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Changing oil: self-driving vehicles and the Norwegian state

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Expectations regarding the imminent arrival of self-driving vehicles has prompted nations to embed such vehicles in policy and explore their potential through pilot projects. The article analyses interviews and document to explore the politics of self-driving vehicles in Norway. Using sociotechnical imaginaries as a theoretical starting point, the article finds that Norwegian policy and legislation frame self-driving vehicles in rather general terms, primarily citing expected economic gains and prospects of improving the transport sector. When these policies were operationalized in the transport innovation project Borealis, the Norwegian Public Roads Administration grafted the policies onto distinctively Norwegian use-cases: self-driving vehicles and associated infrastructures were envisioned to benefit the Norwegian fishing industry, have ramifications for standardization work within the European Union, and possibly foster a Norwegian high-tech industry. The prospect of a high-tech industry links self-driving vehicles to the green shift, a collectively imagined future in which the Norwegian petroleum industry has been phased out and replaced by 'greener' industries. In sum, self-driving vehicles are mobilized both as a desirable transport innovation and as part of a national narrative: through innovation relating to such vehicles, Norway might be able to phase out a petroleum-reliant economy while remaining an affluent nation with high levels of social welfare.

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Introduction

In May 2018, three freight trucks could be seen thundering across the snowy landscape of Northern Norway. The trucks navigated the winding roads while maintaining equal distances between them. While a driver was present in all three vehicles, the drivers in the two hindmost trucks were merely keeping their hands on the wheel. The three trucks were connected through 'advanced radar and camera technology', which allowed the driver in the lead truck to control the acceleration and braking of all three trucks.[1] The event marked Norway's first demonstration of *truck platooning*—the digital coupling of the acceleration and deceleration of multiple trucks in a convoy. The occasion for the demonstration was the opening ceremony of the Borealis project, which is funded by the Norwegian Public Roads Administration (NPRA). In this project, the NPRA has fashioned a 40 kilometre (km) stretch of public road (Fig. 1c) into a site for testing intelligent transport system (ITS) technologies in an arctic environment.

In April 2019, Erna Solberg, Prime Minister of Norway and leader of the Norwegian Conservative Party, visited the city of Tromsø, where she was interviewed by a journalist from the local newspaper *iTromsø*. One of the predetermined topics for the interview was transportation, which was introduced with the question 'How's our railway coming along?' The railway in question is a long-desired railway extension from Fauske to Tromsø (Fig. 1b), an extension that has been envisioned for nearly a century. Solberg responded by first referring to a committee investigating the possibility of extending the railway northwards, before making into the following statement:

> We are approaching a digitalized revolution, where we will have autonomous bus systems, cars, interconnected systems. […] Fish, for example, will probably never be transported heavily along the railway in the future, which is one of the justifications people have offered [for building the railway]. Rather, [fish] will be transported in tightly interwoven trucks that are autonomous, trucks that employ systems where there is not even a driver and will drive twenty-four hours of the day within such a system. There is a high probability we will have this in twenty to twenty-five years. Any railway would take the same time to build.[2]

Solberg's statement is not unique. Expectations to self-driving vehicles have been growing since the late 2000s (Stilgoe, 2018). Whether due to the prospect of reduced emissions of climate gases, a safer road transport sector, or a reduction in automobile-related land use (car parks, roads), self-driving vehicles are commonly framed as an inevitable development (Legacy et al., 2019, p. 98) capable of ushering in dramatic changes within the road transport sector (Milakis et al., 2017; Duarte and Ratti, 2018). Still, there is considerable uncertainty associated with the development and implementation of self-driving vehicles. By steering toward this particular though uncertain future of road transport, other possible transport futures are given lower priority. As technological propositions are always value-laden (Winner, 1980), the prioritization of one particular transport future also represents the subordination of alternative ways of envisioning and organizing a future society.

Together, the two introductory vignettes outline visions for a future when advances in transport technology will allow for new ways of organizing the freight and public transport sectors. In this article, I investigate the relationship between society and the emerging technology of self-driving vehicles through the lens of sociotechnical imaginaries (Jasanoff and Kim, 2009, 2015). This framework concerns the tight-knit relationship between politics and technoscience in contemporary societies and is thus a suitable tool for exploring the role envisioned for self-driving vehicles in Norwegian society and how innovation projects are configured to realize this role. In applying the framework to the case of self-driving vehicles, I address the following questions: What future is envisioned in Norwegian policy and legislation pertaining to self-driving vehicles? How is the envisioned future operationalized and/or altered by actors working in the field of transport automation? How does this future relate to Norwegian policy and society more broadly?

The remaining part of this article is structured as follows. First, I expand upon the framework of sociotechnical imaginaries, which provides the theoretical basis for this article, before elaborating on some important 20th century developments in Norwegian society. Thereafter, I present my methods. In the analysis, I start by focusing on how self-driving vehicles are described in Norwegian government literature and then focus on the Borealis project as an operationalization of the government policies. In the subsequent discussion, I explain how the Norwegian policies for self-driving vehicles relate to Norwegian society, and thereafter present my conclusions.

The pursuit of innovation. As this article investigates the relationship between Norwegian society and an emerging technology, I have chosen the framework of sociotechnical imaginaries (Jasanoff and Kim, 2009, 2015) as a theoretical starting point. Jasanoff (2015a, p. 4) defines sociotechnical imaginaries as

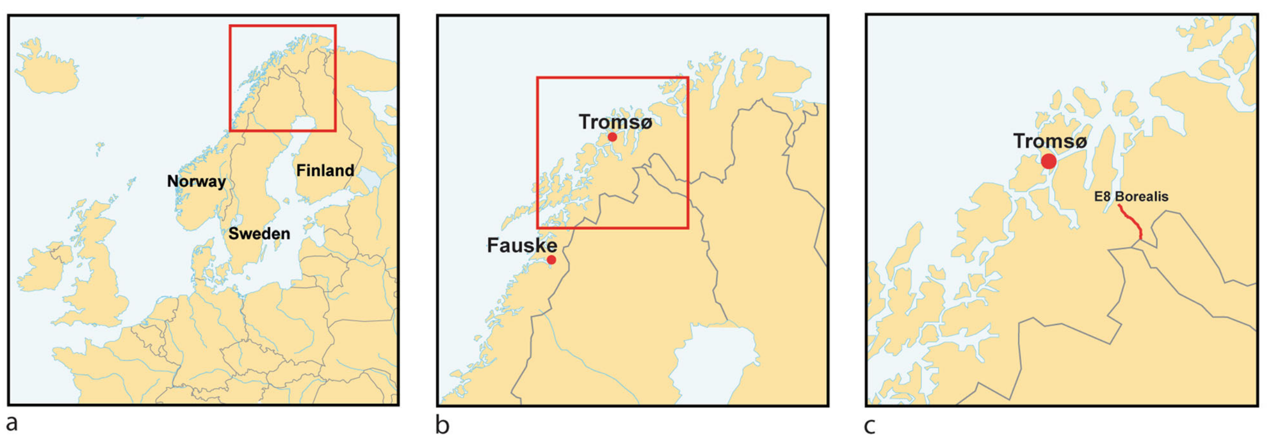

Fig. 1 Location of the Borealis project. a Norway's placement in Northern Europe. **b** The terminal points of the proposed Northern Norway railway line. **c** The location of the Borealis project (© Kartverket under a CC BY 4.0 license, modified by the author).

'collectively held, institutionally stabilized, and publicly performed visions of desirable futures, animated by shared understandings of forms of social life and social order attainable through, and supportive of, advances in science and technology'. Put another way, this concept exhibits an interest in how individuals and/or organizations mobilize resources to establish support for a future they envision as possible through advances in science and technology. This includes an interest in the means that are mobilized to elicit support, such as the manner in which the institutionalization and public performance of such a future helps to propagate and further consolidate an imaginary.

Jasanoff (2015b) suggests there are four phases in the life of a sociotechnical imaginary: origin, embedding, resistance, and extension. *Origin* describe from whom an imaginary originates, whether from individuals or groupings, political or otherwise. While imaginaries might originate in an individual's or group's vision of a possible world, an imaginary needs to be *embedded* within existing social, economic, and material infrastructures in order to gain traction. This might entail playing to a nation's collective memory or widely accepted models of innovation, as well as producing objects and infrastructures. In processes of embedding, *resistance* might arise. Whereas proponents of an imaginary see its merits, other groups might disagree and oppose the imaginary. Finally, a successfully embedded imaginary might be *extended*, for example by being supported over a protracted period or expanded through new institutional jurisdictions or spatially defined domains.

There is an increasingly common tendency for governments to view technological innovations as the pathway toward a desirable future. As evidenced by the recent increase in innovation strategies for cities, regions and nations, innovation appears to have become institutional shorthand for social progress and economic development (Pfotenhauer and Jasanoff, 2017a). This in turn has led nations to seek out or replicate more or less formalized models of innovation to enable a certain type of development (Pfotenhauer and Jasanoff, 2017b). However, until recently the success or failure of such models has often been attributed to how well (or not) the model has been implemented. Such a view ignores the fact that nations have pursued innovation for various reasons, for example to exhibit economic and scientific leadership, to elicit external aid, or to ensure national security (Pfotenhauer and Jasanoff, 2017a). These examples illustrate how innovation is tied to the past as well as the future: when articulating a desirable future, one also identifies contemporaneous challenges to be solved and the past causes of these challenges. Thus, to understand better the role of self-driving vehicles in Norwegian policy, let us examine Norway's past with respect to innovations and economic development and one collectively imagined future which relates to this past.

In a collaborative mood: Norwegian economy and innovation. Throughout the 20th century, Norway underwent a radical economic transformation. In 1870, Norway's gross domestic product (GDP) per capita was three-quarters of the Western European average, but by the early 2000s, the Norwegian GDP per capita had increased to 25% *above* this average (Fagerberg et al., 2009a). However, the Norwegian economy is distinguished from comparable Western European economies by primarily being resource-based. Historically, the Norwegian economy has relied upon maritime industries such as fisheries, refineries, and shipping, the hydropower-driven metallurgical and electrochemical industries, and the country's most recent resource-based enterprise, the petroleum industry. These industries have all emerged from Norway's geographical particularities: an extensive coastline, mountainous terrain, and offshore petroleum reservoirs.

Historically, Norway's industries have either been small-scale and decentralized (e.g. fisheries) or large-scale and centralized (e.g. fertilizer production). These industries have been supported in different ways by Norwegian authorities: small-scale industries have been supported by active regional policies (Teigen, 2012), while the large-scale development of hydropower and related industries was regulated through 'concession acts' intended to 'obtain national control over vital natural resources and to fulfil national development ambitions' (Sæther et al., 2011, p. 376). The concession acts implemented in the early 20th century ostensibly also influenced the organization of the oil and gas industries more than half a century later (Engen, 2009, p. 181). Industry and technology have long been part of the Norwegian national narratives, as drivers of 'modernization processes'. For example, the development of hydropower throughout the 20th century was part engineering feat, part state-making (Sørensen, 2016).

The Norwegian Government has also tried to foster industries that are not resource-based. This sector, described as 'knowledge-intensive [and] network-based' (Fagerberg et al., 2009a, p. 439), encompasses high-tech industries characterized by a relatively high research and development (R&D) expenditure. Examples include consumer electronics and ICT (Sørensen, 2016; Fagerberg et al., 2009a, p. 440), as well as the Norwegian attempt at establishing an electric vehicle (EV) industry (Ryghaug and Skjølsvold, 2019), all of which the Norwegian Government has supported in the past. Ultimately, none of these ventures succeeded, and the third industrial sector remains relatively small (Fagerberg et al., 2009a). Still, successful or not, the above-mentioned examples illustrate how the Norwegian Government has cast technology and industry in a central role in the nation's grand narratives, accompanied by both political and economic support.

However, the 1980s marked a change in Norwegian technology policy, characterized by a shift from public support for particular industrial ventures toward generalized support schemes meant to foster innovation (Sørensen, 2016). As a result, the current Norwegian innovation policy is characterized by an economic R&D-centred approach that often overlooks the importance of socialization (e.g. developing regulations or infrastructures, shaping public attitudes) for successfully fostering new technologies and/or industries (Sørensen, 2013). This may be part of the reason why Norway continues to exhibit a characteristic lack of a major high-tech industry (e.g. ICT, biotechnology, pharmaceuticals) compared with other high-income Western European countries (Fagerberg et al., 2009a).

Although Norway lacks a high-tech industry, innovation has still been practised in relation to the resource-based industries. However, these industries have been characterized by low R&D expenditure. Innovation has often been problem-oriented, with the necessary competence for problem-solving being sourced outside companies. Often, intrafirm R&D was only pursued if the necessary expertise was not available elsewhere (Fagerberg et al., 2009a). Throughout the 20th century, such problem-oriented collaborations fostered both organizational and technological innovations, but these were often directed toward improving efficiency and increasing profitability within the resource-based industries, including the petroleum industry, rather than the development of new industries (Fagerberg et al., 2009a). As the recognition of problems relating to climate change have become mainstream, there has been an associated uncertainty regarding the future demand for petroleum and petroleum products. Accordingly, an economy that relies heavily upon petroleum production seems increasingly out of step, thus raising the by now idiomatic question: 'What will sustain Norway after the oil?'

Enter *the green shift*. This ill-defined term has seen a sharp increase in use over the last decade and is often invoked by

Norwegian politicians and media. Although the term lacks a precise definition, it is often used to describe a desirable and supposedly ongoing process in which Norway is phasing out the petroleum industry and establishing new, sustainable industries (Haarstad and Rusten, 2018). The lack of an agreed-upon definition allows the term to be used to describe both a nationwide transition toward a sustainable low-emission society and a general shift towards less carbon-intensive products and services. Paired with the question of a Norwegian society post-oil, this suggests that the green shift is not only about phasing out petroleum but also a question of retaining an established standard of living (Dale and Andersen, 2018). Thus, the green shift is not only a moral imperative but also a question of economy.

The origins of the green shift may be traced back to the *Our Common Future* report (World Commission on Environment and Development, 1987) and further to the deep ecology developed by Norwegian philosopher Arne Næss (e.g. Næss, 1973). These lines of thought echo through the Norwegian Government's websites, which describe a future society 'where growth and development happens within the planetary boundaries'.[3] Its frequent invocation suggests that the green shift has taken root in Norway's collective imagination, grounded in the characteristics of contemporary Norway and in the imagination of what Norway might become through advances in technoscience. Additionally, the green shift has been institutionalized through government initiatives such as Nysnø climate investments; Enova, a government enterprise promoting sustainable energy production and use; Innovasjon Norge's environmental technology scheme; and the digital platform The Explorer, which is dedicated to the international promotion of green technologies produced and developed in Norway.[4] As such, the green shift exhibits the defining characteristics of a sociotechnical imaginary (Jasanoff and Kim, 2015, 2009).

Method

To address my research questions, I have chosen a dual approach. With regard to the question of how self-driving vehicles have been taken up in politics, I use the findings from a document analysis. I started by checking 42 documents (White Papers, government commissioned reports, legislation, tender documentation) that contain references to self-driving vehicles. In many of the documents, the term self-driving vehicles is merely used as shorthand for technological progress. Accordingly, my analysis focused on the seven documents that specify the Norwegian Government's policies relating to self-driving vehicles, constitute the knowledge base for those policies, or represent operationalizations of the policies (Table 1). First, I read the documents with an eye for the immediate benefits and challenges associated with self-driving vehicles. In subsequent readings, I focused on how self-driving vehicles were situated in the broader political milieu as well as how they were envisioned to influence societal aspects outside the transport sector. Through such an iterative reading, I gained a comprehensive overview of the visions and expectations associated with self-driving vehicles in Norwegian policy, as well as the actions that the government has since undertaken to support the policies.

In addition to the policy documents, this article builds upon in-depth interviews conducted in 2019 in relation to the Borealis project. The project, which was instigated by the NPRA, has involved the NPRA and its partner companies testing ITS technologies in Arctic conditions. When researching Borealis, three colleagues and I conducted eight in-depth interviews: four with employees of the NPRA, three with employees of the NPRA's business partners, and one with a regional politician from the municipality where Borealis was conducted. The interviewees with the NPRA employees were chosen strategically: the interviewees were either project leaders or had otherwise worked closely towards the realization of Borealis. Similarly, the interviewed NPRA business partners had been involved with Borealis since the project was announced, and thus had extensive knowledge of the project.

The interviews were conducted with the help of an interview guide (Rapley, 2004), with the purpose of investigating the provenance of the Borealis project, its relationship to policies and visions of self-driving vehicles, the benefits the project might have for the Northern Norway region, and the importance ascribed to testing in this region. All interviews were audio-recorded and subsequently professionally transcribed. All quotes in this article, whether from interview transcriptions or from documents, have been translated by me and pseudonyms are used for the quoted interviewees.

The transcribed interviews were subjected to an open coding process (Charmaz, 2006). In the course of that process, I became increasingly interested in the interplay between visions of technological futures and the testing activities being undertaken in Borealis. Through iterations of the coding process, the relationship between self-driving vehicles and politics became increasingly apparent. This prompted me to re-examine the seven government and government-commissioned documents in order to better understand the relationship between transport policy and technological pilot project activities, and the wider ramifications of these policies and activities.

In addition to the interviews, two colleagues and I visited the Borealis test site in March 2019, a visit that coincided with the first set of technology tests. Our visit took the form of participant observations, in which we were introduced to most of the NPRA's partners, sat in on troubleshooting exercises in the small control centre erected at the roadside, and generally observed and inquired about the project. At the end of the working day, the Borealis partners reconvened at a nearby hotel for a project meeting. We were invited to attend their meeting, during which their experiences and the challenges encountered that day were summarized. This allowed us to make further observations of the dynamics between the partners and to inquire further about the project.

Table 1 Analysed documents.

Document title	Document type
Act Relating to Testing of Self-Driving Vehicles (2017)	Legislation
Call for R&D proposals for E8—the Borealis project (Statens vegvesen, 2017)	Tender documentation
National Transport Plan 2018–2029 (Meld. St. 33 (2016–2017))	White Paper
Smarter transport in Norway (Samferdselsdepartementet, 2017)	Tender documentation
Pilot-T (Forskningsrådet, 2019a)	Tender documentation
Technology for sustainable freedom of movement and mobility (Ekspertutvalget—teknologi og fremtidens transportinfrastruktur, 2019)	Report
Transport 21 (Forskningsrådet, 2019b)	Report

Subsequent to the field visit, I attended the ITS Arena seminar held in Oslo in April 2019. The conference was arranged jointly by the NPRA and ITS Norge (ITS Norway). ITS Norge is a national membership association that acts as 'the contact point for Norwegian expertise on ITS'.[5] The seminar in 2019 was a field configuring event (Lampel and Meyer, 2008). It attracted actors from different businesses and organizations, as well as from different geographical regions, to an event that included both presentations from professionals and opportunities for informal face-to-face interaction. All presentations at the seminar, including those on Borealis, were held by NPRA employees. The overarching theme of the seminar was the current challenges associated with ITS. Through this focus, the NPRA implied the limitations that partners, both current and prospective, would have to work with or face, while simultaneously expounding what goals ITS should be mobilized toward. As such, the ITS Arena seminar was an event at which the NPRA contributed to configuring the field of ITS and its expression in the Norwegian context. In sum, the examined documents, interviews, and experiences provided the background for my understanding of the Borealis project and its internal dynamics, as well as how the project fits within the national context.

Analysis, part I: policy and legislation. While many Western European nations have expressed an interest in self-driving vehicles (Hopkins and Schwanen, 2018; Blyth, 2019; Mladenović et al., 2020), the motivations for engaging with such technology appear to differ. For example, Finland sees self-driving vehicles as an interesting opportunity for the country's comprehensive ICT industry (Blyth, 2019). By contrast, the UK interprets the technology in light of the country's past as automotive manufacturer and a perceived 'global race for supremacy in AV [autonomous vehicle] innovation' (Hopkins and Schwanen, 2018, p. 9). How, then, does the Norwegian Government conceive self-driving vehicles? To answer this question, I will explore how self-driving vehicles have been institutionalized in Norwegian policy documents and legislation.

Every 4 years, the Norwegian Government releases a new version of the National Transport Plan (NTP), a document that lays out the Government's transport strategy for the next 12 years, including funding priorities and expected technology trends. The 2017 NTP marked the first in-depth discussion of self-driving vehicles in Norwegian government literature (Meld. St. 33 (2016–2017), pp. 26–49). This NTP lists the benefits self-driving vehicles are expected to realize, which coincide entirely with the NTP's vision of a future 'transport system that is safe, facilitates value-creation, and contributes to the transition toward a low-emission society' (Meld. St. 33 (2016–2017), p. 27). The 2017 NTP proceeds to emphasize that trials and pilot projects are necessary to explore how self-driving vehicles might contribute to this overarching objective (Meld. St. 33 (2016–2017), p. 35). With the Act Relating to Testing of Self-driving Vehicles (2017), the Norwegian Parliament allowed for testing of self-driving vehicles on public roads. Since the Act's implementation in 2018, multiple companies (public and private) have conducted such tests, primarily with self-driving buses at low speeds (12–20 km per hour). Beyond creating a legal framework to facilitate testing, the Norwegian Government has also supported such trials through funding. This includes the allocation of NOK 100 million to the 2017 competition 'Smartere transport' and NOK 60 million to the Research Council of Norway's 2019 funding scheme Pilot-T.

However, beyond the immediate objectives of the NTP Pilot-T the institutionalization of self-driving vehicles emphasizes the economic importance of transport innovation other than mere value creation through a robust and reliable transport system. There is a prospect of economic gain (Meld. St. 33 (2016–2017), p. 38), whereby transport innovation can lead to 'increased welfare and economic growth' (Samferdselsdepartementet, 2017, p. 4). Beyond new business models and the elimination of human drivers, the prospect of socio-economic trade-offs is worth noting. In a report on technology for sustainable freedom of movement and mobility, written by an expert committee appointed by the Ministry of Transport and Communications, the authors argue that developments within the field of self-driving vehicles could render expensive, near-future developments of safety infrastructure obsolete (Ekspertutvalget—teknologi og fremtidens transportinfrastruktur, 2019, p. 40). Thus, self-driving vehicles appear not only as a boon for Norwegian businesses and industry clusters, but also for the socio-economic management of the nation itself.

The NTP for 2017 spells out the division of responsibility between government and businesses in no uncertain terms: 'Commercial companies will be important in the development of new technology and solutions. The role of the authorities is to develop and adapt legislation and policy framework, and to ascertain sufficiently safe solutions' (Meld. St. 33 (2016–2017), p. 41). This is also reflected in the Norwegian legislation on testing, which is configured in a way that is beneficial for companies and businesses. Through public trials, companies develop interpretations of the social aspects of the technology. The companies' understandings of ideal modes of implementation are communicated to the Directorate of Public Roads through law-mandated final reports. These reports then enter processes of law-making and policymaking, potentially influencing the institutional understanding of self-driving vehicles (for an in-depth discussion, see Haugland and Skjølsvold, 2020).

The manner in which self-driving vehicles have been institutionalized in Norwegian policy and legislation is notable for two reasons. First, they are referred to in rather general terms. Rather than reflecting upon how Norwegian society might benefit from the implementation of self-driving vehicles, the Norwegian goals echo the benefits commonly cited in academic literature (Milakis et al., 2017; Duarte and Ratti, 2018; Legacy et al., 2019) and the expectations that have been documented in Finland, Germany and the UK (Hopkins and Schwanen, 2018; Mladenović et al., 2020). Second, there is an obvious economic orientation, in which participation in an emergent field is framed as an economic opportunity for Norway in general (Meld. St. 33 (2016–2017), p. 38), and for technology and transport companies in particular. In sum, the Norwegian Government's efforts to support the realization of self-driving vehicles appear to have been motivated as much by the prospect of economic gain from a transport sector that is considered to be on the brink of a rapid and radical transformation (Meld. St. 33 (2016–2017), p. 37; Ekspertutvalget—teknologi og fremtidens transportinfrastruktur, 2019, p. 40), as by such vehicles being able to fulfil the overarching goals of the NTP. The Norwegian Government frames self-driving vehicles primarily in economic terms, rather than connecting visions of self-driving vehicles with distinctively Norwegian conditions and challenges. However, through the innovation activities within the Borealis project, such connections were made.

Analysis, part II: the Borealis project. The Borealis project was the result of a Finnish-Norwegian collaboration. In 2017, the Finnish Transport Agency (FTA) conducted the Aurora project, in which a 10 km stretch of road was equipped with intelligent infrastructures.[6] At the same time, the NPRA had undergone a reorganization that had freed up technical personnel for new projects. Combined with a NOK 30 million surplus from a previous road development, the NPRA's Region North office had the funding and personnel necessary to establish a collaboration with the FTA. Consequently, the NPRA designated the 40 km stretch of road from Skibotn to the Norwegian-Finnish border (Fig. 1c) as a test area. This stretch is part of the European route E8, which runs from Skibotn in Norway to Kilpisjärvi in Finland. There, the NPRA deliberately chose to test other technologies than the ones the FTA tested across the border, as that would allow the agencies to 'double the number of projects while halving the price and resource allocation' (Irene, former project leader, NPRA).

In preparation for Borealis, the NPRA made a needs assessment, asking local road users (from the fishing industry, customs office, road maintenance, and public transport companies) what challenges they experienced when travelling along the road. The results from the assessment informed the NPRA's subsequent call for partners for R&D projects, which in addition informed prospective partners about the types of data the NPRA would be able to provide. The call was distributed through both official channels for procurement and network organizations, such as ITS Norge, asking companies to submit project proposals. After assessing the proposals, the NPRA partnered with nine companies and institutions, funding 50% of the partners' project expenses. All but two of the chosen partners were based in Norway. Beyond the acquisition of competence that was not available internally at the time, the NPRA saw these partnerships as an opportunity to support industry: while the NPRA funded half of the partners' expenses, the NPRA 'did not place any limitations regarding what [the partners] might develop and commercialize. We leave that to the companies.' (Vaughn, NPRA engineer). By choosing predominantly Norwegian partners and leaving them free to commercialize any concept they tested, the NPRA interviewees suggested that Borealis might help foster a new Norwegian industry.

Testing infrastructures. At the start of this article, I referred to the platooning demonstration conducted within the Borealis project. The demonstration took place during the opening of the project, before an audience comprising the NPRA's project partners, the Regional Director of the NPRA's Region North office, and Norwegian media. However, when my two colleagues and I visited the Borealis test site the technology had disappeared from the project's portfolio of technologies. As the platooning demonstration was broadcast via the NPRA's website and different media channels, we were curious to understand what had happened to it. Upon enquiring, we were told that the technology was rather immature. It had malfunctioned when tested in sleet the day before the demonstration, and rather than actual platooning, the technology was 'really cruise control with something extra' (Vernon, NPRA engineer). The demonstration had something of a performative function: by 'drawing up these larger visions of self-driving and platooning', the NPRA could rally up some excitement for the project, while simultaneously giving 'politicians something large and nice to point to, as a way out of our current predicament' (Vernon, NPRA engineer). The only example of vehicle automation in Borealis had been more of a promotional stunt than a technology test.

Beyond platooning, the technologies tested at the Borealis site were out-of-the-box technologies. Some technologies were simply installed and used for their intended purposes, for example digital signs used to display weather conditions, and vehicle-to-vehicle (V2V), vehicle-to-infrastructure (V2I), and infrastructure-to-infrastructure communications. Other technologies were used differently than intended. Examples included equipping an uphill slope with parking sensors that used a magnetic field to identify the type of vehicle passing, as well as its speed. The sensors were also able to identify a vehicle coming to a stop. Similarly, LIDAR technology was mounted on poles along the road and was used to identify trucks coming to a stop on slopes, with the aim of relaying the information to vehicles and/or to the aforementioned digital signs. Fibre-optic cables were set into the asphalt to monitor traffic through distributed acoustic sensing (DAS), a technique commonly used in the oil industry. Whether used for their intended purposes or repurposed, the tested technologies were intended to make the road more predictable (travel time, road conditions) and manageable (maintenance, accidents) for users and relevant agencies.

Some of the technologies used in the Borealis project overlapped in terms of functionality. The parking sensors and poles used in the LIDAR scanning were intended to solve similar problems, allowing for A/B testing of functionality and cost. Similarly, cheap and expensive DAS cables were laid side by side to enable comparison of results. The sets of cables were also set into in different parts of the road surface (toward the edges, in the middle) to ascertain which combinations of cables and positions provided the best signal. These examples point to the experimental nature of Borealis. In addition to the aforementioned technologies, the stretch of road was provided with electricity to power the technologies and the broadband cables necessary to operate the technologies in an area in which phone coverage was not considered sufficiently reliable. Together, the infrastructural developments and the technologies that were tested point to attempts at making the road stretch in question more predictable and controllable. For example, trucks blocking a lane could be readily communicated to relevant agencies, other road users, and/or infrastructures. Additionally, the need for road maintenance (salting, snow ploughing) could more easily be assessed. Rather than implementing technology for its own sake, the tested technologies were intended to solve certain preconceived problems. Interpreted in this manner, the technologies clearly addressed two of the central aims of the 2017 NTP: road safety and facilitation of value creation. The prospect of value creation is also discernible in the public–private partnerships characterizing the organization of Borealis: whilst the NPRA facilitated the tests, any future commercialization was left to the commercial partners.

From Silicon Valley to Skibotn Valley. Both Borealis and Aurora were conducted in the northern reaches of the Nordic region, where snow and freezing temperatures are common. Fish are transported from Norwegian coastal islands and onward through Finland, entailing relatively rapid shifts from mild coastal climates to freezing inland temperatures for much of the year. By testing technologies in the region, their resilience and functionality can be ascertained, even in freezing conditions or heavy snow. In terms of self-driving, one NPRA engineer likened the stretch of road used in Borealis to the equivalent of master's level or doctoral level of difficulty, as opposed to the kindergarten level of difficulty experienced when driving in Arizona. As such, the engineer was alluding to the importance of transport innovation in the High North—whereas Norway might not be *leading* the development of self-driving vehicles, the Finnish–Norwegian collaboration still has a role to play in ensuring that new transport technologies work under all conditions, rather than merely in the flat and temperate deserts of Arizona. The perceived difficulty of the test site gave the tests credence (Gieryn, 2006). Testing under arctic conditions meant testing what engineers refer to as corner cases, meaning conditions under which multiple parameters are extreme (e.g. freezing temperatures, slippery roads, heavy snow, challenging topography; for the fishing industry, time constraints).

Whereas ensuring that technologies work under the abovementioned conditions might appear as a niche concern for the

Nordic countries, NPRA interviewees argued that such testing would benefit all of Europe. This points toward an envisioned division of labour between nations, as well as a focus on collaboration rather than competition. First, with regard to the Aurora-Borealis collaboration, the NPRA and the FTA actively chose to test different technologies in order to diversify. Rather than conducting the same trials, the promise of knowledge-transfer allowed the NPRA to wait for the FTA to 'narrow down their trials to something that looks exciting' (Vernon, NPRA engineer), and subsequently adopt the technologies that showed promise. Second, the NPRA interviewees argued that the conditions under which the tests were run represented an important contribution to standardization work within the European Union (in which Norway participates through the European Economic Area Agreement). Whereas the weather conditions in Norway and Finland were acknowledged as distinctive, there was something to be gained from testing in the two countries: after all, if a future transport system encompassing self-driving vehicles is not able to handle snow or low temperatures, 'how many days of snow will the European economy be able to handle?' (Vernon, NPRA engineer). Rather than adopting the UK view of a race to the finish line (Hopkins and Schwanen, 2018), the Aurora-Borealis project is characterized by a collaborative approach where the northern reaches of the Nordic countries act akin to a 'truth-spot' (Gieryn, 2006) with regard to the development of self-driving technology.

Barring a failed attempt at establishing a Norwegian EV industry (Ryghaug and Skjølsvold, 2019), Norway has little experience of car manufacturing. In light of this, the shift towards digital infrastructures rather than vehicle automation may be interpreted as a bet on a field where Norway might take the lead. By focusing on the conditions particular to Norway, the NPRA carved out a niche that might represent an opportunity for Norway. In the case of Borealis, the partners were also predominantly Norwegian, which points to how, in the future, the project might help foster a Norwegian industry relating to self-driving vehicles by producing reliable transportation innovations that will work everywhere, rather than merely in flat and temperate deserts.

Discussion

In my analysis I have shown how the manner in which self-driving vehicles have been institutionalized in Norwegian policy and legislation convey the benefits of such vehicles in rather general terms. The NTP cites the prospect of self-driving vehicles contributing to increased traffic safety, a more robust transport system, and a reduction in greenhouse gas emissions. These same benefits have been cited elsewhere in Western Europe (Hopkins and Schwanen, 2018; Mladenović et al., 2020), suggesting that hitherto little concern has been paid to how self-driving vehicles might help to solve transport problems or enable new forms of social life that are particular to Norway. Thus, the Norwegian institutionalization of self-driving vehicles is evidently *not* the origin of a sociotechnical imaginary. Rather, it is merely an institutionalization of visions that circulate transnationally, visions that Norwegian policy and legislation fail to connect to the country's cultural and geographical particularities.

Still, the Norwegian Government has allocated funding to trial projects with self-driving technology, including competitions (Smartere transport), funding schemes (Pilot-T) and projects carried out by governmental agencies (Borealis). This reflects the long-running development in which the government has attempted to facilitate innovation through more or less generalized funding schemes, rather than by directly supporting a particular technology (Sørensen, 2016). I contend that self-driving vehicles were institutionalized as part of a sociotechnical imaginary, although not an imaginary centred on self-driving vehicles. However, to explore this point more fully, it is first necessary to discuss Borealis in more detail.

Northern provenance. In the second part of my analysis, I suggested that the motivations underlying Borealis were three-fold. The first and most immediate application of the technologies tested in the project simply relates to the road: What technologies can be used to improve predictability and control, and what configurations of technologies manage to do so in the most efficient manner? Herein lies also the prospect of transferring the technologies to other sites for similar or different purposes.

Second, the project was motivated by the need to solve challenges particularly associated with the E8. The NPRA's websites states that the road was chosen due to its 'significant economic importance'.[7] Since 2010, the road has seen a sharp increase in freight traffic, partially due to the road being the main route for transporting fish from the coast of Norway to Finnish airports, where the cargo is distributed to European or Asian markets by plane. Fish represents Norway's second largest export goods, surpassed only by petroleum products (oil and gas). As such, the Borealis project is also directed toward the resource-based industry of fishing and fish farming, and the prospect of facilitating a more efficient and predictable route for transporting fish. This resonates with Norwegian history, in which domestic innovations have predominantly been implemented in the resource-based industries in order to strengthen their long-term competitive advantage (Fagerberg et al., 2009a).

Third, and finally, there is the prospect of Borealis contributing to the standardization of self-driving technologies with regard to the European Union, in particular V2V and V2I communications technologies. Historically, innovation in Norway has either been directed toward resource-based industries or, less successfully, toward establishing high-tech industries (Fagerberg et al., 2009a; Sørensen, 2016). However, the Borealis project exhibits a dual orientation: whereas one leg is firmly placed in the fishing industry, the prospect of standardization lifts the project from being just another domestic innovation project to possibly becoming the beginning of a new industry. Thus, being grounded in the resource-based industry might be a strength, a form of support that might help to facilitate the emergence of a new high-tech industry (cf. Sørensen, 2013).

Borealis reflects Norway's historical bent toward the resource-based industries, yet it differs from the past in the project's dual orientation. On the one hand, its innovations are directed inwards, toward the domestic fishing industry and the prospect of increasing the efficiency and predictability of this industry. On the other hand, the focus on how Norway might become a central location for trans-European standardization work suggests that the project's link to the resource-based economy might also facilitate the emergence of a new industry. As such, the Borealis project is both an extension of the traditional Norwegian mode of innovation, in which private–public collaboration is directed toward resource-based industries (Fagerberg et al., 2009a), and an example of a high-tech mode of innovation in which value-creation emerges from the development of products or patents.

Subcontracted politics. The policy and legislation discussed in the preceding section show how the Norwegian Government has pointed out the direction for technology development without establishing the purpose of the development beyond the most general of benefits (for another example, see Haugland and Skjølsvold, 2020). The same approach has characterized most of Norwegian technology and innovation policy since the 1980s:

rather than promoting particular technologies, the Norwegian state has facilitated innovation through support schemes (Sørensen, 2016). Generally, most aspects of innovation have been left to commercial actors and the selection pressures of the market, suggesting a narrow conception of innovation (Sørensen, 2013). However, Borealis exhibits some particularities that set it apart. First, the project does not rely upon support schemes. Rather, it is a private–public partnership instigated by the NPRA. Second, the NPRA interviewees considered Norway to be in an exceptional position within Europe. While 'many European nations have exchanged their engineers for procurers' (Vernon, NPRA engineer), the NPRA has retained a number of professionals within the organization. Together, these two aspects allowed the agency to take on the leading role in developing a prospective sociotechnical imaginary pertaining to self-driving. When preparing for Borealis, for example, the NPRA staked out a particular direction. NPRA professionals appraised the received proposals for feasibility and technological potential, while also considering how those technologies, if functional, might be applied to the NPRA's core operations beyond Borealis. Hence, the agency's professional judgements influenced the development of this sociotechnical imaginary.

The direction staked out by the NPRA is interesting for three reasons. First, it draws upon Norwegian expertise, including the ICT expertise pointed out in White Papers (e.g. Meld. St. 27 (2016–2017)). Second, the focus on digital infrastructures contrasts with the common narrative of autonomy. Peddled by prominent figures such as Tesla CEO Elon Musk, this narrative suggests that self-driving vehicles will have the capability to deal with the complexities of the real world in a manner superior to human drivers, and due to these capabilities there not be any need for governance or regulations (Stilgoe, 2017). By focusing on infrastructural requirements, the NPRA aligns with earlier conceptions of self-driving vehicles, in which the operation of such vehicles was expected to rely upon communication with smart infrastructures (Kröger, 2016; Wetmore, 2003). Third, and finally, both the NPRA interviewees and the interviewed partners considered the weather conditions in Northern Norway a boon to the development of reliable digital infrastructures, not only for Norway but also for the whole of Europe. Together, the three aspects show how the relatively non-descript visions from policy and legislation are being operationalized by the NPRA. This suggests that decision-making pertaining to self-driving vehicles has been subcontracted to a government agency, making it an administrative concern rather than a political one.

The mode of innovation characterizing Borealis, in which the NPRA acted as a technological arbiter, shows how the lack of policy guidelines allowed the agency to steer technology development in its desired direction. The ITS Arena conference held in Oslo in 2019 may be considered another example of this steering, as it functioned as a field-configuring event (Lampel and Meyer, 2008) for self-driving vehicles in Norway, laying out current limitations and challenges pertaining to the field. Such institutional subcontracting of politics results from a hybrid mode of innovation, which draws upon elements from technology as nation-building (although promoted by the NPRA, rather than at a national level) and the more recent mode wherein the state acts as a facilitator for innovation. The institutional subcontracting of politics leaves the preferred direction for the development of self-driving vehicles to professionals. This exemplifies how decision-making in relation to self-driving vehicles happens outside traditional democratic politics, similar to how the Norwegian legislation on self-driving vehicles is configured in a manner that allows commercial actors to influence institutional understandings of the technology (Haugland and Skjølsvold, 2020).

The above discussion suggests that the Borealis project might represent the origin (Jasanoff, 2015b) of a distinctively Norwegian sociotechnical imaginary pertaining to self-driving vehicles. Nondescript visions from policy and legislation are grafted onto Norwegian conditions, namely the country's particular geography, its resource-based economy, its responsibility toward Europe, and its prospective future, as well as a specific, professionally informed conception of what technological future is viable. If Borealis represents the origin of a sociotechnical imaginary pertaining to self-driving, this would suggest that the embedding of an imaginary might happen before its articulation. For example, Borealis was accommodated through the institutional embedding of self-driving vehicles, but the project simultaneously represents the possible origin of a sociotechnical imaginary relating to such vehicles. This suggests that the development of sociotechnical imaginaries might sometimes be a non-linear process, where, for example, the embedding both precedes and is an integral part of a new imaginary's origin.

Infrastructure and socio-economics. At the start of this article, I described how Prime Minister of Norway Erna Solberg mobilized tightly interwoven trucks and autonomous systems to contrast with the rigid and expensive infrastructure of a railway extension. She suggested that technological progress would usher in a transport system characterized by an increased flexibility for both public and freight transport. Solberg clearly mobilized the narrative of autonomy described above, despite Borealis's focus on infrastructures. Similarly, the authors of the report *Technology for sustainable freedom of movement and mobility* argue that self-driving vehicles would be so safe that they might render the near-future development of infrastructure for road safety unnecessary (Ekspertutvalget—teknologi og fremtidens transportinfrastruktur, 2019, p. 40). Whether arguing against the railway extension or safety infrastructure, Solberg and the report by Ekspertutvalget—teknologi og fremtidens transportinfrastruktur (2019) both envision a future when costly investments in inflexible infrastructures will no longer be necessary. However, the systems tested in Borealis entail comprehensive infrastructural developments in which roads are fitted with the necessary technologies and associated electrical and communications infrastructure. As such, the socio-economic benefits of self-driving vehicles in relation to the transport sector are currently highly uncertain. However, I contend that socio-economic aspects are at the core of the Borealis project, as well as the Norwegian Government's push for self-driving vehicles.

Erna Solberg promoted an autonomous system hinging on the contingencies of 20–25 years of technology development over a currently possible infrastructure development. The above discussion might provide the key to understanding this prioritization. At the start of the discussion, I stated that self-driving vehicles were institutionalized as part of a sociotechnical imaginary, though not an imaginary centred on such vehicles. Rather, Norwegian policy relating to self-driving vehicles appears to first have been an extension of the green shift imaginary into a new technological domain, a new opportunity for innovation and value creation. Only after Borealis did this extension come to represent the origin and embedding of a new sociotechnical imaginary which centres self-driving vehicles (cf. Jasanoff, 2015b). By exhibiting characteristics of both resource-based innovation and high-tech industry, Borealis represents a possible answer to what will sustain a post-oil Norwegian society, namely a more efficient and predictable resource-based sector and a prospective new industry. Prime Minister Solberg's measured response to the question of a railway extension is an extension of this belief: Rather than the railway being old-fashioned in itself, its relative undesirability arises from its lack of future orientation. Had the railway extension been developed subsequent to the 1992 official report on the Northern Norway railway line, there would have been a prospect of innovation. The report suggests that a development of the extension would have to make use of the most advanced technology currently available, and even then, the development of new technologies with more advanced capabilities might have been necessary (NSB, 1992, p. 126). However, in her statement, Solberg suggested that this prospect of innovation has now taken to the road—a road that might lead Norway to a green and prosperous future.

Conclusions

In this article, I have suggested that the Norwegian interest in self-driving vehicles should be interpreted in light of Norway's history as a resource-based economy and in particular the nation's petroleum industry, rather than as transport policy. In light of climate change, the future demand for oil is highly uncertain, meaning that the Norwegian state will need new means for sustenance. Domestically, this awareness is expressed in terms of the green shift, which describes a sustainability transition in which new, green industries are facilitated through market mechanisms, while the nation's current affluence is maintained. The Borealis project shows a dual orientation, in which it might simultaneously help establish a Norwegian high-tech industry and increase both efficiency and predictability for the fishing industry. The NPRA and its partners suggest that the weather-based challenges facing the fishing industry make Northern Norway a favourable region for establishing the reliability of new technology, suggesting that the combination of resource-based and high-tech innovation might be less clear-cut than it appears (Fagerberg et al., 2009a, p. 441). By drawing upon insights from literature on national innovation systems (e.g. Fagerberg et al., 2009b), this article shows the Norwegian interest in self-driving vehicles is both the result of and a reaction to established patterns of economic development and modes of innovation. This in turn shows how national innovation systems literature may fruitfully inform more agency-oriented and/or practice-oriented approaches to studying innovation (Pfotenhauer and Jasanoff, 2017a, 2017b).

In Norway, self-driving vehicles feature in two sociotechnical imaginaries, one established and one emergent. The institutionalization of self-driving vehicles appears to have primarily been an extension of the green shift imaginary into a new technological domain (Jasanoff, 2015b). Accordingly, the manner in which the Norwegian Government has institutionalized self-driving vehicles is rather non-descript and often phrased in economic terms. However, through Borealis the NPRA has articulated some possible links between self-driving vehicles, intelligent infrastructures and Norwegian society, such as the role of these technologies for the NPRA's core operations, the Norwegian fishing industry, European standardization, and the prospect of a Norwegian high-tech industry. As such, Borealis represents the possible origin of a new sociotechnical imaginary centred around self-driving vehicles.

The manner in which Borealis was facilitated by the extension of the green shift imaginary suggests that sociotechnical imaginaries might sometimes be nested, with established imaginaries facilitating the emergence of new ones. This in turn suggests that new imaginaries do not necessarily proceed in a linear fashion through the four phases in the life of a sociotechnical imaginary proposed by Jasanoff (2015b). Borealis was facilitated by the institutionalization of self-driving vehicles, which was initially an extension of the green shift imaginary. Should the imaginary originating from Borealis take hold, it would already be embedded in policy and legislation. This suggests that the extension of the green shift imaginary through the institutionalization of self-driving vehicles might have embedded a future self-driving vehicle imaginary before it was articulated through Borealis.

Whereas conventional wisdom suggests that links between technology development and state-making have become the exception rather than the norm, I argue that this link has merely been reconfigured. To the Norwegian Government, self-driving vehicles carry the promise of innovation and a domestic high-tech industry, and thus represents a possible path away from a petroleum-dependent economy. Further, the manner in which the government has facilitated the emergence of self-driving vehicles is grounded in a particular imaginary of innovation (Pfotenhauer and Jasanoff, 2017a) 40 years in the making (Sørensen, 2016), in which support schemes are considered the ideal mechanism for producing (or facilitating) the desirable future. By facilitating the emergence of self-driving vehicles through this mechanism, the technology is expected to contribute to the green shift, thus exemplifying how innovation is closely tied to state-making. In sum, the Norwegian Government's institutionalization of self-driving vehicles and the NPRA's subsequent operationalization of the Government's policies suggest a possible pathway toward a desirable future: through innovation relating to self-driving vehicles, Norway might retain its current levels of social welfare and GDP per capita while facilitating a comprehensive transition toward new industries and a greener society.

Data availability

The datasets generated during and/or analysed during the current study are not publicly available due to the privacy agreement between the author and the interviewees, as required by the Norwegian Centre for Research Data. Upon reasonable request, the data (anonymized and in Norwegian) are available from the corresponding author.

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Notes

1 My translation. The quote is from a video on the Norwegian Public Roads Administration's website at https://www.vegvesen.no/Europaveg/e8borealis/nyhetsarkiv/forste-test-pa-norske-veger (accessed 21 Jan 2020).

2 My translation. The full video stream (in Norwegian) has been made available for *iTromsø* subscribers at: https://www.itromso.no/pluss/eksklusiv/2019/04/30/Her-kan-du-se-iTroms%C3%B8s-folkem%C3%B8te-med-Erna-Solberg-p%C3%A5-Skarven-18925419.ece (accessed 7 Jan 2020).

3 https://www.regjeringen.no/no/tema/klima-og-miljo/klima/innsiktsartikler-klima/gront-skifte/id2076832/ (accessed 3 Sep 2020). The translation of '*naturens tålegrenser*' as 'planetary boundaries' is a matter of convention, rather than a precise translation. A literal translation of the term is 'nature's critical load', which connects the term more clearly to the principles underlying deep ecological thinking.

4 These initiatives are the ones highlighted by the Norwegian Government's website regarding the green shift: https://www.regjeringen.no/no/tema/klima-og-miljo/klima/innsiktsartikler-klima/gront-skifte/id2076832/ (accessed 3 Sep 2020).

5 https://its-norway.no/category/english/ (accessed 1 Sep 2020)

6 In 2019 the Finnish Transport Agency changed its name to the Finnish Transport Infrastructure Agency (FTIA).

7 https://www.vegvesen.no/Europaveg/e8borealis (accessed 24 Aug 2020).

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Competing interests

The author declares no competing interests.

Additional information

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