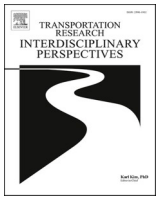
Transportation Research Interdisciplinary Perspectives 21 (2023) 100874

Contents lists available at ScienceDirect

Transportation Research Interdisciplinary Perspectives

journal homepage: www.sciencedirect.com/journal/transportation-research-interdisciplinary-perspectives



How can authorities be enablers in the deployment of CCAM? An experienced-based expert study from Norway

Randi A. Fagerholt *, Hanne Seter, Petter Arnesen

Mobility, SINTEF, Trondheim, Norway

ARTICLE INFO

Keywords:
CCAM
Interdisciplinary innovation
Transport policy
Transport system

ABSTRACT

Despite extensive literature on transport planning, research has so far been sparse in exploring the socio-political aspects of transport innovations, which is particularly scarce within the emerging Cooperative, Connected and Automated Mobility (CCAM) literature. This study sets out to assess how the public administration in the transport authorities in Norway perceive CCAM and what they see as the drivers and barriers for CCAM deployment. Our analysis is based on a unique combination of different data collection methods: interviews, survey and workshop, a mixed-method approach using a stepwise-deductive induction research design. The research design is tailored to understand individuals working with deploying CCAM policies in the public administration, an issue that is not well understood today because research is lacking. We investigate both how they perceive the deployment of CCAM, and how they suggest that the public sector should work to act as enablers of deployment of CCAM. The most prominent drivers identified in the analysis are competence, followed by cooperation, while the most prominent barriers are resources and technical maturity. Political steering and regulations are considered as being neither drivers nor barriers. Based on our results we provide three policy recommendations: first, there is a need for more clear and powerful strategies, second, there is a need to increase focus on learning-oriented approaches, and three, a need to expand cooperation and interest across the organizations.

1. Introduction

The transport sector is undergoing significant technological changes that have the potential to change mobility fundamentally in a positive way, e.g., increase traffic safety, increase efficiency in traffic flow, better utilization of space, environmental benefits, and increased mobility. Roadmaps and strategies for the future mobility system have high expectations of the positive effects offered by technology, and "making connected and automated multimodal mobility a reality" is identified as one of the flagships in the *Sustainable and smart mobility strategy* developed by the European Commission (2021c, p.12). This strategy lays the foundation for how the transport system in Europe will contribute to the fulfillment of the European Green Deal (2021a) where the aim is to cut emissions in the transport sector by 90% by 2050. Technology is important for reaching these ambitious goals and should be "integrated into the mobility and transport system, its infrastructure, operations, and new services" (European Commission, 2021b). In this picture, Cooperative, Connected and Automated Mobility (CCAM[1]) technologies and services are introduced where automated vehicles are supported by data exchange between vehicles and infrastructure. By using advanced technologies and communication between vehicles and infrastructure, CCAM aims to create a safer, more efficient, and sustainable transportation system for the future.

Research on automated vehicles continues to articulate the considerable potential for enhancing safety, improving transport efficiency, and the overall mobility, and car manufacturers increasingly implement new functionalities in vehicles, such as advanced driver assistance systems (ADAS), connectivity features, and Vehicle-to-everything (V2X). However, the vision of CCAM, where the automated vehicles are cooperative and connected to each other and the infrastructure, requires

* Corresponding author at: no, S.P.Andersens vei 3, 7031 Trondheim, Norway.
E-mail address: randi.fagerholt@sintef.no (R.A. Fagerholt).

[1] Throughout this paper, the term CCAM is used to explore the deployment of the broader concept of connected, cooperative, and automated transportation systems. It encompasses various elements beyond autonomous vehicles (AVs) alone, including intelligent transportation systems and cooperative mobility solutions. However, it is important to note that some studies referenced in this paper specifically focus on Connected Autonomous Vehicles (CAVs) or AVs. While CAVs are a subset of CCAM, this clarification is provided to ensure clarity for readers who may encounter references to CAVs or AVs within the context of CCAM.

https://doi.org/10.1016/j.trip.2023.100874
Received 3 February 2023; Received in revised form 22 June 2023; Accepted 2 July 2023
Available online 10 July 2023

large changes to the complex socio-technical system that the transport system represents. Wide-scale deployment of CCAM will require many changes in infrastructure, policies, industry, consumers, and in our culture in general (Bansal & Kockelman, 2017; Cohen et al., 2020; Milakis, 2019; Milakis & Müller, 2021). To enable the positive effects of new technology, coordinated action across sectors and stakeholders is required (Glaser et al., 2019), but this cooperation takes place in a complex landscape with many involved stakeholders (Puerari et al., 2018).

This development calls for research that combines technical perspectives and social sciences (see Cohen et al., 2020; Waltermann & Henkel, 2023), to address the challenges facing the transport sector. While the technological perspectives focus on the development of core technologies, social science seeks to understand the societal dimension and how interaction across different stakeholders could be carried out in a way that facilitates learning across professions, domains, and sectors (Ryghaug et al., 2023) which ultimately should lead to deployment of CCAM. Still, there is a lack of knowledge on the role of the public sector in the deployment of CCAM. A literature review also points to this: only 13% of the papers in the review consider specific aspects of the policy cycle[2] (Marsden & Reardon, 2017). Policies may help accelerate development and innovation, control some of the uncertainties related to CCAM, and help maximize the potential benefits, or the exact opposite: policies can also hamper innovation and generate more uncertainty (Li et al., 2019; Taeihagh & Lim, 2019). To start unravelling the complexity of these issues, a deeper understanding of how the policy system works in the face of CCAM is needed. Particularly interesting is a deeper understanding of the humans involved in decision-making. This is an area where there is a considerable lack of research and knowledge, although one exception is Fraedrich et al. (2019) who interviews urban planning authorities in Germany with regards to the deployment of automated vehicles.

The added value of this paper lies in exploring the perception of the Norwegian public administration on the deployment of CCAM. Our approach is based on a unique combination of different data collection methods, including interviews, survey and workshop, a mixed-method approach that is tailored to understanding individuals working with deploying CCAM policies in the public administration. This triangulation of data collection methods enables us to investigate how common the perceptions found in the interviews are in a larger survey sample and investigate in-depth data and acquire information about the lifeworld of the informants. Understanding the perceived drivers and barriers for deploying CCAM, seen from the public administration's point of view is interesting because the "lack of awareness, acceptance and adoption by citizens and policymakers" is suggested to be one of the main challenges for deploying CCAM (European Commission, 2021c, p.22). As awareness, acceptance and adoption by policymakers is brough forward as one of the main challenges, this paper asks: 1) What do the Norwegian public administration perceive to be the drivers and barriers for the deployment of CCAM? And 2) How do the public administration suggest that the public sector should work to act as enablers for deployment of CCAM?

We use a stepwise-deductive induction research design, as there is not much existing research on how the public administration perceives deployment of CCAM. This research design is a systematic approach where we start with in-depth qualitative data collection on what the drivers and barriers for CCAM deployment are perceived to be among the public administration. After an initial coding and analysis of the interviews we identified nine main factors and developed a survey, sent to a larger sample representing the public administration in Norway. In the end of our data collection, we hosted a workshop to consult with an expert panel. Based on this systematic approach it is possible to give recommendations to how the public administration could act as an enabler of CCAM deployment. This paper offers a contribution to the research field of CCAM by giving insights into how CCAM is perceived and met by the public administration, and we give specific recommendations based on empirical data on how this stakeholder group could function as enablers of CCAM deployment.

The remainder of the paper is structured as follows: first, a literature review over barriers, the nature of policymaking and a description of collaborative approaches for addressing complexity in transport systems is presented. Second, the Norwegian context and the methodology is described. Third, we present our main results. Last, we provide three main policy recommendations and our conclusions.

2. Literature review

2.1. Barriers and drivers

The deployment of CCAM in the transport sector faces various challenges and barriers that hinder the realization of its intended benefits, such as safety, mobility, and sustainability (Li et al., 2019; Sharma & Mishra, 2022). This is highlighted in the literature and reiterated across multiple studies (see Sharma & Mishra, 2022 for a recent review). Based on Sharma & Mishra (2022) review, the barriers identified in studies regarding the adoption of CAVs can be categorized into different clusters: 1) User Acceptance/Reaction Cluster: This cluster encompasses barriers related to the acceptance and perception of CAVs by the public. It includes factors such as user acceptance, public perception of CAV usage, and the cost associated with CAV adoption (Bezai et al., 2021; Fagnant & Kockelman, 2015). 2) Safety Cluster: Safety concerns are a significant barrier to CAV adoption. This cluster includes issues such as crash liability, lack of control safety, and cybersecurity threats that can compromise the safety and reliability of CAV systems (König & Neumayr, 2017; Raj et al., 2020). 3) Regulations Cluster: Regulatory barriers play a crucial role in CAV adoption. Disparate state legislations and standards create inconsistencies and complexities in the legal framework for CAV deployment. Insufficient standards and regulations can hinder the progress and implementation of CAV technology (Bezai et al., 2021; Fagnant & Kockelman, 2015). 4) Employment and Economic Cluster: This cluster focuses on the potential impact of CAV adoption on employment opportunities and manufacturing costs. Barriers include decreased employment opportunities and high manufacturing costs associated with CAV technology (Raj et al., 2020). 5) Privacy and Ethical Issues Cluster: This cluster highlights concerns regarding privacy infringement, ethical considerations, and cybersecurity risks associated with CAVs. Issues such as data privacy, ethical implications of autonomous decision-making, licensing standards, and cybersecurity threats are considered barriers to CAV adoption (Bagloee et al., 2016; Raj et al., 2020).

On the other hand, there is limited specific research on drivers for the deployment of CCAM or CAVs. Most studies tend to focus on barriers and challenges rather than drivers. However, some broader factors can be considered as potential drivers for CAV deployment, such as policy and government initiatives and investments in CCAM infrastructure, regulatory framework aimed at fostering innovation and creating an enabling environment for CCAM (both in Norway and in the EU), or stakeholder collaborations including government agencies, industry players, research institutions that facilitate knowledge sharing, resource pooling and coordinated decision-making.

2.2. Policymaking for deploying CCAM

Policymaking concerns making choices regarding a system, such as the transport system, to change the system outcomes in a desirable manner (Walker & Marchau, 2017). The world is changing faster and

[2] The policy cycle is a framework that organizes and guides research on public policy, encompassing stages such as agenda-setting, policy formulation, decision-making, policy implementation, and policy evaluation (see Marsden & Reardon, 2017).

becoming increasingly complex because of new knowledge and priorities, more advanced technologies, and innovative business models (Abbott, 2005; Taeihagh & Lim, 2019). More ADAS are becoming available, and many ADAS are now sold as standard equipment in new cars, which means that the driver can increasingly hand over tasks to the vehicle. The shared responsibility between the driver and the vehicle is described in the SAE International (2018) scale, which describes increased levels of automation ranging from level 0 to level 5. In level 1 and 2, the driver is still responsible, and the vehicle assists with driver assistance systems. In level 3, the vehicle can drive itself, but the driver needs to be prepared to take control at any time. This is called conditional driving automation. In level 4, the vehicle can drive itself within its operational domain, while in level 5, the vehicle can drive itself everywhere, always. This transformation is highly complex because today the roads, legislations, and regulations within the transport system are maximized in terms of being functional for the human driver.

When starting to move driving tasks from the driver to the vehicle, decision-making becomes increasingly complex as the transport sector becomes more multi-level and cross-sectoral. At the same time, there are also substantial changes to ownership and management within the transportation system. There has been a rise of shared mobility and other innovative services (e.g., Uber, car-sharing services, micro-mobility), electrification of cars, and a transition referred to as "smart mobility" (Docherty et al., 2018). At the same time, much of the "push" toward smart mobility comes from the technology sector, which has products to sell and where there is a strong interest in creating a market (Docherty et al., 2018; Milakis & Müller, 2021). Emerging innovations often depend on excitement, interest, and hype (Hopkins & Schwanen, 2021). An illustrating example is the proclamations of when the self-driving car will be available on public roads, which has followed a classic "hype cycle" pattern (Shladover, 2022).

This article focuses on the authorities and their role in the deployment of CCAM. Moreover, it explores how the public sector should proceed in deploying CCAM. There has been a notable shift away from policy is being 'done by the state' and passively 'received by the system' and instead an increasingly complex negotiation through networks of private and public actors (Dudley & Richardson, 2000; Marsden & Reardon, 2017). Marsden & Reardon (2017, p.249) argue that it is essential to know the 'who, what, and why' of influence in a policy sphere to understand the potential barriers and opportunities for policy change, as well as recognize the informal networks and sub-systems of actors that coalesce around policy issues. Understanding more of the complexity of the network of actors, and the management of the issues, would help highlight some of the elements that are poorly accounted for in transport policies today (Vigar, 2017).

Overall, policies on transport tend to lag the introduction of new technology, and the risk of allowing new technology must be seen up against the potential benefit (Mordue et al., 2020). This can be seen as a balancing act between industrial policy and regulatory policy, where the pros and the cons are weighed against each other (Wiener, 2004). Within the issue of automated vehicles, one of the key issues is that the current international laws and regulations require a human driver to be in control of the vehicle, and the individual countries have laws on exemptions from this to allow testing of highly automated vehicles (Hansson, 2020). A second issue is that public organizations can be argued to be "organized anarchies", implying that the organization is characterized by unclear preferences and unstable goals and dynamics (Metzger et al., 2021). A third issue is the decoupling of decision-makers and the implementation of the decisions. There is often a considerable underestimation of the administrative requirements of a policy (Metzger et al., 2021).

2.3. Collaborative approaches in complex transport systems

The deployment of CCAM in the transport sector encounters a significant complication: its reliance on technological advancements from other sectors (Lyons & Davidson, 2016). This necessitates collaboration with these sectors, marking a potential shift from the transport domain's historical isolation (Docherty et al., 2018). As a complex socio-economic system, the transition of the transport system involves interconnected changes in various areas, including technology, economy, institutions, behavior, culture, ecology, and belief systems (Rotmans & Kemp, 2003:9). Consequently, transport authorities must reassess their roles and responsibilities regarding other sectors to steer the transport system effectively and achieve political goals (Docherty et al., 2018).

Deploying CCAM and reaping its societal benefits require going beyond the involvement of traditional actors solely within the transport sector. It demands a collaborative, multi-actor process encompassing strategy formulation, resource mobilization across different actors, and policy implementation (Malekpour et al., 2020). With different sectors converging in the transport sector, successful CCAM deployment and the realization of its societal benefits depend on collaboration between established players in the transport sector and new actors (Wockatz & Schartau, 2015). Road authorities must adapt the infrastructure to accommodate new technology and the requirements of CCAM, relying on competence, knowledge, and collaboration with other sectors, such as communication and positioning authorities.

Engaging other sectors poses a key challenge in this collaborative endeavor (Vigar, 2017). Policymakers, in general, face an overwhelming abundance of information of varying quality. Thus, filtering relevant information and assessing its quality become crucial, particularly in the context of multi-sectoral collaborations (Jones & Baumgartner, 2005). One potential approach is the creation of forums for discussion and communication. Such collaborative forums provide an equal platform for participants to exchange arguments, promote cooperation between different sectors, and reduce transaction costs associated with knowledge and information sharing (Vigar, 2017;Jones & Baumgartner, 2005).

The collaborative approach recognizes the limitations of disciplinary boundaries in addressing the complexity of the transport system, which operates as a highly intricate socio-technological entity requiring optimization from both technical and societal sub-systems (Milakis, 2019; Vigar, 2017). Addressing these challenges necessitates collaboration across disciplines and sectors, allowing experts from diverse fields to provide new insights and foster mutual learning, where "different disciplines work together to benefit from each other's areas of expertise" (Kalinauskaite et al., 2021, p.1).

3. The Norwegian case, methods, and data

3.1. The Norwegian case

This paper addresses a global issue and shows insights from the Norwegian context. As a testing area (e.g. Eitrheim et al., (2022) and the NordicWay EU projects (NordicWay, 2022), for instance Seter & Arnesen, (2017)), Norway has a harsh winter climate and a challenging geography where most of the industry is located along the coast. Commodities must therefore be transported along the road network or by sea. Therefore, Norway represents a country with significant challenges in its existing infrastructure. This is vital for the future deployment of CCAM – vehicles will never be isolated to the major highways located around urban areas. The same vehicles will also drive on small roads located in rural areas and experience various climatic conditions.

Further, Norway is a frontrunner in readiness for self-driving cars and autonomous vehicles and was ranked third in KPMG's global Autonomous Vehicle Readiness Index (AVRI) from 2017 to 2020 (KPMG International, 2020). This is caused by a population that is particularly open to new transport technology, has a high concentration of electric-powered vehicles, and is rated second on the availability of the latest technologies (KPMG International, 2020). Furthermore, Norway has excellent broadband and 4G (and increasingly 5G) coverage, and in 2021 The Norwegian Parliament introduced a requirement for 4G

coverage along all new highways throughout Norway (Meld.St. 28, 2021). In this view, the Norwegian case could represent a frontrunner in implementing new technology in the transport system. Hence, other countries with less "societal readiness for automation" can learn from the lessons made in Norway.

One of the significant uncertainties associated with CCAM is how much additional technology development will be needed (Shladover, 2022). This relates to the vehicle manufacturers, but it also relates to the authorities because they are responsible for providing the physical infrastructure the vehicles use. Furthermore, the road infrastructure may need to be changed because the automated driver has different needs than a human driver (Storsæter et al., 2021).

In Norway, **the Norwegian Public Road Administration (NRPA)** serves as the national road authority, responsible for the physical infrastructure, and fulfills the roles of a road owner and administrative agency. Their overall responsibility is to provide an efficient and accessible road system to avoid human or environmental damage (NRPA, 2022). **Nye veier "New roads" (NV)** is a state-limited construction organization owned by the Norwegian Ministry of Transport. This company serves as a road builder, planner, operator, and maintainer of main roads in Norway. In addition, the **Counties** and **Municipalities** also own, operate, and maintain roads. When it comes to digital infrastructure, the picture becomes even more complex. The **Norwegian mapping authority (NMA)** has the national responsibility of managing geographical information in Norway, including maps, accurate positioning services, and the national reference frame. The NPRA and the NMA have had a long history of collaboration, for instance related to the National Road Databank (NVDB), a public system for handling road data. **The Norwegian Communications Authority (NKOM)** is the authority for digital communication infrastructure and is responsible for communication and frequency resources needed to provide wireless communication services such as telecom and short-range communication (ITS-G5). The NPRA and NKOM have collaborated on communication systems in tunnels, but more extensive collaboration on issues related to vehicle-to-vehicle (V2V) communication or vehicle-to-infrastructure (V2I) communication is just getting started. **The Norwegian Space Agency (NSA)** is a government agency coordinating Norwegian space activity and is an actor in the transport system because of the use of satellites in transport. Fig. 1 shows the physical and digital infrastructure surrounding CCAM in Norway. It encompasses A) the road infrastructure, including maps, which are connected to the authorities NRPA and NMA, B) communication infrastructure overseen by NKOM, and C) positioning infrastructure for which NMA holds authority responsibility.

In addition to the public actors mentioned above, a wide range of private actors is involved in providing products and services to the physical and digital infrastructure around the road. Examples from the digital infrastructure include digital communication used by vehicles such as telecom (3G/4G/5G) or short-range communication (e.g., ITS-G5). Private telecom operators are currently providing digital communication along the road. However, there needs to be more knowledge on how well the quality of this communication is good enough for different SAE levels (Khan et al., 2023). There is also much uncertainty concerning when 5G will be realized to a large extent in public networks and what this technology can provide (Aggarwal, 2021; Moqaddamerad & Tapinos, 2022).

Research design

Given the lack of preexisting research on transport authorities' collaboration toward CCAM, we take an exploratory, abductive approach and collect data through a stepwise-deductive induction flexible research design, illustrated in Fig. 2. This method was chosen because it aims to elaborate on new ideas from empirical data. The deductive approach scans existing research (theories and empirical studies) and derives hypotheses from these, and then tests these hypotheses using empirical information. The inductive approach uses empirical observations to suggest theoretical propositions (Tjora, 2018). Similar research designs can be found in other similar studies (Fraedrich et al., 2019).

As there is little preexisting knowledge on this subject, a pure deductive approach where hypotheses are developed based on theory and previous studies was not feasible. We, therefore, used a combination of data collections, which include:

- Interviews; ten focus group interviews
- Survey conducted among authorities and professionals in relevant sectors in the transport system
- In-depth discussions (workshops and round tables) with leading experts to enable deeper understanding of the survey results

First, we assessed interview data from two research projects (LambdaRoad and TEAPOT), consisting of 10 in-depth semi-structured focus group interviews of professionals and state administrators

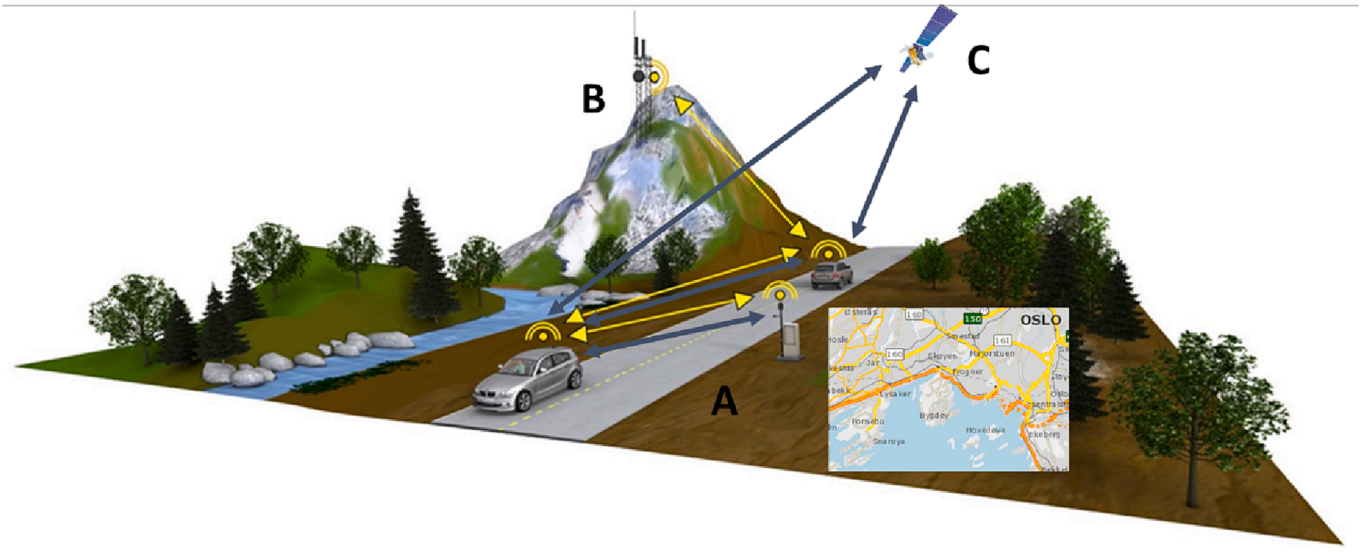


Fig. 1. Physical and digital infrastructure related to A) the road including maps (NPRA and NMA), B) communication (yellow arrows) (NKOM), and C) positioning (blue arrows) surrounding CCAM (NMA).

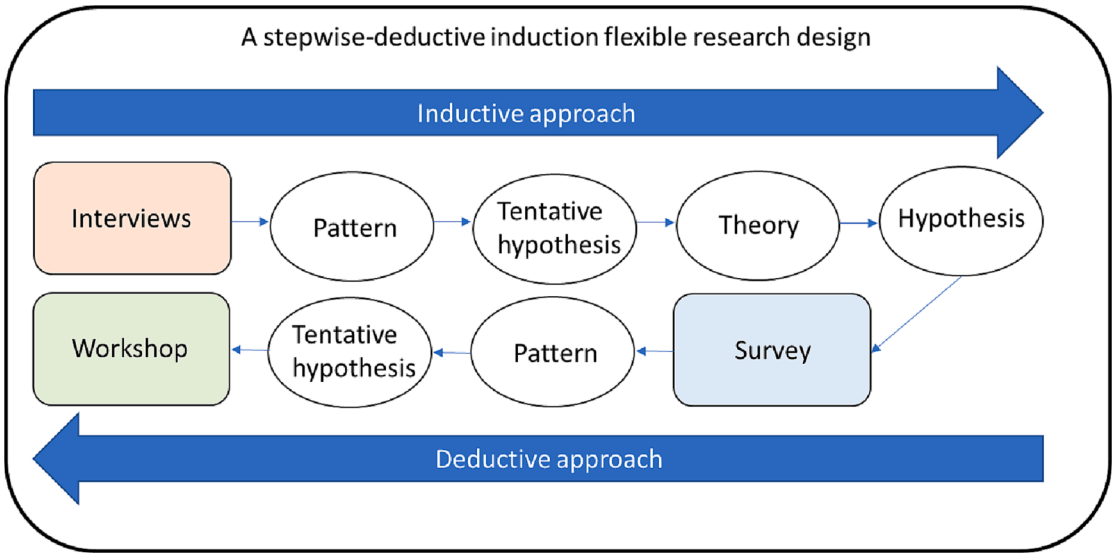


Fig. 2. A stepwise-deductive induction flexible research design.

representing stakeholders within the physical and digital infrastructure of the transport system. More specifically we interviewed several professionals in the NRPA, both within the role as a road owner, and in the administrative agency in NRPA. Several interviews were conducted with professionals in the NMA and NKOM, as well as interviews with professionals in two companies developing technology for autonomous vehicles, and a Norwegian telecom company. For each interview we defined an interview guide, with focus on roles, responsibilities, and collaboration to employ the respective technologies. In these interviews, we were interested in these individual's experiences, knowledge, and attitudes toward deployment of CCAM. Interviews were transcribed, preliminary coded and analyzed. The in-depth interviews helped provide information on how the respondents experienced roles and responsibilities in CCAM deployment. The interviews were also instrumental in gaining information on what the different stakeholders perceive the drivers and barriers to be for such a development. This issue is characterized by a lack of pre-existing knowledge (some notable exceptions, e.g., Bezai et al., 2021; Fagnant & Kockelman, 2015). This information was used to create questions and categories in the survey, hence, the interviews were critical for designing the survey.

Second, leaning on insights from the interviews, we developed an online questionnaire survey. The initial coding of the qualitative interviews enabled us to develop questions and categories. We distributed the survey to experts in various Norwegian authorities and regulatory bodies that play or will play a role in the future transport system. The questionnaire was distributed digitally using Survey Design, from September to October 2021. As the paper's subjects are highly specialized, cross-sectoral, and complex, it was essential to target respondents, and we used snowballing as a sampling method where gatekeepers identified relevant individuals. Snowball sampling is a time-efficient, cost-effective way to access people who otherwise could be difficult to reach (Tjora, 2018). When we reached a sufficient selection of respondents, we conducted the survey where all stakeholder sectors were well represented. The survey covered three main topics: (1) Knowledge and competence, (2) Drivers and barriers, and (3) Collaboration and interaction. The topic on drivers and barriers for deploying CCAM was particularly complex to translate from qualitative data to a measurable variable. We chose an approach where we used a 5-point Likert scale. We identified nine factors, and the respondents were asked to categorize these as either drivers (5) or barriers (1) for deploying CCAM. One of the key interests was that we wanted to capture not just the barriers, but also the drivers. Similar studies have focused on identifying the importance of barriers only (e.g., Raj et al., 2020). Hence, we believe our operationalization of this variable gives more detailed insight. Additional detailed insight could be gained if one divides the question into two questions, where the first asks whether the respondent perceive the factor to be a driver or a barrier, and second, asks to what extent. This would force the respondents to rank all the factors. In addition, we asked an open-ended question to gain more qualitative insights into which areas of cooperation the respondents have attended, how useful they were and how their organization can be better prepared to contribute to the deployment of CCAM. The survey represents the deductive approach of our study, where we used the information gained in the interviews to deduce questions and categories used in the survey (Tjora, 2018).

As the third step, we invited 13 experts to a workshop to discuss the survey results. The experts were all employed in the public sector and working on CCAM-related issues. The experts represented three sectors; the transport sector (represented by the road authorities at different levels), the communication authority (represented by NKOM), and the mapping and positioning authority (represented by NMA). The workshop represents a deductive approach, leaning on the results from the survey (Tjora, 2018). The workshop helped to deepen and explain the results from the survey, and was based on a collaborative process where a common understanding is generated (Neeley et al., 2019). Therefore, workshops are particularly well suited for tracing this exploration of the need for realizing the implementation of new technology in the transport system. The in-depth discussions effectively allowed the experts to understand the survey results seen from each sector's point of view and thus enabled a data collection leading to a deeper understanding of the findings made in the survey.

To sum up the methodological approach of this paper (see Fig. 2), we started with conducting interviews, which were analyzed and categorized in patterns, which we again used to pose tentative hypotheses. The tentative hypotheses were then adjusted with regards to existing theory and previous research when this was available (Bezai et al., 2021; Raj et al., 2020; Sharma & Mishra, 2022). Based on the revised hypotheses we developed the survey. We then analyzed the descriptive statistics from the survey results, looked for patterns, and suggested tentative hypotheses that we discussed at the expert workshop.

Some additional issues should be addressed in terms of using this methodological approach. These data represent a snapshot of the perceptions of this group at a specific time. We expect perceptions of CCAM to be dynamic and that perceptions evolve over time. One can expect for instance technological advancements in vehicles, new regulatory frameworks, and public perceptions to change over time, sometimes such changes can happen rather fast, such as if a new law is passed or if

there is a radical improvement of in-vehicle technology. In addition, new drivers and barriers may emerge, while existing ones may diminish or be addressed. In this perspective, it is likely that the perceptions of the public administration in Norway will evolve over time. Furthermore, we expect that the geographical context in which the data is collected will influence the perceptions of the public administration. It is likely that the results found in Norway will be different from the results in for instance Germany or the US. Similar studies should therefore be executed in other countries as well.

3.3. Data assessment

In a small country with 5.3 million inhabitants, the number of our targeted population (i.e., people working in the public administration with the deployment of CCAM) is limited. As one expert participating in the workshop emphasized: "I am practically the only one in our organization interested in this topic". Hence, this study is based on a small sample (n = 53). We have utilized this to our advantage by using collaboration platforms, CCAM professional networks, and their gatekeepers to distribute the survey, i.e., snowballing (Goodman, 1961). Our findings also emphasize this line of reasoning. This approach could limit the generalizability of the sample. However, in-depth studies that contribute to cumulative knowledge and understanding are vital to understanding the bigger picture of the subject in focus. Hence, studies should not only work towards uncovering a "generalizable truth" but consider other ways of acquiring knowledge that widens the approach (Richardson, 2018). More qualitative research is needed to expand the description of a particular phenomenon.

One significant contribution to the research field of CCAM is giving insights into how this is met by the bureaucracy in a specific place and at a specific time. Qualitative research has a clear advantage in offering insights into the complex lifeworld of those working within the bureaucracy and how these acts to shape the future of CCAM. Exploring how this stakeholder group works with developing public policies, how the bureaucracy collaborates, and how they work on executing the current political framework is difficult to capture in extensive sample correlations.

Results and discussion

The survey aims to study the experiences of the experts within the public administration in Norway working with deploying CCAM. The survey was distributed to 99 respondents fitting this definition. It is hard to know how large the actual population is, but a survey distribution of 99 respondents is likely to give reasonable representability for this population within Norway. In the end, 54% of the survey distribution did answer the survey, i.e., n = 53 responses in total, which constitutes an acceptable result in a Norwegian context when studying this population.

In Table 1, some main characteristics of the sample are shown. Overall, the sample is quite evenly distributed regarding sector, type of position, and years of experience.

First, respondents were divided into (1) "road owners" representing NPRA, municipalities, and counties, and (2) "not road owners" representing the Norwegian Communications Authority (NKOM), the Norwegian Mapping Authority (NMA), and other non-road authorities involved. As we can see, the near fifty-fifty split suggests that our sample should capture the opinions of those working more directly in the transport sector and those working more indirectly on the subject. Second, we count whether the respondents hold a position as a (1) leader or (2) have a role aimed towards executing day-to-day tasks. Those who work on the future vision of CCAM in Norway tend to hold leading positions. Hence, the distribution between leaders and professionals seems balanced in this perspective. Third, we make four groups separated by the years the respondents have had their current position, also deemed sufficiently representative.

Table 1
Main characteristics of the studied experts (n = 53).

	Categories	Frequency	%
Sector	Not road owner	22	42
	Road owner	31	58
Position	Leader	25	47
	Holds a professional position	28	53
Experience in the position	0–4 years	13	24.5
	5–9 years	14	26.5
	10–15 years	13	24.5
	More than 15 years	13	24.5

In the rest of the paper, separate results for the groups made in Table 1 will not be presented, as no significant difference in opinions between groups was found for any of the groupings and questions. These results, therefore, reflect a coherent group of experts, strengthening the results of the sample.

4.1. The perception of the public administration on deployment of CCAM

After the initial interviews were conducted and a preliminary coding of the transcribed interviews, we identified nine factors to be dominating subjects among the respondents (see Table 2). Leaning on the stepwise-deductive induction research design, the interviews and coding represents the first steps in our methodology. The respondents were asked in the survey to rank the nine factors seen in Table 2 as either drivers or barriers to deploying CCAM on a scale from significant barrier (1) to the significant driver (5), and in addition the option "Do not know". From visually inspecting the percentages, one can see that some of the factors are leaning more in the direction of being a barrier, others are leaning more towards being a driver, while others are neither. The scale offers a structured framework for participants to express their perceptions and judgments regarding the drivers and barriers being evaluated. It allows for a systematic approach to gathering data and facilitates the process of analysis and interpretation. The use of a standardized scale also enables comparisons across different factors and contexts, making it easier to identify patterns and trends.

In the assessment of whether a factor is a driver or barrier certain challenges may arise. For instance, if individuals perceive a factor to be of great importance but are unsure whether it functions as an enabler or a barrier, they may select the middle category, "neither a barrier nor a driver". However, if individuals believe a factor to be irrelevant, they may also choose the middle category. Consequently, interpreting the results can become challenging. This situation can lead to ambiguity in understanding the true nature of the factor and its impact on CCAM deployment. The inability to distinguish between factors that are neutral and those that truly do not contribute significantly can hinder the accuracy and validity of the findings. It can become difficult to discern whether the lack of categorization indicates that the factor does not play a substantial role or if it is merely a result of uncertainty or inadequate information. However, the scale provides a level of granularity by allowing respondents to select values between 1 and 5. This allows for a more nuanced assessment of the factors' impact, capturing subtle differences in their perceived importance. It helps to avoid oversimplification and provides a more detailed understanding of the complexities involved in assessing drivers and barriers.

To address the challenges concerning the use of a 5-point scale, it was crucial to encourage participants to provide clear justifications for their assessments and consider additional qualitative data and complementary data in the workshop to gain a more comprehensive understanding of the factors in question. The survey results were discussed in detail at the workshop where key experts representing each sector and discipline participated, giving in-depth reflections on what represents drivers and barriers to deploying CCAM in the transport system. The main aim was to provide more insight into how the results from the survey could be understood and interpreted. This approach helped us gain deeper

Table 2
Barriers and drivers for CCAM deployment in % (n = 53).

Factors	Significant barrier	Small barrier	Of no consequence	Small driver	Significant driver	Do not know	Total
Competence in own sector	4	13	19	44	19	0	100
Competence in other sectors	4	11	23	45	13	4	100
Cooperation between sectors	4	28	25	17	23	4	100
Political steering	9	26	32	23	8	2	100
Regulations	15	36	28	2	6	13	100
GDPR	21	32	34	4	2	8	100
Economy	26	30	25	11	8	0	100
Technological maturity	32	28	11	11	15	2	100
Time and personnel resources	25	38	26	9	2	0	100

insights into the factors that influence the deployment of CCAM and allowed us a more nuanced interpretation of the results.

To ease the interpretation of Table 2 and with inputs from the workshop discussions regarding these scores, the results can be illustrated using Fig. 3. The green color illustrates the variables being drivers, the orange color illustrates the variables being neither a driver nor a barrier, and the red color illustrates the variables being barriers. We arrived at these colors using a combination of the response in the workshop (presented in Section 4.2 to 4.4 below) and a numeric approach where we assign green for the three factors with highest score for the driver categories (small driver + significant driver), red for the three factors with highest score for the barrier categories (small barrier + significant barrier), and yellow for the three that is left.

4.2. Drivers: Competence and cooperation

Competence and cooperation have clustered as drivers at the top of Fig. 3. The experts underlined that each sector lends credence to the competence in their different professional areas. The representatives from the different sectors all emphasize that they possess CCAM competence. Supporting this, 94 percent of the sample highly prioritize updating themselves on new knowledge and competence. However, one interesting observation made in the workshop was that some experts experience that they need more competence from other sectors than previously. According to one participant, the authorities want to be "*competency-driven and knowledge-based, not just experience-based*". Thus, they rely on a multidisciplinary collaboration to integrate complementary resources and competencies. As one expert underlines: "*CCAM is not based on one subject area. One single sector is not able to handle this alone*".

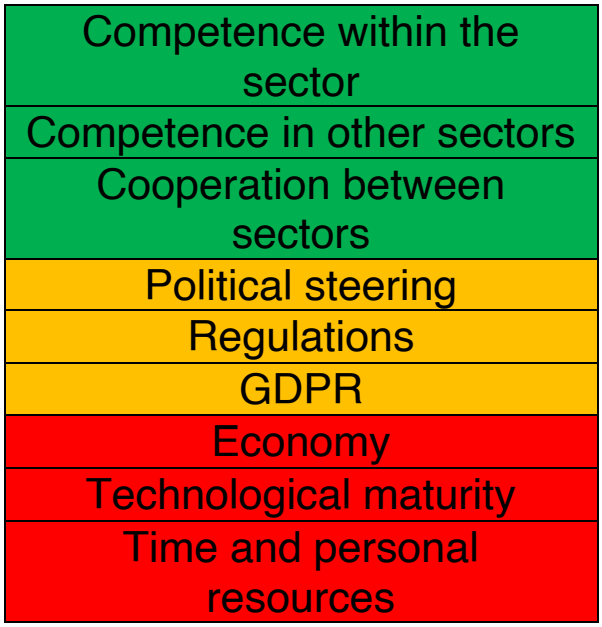


Fig. 3. An illustration of the drivers and barriers for CCAM deployment.

A strong motivation for cooperation across organizations and sectors is the need to overcome a lack of resources. Other organizations can obtain significant resources, such as economy, staff, premises, information, legitimacy, and legal authority on relevant issues. The survey revealed that 70 percent participate in collaborating forums where the focus is related to CCAM. Participating in such forums was expressed as valuable for expanding their professional network, having informal discussions, closing the knowledge gap between sectors, and asking critical questions, as shown in Table 3 (see full table in Appendix 1).

However, on the negative side, cooperation can be complicated and costly, resulting in a loss of autonomy (Lundin, 2007). Several of the participants in the workshop emphasize that they are participating in building a collaborative environment. One expert representing the communication sector emphasized the following: "*Competence in other sectors and the cooperation between sectors could just as easily have been a barrier. We must work with those who build infrastructure. Representing the public sector, we cannot oppose such collaborations*". However, there needs to be certainty about the overall objective and strategies for the agencies and sectors involved. 30 percent disagree with having a good overview of other sectors' overall objectives and strategy, as shown in Table 4.

Various coordination techniques, such as interagency committees and taskforces, are examples of ways to assess how organizations work together (Lundin, 2007). We asked both the respondents in the survey in open text answers and the experts at the workshop to summarize which areas of cooperation they attended and how useful they were. Several cooperative national and international forums were mentioned. The forums were underlined as critical: for a) expanding the professional network and having informal professional discussions, b) for closing the knowledge gap between sectors, c) for asking critical questions, and d) as a formal meeting point for top executives to put the topic on the agenda in each sector and speed up crucial decision-making.

In addition to collaborative forums, research projects and research and development collaborations were highlighted as innovative platforms for new ideas to arise. One example is that traditionally the geodetic community and NMA have been concerned with stationary measurements. However, the development of CCAM might set new requirements for positioning, as vehicles move. This challenge has been

Table 3
Assessment of cooperation forums, activities are measured from 1 to 5, to no extent – to a very large extent (n = 37).

How useful are the following associated with the cooperative forums?	Mean	Std. err.
Expanding professional network	4.54	0.106
Informal discussions	4.189	0.108
Close the knowledge gap between sectors	3.972	0.157
Ask critical questions	3.891	0.143
Formal discussions related to decisions	3.675	0.164
Challenge regulations	3.459	0.167
New project development	3.459	0.175

Table 4
CCAM competence development, statements measured from 1 to 5, strongly disagree – strongly agree (n = 53).

	Mean	Std. Dev.
It is absolutely essential for my organization to gain insight into the role of other sectors	4.18	0.83
I have good overview of the overall objective of other organizations that work with the future transport system	3	0.75
When increasing my competence within the future transport system, I am mainly interested in competence development within my own subject area	2.83	1.06
In my daily work, the future transport system is a non-priority topic	1.98	1.11

addressed in research projects and shows that a collaborative approach can accelerate the technology and knowledge based on knowledge of each other's core business. Glaser et al. (2019) found that learning is an integral part of the innovation process and may not be bound by predetermined outcomes but involve a constellation of complex, social, and organizational conditions and mechanisms that shape each other. A collaborative approach makes it possible to gain knowledge and challenge the sectors' current services and technologies.

Other findings in the survey also support the focus on collaboration. 90 percent either strongly agree or agree that it is essential for their organization to gain insight into the role of other sectors (see Appendix 1 for full table). This insight is likely to give positive outcomes in decision-making, where including other relevant sectors make it easier to coordinate complicated matters. In this way, decision-making becomes more informed and holistic, and hopefully, avoid significant expenses by having to undergo revisions due to a lack of knowledge on questions related to other sectors. The experts strongly emphasize this; closer ties between sectors make communication easier, more flexible, and more accessible when new issues arise, echoing previous research (Laurian, 2009).

4.3. Between a rock and hard place: Political steering and regulations

Political steering and regulations are neither considered drivers nor barriers at this point. This does not mean that these factors are not important, however it can suggest that attention should be directed towards other critical factors that influence CCAM deployment at this stage. One of the experts interpreted the ranking for political steering in the yellow area in Fig. 3 to imply that professionals were driving this process: "*It is positive that political steering is further down [on the ranking]. The process is run by people with expertise, not for political reasons. This way, the topic can be prioritized in terms of finances*". However, some interviewees stated that it might be unclear what comes first in political steering and the organizations taking the lead, as the organization itself can also set the agenda and the direction. A possible interpretation of this result is that political steering can be both a driver and a barrier, depending on the context.

The placement of regulation in the middle yellow part of Fig. 3 represents that this factor is neither barrier nor a driver, which the experts affirm as a reasonable position. Regulations are preventing and slowing down new rapid innovations to hinder the unleashing of market forces, where undesirable and risky situations can arise. Automated driving at higher SAE levels is regulated by the Experimental Act (Prop. 152 L, 2016) in Norway. Through the act, piloting, and testing CCAM technologies allows one to identify and solve potential problems with the technology. Regulations such as the Experimental Act serve as both restraint and facilitate pilot testing of the technology because "*the regulation does not interfere with the processes*", as one expert phrased it. However, legislation must still be considered as a point for further development and careful investigation. There is a difference between the temporary Experimental Act and future permanent legislation. Thus, considerations must be made where risks are managed. GDPR is also located in the middle of Fig. 3. However, the sum-up shows that GDPR is, to a greater degree, a barrier than a driver. The experts discussed the extensive need for data to accomplish autonomous driving. As of now, personal data is not the primary concern; hence GDPR is not a significant issue. Consequently, some experts disapprove that GDPR is a barrier: "*This is a double-edged sword; it depends on the implementation of the solutions. GDPR is not an obstacle, but its knowledge can be an obstacle. The knowledge about data aggregation must be disseminated. This is the barrier, not the GDPR itself*".

4.4. Barriers: Resources and technological maturity

The lower red part of Fig. 3 shows that economy, technological maturity, and time and personal resources are considered barriers. Economy can be interpreted as the financial costs associated with deploying CCAM (such as cost of upgrading infrastructure, investing in advanced technology and the strategic emphasis on deploying CCAM). The experts in the workshop elaborated on that physical infrastructure (e.g., road infrastructure) is the "winner" financially in the transport sector when looking at the national budget. Norway is also at the top of the list when looking at transport infrastructure investments as a percentage of GDP compared to similar countries, see Fig. 4. At the same time, digital infrastructure, which is the basis for future technological innovations, needs more funding and strategic emphasis. It is expensive to prepare the road with the physical infrastructure necessary for CCAM, such as road sensors. An expert elaborated on possible causes of this matter: "*The benefits for making these investments are not prominent or highlighted enough. Collecting information continuously along the road can bring extensive benefits, such as traffic safety, but this has not been communicated well enough*".

Technological maturity is rated a significant barrier and was interpreted differently in the workshop. Some are surprised that this is considered a barrier. At the same time, most experts point out that key technologies have yet to reach a sufficient technology readiness level to be considered a driver. One expert said: "*Much glossy paper has been sold.*

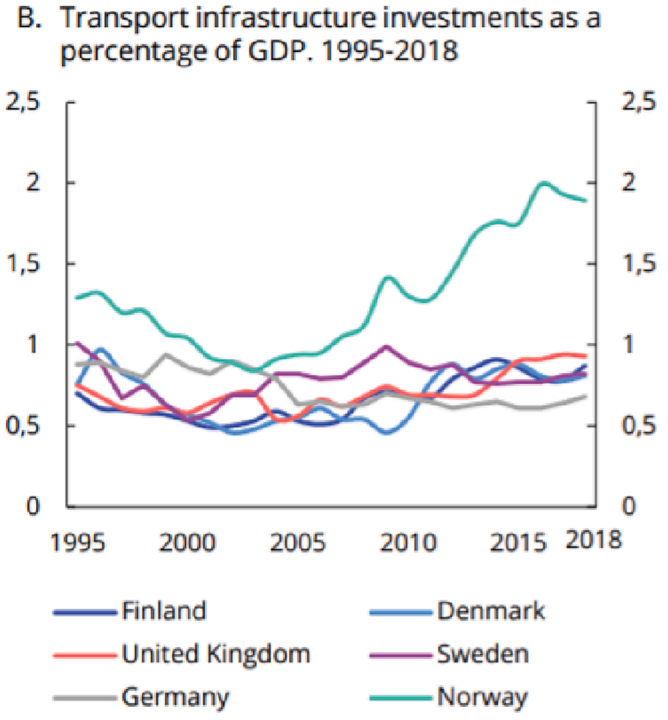


Fig. 4. Transport infrastructure as a percentage of GDP, 1995–2018. (Source: The Ministry of Finance, 2021).

CCAM is in the pilot stage. The industry must get some room to build up". Another expert points out that the level of ambition has been too high. Positioning, for instance, must have high levels of accuracy to be used as a feature of autonomous driving technology. At this point, most of the technologies needed for realizing CCAM are not necessarily mature enough: "*Naturally, technology is at the bottom. 5G is completely premature, and we do not have the technology. There is a gap between the ambitions and technology's progress*". One expert points to another possible reason for the technology being oversold: the unsettled managing of the cooperation between the actors involved in developing new technology:

"There must also be a demand among road users. One may ask whether ITS (intelligent transport system) technology is still a nerdy forum, missing leading professionals asking good questions. There is not enough dialogue between the ITS-technologists and the road expertise, e.g., at NRPA. The technology is sold as more finished than it is".

This quote could imply that the authorities should engage more with the industry to know more about the technology and its maturity. Lack of demand from potential users is also listed as one of the main "problem drivers" for CCAM in the CCAM Strategic Research and Innovation Arena (SRIA, 2021).

Time and personal resources rank as the most significant barrier, implication that this is not a prioritized field. Attention is often scarce in organizations, particularly sustained attention over time. Over a period, attaining attention to an issue means less attention to other competing issues. Hence, this could generate competition between different issues (Metzger et al., 2021).

Even though the sectors are confident that they possess relevant competence internally and externally, the survey exposed a challenge across the sectors: the sectors depend on a few individuals' knowledge and insights into the future transport system, as shown in Fig. 5. This is a key challenge: how to utilize knowledge and competence internally and between sectors when few individuals seem so essential? The workshop thoroughly discussed this, and the experts recognized this as a known issue. The experts stressed that preparing for deployment of CCAM is a long-haul practice, which may take time to prioritize.

The development depends on explicit ambitions from the top management in each organization to gain continuity and build competence, establishing this topic as a vital area of focus. However, this seems contractionary to some findings to other questions asked in the survey: 4 out of 5 leaders "strongly disagree" or "disagree" that the future transport system is a non-priority topic in their daily work. One interpretation could be that CCAM is somewhat on the agenda or manifested in the different sectors at the management level. However, time or personnel resources are only sometimes prioritized for this topic and depend on a few key experts. The experts at the workshop underpin this reasoning. One expert related this barrier to the fact that the sectors (for instance, in the mapping authority or the county) core business is not necessarily related to CCAM: "*Time and personal resources, in general, are an issue. The transport system is not necessarily the core business in these sectors, so it can be difficult to get the topic on the agenda*". In this view, CCAM competes with many other topics, making it problematic to shift the focus away from the day-to-day business that needs to be addressed.

This contradiction is likely related to how well the topic is founded in the organizations. Transport in general and CCAM especially are only two of many issues that are prioritized in the organizations, both within the road authorities and the other sectors (Meld. St. 20, 2020–2021). It can also be related to the fact that the transport system and CCAM is multidisciplinary fields of expertise, and none of the sectors are the ones driving the process forward. The experts also point out that the discussions of the future transport system lack the question of which sector should take the lead.

4.5. Supplementary barrier

Another barrier the survey did not mention but that was voiced in the workshop is the shift from physical infrastructure to digital infrastructure and funding this shift. There is a strong need for digitalization and better data flow in the road sector. The Norwegian government platform document from 2021 strongly emphasizes digitalization by encouraging policy to give incentives to explore and use new technology, especially in autonomous systems and IoT (Hurdalsplattformen 2021–2025, 2021). In this document digitalization is highlighted as crucial to ensure a sustainable and efficient transport sector. The platform suggests reviewing Norwegian legislation to identify and remove obstacles to innovation and digitalization. For the future evolution of the transport system, the experts highlighted that it is important to plan and act holistically in planning transport development, where digital infrastructure is equalized with other infrastructures such as roads and railways. One expert elaborated:

"In Norway, when we talk about spending money on the road, we

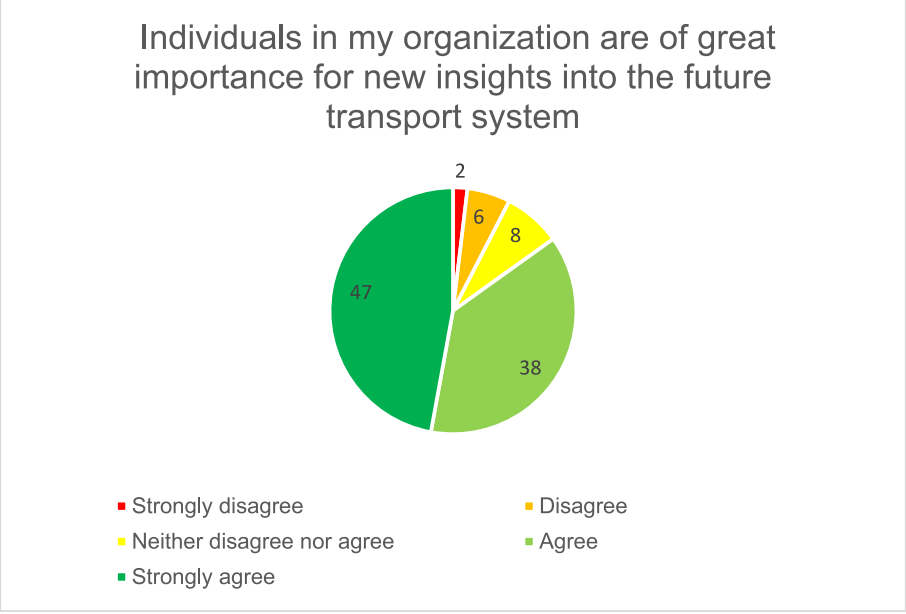


Fig. 5. Individuals' importance for new insights (n = 52).

immediately think of the number of meters of asphalt. We must talk about digitalization and data as part of the road. If the transport authorities cut a few kilometers of asphalt, they would have financed innovation with ITS. We must think more in terms of data-driven economics. Continuous updating of the data must take place and be financed".

One illustration of this digital shift discussed in the workshop is updating the Norwegian National Road Data Bank (NVDB). The databank was initially established in the 1970 s to serve state administration users land measurement data. Today, the NVDB has challenges adapting to new demands for updating and maintaining data. This becomes especially problematic if the database is expected to be used for underlying data for CCAM, where future users need more extensive and real-time data. A significant challenge for the future is deciding whether the NVDB should be adjusted for future needs or whether a new system should be developed that is tailor-made for the needs of the future. This is only one of many issues that require cross-sectoral action to fulfill the deployment of CCAM.

5. Policy recommendations – how can the public sector be enablers of CCAM deployment?

This study has aimed at increasing understanding of 1) What do the Norwegian public administration perceive to be the drivers and barriers for the deployment of CCAM? And 2) How do the public administration suggest that the public sector should work to act as enablers for deployment of CCAM? Our analysis is based on a stepwise-deductive induction research design, where we find that competence and cooperation are considered as being the strongest drivers for employment of CCAM among the public administration in Norway. Political steering and regulations are considered as being neither drivers nor barriers. The strongest barriers are economy, technological maturity, and time and personal resources. Based on this systematic approach, our recommendation is that the public administration should use the enabling factors, competence, and cooperation, as action points. When acting upon these enabling factors, the public administration could in themselves be an enabler of CCAM deployment.

The results show that the public administration is working to reconcile their competence and knowledge across sectors. A specific example is meeting arenas for collaboration. These are a characteristic part of the collaborative culture established on this domain in Norway and they are used to ensure progress and inclusion in the processes initiated to prepare for deploying CCAM. Scharpf's (1997) introduces the concept of weak trust as expecting that the communicated preferences of other actors are honest and not purposefully misleading. Hence, actors will stick to their commitments if the circumstances have not altered dramatically. The experts in the workshop underlined that they have "*confidence that the sectors sensibly manage their expertise*", demonstrating trust between the sectors. In general, the Norwegian public administration is considered highly efficient (OECD, 2022), and one of the reasons is the high levels of trust (Laurian, 2009). High levels of trust and close-knit relationships make progress more efficient because fewer resources and less time are spent on specific tasks. Trust can also enhance the capacity of organizations to respond to crises (Laurian, 2009). The transparency and high levels of trust shown between the sectors have, in this case, raised the levels of understanding of each sector's expertise and interests and lowered the levels of conflict.

The US DOT, (2018) highlights some similar experiences in the Tampa connected vehicle pilot where vendors, vehicle integrators, and infrastructure integrators worked in a close collaboration, which resulted in a close-knit relationship where problems could be openly discussed without a confrontational attitude, resulting in that issues were solved more efficiently. However, as Lundin (2007) underscores: "[T]rust can make cooperation easier, but it is not something that boosts cooperation if there are no other reasons". The experts also stressed that this trust must not be taken for granted: "*Sometimes things can happen, and you want to take ownership of results yourself, so we have to take care of the trust that has been built up between these organizations*". This is supported by Lundin (2007, p. 652), who emphasizes that similar priorities have no importance if the sectors do not trust each other, and "if the authorities' objectives diverge to a large extent, trust does not increase cooperation". This underscores the importance of formalizing a common strategy for the transport system and why one sector must take the lead.

Based on the main results discussed above, we have summarized our policy recommendations into three main points: First, clear and powerful strategies, second, increase focus on collaborative-oriented approaches in the organizations, and third, expand cooperation and interest across the organizations. These three recommendations aim at solidifying the enabling factors for CCAM deployment (competence and collaboration), and reducing the effect of the barriers (economy, technological maturity, and time and personal resources). As added value, we have also coded qualitative data from an open-text question in the survey, asking how the respondents' organization can be better prepared to contribute to the deployment of CCAM.

The first recommendation is 1) *clear and powerful strategies,* which implies that if deployment of CCAM is a political goal (as seen in several political documents such as European Commission, 2021c) it should be rooted in strategies in each individual sector. Alternatively, there should be a national strategy where the different sectors and stakeholders are contributors. Clear CCAM strategies can help gain more attention towards cross-sectoral collaboration. This could reduce the impact of the barrier on time and personal resources. Furthermore, collaborating across sectors on strategies may accelerate the deployment of CCAM even further. The experts at the workshop stated that the management level often interacts with other sectors, while the interaction among the professionals across sectors is more random. Management level interactions are often founded in formal obligations. In addition, only a limited number of individuals exclusively focus on CCAM within their respective sectors; rather, CCAM is integrated within broader disciplinary domains. Consequently, individuals play a crucial role in harnessing the sector-specific expertise pertaining to CCAM, as the number of dedicated professionals working exclusively on this topic is limited. Their knowledge and insights contribute significantly to the overall understanding and advancement of CCAM within their sectors. The multidisciplinary nature of CCAM necessitates collaboration and knowledge sharing across sectors, where individuals' expertise becomes invaluable in bridging the gap and fostering a comprehensive understanding of CCAM-related challenges and opportunities. Hence, if cross-sectoral collaboration on CCAM is rooted in formal strategies it will be easier for professionals to establish more interaction with other sectors working on related issues and achieving meaningful progress in the field of CCAM. One specific idea suggested in the workshop was that trainees, the future leaders, would have profited from conducting internships across different sectors, for example in NPRA, NMA and NKOM. Such an intersectoral trainee exchange would provide perspective and valuable insights for future leaders in developing the transport system to get to know each sector's concerns, mode of work, interest, and domain.

The second main recommendation is to 2) *increase focus on collaborative-oriented approaches in the organizations*. Learning-oriented approaches would allow the organizations to benefit even more from the drivers competence and cooperation. The survey results indicate that the focus on collaborative-oriented approaches in the organizations is key, aligning with the notion that competence in other sectors and collaboration between sectors is widely recognized as a significant driver for CCAM deployment. The high level of confirmation received during the workshops further reinforces this notion. This is also supported by Glaser et al., (2019, p.8), who underscore the need for more explicitly orient policy learning and transfer methodologies towards social, group and collective learning processes and emergent dynamics. Another clear finding in our analysis is the importance of collaboration arenas. The respondents stated that participating in various collaboration arenas and forums is important for gaining knowledge on future

assignments, tasks, and challenges. Both informal and formal collaboration arenas could be important as arenas for learning. Hence, going from an approach based on status quo where the past is used to predict the future, to a more learning-oriented approach (Vigar, 2017), could help stimulate the deployment of CCAM.

The third recommendation is to 3) *expand cooperation and interest* across the organizations. The findings from both our qualitative and quantitative data strongly support the notion that there is a critical need for expanding collaboration, which clearly would accelerate the drivers on competence and cooperation even further. The transport sector is witnessing a convergence of various sectors, necessitating collaboration between both established players within the transport industry and emerging actors, thereby transcending conventional sector boundaries. This is particularly important as there are currently substantial changes to the ownership and management of part of the transportation system. The respondents in the analysis call for a triple helix model of innovation to deploy CCAM, with public–private partnerships and R&D collaborations between research institutions, the government, and the automotive industry. By adopting this model, the collective expertise and resources of these stakeholders can be harnessed to effectively address the challenges and complexities associated with CCAM deployment. The convergence of sectors in the transport industry necessitates a paradigm shift in thinking and operating beyond traditional sector boundaries. Establishing collaborations and partnerships among diverse actors enables the integration of cross-sectoral knowledge, perspectives, and resources. Such collaborations facilitate the exploration of innovative solutions, the exchange of best practices, and the realization of synergies that can drive the successful deployment of CCAM.

The three recommendations emphasize that CCAM should be deployed in a close, formalized, interdisciplinary collaboration. However, cooperation is a tool that must be administered sensibly. There has already been a shift from coexistence, where the authorities exist and affect each other indirectly, without direct interaction, towards cooperation in an interdisciplinary approach where they interact and combine complementary knowledge or resources to achieve a common goal (Lundin, 2007). The complexity and requirements set to the transport system presuppose close cooperation between the authorities in the road sector and other sectors, such as the communication sector or the mapping authorities. These various sectors all hold competence that can be associated with CCAM and innovation competence. However, this is also risky because of the high emphasis on a few individuals' competencies. As mentioned, policymaking is increasingly becoming a complex negotiation through networks of actors (Dudley & Richardson, 2000), and in smaller countries, individuals may become more crucial for CCAM processes than before.

The policy recommendations made here will not alone assure that positive societal impacts from CCAM deployment. Here lies a dilemma for the public administration and policymakers. There is a strong incentive in terms of the possible gains of CCAM, but even when following our three recommendations, there will still be many uncertainties that are not controllable from an authority perspective, such as technological maturity or lack of demand from potential users (see European Commission, 2021b for elaboration on these two problem drivers). While the findings from our data point to cooperation and competence as essential ingredients in deploying CCAM, there is still need for one authority to take a leading role. We therefore suggest that there should be a collective process, but led by one organization, where a common understanding is created around the complex issue of deploying CCAM. Appointing one organization to take the lead will help the process run more efficiently, increase cooperation, and help utilize each sector's expertise. In Norway it would be reasonable to appoint NPRA to take the lead because of their position as both national road authority, road owner, and an administrative agency. This may differ between the countries. There are also reasons to consider whether political measures and policies are needed to formalize the cooperation between the sectors. Examples could be national strategies for automated transport or white papers that are cross sectoral.

6. Conclusion

This study contributes with insights into how the public administration in Norway perceive CCAM and what they see as the drivers and barriers for CCAM deployment. The strongest barriers we find based on our analysis are economy, technological maturity, and time and personal resources, while the strongest drivers we find are collaboration and competence. The suggested policy recommendations of this study emphasize clear and powerful strategies, increased focus on collaborative-oriented approaches in the organizations and expanding cooperation and interest across the organizations. However, addressing the uncertainties and complexities of CCAM deployment requires continued efforts, strategic coordination, and the involvement of multiple stakeholders.

We would like to acknowledge that the drivers and barriers associated with the deployment of CCAM are dynamic and subject to change over time. It is essential to recognize the evolving nature of these factors and their influence on the adoption and implementation of CCAM technologies. We also recognize that the drivers and barriers identified in this study may not capture the entire complexity of the CCAM landscape, as the field is constantly evolving. Furthermore, we acknowledge that the context in which these drivers and barriers operate can vary across different countries and continents. Future research of the CCAM ecosystem will be necessary as the complexity and dynamic nature of CCAM necessitate a deeper exploration of the various factors influencing their successful deployment both in the Norwegian context and beyond.

CRediT authorship contribution statement

Randi A. Fagerholt: Conceptualization, Methodology, Writing – original draft, Writing – review & editing. **Hanne Seter:** Conceptualization, Methodology, Writing – original draft, Writing – review & editing, Project administration, Funding acquisition. **Petter Arnesen:** Conceptualization, Methodology, Writing – original draft, Writing – review & editing, Funding acquisition.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

Data will be made available on request.

Acknowledgements

The authors wish to thankfully acknowledge the funding for this research from The Research Council of Norway, grant number 295811. We also thank all informants participating in interviews, the experts participating in our workshop, our project partners for aiding with the distribution of the survey, and all respondents for providing their answers to the survey. We are grateful for helpful comments and feedback from colleagues involved in the Lambda project (https://www.sintef.no/prosjekter/2019/lambda-road/).

Appendix 1

Table I. Full table of assessment of cooperation forums in % (n = 37

.

	To no extent	To little extent	Neither	To a large extent	To a very large extent	Mean	Std.err
Expanding professional network	0	3	0	38	59	4.54	0.106
Close the knowledge gap between sectors	0	11	14	43	32	4.189	0.108
Informal discussions	0	3	5	62	30	3.972	0.157
Ask critical questions	0	8	19	49	24	3.891	0.143
Challenge regulations	0	19	35	27	19	3.675	0.164
New project development	2.7	11	46	22	16	3.459	0.167
Formal discussions related to decisions	0	16	19	49	14	3.459	0.175

Table II. Full table of CCAM competence development in % (n = 53

.

	Strongly disagree	Disagree	Neither agree nor disagree	Agree	Strongly agree	Do not know	Mean	Std. Dev.
In my daily work, the future transport system is a non-priority topic	44	33	10	12	2	0	1,98	1,11
When increasing my competence within the future transport system, I am mainly interested in competence development within my own subject area	4	42	34	11	8	2	2,83	1,06
It is absolutely essential for my organization to gain insight into the role of other sectors	2	4	4	55	36	0	4,18	0,83
I have good overview of the overall objective of other organizations that work with the future transport system	0	28	43	28	0	0	3	0,75

References

Abbott, J., 2005. Understanding and managing the unknown the nature of uncertainty in planning. J. Plan. Educ. Res. 24 (3), 237–251. https://doi.org/10.1177/0739456X04267710.

Aggarwal, G., 2021. *How Is 5G Relevant In The Present Day? - The Architect Coach*. https://thearchitectcoach.com/how-is-5g-relevant-in-the-present-day/.

Bagloee, S.A., Tavana, M., Asadi, M., Oliver, T., 2016. Autonomous vehicles: challenges, opportunities, and future implications for transportation policies. J. Modern Transport. 24 (4), 284–303. https://doi.org/10.1007/s40534-016-0117-3.

Bansal, P., Kockelman, K.M., 2017. Forecasting Americans' long-term adoption of connected and autonomous vehicle technologies. Transp. Res. A Policy Pract. 95, 49–63. https://doi.org/10.1016/J.TRA.2016.10.013.

Bezai, N.E., Medjdoub, B., Al-Habaibeh, A., Chalal, M.L., Fadli, F., 2021. Future cities and autonomous vehicles: analysis of the barriers to full adoption. Energy Built Environ. 2 (1), 65–81. https://doi.org/10.1016/j.enbenv.2020.05.002.

Cohen, T., Stilgoe, J., Stares, S., Akyelken, N., Cavoli, C., Day, J., Dickinson, J., Fors, V., Hopkins, D., Lyons, G., Marres, N., Newman, J., Reardon, L., Sipe, N., Tennant, C., Wadud, Z., Wigley, E., 2020. A constructive role for social science in the development of automated vehicles. Transport. Res. Interdiscipl. Perspectives 6, 100133. https://doi.org/10.1016/j.trip.2020.100133.

Docherty, I., Marsden, G., Anable, J., 2018. The governance of smart mobility. Transp. Res. A Policy Pract. 115 (October 2017), 114–125. https://doi.org/10.1016/j.tra.2017.09.012.

Dudley, G., Richardson, J., 2000. Why Does Policy Change? Routledge.

Eitrheim, M.H.R., Log, M.M., Tørset, T., Levin, T., Pitera, K., 2022. Opportunities and barriers for truck platooning on Norwegian rural freight routes. Transp. Res. Rec. 2676 (6), 810–824. https://doi.org/10.1177/03611981221076438.

European Commission. (2021a). *A European Green Deal*. https://commission.europa.eu/strategy-and-policy/priorities-2019-2024/european-green-deal_en.

European Commission. (2021b). *Strategic Research and Innovation Agenda*. https://op.europa.eu/en/publication-detail/-/publication/f9b12d1d-74ea-11ec-9136-01aa75ed71a1.

European Commission. (2021c). *Sustainable and Smart Mobility Strategy*. https://transport.ec.europa.eu/system/files/2021-04/2021-mobility-strategy-and-action-plan.pdf.

Fagnant, D.J., Kockelman, K., 2015. Preparing a nation for autonomous vehicles: opportunities, barriers and policy recommendations. Transp. Res. A Policy Pract. 77, 167–181. https://doi.org/10.1016/J.TRA.2015.04.003.

Fraedrich, E., Heinrichs, D., Bahamonde-Birke, F.J., Cyganski, R., 2019. Autonomous driving, the built environment and policy implications. Transp. Res. A Policy Pract. 122 (March 2018), 162–172. https://doi.org/10.1016/j.tra.2018.02.018.

Glaser, M., te Brömmelstroet, M., Bertolini, L., 2019. Learning to build strategic capacity for transportation policy change: An interdisciplinary exploration. Transport. Res. Interdisciplinary Perspect. 1, 100006.

Goodman, L.A., 1961. Snowball sampling. *32*(1), 148–170. https://doi.org/10.1214/AOMS/1177705148.

Hansson, L., 2020. Regulatory governance in emerging technologies: the case of autonomous vehicles in Sweden and Norway. Res. Transp. Econ. 83, 100967 https://doi.org/10.1016/j.retrec.2020.100967.

Hopkins, D., Schwanen, T., 2021. Talking about automated vehicles: What do levels of automation do? Technol. Soc. 64 (February) https://doi.org/10.1016/j.techsoc.2020.101488.

Hurdalsplattformen 2021–2025. (2021). *Hurdalsplattformen*. https://www.regjeringen.no/contentassets/cb0adb6c6fee428caa81bd5b339501b0/no/pdfs/hurdalsplattformen.pdf.

Jones, B.D., Baumgartner, F.R., 2005. The Politics of Attention: How Government Prioritizes Problems. University of Chicago Press.

Kalinauskaite, I., Brankaert, R., Lu, Y., Bekker, T., Brombacher, A., Vos, S., 2021. Facing societal challenges in living labs: towards a conceptual framework to facilitate transdisciplinary collaborations. Sustainability (Switzerland) 13 (2), 1–14. https://doi.org/10.3390/su13020614.

Khan, M.A., Sayed, H.E., Malik, S., Zia, T., Khan, J., Alkaabi, N., Ignatious, H., 2023. Level-5 autonomous driving - are we there yet? a review of research literature. ACM Comput. Surv. 55 (2), 1–38.

König, M., Neumayr, L., 2017. Users' resistance towards radical innovations: the case of the self-driving car. Transport. Res. F: Traffic Psychol. Behav. 44, 42–52. https://doi.org/10.1016/j.trf.2016.10.013.

KPMG International. (2020). *2020 Autonomous vehicles readiness index: assessing the preparedness of 30 countries and jurisdiction on the race for autonomous vehicles*.

Laurian, L., 2009. Trust in planning: theoretical and practical considerations for participatory and deliberative planning. Plan. Theory Pract. 10 (3), 369–391. https://doi.org/10.1080/14649350903229810.

Li, S., Sui, P.C., Xiao, J., Chahine, R., 2019. Policy formulation for highly automated vehicles: emerging importance, research frontiers and insights. Transp. Res. A Policy Pract. 124, 573–586. https://doi.org/10.1016/J.TRA.2018.05.010.

Lundin, M., 2007. Explaining cooperation: how resource interdependence, goal congruence, and trust affect joint actions in policy implementation. J. Public Adm. Res. Theory 17 (4), 651–672. https://doi.org/10.1093/jopart/mul025.

Lyons, G., Davidson, C., 2016. Guidance for transport planning and policymaking in the face of an uncertain future. Transp. Res. A Policy Pract. 88, 104–116. https://doi.org/10.1016/j.tra.2016.03.012.

Malekpour, S., Walker, W.E., de Haan, F.J., Frantzeskaki, N., Marchau, V.A.W.J., 2020. Bridging Decision Making under Deep Uncertainty (DMDU) and Transition Management (TM) to improve strategic planning for sustainable development. Environ. Sci. Policy 107 (February), 158–167. https://doi.org/10.1016/j.envsci.2020.03.002.

Marsden, G., Reardon, L., 2017. Questions of governance: rethinking the study of transportation policy. Transp. Res. A Policy Pract. 101, 238–251. https://doi.org/10.1016/j.tra.2017.05.008.

Meld.St. 28 (2020-2021). (2021). *Vår felles digitale grunnmur*. Samferdselsdepartementet. https://www.regjeringen.no/no/dokumenter/meld.-st.-20-20202021/id2839503/.

Metzger, J., Carlsson Kanyama, A., Wikman-Svahn, P., Mossberg Sonnek, K., Carstens, C., Wester, M., Wedebrand, C., 2021. The flexibility gamble: challenges for mainstreaming flexible approaches to climate change adaptation. J. Environ. Plann. Policy Manage. 23 (4), 543–558. https://doi.org/10.1080/1523908X.2021.1893160.

Milakis, D., 2019. Long-term implications of automated vehicles: an introduction. Transp. Rev. 39 (1), 1–8. https://doi.org/10.1080/01441647.2019.1545286.

Milakis, D., Müller, S., 2021. The societal dimension of the automated vehicles transition: towards a research agenda. Cities 113, 103144.

Moqaddamerad, S., Tapinos, E., 2022. Managing business model innovation uncertainties in 5G technology: a future-oriented sensemaking perspective. R&D Manag. https://doi.org/10.1111/RADM.12559.

Mordue, G., Yeung, A., Wu, F., 2020. The looming challenges of regulating high level autonomous vehicles. Transp. Res. A Policy Pract. 132, 174–187. https://doi.org/10.1016/J.TRA.2019.11.007.

Neeley, K.A., Wylie, C.D., Seabrook, B., 2019. In search of integration: Mapping conceptual efforts to apply STS to engineering education. ASEE Annual Conference and Exposition, Conference Proceedings.

NordicWay, 2022. *NordicWay EU project Portfolio.* https://www.nordicway.net/.

NRPA, 2022. *Vårt samfunnsoppdrag.* NRPA. https://www.vegvesen.no/om-oss/om-organisasjonen/om-statens-vegvesen/samfunnsoppdrag-ansvar-oppgaver/vart-samfunnsoppdrag/.

OECD, 2022. Drivers of Trust in Public Institutions in Norway. OECD. https://doi.org/10.1787/81b01318-en.

Prop. 152 L (2016 –2017) Lov om utprøving av selvkjørende kjøretøy. (2017).

Puerari, E., de Koning, J.I.J.C., von Wirth, T., Karré, P.M., Mulder, I.J., Loorbach, D.A., 2018. Co-creation dynamics in Urban Living Labs. Sustainability (Switzerland) 10 (6). https://doi.org/10.3390/su10061893.

Raj, A., Kumar, J.A., Bansal, P., 2020. A multicriteria decision making approach to study barriers to the adoption of autonomous vehicles. Transp. Res. A Policy Pract. 133, 122–137.

Richardson, A.J., 2018. The discovery of cumulative knowledge: Strategies for designing and communicating qualitative research. Account. Audit. Account. J. 31 (2), 563–585. https://doi.org/10.1108/AAAJ-08-2014-1808.

Rotmans, J., & Kemp, R. R. (2003). Managing Societal Transitions: Dilemmas and Uncertainties: The Dutch energy case study. *OECD Workshop on the Benefits of Climate Policy: Improving Information for Policy Makers*, 31. http://www.oecd.org/env/cc/2483769.pdf.

Ryghaug, M., Subotički, I., Smeds, E., von Wirth, T., Scherrer, A., Foulds, C., Robison, R., Bertolini, L., Beyazit İnce, E., Brand, R., Cohen-Blankshtain, G., Dijk, M., Pedersen, M.F., Gössling, S., Guzik, R., Kivimaa, P., Klöckner, C., Nikolova, H.L., Lis, A., Marquet, O., Milakis, D., Mladenović, M., Mom, G., Mullen, C., Ortar, N., Paola, P., Oliveira, C.S., Schwanen, T., Tuvikene, T., Wentland, A., 2023. A Social Sciences and Humanities research agenda for transport and mobility in Europe: key themes and 100 research questions. Transp. Rev. 43 (4), 755–779.

SAE International. (2018). *Taxonomy and Definitions for Terms Related to Driving Automation Systems for On-Road Motor Vehicles - SAE International*. https://www.sae.org/standards/content/j3016_202104/.

Scharpf, F.W., 1997. Games Real Actors Play: Actor-Centered Instituionalism in Policy Reseach. Westview Press.

Seter, H., Arnesen, P., 2017. *Evaluation outcome report - Norway. Project note. NordicWay EU project.* https://www.nordicway.net/previousprojects.

Sharma, I., Mishra, S., 2022. Quantifying the consumer's dependence on different information sources on acceptance of autonomous vehicles. Transp. Res. A Policy Pract. 160 (April), 179–203. https://doi.org/10.1016/j.tra.2022.04.009.

Shladover, S.E., 2022. Opportunities, challenges, and uncertainties in urban road transport automation. Sustainability (Switzerland) 14 (3). https://doi.org/10.3390/su14031853.

SRIA. (2021). *Strateggic Reseach and Innovation Agenda 2021-2027*. CCAM. https://www.ccam.eu/wp-content/uploads/2022/05/CCAM_SRIA-report_web.pdf.

St., Meld.. National transport plan 2022–2033. https://www.regjeringen.no/no/dokumenter/meld.-st.-20-20202021/id2839503/.

Storsæter, A.D., Pitera, K., McCormack, E.D., 2021. The automated driver as a new road user. Transp. Rev. 41 (5), 533–555. https://doi.org/10.1080/01441647.2020.1861124.

Taeihagh, A., Lim, H.S.M., 2019. Governing autonomous vehicles: emerging responses for safety, liability, privacy, cybersecurity, and industry risks. Transp. Rev. 39 (1), 103–128. https://doi.org/10.1080/01441647.2018.1494640.

The US DOT. (2018). Lessons Learned from Tampa (THEA) Connected Vehicle Pilot Onboard Unit (OBU) Quality, Maturity and Deployment Readiness. https://www.its.dot.gov/pilots/thea_obu.htm.

Tjora, A. (2018). *Qualitative Research as Stepwise-Deductive Induction* (1st ed.). Routledge. https://doi.org/10.4324/9780203730072.

Vigar, G., 2017. The four knowledges of transport planning: enacting a more communicative, trans-disciplinary policy and decision-making. Transp. Policy 58 (April), 39–45. https://doi.org/10.1016/j.tranpol.2017.04.013.

Walker, W.E., Marchau, V.A.W.J., 2017. Dynamic adaptive policymaking for the sustainable city: the case of automated taxis. Int. J. Transp. Sci. Technol. 6 (1), 1–12. https://doi.org/10.1016/j.ijtst.2017.03.004.

Waltermann, J., Henkel, S., 2023. Public discourse on automated vehicles in online discussion forums: a social constructionist perspective. Transport. Res. Interdiscipl. Perspectives 17, 100743. https://doi.org/10.1016/J.TRIP.2022.100743.

Wiener, J.B., 2004. The regulation of technology, and the technology of regulation. Technol. Soc. 26 (2–3), 483–500. https://doi.org/10.1016/j.techsoc.2004.01.033.

Wockatz, P., Schartau, P., 2015. *Traveller Needs and UK Capability Study – Transport Systems Catapult. October*, 35. https://ts.catapult.org.uk/current-projects/traveller-needs-uk-capability-study/.