version highlighted traffic safety and accident reduction as key societal benefits of self-driving vehicles. It also envisioned increased transport efficiency, improved access to mobility across society, and reduced need and demand for personal car ownership due to autonomous transport becoming integrated in ride-sharing services. These expectations resonate with the growing scholarly literature on self-driving (Duarte and Ratti 2018; Milakis, van Arem, and van Wee 2017), and were similarly echoed in the public's responses to the draft legislation.

While all of the commentators acknowledged the possible benefits of self-driving vehicles, some also addressed unintended consequences. Certain concerns were shared among nearly all commentators, such as issues relating to data and privacy. More often, unintended implications were framed in terms of specific interests. The Norwegian Association of the Blind, for example, argued that people with limited vision still would require special assistance, even if self-driving vehicles improved their mobility. Similarly, both the Union of Norwegian Transport Employees and the Norwegian Taxi Association emphasized how the automation of transport might lead to challenges for vulnerable social groups that currently rely upon assistance from professional drivers.

Many of the commentators were concerned with responsibility and safety, often conflating present and future issues. Addressing the draft legislation directly, the discussions frequently revolved around whether to hold the individual operator or a legal body responsible for accidents during testing. With regard to the future, the actors' concern was expressed through comments regarding responsibility: In the absence of a driver, who would be responsible in case of an accident? Few actors explicated a position, but the prevalence of the question reflects a need to assign liability. Some commenters argued that the current testing conditions were closely linked to the future road safety of the technology. For instance, the responses from the Norwegian Motorcyclists' Union and the Norwegian Cyclists' Association emphasized the importance of establishing test sites where the reaction of self-driving vehicles to motorcyclists and cyclists would be assessed, thus raising the question of who would be responsible for ensuring the thoroughness of the testing.

Innovation roadblocks

Few of the commentators questioned the need for legal frameworks and technology development and testing. Business actors and public transport companies emphasized the need for a flexible framework. The former included Acando (a company developing self-driving mobility concepts), Finance Norway (a confederation of firms in the finance industry), Spekter (an employers association), and the Confederation of Norwegian Enterprise (consortium of employers' associations), including its associated suborganizations: Abelia (a trade and employers' association for companies in the knowledge and technology sector), the Federation of Norwegian Transport Companies, and the Norwegian Logistics and Freight Association. The latter incorporates the public transport companies Kolumbus and Ruter—the first two firms to test self-driving shuttle buses on public roads in Norway—and the trade organization Public Transport Norway. The above-mentioned companies and organizations emphasized that the pre-Act conditions for testing were too limited and argued that neither the legal framework nor associated bureaucracy should "hamper an approaching technological development."[5] Characteristically, this quote references the temporal proximity (Michael 2000) of self-driving technology.

Business actors and public transport companies often stressed the importance of a permanent legal framework in order to ascertain predictability for business actors investing in self-driving mobility concepts. Finance Norway and Spekter argued that an act allowing for testing would help produce a valuable knowledge base for such a framework. The responses from Abelia and Ruter even outlined business models based on fleets of shared vehicles that would necessitate a framework allowing for larger-scale implementation. In the belief that access to data is an important enabler of innovation, the Confederation of Norwegian Enterprise called for public authorities to accommodate third-party access to data produced during trials. In this way, the experiments would represent a boon to business actors, as well as for establishing a future legislative framework.

The viewpoints expressed above were questioned by just two of the commenters. Both the Norwegian Motorcyclists' Union and a private respondent raised the following questions: What does society stand to gain from the testing? What is the aim and purpose of testing? Who carries the cost of testing? Who, other than society, has something to gain? We contend that these are highly appropriate concerns and raise similar inquiries later in this article.

Self-driving Stavanger

Phase one: learning at the test track

The pilot project we studied in Stavanger entailed the testing of a self-driving EasyMile EZ10 bus. This six-seater bus uses a combination of global positioning systems (GPS) and sensors to navigate the road. Although certified for 45 kilometers per hour (km/h), its speed during the pilot project ranged from 12 to 15 km/h. The bus was operated using a tablet-like panel located in the middle of the bus, with an operator present at all times, as required by law. The pilot project consisted of two phases. In Phase One (January–May 2017) the vehicle was tested at a closed test track and in Phase Two (June–November 2018) it serviced two bus stops along a 1.2 km stretch of public road. While not heavily trafficked, the road was frequently used by freight trucks and private cars. The route also had multiple pedestrian crossings. The pilot project was established by three companies, namely Forus Business Park, Forus PRT, and Kolumbus (see Table 1), which formed a partnership to assess whether a self-driving bus could service the areas of the business park that were without public transport coverage. As made explicit in Kolumbus's response to the draft legislation, the testing was also motivated by a shared belief in the viability and importance of autonomous transport in a future mobility system.[6]

The partnership acquired the EasyMile bus in anticipation of legislation allowing for public testing of self-driving vehicles. During Phase One, the bus was tested for 1800 hours at the closed track, where the partners simulated different situations, ranging from regular traffic interaction to a person running in front of the bus. The testing was instrumental in documenting the safety of the bus, thus laying the groundwork for the second test phase. When applying to the Directorate of Public Roads for Norway's first permit to publicly test a self-driving bus, the partnership was readily able to deliver its documentation alongside the application. This documentation also lowered the bar for similar initiatives, as subsequent applicants "could take all [our] documentation, and really just deliver it alongside their application" (Vincent, Forus Business Park). Similar streamlining happened at the Directorate. After taking three months to approve the application of the Stavanger partnership, the turnover rate for subsequent similar applications was reduced to 2–4 weeks.[7] Thus, the original application can be considered a kind of *bureaucratic* pilot project which tested the legislative framework.

Phase two: learning on the road

In the second phase of the pilot project, the partnership shifted the EasyMile bus onto a public road. The purpose of this move was to bring social learning to the fore by exploring people's reaction to and interaction with a self-driving bus. This facilitated a broader learning process that encompassed social as well as technical learning. In terms of upscaling, Phase Two exemplified both experiment growth and replication, as the project increased in both scale and difficulty while retaining the core concept from the experiment's first phase.

There were certain challenges associated with acquiring a realistic picture of people's interaction with a self-driving bus. Initially, the bus was allowed a maximum speed of 12 km/h, meaning it operated approximately 40 km/h below the speed of other traffic. During the initial stages of Phase Two, the speed limit for the road was lowered from 50 to 30 km/h, and speed bumps were installed to slow down other vehicles and prevent them from passing the bus. Following safety concerns voiced during the public hearing, these regulatory and material adaptations ensured safe operations. As a side-effect, the adaptations narrowed the gap between the different vehicles' maximum speeds, providing the opportunity for gaining valuable insights into motorist-machine interaction under conditions similar to those envisioned in the future. While the adaptations were intended to deter motorists from passing the slow-moving bus, hazardous situations arose continuously. To reduce risky overtaking and right-of-way infringements, the initial speed limit was reinstated and the speed bumps were removed. Whereas the bus managed to navigate "make-believe cities and make-believe people" (Matthew, Norgesbuss) during Phase One, the tendency of human drivers to bend—or even break—traffic regulations represented a challenge for the bus's static and defensive driving practices.

While the abovementioned problems constituted a setback, the three companies agreed that interactions between drivers and the bus improved significantly during the first three months of Phase Two. This implies that social learning was a two-way process in which the firms involved in the pilot project learned how motorists interacted with the self-driving bus, and that simultaneously the mobility culture was changed by the bus's presence. This implication also ties into expressions of regional and/or national mobility cultures (Sheller 2012). At Forus, the companies saw that "motorists were the cause of stops. In the Netherlands, it is the cyclists" (Jenny, Kolumbus), highlighting that social learning is somewhat site-specific and even culture-specific. This indicates that the challenges pertaining to the implementation of self-driving vehicles may differ depending on regional and/or national mobility cultures, thus emphasizing the importance of experimental replication in different contexts. While the learning process encompassed social and technical aspects, some Kolumbus employees argued that the testing was too focused on technology. They suggested that rather than trial the technology, the pilot project should have simulated the *service(s)* that the bus was expected to provide. In the absence of self-driving technology capable of testing more advanced mobility concepts, the employees argued that these could be simulated using vehicles with human drivers. Such a proposal could be construed as a call to research the actual use of, or need for, such vehicles in the future.

While motorists soon adapted to the performance of the autonomous bus, the companies still emphasized that the vehicle's "operating speed must be raised to ensure that self-driving buses interact properly with regular traffic" (Vincent, Forus Business Park). In terms of speed and site of operation, the partnership envisioned future self-driving vehicles to perform within the same infrastructures and at the same speeds as today's vehicles. With the bus's maximum speed raised from 12 to 15 km/h over the course of Phase Two, a small step was taken toward such a shared speed limit. Although this was not exactly an institutional *transformation* (Naber et al. 2017), the slight increase in speed was a gentle institutional *expansion* of the conditions under which the bus would be allowed to operate. Forus PRT has recently secured a permit allowing for testing at a maximum speed of 20 km/h (Norheim 2019), thus representing a further expansion.

Shaping technology, striking preemptively

In addition to institutional expansions, the prospect of upscaling self-driving technology was substantiated through processes of accumulation (Naber et al. 2017). The first such process related to Kolumbus's involvement in the European Union project FABULOS (Future Automated Bus Urban Level Operation Systems). In that instance, Kolumbus was invited to join a larger innovation project due to the company's previous experience with self-driving vehicles. When defining the call for tenders, the partner cities of the FABULOS project sought Kolumbus's recommendations, simultaneously giving the company the opportunity to nudge the future of self-driving vehicles toward being able to meet the specificities of Norwegian weather and road conditions.

This reflects the pilot project companies' lived experiences that "whatever [self-driving technology] works in France, in sunny weather and 15 degrees [Celsius], is not the same as works in Western Norway, in rainy and windy weather, and on these roads" (Olivia, Forus PRT). Through FABULOS, Kolumbus became involved in defining the specifications that future vehicles would need to fulfill in terms of battery capacity, top speed, and slope traversal, rather than having to adopt technologies matured in, for example, more temperate France. The partnership often emphasized this point as justification for testing the bus at Forus, as by engaging with immature technologies, it would be possible to adapt them to local contexts and needs. For example, in Stavanger this would mean ensuring that future buses could handle heavy downpours, wind, and fog.

Parallel to the pilot project at Forus, Kolumbus was conducting another experimental project in the small municipality of Sauda, located approximately 80 km northeast of Stavanger. The regular bus service in Sauda runs infrequently, carrying on average 1.5 passengers in a full-size diesel bus–hardly sustainable, either economically or environmentally. In addressing this challenge, Kolumbus developed a service with the Norwegian name *HentMeg*

(*PickMeUp*), whereby people place a reservation on a website or by telephone, specifying the point and time of departure and their destination. If multiple bookings overlap with respect to time of departure and general direction, an algorithm computes an appropriate route for effectively picking up all the passengers and taking them to their destination(s).

As *HentMeg* is aimed at replacing the regular buses, the cost of any trip requested through the service is the same as the regular bus fare. The challenge is profitability. Given that more than half of the operational costs of running a bus service comprise the driver's salary, bus fares do not pay for a driver waiting in stand-by mode for reservations to be made. As explicitly stated by one interviewee, Kolumbus conducted *HentMeg* "to understand how [the company] can use this kind of algorithm, with a view to using it for the autonomous bus in the long term" (Jenny, Kolumbus). The key to profitability lies in eliminating the driver, which is the anticipated outcome of self-driving vehicles in the future.

Discussion

Rather than prescribing a preferred transport future, Norway's current National Transport Plan stresses the work that is needed for any self-driving future to come to fruition, and how this necessitates exploration of the potential of new technologies through pilot projects (Ministry of Transport 2017). This claim was almost unanimously supported in the responses to the draft legislation, and the widely recognized need for a policy framework was also present in our interviews, in which it was further emphasized by statements such as "[self-driving technology] is approaching, and it is approaching fast" (Vincent, Forus Business Park). In terms of the dimensions outlined by Michael (2000), our interviewees stressed self-driving vehicles' arrival in terms of temporal distance and speed (proximal and rapid, respectively)—they will arrive, and soon. In conveying a sense of urgency, such statements may serve to bypass or mitigate processes of deliberation, by hurrying the establishment of legislation without concern for the societal effects of such vehicles. To ascertain future competitiveness, for example, when responding to a call for tenders, mobility providers need know the benefits and limitations of the technology.

With their EasyMile pilot project, the Stavanger partnership experienced some of the challenges of current self-driving technology. When testing the bus amid regular traffic, the operators were surprised by how regularly traffic regulations were broken. Although precautions were taken to ensure traffic safety (installation of speed bumps, lowered speed limit), risky overtaking and right-of-way infringements were frequent. As motorists perceived the bus as an impediment to traffic flow, the partnership responsible for the project emphasized the need for raising its operational speed. In our interpretation, this solution is emblematic of a certain dynamic of real-world testbeds for transportation innovations. As testing is legally prescribed to proceed with caution, emergent transport technologies often impede traffic flow through technical and/or regulatory restrictions. With the test bus operating (and causing disruptions) within the confines of a well-established system, the impulse is to adapt the bus to this system, rather than to envision separate infrastructures (as was the norm until recently, cf. Kröger 2016). This explicates how the testbed's social embeddedness informs current understandings of self-driving vehicles, reproducing existing practices and systems such as the expected speed of traffic or, more broadly, the current characteristics of the road-based transport system.

In the case of Stavanger, the above dynamic may also shape technology. Through FABULOS's call for tenders, Kolumbus suggested certain technological requirements. In addition to aspects such as slope traversal and battery capacity, it suggested a required top speed of 50–60 km/h, matching the typical speed limit in Norway's densely populated areas. These adaptations highlight how the societal embeddedness of testbeds may lead technology development in specific directions. The partnership responsible for the pilot project envisioned a raise in operational speed to solve the messy motorist-machine interactions in Phase Two. This prescribed solution may enter processes of technology development through the call for tenders. By extension, having self-driving technology imitate the characteristics of the current system in terms of speed and flexibility (Steg 2005) can help uphold or reinforce certain forms of urban spatiality and temporality (Ziljstra and Avelino 2012). It follows that adapting to current traffic practices can be considered a positioning in relation to collectively held expectations regarding the characteristics of a (good) transport system.

At the end of Phase Two, the three companies concluded that the EasyMile bus was unfit for its intended function due to its low speed and weather-based problems. However, both Kolumbus and Forus PRT are still involved in new projects on self-driving buses. This echoes the claim of Engels, Wentland, and Pfotenhauer (2019) that the conditions of failure in this kind of experimentation are often unclear. Even as the partnership judged the bus to be an unviable option for transport within the business park, none of the companies appear to be disillusioned. Social theorist Niklas Luhmann has argued that "modern society produces its own newness … by way of stigmatizing the old" (Luhmann 1994, 10). An analogous strategy is used to rationalize the self-driving bus's performance and continued investment in self-driving technology. From being considered "the best possible tool" (Jenny, Kolumbus) for testing self-driving buses, two years of testing turned the EZ10 model into "an old fossil" (Olivia, Forus PRT), ripe for being "placed in a science museum" (Jenny, Kolumbus). Emphasizing the bus's obsolescence serves to rationalize "past disappointments … such that they present a reduced threat to new and successive expectations" (Borup et al. 2006, 290). Thus, expectations are regenerated through belief in continuous technological progress.

A similar belief motivated the development of *HentMeg*. Shared expectations of the materialization of self-driving vehicles were "used to justify other statements and actions" (Borup et al. 2006, 289). With autonomous transport being anticipated to the point of being commonsensical, there is ample space to think two steps ahead: How can the possibilities presented by such vehicles be utilized appropriately? This incessant future-orientation may impede deliberative processes, as there is no question of whether such forms of transport should be implemented, only how their benefits can be properly reaped. Echoing expectations present in the draft legislation statements and the national transport strategy, Kolumbus envisioned a business model relying on the realization of self-driving vehicles. *HentMeg* was a preemptive strike, thought to prove advantageous *when* the expected future materializes.

In shunning technical requirements that might hamper technological development, the current act allows for testing any of the various technological configurations characterizing today's self-driving vehicles (Van Brummelen et al. 2018) as long as the testing is conducted "gradually, especially concerning the maturity of the technology" (Act Relating to Testing of Self-Driving Vehicles 2017, §1). This intention clearly caters to the needs expressed by trade associations and public transport companies. Simultaneously, they are awarded more than a flexible framework. The Act (§9) requires companies conducting testing to provide the Directorate of Public Roads with a final report. In Stavanger, we observed how the embedded test site in Phase Two shaped how the partnership *understood* the self-driving bus, both in itself and in relation to traffic. This indicates that the reports being passed to the Directorate are not merely an "accumulation of data and facts" (Naber et al. 2017, 343). Rather, the documentation appears to communicate understandings produced at the test site, allowing these understandings to enter policy- and law-making processes. Through this configuration, business and industry actors are granted significant power to influence the characteristics of future implementation. In the pilot project we studied, this means that the partnership's ideals concerning implementation might be institutionalized.

To counter the power currently wielded by business and industry actors, we suggest that policymakers take up a more active role in pointing out desirable outcomes of transport automation. Is the "clean and shared" or the "private autonomy" scenario of the National Transport Plan more desirable, for example? A set of preferred outcomes might serve as a basis for developing an experimental protocol, which would be useful for (1) clearly articulating the conditions of success/failure and (2) locating responsibility and establishing the technology's safety.

Further, we suggest that public trials may be reconfigured to enable deliberative processes. Asdal (2008, 13) has suggested that public hearings may be understood as *political technologies*, "as tools for public involvement, for democratization or deliberation." Public trials may be considered another such technology, as they can be (but often are not) configured to "enable the elicitation of social, political and ethical aspects of new technology that are not already apparent" (Marres 2017, 16). Public hearings and experiments may serve as complementary tools, providing both an initial articulation of public concerns and a subsequent broadening or transformation of them in light of test experiences, thus enabling the public(s) and authorities to collaborate in shaping a desirable future through an iterative back-and-forth approach. Our suggestion may enable self-driving technology to benefit the larger public (Martens 2017), rather than merely benefitting commercial actors and/or exacerbating existing transport problems (as have, for example, Lyft and Uber, cf. Schaller 2018).

Conclusion

In this article, we have probed the expectations and work associated with self-driving vehicles in a Norwegian context. In deploying a two-pronged empirical approach, we have studied expectations relating to autonomous transport, and the practices and understandings informed by these expectations. Reflecting our empirical approach, we have employed two distinct, though related theoretical approaches. First, we approached the role of visions and expectations as they have developed in Norway. Drawing on the sociology of expectations, we have demonstrated how expectations for self-driving vehicles have been instrumental in developing legislation allowing for their public testing. In analyzing the responses to the proposed legal framework, we highlighted three issues: (1) issues relating to safety and responsibility, (2) concerns that legislation or bureaucracy might hamper technological development, and (3) questions regarding the purpose and beneficiaries of public testing.

Second, we drew on literature on experiment upscaling and public experimentation when analyzing our case study. We observed the challenges of upscaling, namely moving from a controlled test circuit to a messy real-life setting. Under the latter circumstances, the test bus's low speed gave rise to tension in motorist–machine interactions. The pilot project partnership expected that this friction would be alleviated by raising the operational speed, a belief that soon entered processes of technology development through FABULOS's call for tenders, possibly shaping future self-driving technology. This explicates how current testing, inextricably linked to existing infrastructures, also produces an understanding of self-driving vehicles that is tightly interwoven with the (written and unwritten) practices and rules of these infrastructures. Hence, further upscaling will rely on future self-driving technology approaching the requirements of this transport system. Such a development was expected to happen soon, as expressed by Kolumbus's development of algorithms and business models for the future. Together, this highlights the power of expectations, seeing how they underpin actions conducted in preparation for a highly uncertain future.

In this article, we have also argued that trials produce understandings of both self-driving vehicles and their ideal relationship to general traffic. In our interpretation, these understandings have entered policymaking and lawmaking processes in Norway through reports to the Directorate of Public Roads and contributed to further shape the institutional understanding of such vehicles. Against this background, we offer the following insights for future public initiatives pertaining to autonomous transport. First, we want to emphasize the benefits of articulating desirable transport futures at the governmental level. In doing so, policymakers give innovation processes direction beyond the deployment of self-driving vehicles, for example by establishing a decrease in private car ownership as the intended outcome of the automation of transport. Second, we suggest that these desirable futures serve as the basis for developing an experimental protocol. Such a protocol would allow for (1) assessing currently available technology in relation to desirable futures and (2) ensuring the safety of the technology, for example, in relation to vulnerable road users. Finally, we suggest that public hearings and public experiments may serve as complementary political technologies for abating the influence of business and industry actors over future conditions of implementation. By facilitating a back-and-forth between the public (or publics) and the government, the scenario(s) of future implementation might be shaped to benefit the general public rather than chiefly being adapted to the needs and understandings of commercial interests.

As exemplified in this article by concerns regarding legislation and bureaucracy impeding testing, emergent technologies are often embroiled in narratives of legislation lagging behind technological development. Drawing upon the findings from our case study, such concerns seem misguided. Rather than technology running ahead of the legislation, the opposite appears closer to the truth, at least in this instance. An immature technology is tested publicly *because* of the associated high expectations. The test experiences then influence how the technology is understood in terms of mode(s) of implementation and necessary technological capabilities, which go on to shape further expectations. As succinctly summarized by one interviewee, the EasyMile bus served the dual function of showing "how far the technological development has come, but how immature [self-driving technology] still is" (Jenny, Kolumbus). Existing in this paradoxical state, simultaneously obsolete and representing the (expected) possibilities of future autonomous transport, the self-driving bus comes to represent the proto-existence of a specific technological future, a conduit through which this future may flow into existence.

Disclosure statement

No potential conflict of interest was reported by the author(s).

Notes

1. The terms autonomous, driverless, and self-driving vehicles are used interchangeably. In this article the term self-driving vehicles is used consistently, reflecting the usage in the Norwegian legislative framework.
2. The draft legislation and all responses are available at https://www.regjeringen.no/no/dokumenter/horing—forslag-til-ny-lov-om-utproving-av-selvkjorende-kjoretoy-pa-veg/id2523663/?expand=horingssvar (accessed 7 February 2019).
3. Although it might seem counterintuitive to use the word "operator" in relation to a self-driving bus, this term was used by the three companies that conducted the pilot study. During our four trips, we observed how the operator frequently chose to manually

override the shuttle bus due to its defensive driving style, thus substantiating the logic behind the choice to use the term “operator.”

4. This section references multiple Norwegian companies and organizations whose designations differ from Norwegian to English. As not to clutter the main text, this endnote includes a legend for these companies and organizations. The list is alphabetical, sorted by the company or organization’s English designation: the Confederation of Norwegian Enterprise = *Naeringslivets Hovedorganisasjon (NHO)*, the Federation of Norwegian Transport Companies = *NHO Transport*, Finance Norway = *Finans Norge*, the Norwegian Association of the Blind = *Norges Blindeforbund*, the Norwegian Cyclists’ Association = *Syklistforeningen*, the Norwegian Logistics and Freight Association = *NHO Logistikk og Transport*, the Norwegian Motorcyclists’ Union = *Norsk Motorcykkel Union (NMCU)*, the Norwegian Taxi Association = *Taxiforbundet*, Public Transport Norway = *Kollektivtrafikkforeningen*, the Union of Norwegian Transport Employees = *Yrkestrafikkforbundet (YTF)*.
5. As argued in the response from the Confederation of Norwegian Enterprise, available at: https://www.regjeringen.no/contentassets/d85eaf3bf13d4be7ac64a59d155ebe88/naringslivets-hovedorganisasjon.pdf?uid=Naeringslivets_Hovedorganisasjon.pdf (accessed 4 December 2019).
6. The response from Kolumbus is available at: https://www.regjeringen.no/contentassets/d85eaf3bf13d4be7ac64a59d155ebe88/kolumbus.pdf?uid=Kolumbus.pdf (accessed 20 February 2020).
7. Multiple such initiatives have been conducted in the wake of the project at Forus. These trials have tested either EasyMile buses or similar buses produced by the company Navya, driving routes similar to or less advanced than the one at Forus. At the time of writing, projects have been conducted in or near the cities of Oslo (areas Fornebu and Vippetangen), Kongsberg, Gjøvik, and Longyearbyen, in addition to Stavanger.

ORCID

Bård Torvetjønn Haugland http://orcid.org/0000-0002-2385-416X
Tomas Moe Skjølsvold http://orcid.org/0000-0001-6965-756X

References

Act Relating to Testing of Self-Driving Vehicles 2017. *Lov om utprøving av selvkjørende kjøretøy (LOV-2017-12-15-112) [Act No. 112 of December 15, 2017* relating to the testing of self-driving vehicles]. https://lovdata.no/dokument/NL/lov/2017-12-15-112?q=lov%20om%20utprøving

Akrich, M. 1995. “User Representations: Practices, Methods and Sociology.” In *Managing Technology in Society: The Approach of Constructive Technology Assessment*, edited by A. Rip, T. Misa, and J. Schot, 167–184. London: Pinter.

Asdal, K. 2008. “On Politics and the Little Tools of Democracy: A Down-to-Earth Approach.” *Distinktion: Journal of Social Theory* 9 (1): 11–26. doi:10.1080/1600910X.2008.9672953.

Atkinson, R., and J. Flint. 2004. “Snowball Sampling.” In *The SAGE Encyclopedia of Social Science Research Methods*, Vol. 1, edited by M. Lewis-Beck, A. Bryman, and T. Liao, 1044–1044. Thousand Oaks, CA: SAGE. doi:10.4135/9781412950589.n931.

Ballo, I. 2015. “Imagining Energy Futures: Sociotechnical Imaginaries of the Future Smart Grid in Norway.” *Energy Research & Social Science* 9: 9–20. doi:10.1016/j.erss.2015.08.015.

Berkhout, F. 2006. “Normative Expectations in Systems Innovation.” *Technology Analysis & Strategic Management* 18 (3–4): 299–311. doi:10.1080/09537320600777010.

Borup, M., N. Brown, K. Konrad, and H. van Lente. 2006. “The Sociology of Expectations in Science and Technology Studies.” *Technology Analysis & Strategic Management* 18 (3–4): 285–298. doi:10.1080/09537320600777002.

Brown, N., and M. Michael. 2003. “A Sociology of Expectations: Retrospecting Prospects and Prospecting Retrospects.” *Technology Analysis & Strategic Management* 15 (1): 3–18. doi:10.1080/0953732032000046024.

Brown, N., B. Rappert, and A. Webster, eds. 2000. *Contested Futures: A Sociology of Prospective Techno-Science*. Aldershot: Ashgate.

Bulkeley, H., V. Broto, and G. Edwards. 2014. *An Urban Politics of Climate Change: Experimentation and the Governing of Socio-Technical Transitions*. London: Routledge.

Charmaz, K. 2006. *Constructing Grounded Theory: A Practical Guide Through Qualitative Analysis*. London: Sage.

Duarte, F., and C. Ratti. 2018. “The Impact of Autonomous Vehicles on Cities.” *Journal of Urban Technology* 25 (4): 3–18. doi:10.1080/10630732.2018.1493883.

Engels, F., and A. Münch. 2015. “The Micro Smart Grid as a Materialised Imaginary Within the German Energy Transition.” *Energy Research & Social Science* 9: 35–42. doi:10.1016/j.erss.2015.08.024.

Engels, F., A. Wentland, and S. Pfotenhauer. 2019. “Testing Future Societies? Developing a Framework for Test Beds and Living Labs as Instruments of Innovation Governance.” *Research Policy* 48 (9): 103826. doi:10.1016/j.respol.2019.103826.

Gandia, R., F. Antonialli, B. Cavazza, A. Neto, D. de Lima, J. Sugano, I. Nicolai, and A. Zambalde. 2019. “Autonomous Vehicles: Scientometric and Bibliometric Review.” *Transport Reviews* 39 (1): 9–28. doi:10.1080/01441647.2018.1518937.

Geels, F. 2012. “A Socio-Technical Analysis of Low-Carbon Transitions: Introducing the Multi-Level Perspective into Transport Studies.” *Journal of Transport Geography* 24: 471–482. doi:10.1016/j.jtrangeo.2012.01.021.

Geels, F., and R. Raven. 2006. “Non-Linearity and Expectations in Niche-Development Trajectories: Ups and Downs in Dutch Biogas Development.” *Technology Analysis & Strategic Management* 18 (3–4): 375–392. doi:10.1080/09537320600777143.

Hopkins, D., and T. Schwanen. 2018. “Automated Mobility Transitions: Governing Processes in the UK.” *Sustainability* 10 (4): 956. doi:10.3390/su10040956.

Kemp, R., J. Schot, and R. Hoogma. 1998. "Regime Shifts to Sustainability Through Processes of Niche Formation: The Approach of Strategic Niche Management." *Technology Analysis & Strategic Management* 10 (2): 175–195. doi:10.1080/09537329808524310.

Kröger, F. 2016. "Automated Driving in Its Social, Historical and Cultural Contexts." In *Autonomous Driving: Technical, Legal and Social Aspects*, edited by M. Maurer, J. Gerdes, B. Lenz, and H. Winner, 41–68. Berlin: Springer.

Luhmann, N. 1994. "The Modernity of Science." Translated by K. Behnke. *New German Critique* (61): 9–23. doi:10.2307/488618.

Marres, N. 2017. *What if Nothing Happens: Street Trials of Intelligent Cars as Experiments in Participation.* http://wrap.warwick.ac.uk/95442/

Martens, K. 2017. *Transport Justice: Designing Fair Transportation Systems*. New York: Routledge.

Marvin, S., H. Bulkeley, L. Mai, K. McCormick, and Y. Palgan, eds. 2018. *Urban Living Labs: Experimenting with City Futures*. London: Routledge.

Michael, M. 2000. "Futures of the Present." In *Contested Futures: A Sociology of Prospective Techno-Science*, edited by N. Brown, B. Rappert, and A. Webster, 21–39. Aldershot: Ashgate.

Milakis, D., B. van Arem, and B. van Wee. 2017. "Policy and Society Related Implications of Automated Driving: A Review of Literature and Directions for Future Research." *Journal of Intelligent Transportation Systems* 21 (4): 324–348. doi:10.1080/15472450.2017.1291351.

Ministry of Transport. 2017. *Nasjonal transportplan 2018–2029 [National Transport Plan 2018–2019]*. Oslo: Ministry of Transport. https://www.regjeringen.no/contentassets/7c52fd2938ca42209e4286fe86bb28bd/no/pdfs/stm201620170033000dddpdfs.pdf

Naber, R., R. Raven, M. Kouw, and T. Dassen. 2017. "Scaling Up Sustainable Energy Innovations." *Energy Policy* 110: 342–354. doi:10.1016/j.enpol.2017.07.056.

Norheim, H. 2019. Nå skal denne selvkjørende bussen trafikkere Forus [This Self-driving Bus Will Soon Be Driving at Forus]. *Stavanger Aftenblad*, August 20. https://www.aftenbladet.no/lokalt/i/lAl1rA/Na-skal-denne-selvkjorende-bussen-trafikkere-Forus

Rapley, T. 2004. "Interviews." In *Qualitative Research Practice*, edited by C. Seale, G. Gobo, J. Gubrium, and D. Silverman, 15–33. London: Sage.

Rotmans, J., R. Kemp, and M. van Asselt. 2001. "More Evolution than Revolution: Transition Management in Public Policy." *Foresight* 3 (1): 15–31. doi:10.1108/14636680110803003.

Schaller, B. 2018. "The New Automobility: Lyft, Uber and the Future of American Cities." http://www.schallerconsult.com/rideservices/automobility.pdf

Schot, J., and F. Geels. 2008. "Strategic Niche Management and Sustainable Innovation Journeys: Theory, Findings, Research Agenda, and Policy." *Technology Analysis & Strategic Management* 20 (5): 537–554. doi:10.1080/09537320802292651.

Sheller, M. 2012. "The Emergence of New Cultures of Mobility: Stability, Openings and Prospects." In *Automobility in Transition? A Socio-Technical Analysis of Sustainable Transport*, edited by F. Geels, R. Kemp, G. Dudley, and G. Lyons, 180–202. London: Routledge.

Sheller, M., and J. Urry. 2000. "The City and the Car." *International Journal of Urban and Regional Research* 24 (4): 737–757. doi:10.1111/1468-2427.00276.

Skjølsvold, T. 2014. "Back to the Futures: Retrospecting the Prospects of Smart Grid Technology." *Futures* 63: 26–36. doi:10.1016/j.futures.2014.08.001.

Skjølsvold, T., and C. Lindkvist. 2015. "Ambivalence, Designing Users, and User Imaginaries in the European Smart Grid: Insights from an Interdisciplinary Demonstration Project." *Energy Research & Social Science* 9: 43–50. doi:10.1016/j.erss.2015.08.026.

Steg, L. 2005. "Car Use: Lust and Must. Instrumental, Symbolic and Affective Motives for Car Use." *Transportation Research Part A: Policy and Practice* 39 (2-3): 147–162. doi:10.1016/j.tra.2004.07.001.

Stilgoe, J. 2018. "Machine Learning, Social Learning and the Governance of Self-Driving Cars." *Social Studies of Science* 48 (1): 25–56. doi:10.1177/0306312717741687.

Urry, J. 2004. "The 'System' of Automobility." *Theory, Culture and Society* 21 (4–5): 25–39. doi:10.1177/0263276404046059.

Van Brummelen, J., M. O'Brien, D. Gruyer, and H. Najjaran. 2018. "Autonomous Vehicle Perception: The Technology of Today and Tomorrow." *Transportation Research Part C: Emerging Technologies* 89: 384–406. doi:10.1016/j.trc.2018.02.012.

van Lente, H. 2012. "Navigating Foresight in a Sea of Expectations: Lessons from the Sociology of Expectations." *Technology Analysis & Strategic Management* 24 (8): 769–782. doi:10.1080/09537325.2012.715478.

Wentland, A. 2016. "Imagining and Enacting the Future of the German Energy Transition: Electric Vehicles as Grid Infrastructure." *Innovation: The European Journal of Social Science Research* 29 (3): 285–302. doi:10.1080/13511610.2016.1159946.

Wentland, A. 2017. "An Automobile Nation at the Crossroads: Reimagining Germany's Car Society through the Electrification of Transportation." In *Imagined Futures in Science, Technology and Society*, edited by G. Verschraegen, F. Vandermoere, L. Braeckmans, and B. Segaert, 137–165. London: Routledge.

Woolgar, S. 1991. "Configuring the User: The Case of Usability Trials." In *A Sociology of Monsters: Essays on Power, Technology and Domination*, edited by J. Law, 58–102. London: Routledge.

Ziljstra, T., and F. Avelino. 2012. "A Socio-Spatial Perspective on the Car Regime." In *Automobility in Transition? A Socio-Technical Analysis of Sustainable Transport*, edited by F. Geels, R. Kemp, G. Dudley, and G. Lyons, 160–179. London: Routledge.