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Summary

There is an increasing automation in road transport, involving introduction of fully automated vehicles (AV) in some areas. Organizations that introduce automated vehicles need support on how to develop a sustainable safety culture with zero accidents. There is a need to investigate the gap between the implementation of automated vehicles and human behavior at all organizational levels, and to link to the zero vision with practical applications to enhance the safety culture in transport businesses.

The aim was to explore existing practice and knowledge of safety culture in traffic related to automation, trying to identify and analyze blank spots and risks. Additionally, to identify how companies using automated vehicles can succeed in achieving a good safety culture. At first a literature review was performed, secondly five interviews were made in Sweden and in Norway to explore experiences from innovation projects with fully autonomous vehicles. Thirdly a workshop was conducted with researchers from different areas and developers of AVs. The purpose was to get an interdisciplinary discussion on safety culture and technology development. The aim was to explore potential risks and the meaning of safety culture when autonomous vehicles are introduced. Finally, a proposal for a research project based on the findings were submitted and accepted.

Results from the literature review concluded that a key area that should be examined in future research is the influence of organizational safety culture in implementation of AV in companies, e.g. terminals, ports etc. or professional drivers. The interviews revealed six themes. These themes should be lifted forward when investigating safety culture in industries that plan to introduce new or higher levels of automation. The interviews also explored existing practice and a low knowledge level of safety culture in traffic related to automation. In the workshop two topics were discussed: (i) Safety culture in the organization with Autonomous Vehicles and (ii) Safety culture in product development. It resulted in six themes that should be studied further; 1) Safety vs. Productivity 2) Culture and norms 3) Responsibility 4) Adjustability 5) From user to organizational centered design 6) Built-in safety culture in the design of product.

The conclusion is that there is a lack of studies on safety culture in development of AVs. Automation is technology driven, and the transport sector needs to prepare by organizing safety from a system's perspective, such as safety culture. The themes from the workshop could form the basis to propose methods and instruments to measure and support safety culture in automation. The integration of sustainability and gender equality is also undeveloped and in order to achieve the 2030 agenda, the results could form a starting point to the processes and tools to facilitate change. Additional studies are needed to identify and to produce guidelines for companies using automated vehicles as well as to establish a good safety culture.

The next step is to carry out the new FFI pre-study which forms the basis for a full application where tools for developing safety culture in automation, will be developed, studying best practice, KPIs and routines, using different case studies in the industry. The pre-study contributes with basic knowledge of survey tools for measuring and developing safety culture, sustainability and gender equality, as well as a model for understanding and developing the safety culture. Accomplishing a mutual learning between industries and researchers.



Safety culture for automation in transport companies

1. Background

Traffic safety is one of the goals of the 2030 agenda, and sustainability includes a safe work environment for professional drivers. Automation is technology driven, and the transport sector needs to prepare by organizing safety at all levels of the company. Therefore, organizations that introduce automated vehicles need support on how to develop and maintain a sustainable safety culture with zero accidents. Safety culture is part of the corporate organizational culture (Cox and Cox, 1991). The Swedish Transport Agency (2014) defines safety culture as an organizations common way of thinking and acting in relation to risk and safety, that is how an organization prioritizes and actually works with risks and safety linked to their business.

Automation is often claimed to provide increased traffic safety. In production related matters automation is also argued to increase efficiency and productivity. The expected advent of automated vehicles and processes can also produce employees' fears of being replaced, which in turn could lead to unsafe behaviors. Therefore, it is important to investigate what factors will support or counteract safety within companies. Other matters associated with automation are questions about responsibility, trust, and communication.

A key challenge brought forth by automation is the changed roles of the individual operators: from being an active, operator manually operating the vehicle to a more passive surveyor who is expected to respond to alarms and to take over control when needed ("control room mode"). This makes the safety challenges related to fatigue and distraction relevant, as well as interactive complexity and tight couplings (cf. Perrow 1984). The interaction between automated vehicles and other operators and workers at a terminal is also an important challenge. What are the roles, what and who should be informed and how should the organization learn how to be safety proactive with automation?

Previous research from high-risk sectors indicates a strong relationship between safety culture and safety outcomes (Clarke, 2006a & b). This have also been found in the transport sector (Wallace et al, 2006), but is yet to be examined in the automotive sectors, concerning automated vehicles. Organizations that introduce automated vehicles need support on how to develop a sustainable safety culture with zero accidents. There is a need to investigate the gap between the implementation of automated vehicles and human behavior at all organizational levels, and to link to the zero vision with practical applications to enhance the safety culture in transport businesses.



2. Project set up

2.3 Purpose

The purpose of the pre-study was to investigate safety culture as a factor for achieving safe and efficient introduction and implementation of autonomous vehicles in operation. Safety needs to be acknowledged and exercised at all levels in a company, and by developing a safety culture that can handle humans and automation as (cooperating) agents in a common system. Since automated vehicles is a new and innovative area, new risks need to be identified and analyzed, otherwise the risks can be transferred to others in traffic and environments that are poorly suited for human work can be created. A safety culture which includes the interaction between automations and humans must be developed to prevent incidents and accidents and still maintain the benefits of automation, in e.g. transports.

2.4 Objectives

The aim was to explore existing practice and knowledge of safety culture in traffic related to automation, in order to identify and analyze blank spots, and to produce recommendations for companies using automated vehicles to succeed in achieving a good safety culture.

- 1) What are the specific safety challenges in companies using automated vehicles?
- 2) (How) are these safety challenges different from those in other transport companies?
- 3) How can safety culture contribute to solving the safety challenges in companies with automated vehicles?
- 4) What is the new role of safety culture in companies with automated vehicles?

2.5 Project period

The project started 2020-03-01, just as the Covid-19 epidemic started and the situation was confused. Volvo GTT locked down, closing all contact with our partner and the partner at TØI was in quarantine and became parent with parental leave during some months. Therefore, VTI started single-handed in good hope for the best. No physical meetings in the project group has been possible and telephone interviews and workshop had been made online on the internet. The project closes 2021-03-31.

2.6 Partners

Partners in the project were Christina Stave, Ph.D. VTI, project leader for the project. Volvo Group Trucks Technology (GTT) represented by Mikael Söderman, Ph.D. Dept. Human Behavior & Perception (from June 2020 appointed senior researcher at RISE) Partner was also The Institute of Transport Economics, Transportøkonomisk institutt (TØI) in Norway represented by Tor-Olav Naevestad, Ph.D. Researcher at the Department of Security, Safety and Behaviour, Safety, Culture and Organisation,

3. Method and activities

The activities and methods used in this study was carried out in five steps:



1. A literature review of research focusing safety culture and automation
2. Documentation of interviews with project leaders/companies that strive to implement automated vehicles in their operations.
3. A workshop with experts in the fields of functional safety, human factors, user centered design, automation, safety culture, vision zero and social psychology to discuss and document different aspects of safety culture in companies and the safety challenges that automated vehicles could bring. The workshop was recorded, documented and analyzed.
4. An application for a research project based on the findings and research questions from pre-study presented in this report were submitted.
5. Finally, the results from this pre-study are gathered in this report together with conclusions and next steps.

4. Results and Deliverables

4.1 Results from the literature review

As previous research indicates that safety culture is crucial for road safety, the main aim of the present study is to examine the relationship between safety culture and AVs, and to discuss the role of safety culture in ensuring a safe transition to an increasingly autonomous road sector. This main aim gives rise to five sub goals:

- 1) What is the current implementation of autonomous vehicles?
- 2) Is there a direct focus on safety culture in current AV research?
- 3) Is there an indirect focus on safety culture in current AV research?
- 4) What is the role of safety culture for road transport safety?
- 5) What is the potential role of safety culture for AV safety?

Fulfilling the main aim and the subgoal, the present study applies an exploratory literature review, focusing on both policy documents and empirical studies. Reviewing the identified studies, the sample of the screened publications in the literature review based was on whether they focus on safety culture directly or indirectly. The latter means that the studies do not mention explicitly mention safety culture, but that they focus on phenomena that match our definition of safety culture, as shared and safety relevant ways of thinking and acting (c.f. Nævestad 2010).

The review indicates that AV technology to some extent already is implemented on roads, but on the test or pilot level. This applies to passenger cars, buses and trucks. It is argued that real-world driving experience is an essential ingredient for improving safety, but it also exposes people to the very safety risks we hope to reduce. Our review also indicates that AV technology already is introduced in several enclosed areas, like e.g. freight terminals. AGT (automated guided vehicles) systems for heavy transports or in-plant shuttle traffic are common.

The results from the literature searches indicate that we have generally not been able to identify any empirical studies focusing directly on the relationship between safety culture and AV. Reviewing the current research on AVs, we have however found documents with an indirect focus on safety culture. This indirect focus is divided into three topics:

1. New cultural conceptions of responsibility,
2. Cyber security culture, and



3. Risk acceptance and trust in technology are culturally defined.

Given the non-existing direct focus on safety culture in empirical studies of AV, we have reviewed studies examining the role of safety culture for road transport safety in order to examine the potential role of safety culture for AV safety. This is to indicate crucial areas for future research. The existing research indicates that private and professional road users often tend to share road safety culture (RSC), based on different levels of group membership, e.g. at the national level, regional level, community level, peer-group or even family level (Luria et al 2014; Nævestad et al 2019). RSC at these different levels have been found to influence road safety behaviors and accident involvement of private drivers (Nævestad et al 2019). Additionally, professional drivers are members of transport organizations, in which organizational safety culture (OSC) has been found to be an important predictor of road safety behaviour and accident involvement (Nævestad et al 2019). RSC and OSC indicate two crucial influences of safety culture on road safety.

Based on existing research on the identified role of safety culture for road transport safety, there are two key areas that should be examined in future research on the role of safety culture for AV: 1) The influence of road safety culture (RSC) in interaction between humans and AVs on roads and 2) The influence of organisational safety culture (OSC) in implementation of AV in companies. The latter influence may apply to employees in companies using AV technology, e.g. terminals, ports etc. or professional drivers. Our review indicate that AV technology already is implemented in these settings.

4.2 Results from the interviews

This section presents the results from interviews with people about their experiences from development of automated vehicles and from developing new rules and legislations. In total five interviews were made in Sweden and Norway to explore experiences from innovation projects with autonomous vehicles. Three persons in Sweden were interviewed who are either technology developers or at companies involved in the projects. The vehicles covered were Vera (an autonomous electric vehicle developed by Volvo trucks), The Pod (an autonomous truck developed by Einride) and Elin (an autonomous bus from Navya and EasyMile). Additionally, one former employee in the Norwegian National Public Roads Administration (NPRA), was interviewed, who had been involved in developing the new legislation for self-driving vehicles in Norway. Also, a senior analyst in one of the largest Norwegian unions organizing bus drivers, was interviewed. The purpose was to get information about the unions' experiences and views on the introduction of automated buses in Oslo.

The interviews were made by phone, using a semi-structured interview guide that was adapted to the nature of each project. The interviews took about 30 minutes, which was recorded, and compiled with bearing on the questions.

The content from the interviews is summarized in six topics:

1. *Development and learning phases*

- Automated vehicle is (still) a new area to authorities as well as to developers and to potential customers and users.



- There is currently a learning phase in which technical matters, safety issues, security questions, business models, legal and responsibility matters etc. are processed.
- The development processes are often characterized by “Trial & error” approaches, design-test- evaluate -redesign etc.
- There are mostly small-scale projects with limited scope.
- There are no best-practice processes, methods or technologies established.

2. *Businesses and Services*

- There are different motivating forces for automation, such as:
 - Environmental (provided that automated vehicles are electrical)
 - Efficiency
 - Safety
 - Flexibility (faster and easier to adjust to changes, e.g. transportation needs, routes etc.).
- Automated vehicles are regarded as “service providers” rather than as purchasing products, which means new business models for the (traditional) manufacturing industry.
- Automated vehicles are interlinked with information and communication from infrastructure.

3. *Automation and employment*

- There seems to be different “visions”:
 - Automated vehicles will take current jobs and cause unemployment.
 - Automation will create and require new kind of jobs. It is a matter of adjusting to new circumstances.
 - There will always be a need of human drivers because automated vehicles will not be as “automated” as often described.

4. *Safety: Human vs. Automation*

- There seems to be a conception that “automation”, when completely implemented, is safer than human drivers. At the same time, currently there several measures required which involves humans to safeguard the automated systems.

5. *Remote control and monitoring*

- The role of the remote operators is not clear and how s/he should manage one or several driverless vehicles in terms of monitoring, intervening, taking control etc. There are two assumptions regarding remote operators;
 - i. They are needed to manage automated vehicles and to maintain Safety and Uptime
 - ii. A remote operator can run several vehicles compared to a driver who can drive one vehicle.

6. *Security*



- The interviewees were aware of security problem (thefts, robbery, unauthorized control of automated vehicles etc.), but they seemed to have little insight in security matters. They rely (or know) that it is taken care of elsewhere.

4.3 Results from the workshop

A workshop with researchers from different areas and developers of AVs was carried out on-line. The purpose was to get an interdisciplinary discussion on the subjects Safety culture and technology development. The aim was to explore potential risks and the meaning of safety culture when autonomous vehicles are introduced in workplaces. The participants were:

- Åsa Ek (LTH/LU)
- Johan Ohlstrom (VTI)
- Stefan Andersson (Volvo)
- Emeli Adell (Trivector)
- Ann-Sofi Karlsson (Volvo GTT)
- Anna Vadeby (VTI)
- Tor-Olav Nævestad (TØI)
- Mikael Söderman (RISE)
- Christina Stave (VTI)

An overarching question was how companies can build a safety culture in their daily work in order to deal with the new forms of work, situations and risks that the introduction of automated vehicles can entail.

As an introduction Safety culture was explained and the question *What influences a good safety culture* was discussed. The participants mentioned that a good safety culture is characterized by:

- Everyone understands the benefits of Safety culture, what to do and its consequences
- Respect for each other's roles
- Clear responsibility from individuals and from organisation. To feel ownership of risks and measures
- Prioritize safety culture and make the benefits visible
- An ongoing work - a process with good risk awareness
- A good dialogue between departments and groups
- Positive to report incidents, do not blame each other
- Open climate, dare to remind each other of risky behaviour
- Routines to talk about what "almost" happened (as in aviation)
- Embed Safety culture in products "limitations" (e.g. maximum speed)
- To understand the coherence - organisation and technology

After the introduction two topics were discussed: (i) *Safety culture in the organization with Autonomous Vehicles* and (ii) *Safety culture in product development*.

The outcomes from the discussions are summarized in six themes (Figure 1):

1. SAFETY vs. PRODUCTIVITY



- a. Automated vehicles require large safety margins, which could require more time to complete some tasks. and could this be compensated by longer production cycles (24-7)?
 - b. Automated vehicles entail new systems with new actors and new business models.
 - c. Automated vehicles could make it easier to predict business results.
 - d. A trade-off between productivity and safety could lead to risks
 - e. Acceptance of risks may increase when replacing humans with robots
2. CULTURE AND NORMS
- a. Norms and behaviors are interrelated
 - b. People's behavior and actions in organizations are often based on by what they are measured and rewarded.
 - c. Safety culture is based on social structures, how do this relate to AVs?
3. RESPONSIBILITY
- a. The matter of responsibility is complex. Could be difficult to define who has the responsibility with automated vehicles.
 - b. The developer and the provider of automated vehicles may have to take a greater responsibility than the customer.
4. ADJUSTABILITY
- a. Different levels of automation (cf. SAE levels of automation¹) require different ways to handle safety.
 - b. The more cooperation and co- actions between humans and automated vehicles, the higher demands on safety and good safety culture
 - c. Public vs. confined areas have different prerequisites for automated vehicles in terms of safety, margins, roles and responsibilities.
5. FROM USER TO ORGANISATIONAL CENTERED DESIGN
- a. The developer of automated vehicles may get new roles for safety, which require that they have good knowledge about the customer's safety culture, as well as about their own safety culture.
 - b. Organizational centered design (cf. user centered design), i.e. the developer of automated vehicles need to understand and have knowledge about the organizational context in which the automated vehicles are to operate (organization, roles, work tasks, business)
 - c. To make systematic analyses about how automated vehicles will change the tasks, roles, processes and behavior at a workplace.
 - i. Could the safety requirements on the automated vehicle conflict with the customer's current routines, processes, and business goals?
6. SAFETY CULTURE INTEGRATED TO THE PRODUCT DEVELOPMENT
- a. To integrate "good" safety culture in the early phases of the product development
 - i. Could the product and the technical system be designed to maintain good safety culture?
 - b. The implicit and explicit safety culture at the developers may have influence on performance, limitations and behavior of the automated vehicles they deliver

¹ <https://www.sae.org/news/2019/01/sae-updates-j3016-automated-driving-graphic>



- c. Risk analysis methods (FMEA, SOTIF etc.) are mostly about the vehicle. It is also important to make risk analyses of the changed routines, roles and tasks with automated vehicles



Figure 1, *The six themes that came out from the discussions in the workshop.*

4.4 Results of application to a study

An important component in the SAFER pre-studies is to produce an application for a full study. Due to the Covid pandemic and problem to reach industry and potential partners an application for a pre-study to the Vinnova call FFI program: Traffic safety and Connected and efficient transport was submitted 20-12-08. The title and abstract: *Safety culture and automated vehicles – a pre-study*. The application was approved and started on 2021-03-15. The aim is to inventory and analyze a survey design to integrate measurement of safety culture, sustainability and gender equality, as well as to analyze and prepare a model for working with safety culture in automation. The model aims to support a process for integrating safety culture in both the design of autonomous vehicles and at implementation in the customer's safety culture. An exchange of knowledge about safety at system and organizational level in the development of automated vehicles.



The FFI pre-study consists of analyzes and workshops and begins with a literature study and seminar on safety culture in traffic. Developing proposals for a survey instrument to integrate safety culture, sustainability and gender equality in the development of automation is analyzed in a workshop. Another workshop will analyze different models for working with safety culture in companies that develops, and design autonomous vehicles and one workshop focus on automated delivery vehicles.

The FFI pre-study forms the basis for a full application where tools for developing safety culture in automation, will be developed. Studying best practice, KPIs and routines, using different case studies in the industry. The pre-study contributes with basic knowledge of survey tools for measuring and developing safety culture, sustainability and gender equality, as well as a model for understanding and developing the safety culture. Resulting in mutual learning between industries and researchers.

5. Conclusions and Next Steps

The literature review (4.1) revealed that the influence of organizational safety culture in implementation of AV in companies, need to be further investigated. For example, a case study with a terminal where the public road meets the confined area. At the terminal, there are autonomous trucks and robots and people collaborating. Vehicles from different companies with different degrees of automation have to communicate. There is also a mix of different organizations, different rules and responsibilities. Several different cultures meet and should work safely together. The question is; How can all the actors involved work proactively to create a good safety culture?

The interviews (see 4.2) revealed six themes: 1. Development and learning phases 2. Businesses and Services 3. Automation and employment 4. Safety: Human vs. Automation 5. Remote control and monitoring and 6. Security. These themes should be lifted forward when investigating safety culture in industries that plan to introduce new or higher automation. The interviews also explored existing practice and knowledge of safety culture in traffic related to automation. However, additional studies are needed to identify and analyze blank spots, to produce guidelines for companies using automated vehicles as well as to establish a good safety culture.

In the workshop (4.3) the discussions about the first topic "Safety culture in the organization with Autonomous Vehicles" highlighted the relationship between safety measures and production demands. High demands on productivity may influence the safety at a workplace in a negative way. Under such circumstances AV could seem beneficial as AV are assumed to combine high productivity with high safety. However, the discussion also stressed that safety is not only a technical matter, but also dependent on the organizational culture in a company in terms of attitudes, values and safety routines, as well as how safety communicated from the management and which key performance indicators (KPI) the employees are measured by.

The discussion in the workshop highlighted the prevailing culture and norms at workplaces as key factors for the safety. These factors could also have influence on how the implementation of new technology is managed, such as AV. Therefore, as discussed in the second topic, Safety



culture in the organization with Autonomous Vehicles, the developers of AV may have to take a greater part of the implementation of AV in order to secure that new risks and accidents with AV are prevented. This could mean that the safety culture would be an integrated part of the development process of AV – and even through the AV' complete life cycle. In that sense, good safety culture could be transferred from the AV developer to their customers. Moreover, the AV developer's responsibility could be enlarged not only to include product safety, but also to include the customers' processes, routines and operations with the AV, i.e. the AV developer is going from a user centered design approach to an organizational centered design approach. The workshop resulted in six themes (figure 1) that should be studied further; 1) Safety vs. Productivity and 2) Culture and norms 3) Responsibility 4) Adjustability 5) From user centered to organizational centered design 6) Built-in safety culture in the design of product.

In this pre-study we did not fully managed to achieve all the goals. However, the results provide some indications to the questions that were formulated in the objectives for this pre-study. The question; *What are the specific safety challenges in companies using AVs?* was discussed in the workshop in terms of the new risks with implementing AVs in organizations with poor safety culture. The second question; *How are these safety challenges different from those in other transport companies?* suggested that implementing AVs in an established business also entails major changes in terms of safety measures and how to organize the work. The two other questions in the objectives; *How can safety culture contribute to solving the safety challenges in companies with AVs?*; and *What is the new role of safety culture in companies with AVs?* were partly discussed in the workshop which revealed that safety culture could play a major role in the development of AVs as well as in the implementation of AVs.

Other issues that are interesting to develop:

- Who owns the issue of safety culture How to cooperate?
- When in the design process, and how, should safety culture be integrated?
- Can the AV vehicle provide data to customer safety culture work?
- Which KPIs have a major impact on the safety culture?
- How does automation affect gender equality? Can gender equality be built in?
- Can we link safety culture to environmental culture, Agenda 2030 and automation?

The next step includes to carry out the just started FFI pre-study. The results from this SAFER pre-study will form the basis to inventory models to work with safety culture and fully automated vehicles and to develop tools to measure and to merge sustainability and gender equality with safety culture. Thereafter the goal is a full study.

6. Dissemination and Publications

The project was presented at a SAFER seminar in September 2020 and when finalized will hopefully be presented again through SAFER, VTI and TØI.

The results were used to a FFI pre-study application 201208 in order to prepare for a full-study application. A conference paper on the literature review will be presented at the Conference on Traffic and Transport Psychology, ICTTP 7 in 2022.



7. Acknowledgement

We would like to thank SAFER for the support and finance of this pre-study that made it possible to explore a new multi-disciplinary area of importance. Without the grants no collaboration on the subject between partner had been made, and no discussions revealing new areas for new application for research had been made. It has been vital for the introduction of safety culture into the development of automated vehicles. We hope that this step will lead to new angles of approach to reach the zero vision in traffic safety and to assist the industry in meeting costumers need at an organizational level. We also like to thank our interviewees and participants in the workshop for their time and great interest.

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