A leap towards SAE L4 automated driving features

Use-Case Norway

D5.4 Demonstration of CCAM systems and services of goods transport on motorways and border crossings

A leap towards SAE L4 automated driving features

D5.4 UC Norway

28th February 2026

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Terms and abbreviations

Term / Abbreviation	Description
3C	Coordinated CCAM
ACC	Adaptive Cruise Control
ADAS	Advanced Driver Assistance Systems
ANPR	Automatic Number Plate Recognition
CAM	Cooperative Awareness Message
CCA	Cocreation arena
CCAM	Connected, Cooperative and Automated Mobility
C-ITS	Cooperative Intelligent Transport Systems
CPM	Cooperative Perception Message
CPOS	Norwegian network RTK-service
DATEX II	The reference data standard in Europe for road traffic and travel information
DENM	Decentralized Environmental Notification Message
Digitoll	Norwegian digital system where goods transported into Norway can be digitally declared on beforehand
GIS	Geographic Information System

GLOSA	Green Light Optimal Speed Advisory
GNSS	Global Navigation Satellite System
HD-map	High-definition map
ITS G5	A short-range wireless communication technology tailored for vehicle-to-vehicle communication
L2 / L4	SAE level 2 / SAE Level 4[1]
LTE	Long-Term Evolution
MCM	Manoeuvre coordination message
NPRA	Norwegian Public Roads Administration
OD	Operation Domain
ODD	Operational Design Domain
OEM	Original Equipment Manufacturer
PDI	Physical and Digital Infrastructure
PKI	Public Key Infrastructure
PLMN	Public Land Mobile Network
RFID	Radio Frequency Identification
RO	Remote operator: A fallback or human-in-the-loop risk mitigation function that ensures continuous oversight and allows for the possibility of human intervention under certain conditions to ensure safe operations
R&D	Research and Development
RSU	Roadside-Unit
RTK	Real-Time Kinematic
RWW	Road Works Warning
SAE	Society of Automotive Engineers
SPaT/MAP	Signal Phase and Timing/intersection geometry message
Sub-UC	Sub-use case
SWEPOS	Swedish network RKT-service
TEN-T	Trans-European Transport Network
TMA	Truck-Mounted Attenuator
UC	Use case
V2X	Vehicle-to-everything
VMS	Variable Message Sign
VRU	Vulnerable road users
WP	Work package

Several terms are used to refer to the CCAM solutions/vehicles in the project (e.g. L4 CCAM vehicles, L4 CCAM automated vehicles, CCAM vehicles, CCAM AVs). To ensure coherence in the deliverable, the term "CCAM vehicles" (which in this project refers to either L4 or L2 automated electric vehicles) is used throughout the document. L2 and L4 is specified where needed throughout the text.

[1] https://www.sae.org/blog/sae-j3016-update

Introduction

Across Europe, the logistics sector is entering a pivotal phase as technological advances, regulatory developments, and operational needs increasingly align. Although automated freight systems are evolving quickly, the transition from controlled pilots to large-scale, real-life deployment remains challenging. The MODI project addresses this gap by demonstrating how highly automated freight vehicles can operate effectively in real world conditions. Centred on the Rotterdam–Oslo logistics corridor, MODI brings together industry partners, authorities, and infrastructure providers to test and advance automated freight transport solutions.

Within this corridor, MODI explores five distinct use cases spanning both confined terminal areas and public roads. Together, they illustrate the full spectrum of operational challenges: from access control and charging to border crossings, interactions with other traffic, driving on highways and urban environments, loading and unloading operations, and transitions between confined and public environments.

Four regional use cases are located in the Netherlands, Germany, Sweden, and Norway, while the fifth covers the full corridor from Rotterdam to Oslo:

- The Netherlands: Port operations
- Germany: Motorway to harbour
- Sweden: Hub-to-hub
- Norway: Border to port
- UC CCAM test corridor

This report focuses on Use Case Norway (UC NO).

Purpose of this document

The purpose of this document is to describe the performed demonstration activities of the use-case, provide an identification of the different sub-use-cases, the challenges and solutions demonstrated and the partners' involvement and roles.

The document will describe each sub-use-case separately and provide a description of the vehicles, equipment and physical and digital infrastructure used.

This document will also describe any limitations and constraints that need to be taken into consideration when performing the demonstration activities.

The document will also list how the demonstration activities have been documented in the form of pictures, videos, media coverage, etc. and links

Contribution of UC Norway in the overall MODI project context

UC Norway (UC NO) contributes MODI's cross border and "border-to-port" storyline by (i) demonstrating automated driving with seamless connectivity and GNSS reference at the national border, (ii) integrating Digitoll for digital customs and "green/red route" handling for automated vehicles, (iii) exercising V2X services (e.g., RWW and cooperative manoeuvring) on public roads, and (iv) validating processes for trial permits in two countries, including safety case evidence and conditions for operating with a remote operator. The UC also provides inputs to MODI's guidance on PDI, legal frameworks and operational best practices for scalable CCAM freight.

High-level description of the Use-case overall

Identified Sub-Use-Cases

Use case Norway follows a specific storyline starting with an Einride vehicle driving automated from Sweden crossing the border and through customs utilizing Digitoll for automatic green light clearance. Crossing the border the vehicle needs seamless connectivity in order to keep communication with the remote operator. This vehicle continues e.g. to the Moss area and the inland harbour or the ASKO central storage, where cargo is shifted onto a Volvo vehicle to continue to drive down to the Port of Moss for connection onto the ASKO sea drone. On its way it needs to tackle a range of traffic situation by utilizing V2X and perception technologies. The storyline is investigated in full and the following sub use-cases have been identified for demonstration activities:

- Public Road, Customs and Border crossing driving at Ørje border crossing.
- Public Road and Port driving between ASKO central storage and Port of Moss.

The location of the storyline and its demonstration sites are shown in Figure 1 below.

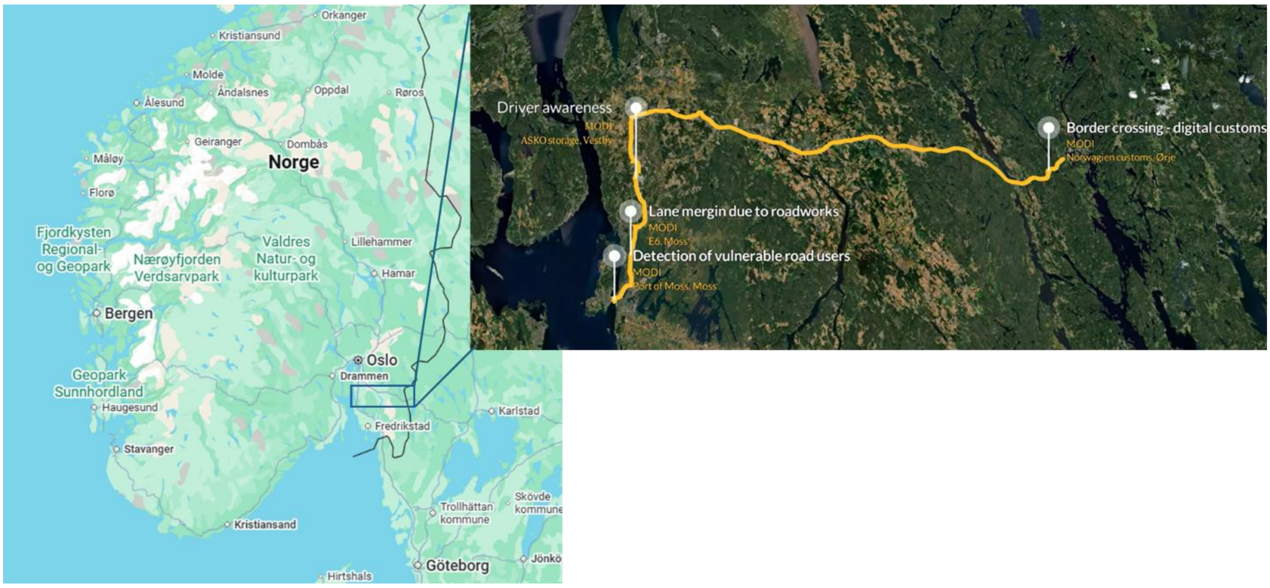


Figure 1: The location of the Norwegian UC storyline and it's demonstration sites.

A movie of the UC Norway storyline along with descriptions and a video of the demo can be viewed here [MODI storyline wp5.4 Norway][2].

The work within the Norwegian use case has been focused on collaboration and involvement of timely involvement of relevant UC partners throughout the project. Processes within the UC, such as the permit process for crossing the border (Annex 7), has been conducted with industry, research and authorities discussing possible set up for safety case, actively utilizing stakeholder networks to secure access to relevant technology and sites, and clearly defining areas of responsibilities. This has been implemented through several series of repeating meetings and workshops – with subsets of partners relevant for different processes in additions to regular meetings for all UC members.

[2] https://www.youtube.com/watch?v=3kQlNxq8u5I

This very collaborative approached for establishing trust as the main driver for our work was used to ensure all relevant perspectives.

Challenges and Solutions Demonstrated

The following challenges in Table 1 have been identified, and the following solutions have been demonstrated.

Table 1: Challenges and solutions demonstrated for UC Norway

UC Norway: From border crossing to a port	
Challenges:	• Driving in mixed traffic with heavy trucks at low and high speeds including merging and interaction with VRUs. • Moving to/from the motorway to regional/local roads. • Driving automated on public road including transition between confined area and public road.
Solutions demonstrated:	• Investigate or demonstrate L4 CCAM functionalities for port/terminal operations and public road driving, including cross-border. • Identification and implementation of PDI needed for L4 CCAM functionalities for public roads. • Identification and implementation of PDI infrastructure needed for L4 CCAM across borders including map data, automated custom routines, non-stop surveillance, and communication. • Demonstrate seamless integration of automated sub-components of the transport chain.

Partners involved in the Use-Case

The following partners with logo have participated in the Use-Case as partners, associated partners or stakeholders.

UC Norway partners (Lead: SINTEF)

In addition, other organisations have also helped without any formal connection to the project. This includes, Telia, PostNord, The Swedish customs and Mesta.

In the next two sections, the demonstrations of the two UC NO sub-use cases are described, including key findings and lessons learned. Thereafter, main learnings of the complete UC are given to supplement the individual demonstrations. In general, the setup of the Norwegian demo builds on vehicle development documented in MODI reports produced in WP3 and for the infrastructure according to work produced in WP4. Most of these works are classified as sensitive and are not referenced for confidentiality reasons, with one exception being the report of infrastructure for driving on public roads, MODI report D4.2 [1].

Sub-use case: Public Road, Customs and Border crossing

The demonstration

This sub-UC focuses on the border crossing between Sweden and Norway driving on public roads. During the setup of the demonstration the location was moved from the intended E6 Svinesund border crossing to E18 Ørje, as the second location was better suited for the state of the technology and to minimize the number of safety measures needed to be implemented to secure permit. This new location with its traffic conditions, matched the operational speed of the vehicle in a way that effectively allowed the operation of the automated vehicle to be demonstrated with significantly less safety measures to secure traffic safety – resulting in a more realistic operation in the end. The change of location was done in line with the risk and mitigation matrix of MODI.

The demonstration was conducted by starting from the Swedish side of the border at Ørje, crossing the border, driving two different routes at the customs area and stopping at the customs on the Norwegian side, see Figure 2.

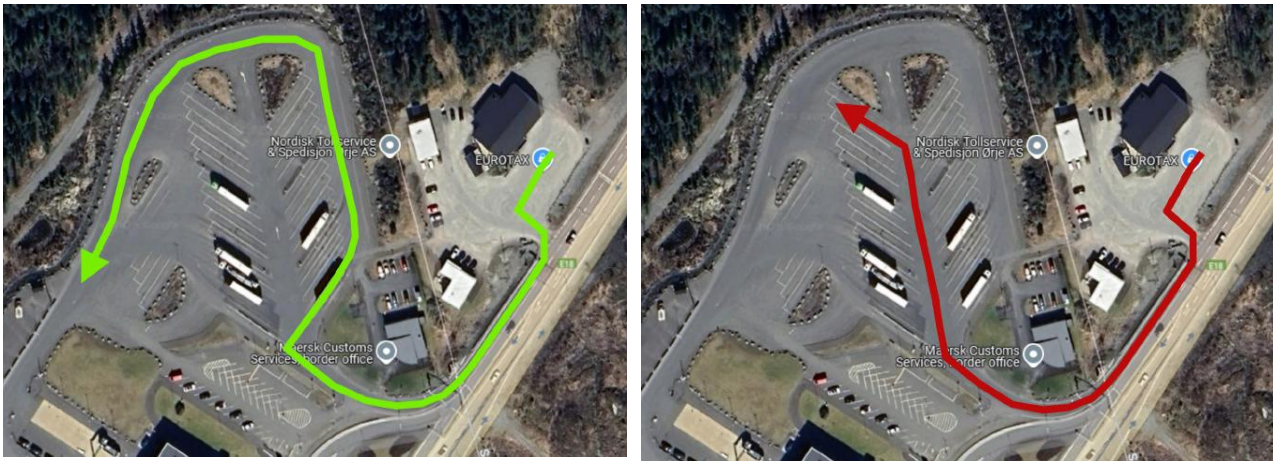


Figure 2: Different routes demonstrated at Ørje. The road stretch was approximately 300 m long, and the speed limit is 30 kph at this section.

The two different routes at the customs area corresponded to 1) approved clearance within the Digitoll and 2) not declared for entry, i.e. manual paperwork or inspection needed, referred to as the “green” and “red” route respectively. In addition, the vehicle did also drive back to the staging point after each iteration in automated mode, including two left turns, on and off E18, respectively.

The aim of the demonstration was to demonstrate a seamless border crossing without the AV needing to stop. It was also to demonstrate the use of Digitoll, provided by the Norwegian customs, and to showcase how C-ITS can support an efficient operation of an AV. Since the demonstration involved automated driving, a test permit was granted by both Norwegian and Swedish authorities, in close collaboration, for this activity. See Annex 6 for details.

The vehicle utilized for the demonstration was an Einride vehicle and a remote operator was supervising the vehicle from Gothenburg in Sweden. The traffic was generally very calm with only some minutes of elevated traffic volumes during the morning and afternoon. The autonomous vehicle was entering the road when an appropriate distance to a vehicle in front and behind was obtained. Since there was not that much traffic on site, there was no idle time/time in congestion e.g. time waiting in a queue or behind vehicles. The weather was cold and bright throughout the week with temperatures from zero degrees Celsius to plus 7 degrees Celsius. The visibility was good during the tests due to road lights on site. Traffic was running as normal and VRUs were moving around in the area going about their usual customs business, giving the project a nice set up to understand road users' interaction with the automated electric truck, which did seem to act normal around the new truck and did not pay much attention to it. A good understanding about the customs situation with document handling, traffic safety and international transports in general was gained by working with this demo and conduction the work documented in Annex 4.

For passing customs the project connected to the Norwegian Digitoll. This solution lets vehicles pre-declare their goods, and if granted a VMS signs will inform the entering vehicle that it can pass directly through customs, placed at point A in Figure 3 below.

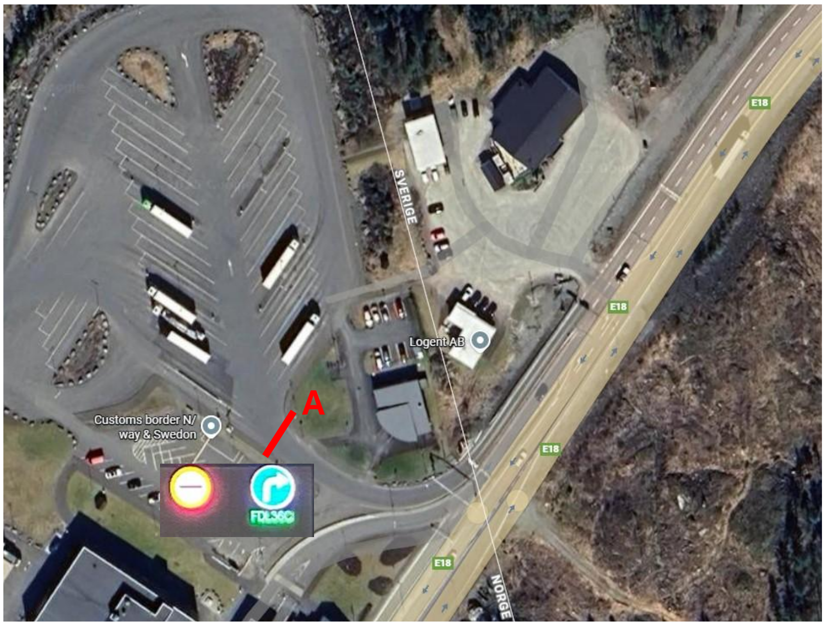


Figure 3: Location of the VMS (point A) for Digitoll at Ørje.

For the already operational Digitoll the vehicles are recognized by the licence plate recognition system of Digitoll. Then the status of the declaration sent by e.g. the logistic operator is checked and the decision of approved or non-approved declaration is sent to the VMS for the driver to react upon. The MODI integrated part takes the decision from the Digitoll back-office system and distribute the clearance status by an ITS message locally transmitted via ITS-G5 to a vehicle on-board unit and via cellular network to the remote operator in Gothenburg in Sweden approximately 250 km away. See Figure 4 below for the architecture.

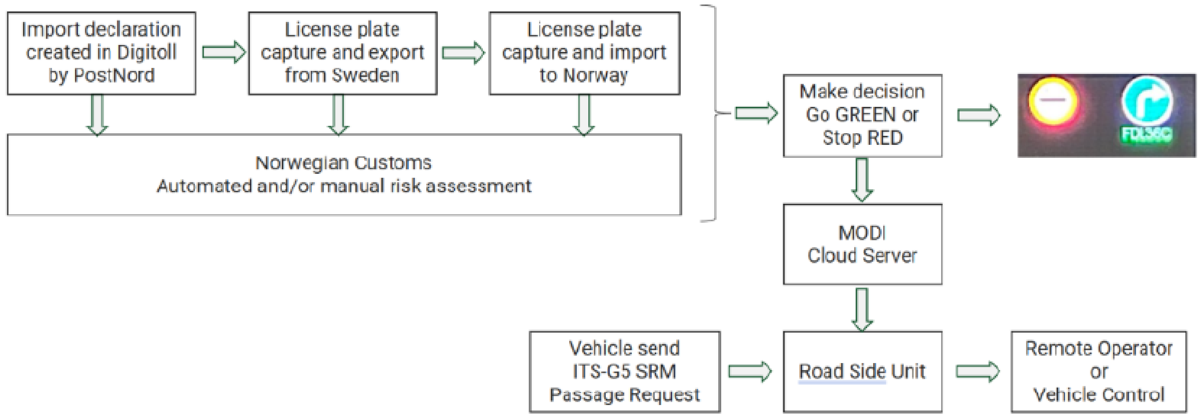


Figure 4: Architecture for Digitoll with the MODI UC Norway integrations.

The full demonstration circle (from Sweden to Norway and then back) included four decision points (A, B, C and D in Figure 5 below) for the remote operator to respond upon request from the vehicle. At Point A the vehicle is turning onto the main road with crossing oncoming traffic. Here the vehicle asks the remote operator to confirm that it is safe for the vehicle to turn. At point B the vehicle asks the remote operator to confirm whether to drive the green or the red route. Point C and D are unprotected left turn on to and off the main road, respectively.

Figure 5: Decision points for the remote operator at Ørje.

During the work with this demonstration, the effect of losing connectivity when driving across borders was investigated at Svinesund, but not repeated at Ørje. At Ørje the connectivity worked seamlessly at the crossing for the demo stretch. Also, securing seamless map reference frames was investigated at Svinesund. However, the final technical setup did not require implementing such a map at Ørje, leaving this as a learning for future functionalities.

Partners involved in demonstration of the sub-UCs

Below, the partners, associated partners and formal stakeholders actively participating in conducting the physical demonstration at site of this sub-UCs is listed.

Partner	Role in the sub-UC
SINTEF	UC leader
Einride	Provided the vehicle and Remote Interface
Q-Free	Provided C-ITS information at site
Norwegian Customs	Provided physical infrastructure and digital service for declaration
Norwegian Public Roads administration	Road authority Norwegian side, who provided access to road and permit
Østfold County council	Local road authority
The Swedish Transport Administration	Road authority on Swedish side who provided access to the road and supported on Swedish side in permit discussion both with NPRA and the Swedish Transport Agency, how provided permit on Norwegian and Swedish side, respectively.

Physical and digital infrastructure

The following physical and digital infrastructure has been used/and or investigated for this UC.

Technology and physical objects	Owner
CCAM vehicle Remote Interface	Einride
Road-side and vehicle unit with C-ITS communication with SPaT/MAP messages.	Q-Free, NPRA
Norwegian Customs area at Ørje Norwegian Customs declaration service with VMS	Norwegian Customs
Mobile network with Inter-PLMN	Telia
SWEPOS and CPOS positioning services (NRTK)	Norwegian mapping authority and Landmeteriet
Road infrastructure and extra lights for testing during night	NPRA and the Swedish Transport Administration
Digital twin for simulation	Einride and AstaZero
Digital declaration message sent from transport provider to Digitoll	PostNord
Norwegian public data as source for HD-maps	NMA and AstaZero

Constraints and limitations

Some environmental limitations to the ODD existed for this demo. The demonstration wouldn't be possible to perform (or limited) had the weather been rainy, snowy or with high wind speeds. Also, with heavy traffic conditions the demonstration activities would have been paused. None of these events did occur, and the demonstration was run under normal operational conditions at site.

Demonstration activities

The following demonstration activities have been performed:

Demonstration activities	Dates
Border crossings set up, pre-tests and filming	22-24th of September 2025
Final public demonstration	25th of September 2025

Some pictures of the demonstration activities are given in Figure 6 below.

Einride vehicle at Ørje custom station

Digitoll VMS with bottom picture showing cleared for green route

Crossing the border

Birds eye view testing

Birds eye view demo day with visitors

Figure 6: Pictures from the demonstration activities at Ørje for the Public road, customs and border crossing sub use case.

Key findings and lessons learned

Safe automated driving was successfully demonstrated across border on public roads between Sweden and Norway. In addition:

- Seamless Digitoll integration: Green/red route status was successfully retrieved and transmitted both to the vehicle (ITS-G5) and the remote operator (cellular)
- Coordinated permits and bi-national collaboration: Effective joint process between Swedish and Norwegian authorities resulted in aligned permit conditions.
- Stable connectivity with Inter-PLMN: Border-crossing connectivity issues identified and successfully mitigated via enhanced roaming configuration.
- Operational realism: Tests were performed under normal traffic, weather, and lighting conditions, useful for assessing true operational readiness.
- Original Svinesund site rejected: Traffic density, speed differentials and lack of legal authority for safety measures (VMS speed reduction, TMA usage) made the site unsuitable but was effectively mitigated through close collaboration. It was concluded that, within the timespan of the project, it was not possible to find a solution for Svinesund with acceptable risk for further delays.
- Digital twins and simulation (AstaZero and Einride) accelerated safe preparation.

Sub-use cases: Public Road and Port

The demonstration

This demonstration focused on three different V2X-based vehicle functions for the following scenarios:

1. Awareness Driveway Access
2. Cooperative Merging
3. Shared perception of VRU and vehicles

These were all placed at different locations, driving from ASKO central storage to the Port of Moss, see the map in Figure 7 below.

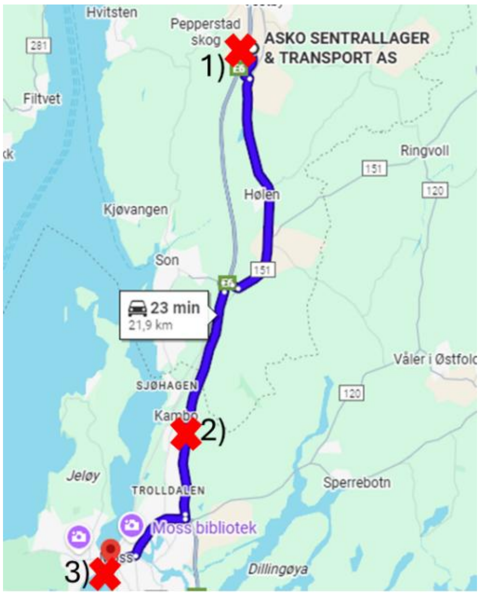


Figure 7: Locations for the three demonstrated V2X-based vehicle functions.

In Figure 7, 1) is the location for the awareness driveway access, 2) is the location for the cooperative merging and (3) is the location for the shared perception of VRU and vehicles case. Volvo brought two test vehicles equipped with C-ITS for this demonstration.

Awareness Driveway Access

This demo was conducted outside of ASKO central storage (Figure 8), when leaving the storage and entering the road "Osloveien"

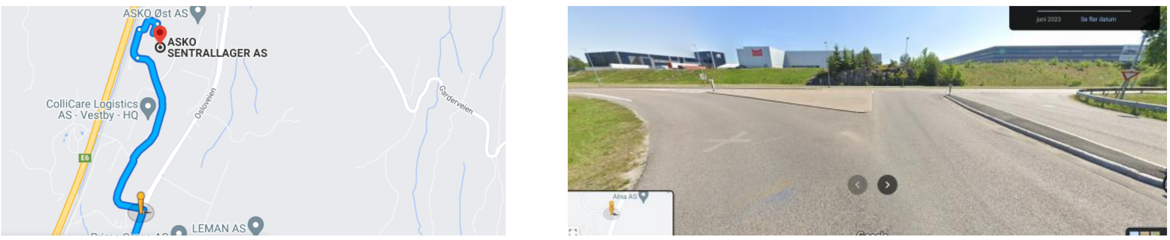


Figure 8: Location for the Awareness Driveway access scenario.

The scenario consisted of a vehicle entering the main road not having sufficient line of sight to an oncoming vehicle due to e.g. the curvature of the road.

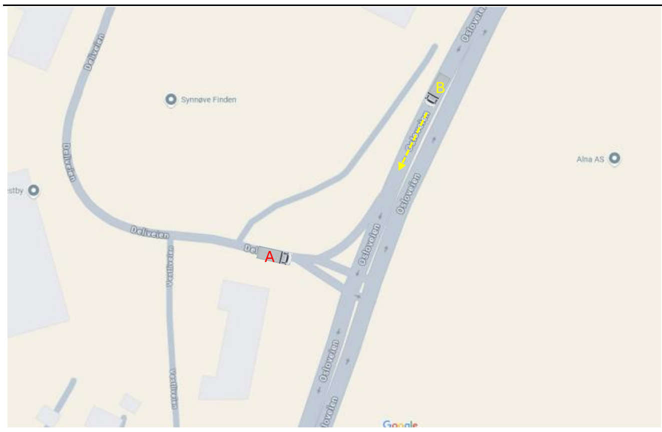


Figure 9: Set up for the Awareness driveway access scenario.

In this case the red truck(A) detected the oncoming yellow truck(B) via CAM messages and V2X communication, see Figure 9 above. This increases the driver's awareness, helps avoid potential negative impacts on ongoing traffic, and enables a more comfortable merging process. Only C-ITS functionality was demonstrated, and no automatic speed adjustment nor steering as included. Two ITS-G5 equipped oncoming production VW ID4 vehicles were also added to the test and CAM messages were retrieved also from one of the vehicles. The other did not send messages appropriately due to a missing software update, demonstrating the vulnerability and necessity of ensuring timely, synchronised updates of such systems. The demonstration was conducted during the afternoon in normal traffic conditions.

Cooperative merging

Figure10: Location for the Cooperative merging scenario.

This demo was conducted at the E6 highway, north of the Patterød junction going north and south (one in each direction) on a road section with good overview, see Figure 10 above. For the demo a physical RWW barrier was established for the southbound direction, in addition to a digital one going north. The data flow of the digital RWW message from the entrepreneur and into the vehicle is given in Figure 11 below, with details to be found in Annex 6. Notably, the digital infrastructure used to convey the RWW message—including the Norwegian national interchange and central C-ITS server—is fully operational production infrastructure, rather than a temporary configuration set up solely for the demo.

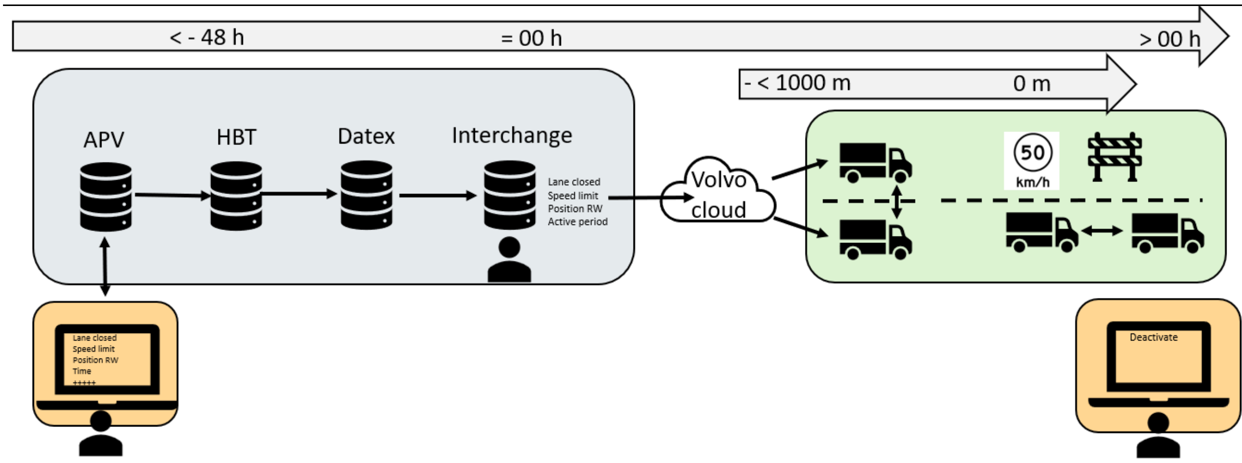


Figure 11: Data flow of RWW message.

Since this is a road with a high level of traffic, it was decided to do the demo during nighttime for safety reasons and to get good testing conditions while operating in normal traffic at this time of the day. The road was not closed off for the testing and there was normal traffic mixed in with the testing vehicles. The merging was done according to the scheme in Figure 12.

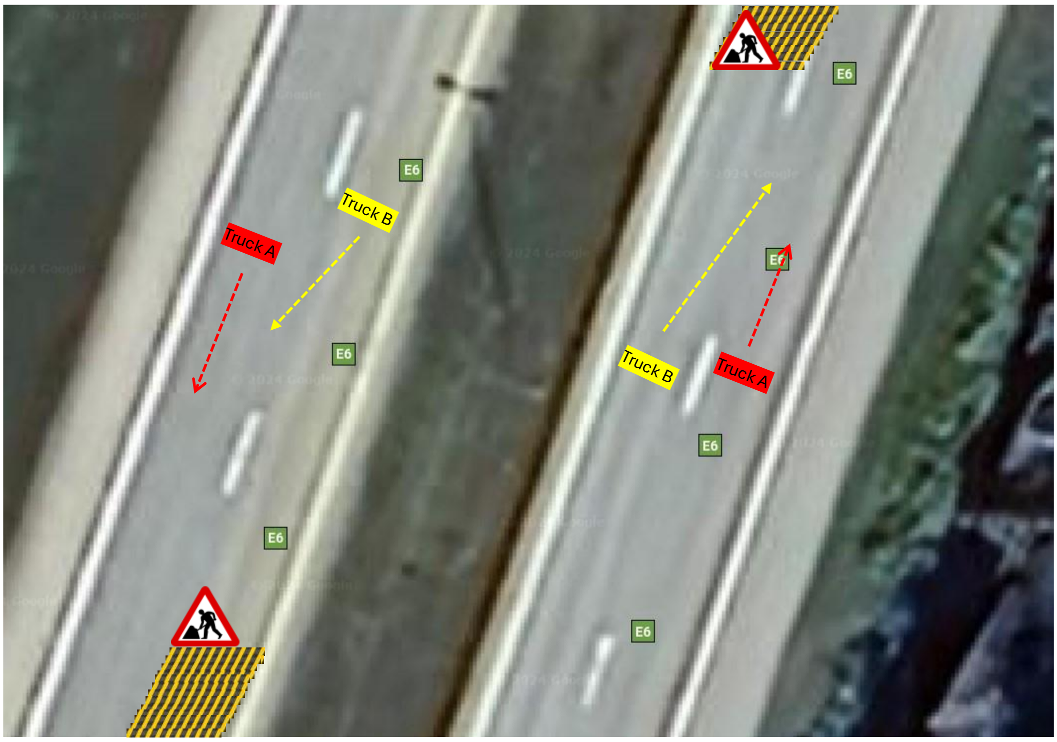


Figure 12: Set up and execution plan for the RWW merging.

The Figure illustrates that the merging is done from the left lane into the right, however, note that only the southbound direction did include a physical RWW.

MCM messages with V2X direct communication between vehicles were used for active trajectory negotiation; both vehicles automatically adjusted their speeds and, if needed, laterally steered themselves, leading to automated safe lane merging. The vehicles were notified on the geographic location of the RWW, retrieved and decoded from the DENM RWW message published over the NordicWay Interchange and the new central ITS server utilizing a cellular mobile network. This message was made available by Mesta, the local contractor who set up the physical RWW barrier, demonstrating the full digital chain of publishing a DENM RWW message from contractor to vehicle. From the vehicle perspective the following was performed:

1. The truck's software digitally subscribes itself to the interchange of NPRA, in order to be notified of traffic events in Norway (such as RWW).
2. The truck will fetch available messages and process the ones that are immediately relevant. For the case of testing the Cooperative Merging driving towards the RWW, the RWW is considered relevant when it is within 1000 meters of the truck.
3. The truck's software will then further process the RWW, i.e., extracting information on positions, lanes and speed limits.
4. MCM messages are exchanged between the vehicles to negotiate a safe merger.

Shared perception of VRU and vehicles

This scenario was conducted at the entrance to Port of Moss, see Figure 13 below.

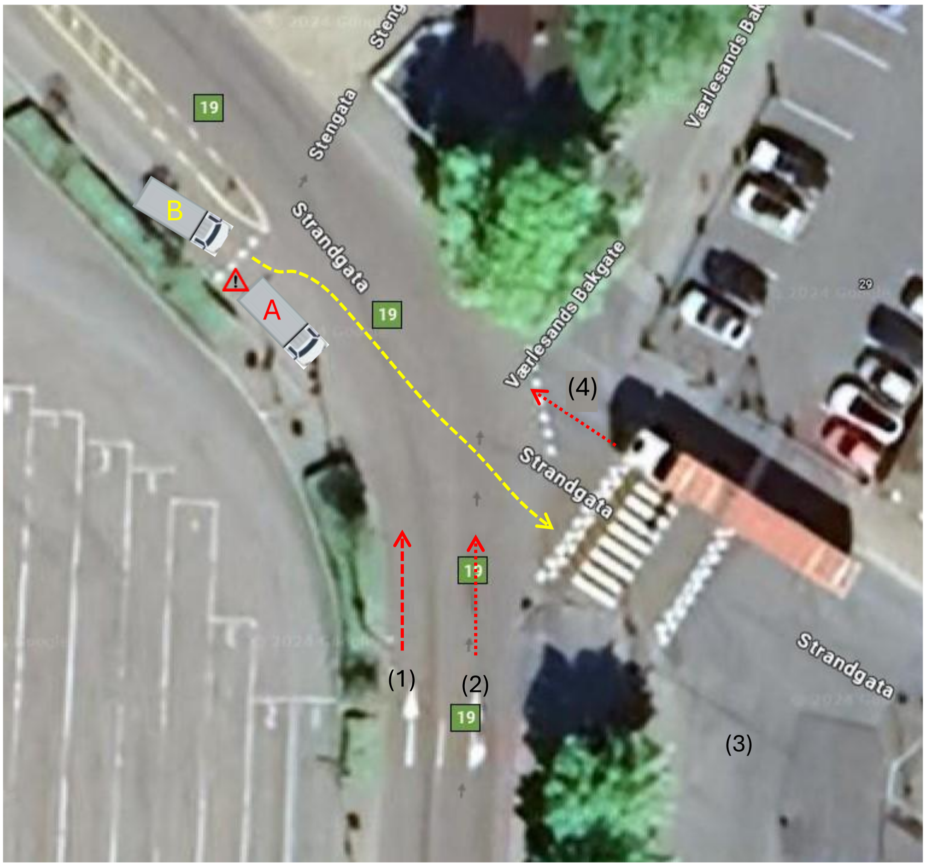


Figure 13: Location for the Shared perception of VRU and vehicles scenario.

Here, the scenario is that a vehicle A has broken down at a busy intersection, blocking all vehicles entering the port, and vehicle B needs to overtake the vehicle A to enter. Vehicle A can still perceive both oncoming vehicles and pedestrians crossing the street and communicate via CPM messages and V2X communication to vehicle B. This is an area with heavy traffic, where vehicles are driving to and from the ferry, see (1) and (2) in picture above, pedestrians crossing the zebra crossing, and traffic are driving into a parking lot or to the access point of the ASKO terminal (3), and out of the port area (4). After crossing the zebra crossing, vehicle B enters the ASKO terminal. The demo was carried out during the morning, under heavy traffic conditions. Only C-ITS functionality was demoed, with no automatic speed adjustment nor steering.

Partners involved in demonstration of the sub-UC

Below, the partners, associated partners and formal stakeholders actively participating in conducting the physical demonstration at site of this sub-UCs is listed.

Partner	Role in the sub-UC
SINTEF	UC Leader
Volvo	CCAM vehicles for demonstration
Port of Moss	Provided of physical infrastructure, landowner
ASKO	Owner of goods, access to central storage area, sea drone connection
NPRA	Road authority, provided RWW message via Interchange
Mesta	Created physical barrier and digital message of RWW
Viken Country Council	Local road authority

Physical and digital infrastructure

The following physical and digital infrastructure has been used/and or investigated for this UC.

Technology and physical objects	Owner
CCAM vehicle	Volvo
NordicWay Interchange and centra ITS server for distribution of ITS messages	NPRA
Access to port area	Port of Moss
Access to Asko central storage area and trailer	ASKO
Physical RWW barrier and digital message on locations	Mesta

Constraints and limitations

The demonstrations were done without any constraints or measures to reduce traffic etc. The merging scenario was conducted during nighttime to get the most out of the functionality as heavy traffic would limit its usefulness and the take over at Port of Moss was coordinated to run between ferry arrivals to avoid queuing and standing stuck at the intersection for too long.

Demonstration activities

The following demonstration activities have been performed:

Demonstration activities	Dates
Pre-test with close to finished functionality of all scenarios	12-15th of January 2025
Demonstration of all three scenarios	17-19th of June 2025

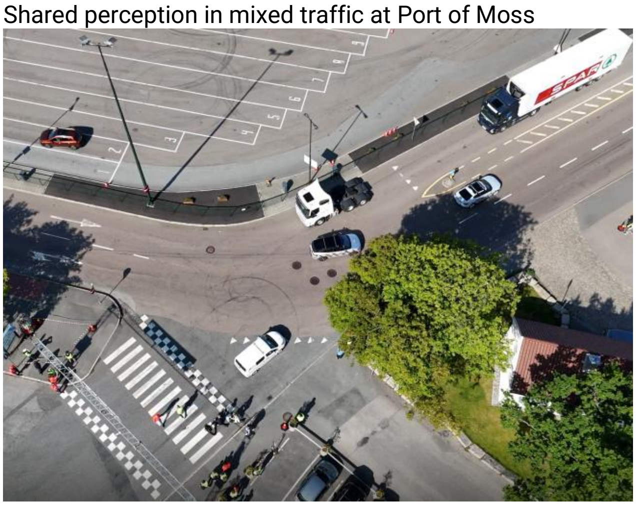
Some pictures of the demonstration activities are given in Figure 14.

Awareness driveway access at ASKO central storage.

RWW cooperative merging.

Cooperative merging inside vehicle with perception.

Shared perception in mixed traffic at Port of Moss



Entering Port of Moss – ASKO harbour, end of MODI route

ASKO harbour end of MODI route

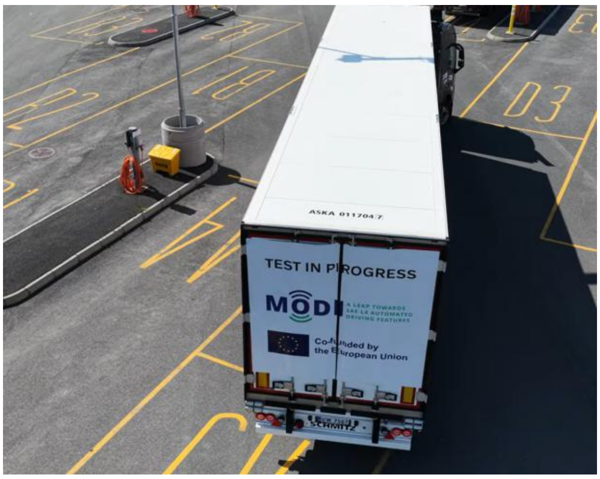


Figure 14: Pictures from the demonstration activities for the Public road and port sub use case.

Key findings and lessons learned

Various C-ITS functionality was successfully demonstrated at the Moss area. In more detail:

- C-ITS CAM-based early warning: Vehicles successfully exchanged CAM messages to detect unseen traffic around curvature-limited sightlines. Also, in integration with production vehicles, however, need to ensure updated conformability.
- Fully digital RWW chain proven end-to-end: From entrepreneur digitally registering the RWW, via DATEX II to Interchange, and finally to the Volvo vehicles. The system worked as designed, and further automation of the process is valuable.
- Automated cooperative merging via MCM: Vehicles autonomously negotiated trajectories, adjusted speed and performed lateral control to merge safely.
- Effective CPM-based awareness: Vehicle successfully broadcast perception of VRUs and oncoming vehicles to assist a second vehicle when overtaking in a congested port area.
- Real world complexity validated: High pedestrian density, mixed vehicle movements and ferry traffic provided meaningful stress testing.

Learnings

This section summarises the main content of the Annexes included in this report. Some of these include learnings and results from considering border crossing at Svinesund. Although the actual demonstration was moved to Ørje, the existing learnings from Svinesund remained relevant. At the end of this section, key findings and lessons learned in relation to the MODI objectives are given.

The focus on the logistics chain perspective and public road driving had high importance within UC NO. Annex 1 gives a comprehensive overview of today's situation and future challenges and possibilities. The document explores the automation of a complete logistics chain in Norway, from the Swedish border at Svinesund to the Port of Moss. It describes the current operational practices for border crossing, customs clearance, driving on public roads, and activities at ASKO's Vestby terminal and sea terminal, highlighting roles, responsibilities, and communication flows. The study then examines how these processes would change with Level 4 CCAM vehicles, identifying technical, operational, and regulatory challenges such as connectivity at borders, HD-maps for confined areas, automated coupling of trailers, digitalized customs and terminal procedures. Key enablers and barriers include economic feasibility, infrastructure readiness, safety considerations, tacit terminal knowledge, and regulatory gaps requiring legal innovation. While automation promises improved safety and efficiency, the transition demands significant investment, workflow restructuring, and harmonized regulations across borders. The report concludes that successful deployment of CCAM vehicles in logistics will depend on addressing these challenges through collaboration between technology providers, authorities, and logistics operators.

The above note is backed up with a survey among logistics-relevant industries in Europe in general and UC NO scenario-specific automation perspectives, to assess automation readiness (more details in Annex 2). The survey aimed to capture perspectives on automation, its benefits, barriers, and future potential, but received a low response rate (13 fully completed responses), limiting generalizability. Results indicate that respondents are generally positive toward automation (average score 3.85/5) and see benefits such as improved efficiency, safety, and reduced driver shortages. Key drivers identified include operational efficiency and safety, while major barriers are lack of standardization, high investment costs, and limited knowledge or capacity. Respondents believe processes like freight documentation and driving in confined areas have the highest potential for automation and would yield significant benefits for both organizations and the transport sector. Despite enthusiasm among respondents, the study highlights low overall engagement in the logistics industry, suggesting that automation readiness remains limited and requires further research, demonstrations and stakeholder involvement. I.e. the interest or focus on automation within this industry is typically limited to a few actors or even engaged single persons. More efforts must be made to put the possibilities and needs of automation on the agenda going forward.

For the border crossing, a paper documenting the challenges of losing connectivity was written [2]. Together with Telia, an Inter-PLMN handover in the 4G network was implemented to support seamless connectivity. The challenges and solutions were documented by collecting data and verifying connectivity measurements, driving across the border 16 times before the implementation (baseline) and 10 times after the implementation, see Figure 15 below for example.

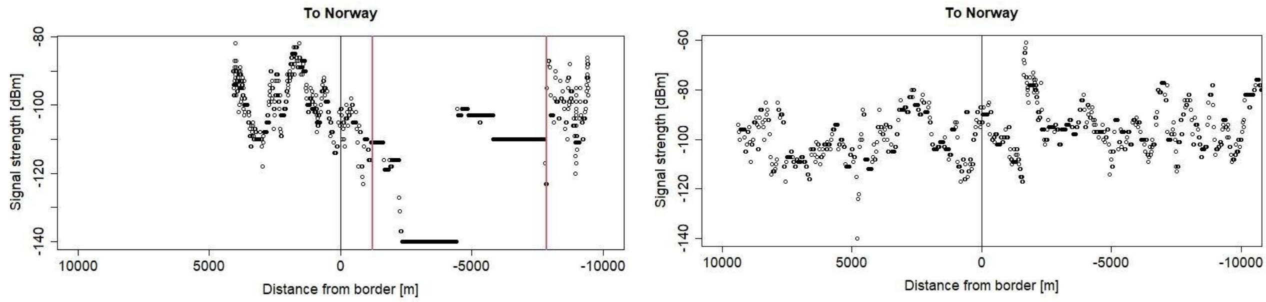


Figure 15: Measured signal strength driving across the Swedish – Norwegian border, with the left picture showing before Inter-PLMN was implemented, red horizontal line indicating connectivity loss, and right picture showing no loss of connectivity service after implementation.

Also, for the border crossing, seamless map reference frames were investigated and documented in Annex 3. The document analyses challenges related to geodetic reference frames for ITS within the MODI project, and UC NO in particular. It highlights discrepancies between national and global reference frames, particularly at borders, where misalignments of up to 0.024 m were observed, confirmed through both theoretical calculations and GNSS-based practical tests. These inconsistencies can cause slight navigation errors for end-users when crossing borders, emphasizing the need for harmonized reference frames. Recommendations include transforming all data to a common frame before deployment, standardizing metadata, and adopting widely recognized systems like WGS84 and EGM08 for consistency.

Automated custom processes are an important perspective in UC NO, and to complement the technical perspectives found in D1.3 on border processes [3], interviews were conducted among users and relevant stakeholder of the already established Digitoll on the border between Norway and Sweden, see Annex 4. This memo examines the benefits and barriers of Digitoll which aims to replace manual customs procedures and the current “10-day rule” with a fully digital process by April 2025, requiring advance submission of customs documentation to enable faster and automated clearance. Interviews with logistics operators and stakeholders reveal strong support for digitalisation and efficiency gains, but also concerns about complexity, tight implementation deadlines, and high costs for system integration and workflow restructuring. While Digitoll reduces waiting times and improves control, challenges remain for multi-consignment transports, legal responsibility for goods, and alignment with the forthcoming EU Customs Reform. For CCAM (automated) vehicles, unresolved issues include communication between remote operators and customs personnel, handling red-light scenarios, and adapting legal frameworks for driverless operations.

Annex 5 provides an overview of Norway’s public data resources relevant for automated driving and ITS, focusing on the E6 Svinesund–Oslo corridor. It describes available static and dynamic datasets from national authorities, including the National Road Database (NVDB), road images (Vegbilder), elevation data, point clouds, and geospatial data portals like Geonorge and FKB. Dynamic data sources such as DATEX II offer real-time traffic, weather, travel times, and webcam feeds, while ITS-G5 roadside units and traffic management systems support connected vehicle operations. The note emphasizes the importance of accurate, accessible, and reliable data to extend ODDs (operational design domains) for automated vehicles and enable redundancy for in-vehicle sensors. It also highlights APIs, data formats, and tools for developers, along with specialized measuring vehicles equipped with lidar, GNSS, and cameras for targeted data collection. Overall, the document aims to guide stakeholders on leveraging Norway's digital infrastructure for planning, simulation, and future deployment of automated transport solutions. Based on this data and LiDAR scannings AstaZero created both a point cloud representation of the E6 border crossing[3] and a digital twin OpenDrive for simulation purposes. The same was later conducted by Einride for the Ørje demonstration preparations, see Figure 16 below.

Figure 16: Digital twin and simulation of the Ørje border crossing demonstration.

In preparation for Ørje, Einride conducted around 150 simulations, totalling 20 hours, before driving and testing on site, in addition to testing physically at AstaZero.

In Annex 6 the data chain for the RWW scenario is outlined—from a contractor registering roadworks in the APV system, through NPRA's HBT event system and DATEX node, to the Interchange where the RWW DENM message is produced and made available to OEMs. The Volvo vehicles automatically subscribe to and process these messages via cellular connectivity, using lane and position data to adjust speed and lateral control for automated merging. The document concludes that while the ecosystem functions end-to-end, further automation of interfaces and reducing manual steps would improve efficiency.

Finally, Annex 7 details the nearly three-year process of obtaining permits for a cross-border demonstration. It explains the regulatory frameworks in Sweden and Norway, the steps in their respective permit processes, and the challenges of aligning requirements for a single trial across two jurisdictions. Initially planned for Svinesund, the trial faced legal and safety constraints, leading to an efficient relocation to Ørje. The memo highlights key issues including harmonization gaps in traffic regulations, complexities around remote operation across borders, and the need for robust safety cases demonstrating risk mitigation and compliance with traffic laws. Permits were ultimately granted in August and September 2025. Lessons learned emphasize early dialogue with road owners, clearer legal frameworks for safety measures, and the importance of harmonizing cross-border trial regulations for future deployments.

[3] pointcloud.astazero.com/Svinesund.html

Contributions to MODI objectives

In addition to the Key findings and lessons learned for each sub-UC this section considers UC Norway in relation to the overall MODI objectives. Across both demonstration of sub-use cases and desktop investigations (Annexes), UC Norway advances MODI's objectives by proving CCAM feasibility, revealing remaining deployment barriers, and providing clear actionable recommendations for infrastructure, regulation, business models, and operational practice.

Together, these represent insights from border connectivity to customs digitalisation, from motorway cooperative merging to port manoeuvring, from simulation to permitting, and from operator readiness to standardisation gaps.

MODI objective 1: Implement the latest technology and overcome major CCAM deployment barriers for logistics by demonstrating business-oriented and well-integrated CCAM systems across a corridor.

- CCAM chain demonstrated in real operations, including automated border crossing, Digitoll-integrated customs flow, cooperative merging at motorway speed, C-ITS-based situational awareness, and shared perception in a congested port.
- Cross-border CCAM operation validated through Inter-PLMN connectivity handover implementation and measurement, GNSS/NRTK reference frame analysis and field testing confirming practical alignment and remaining harmonisation needs, and cross-national permitting for L4 demonstration driving.
- Digital-physical integration achieved, including end-to-end RWW (DENM) messages
- Validated success with L4 driving depended on selecting environments that fit current ADS maturity (e.g., moving from Svinesund to Ørje)
- C-ITS significantly increases operational awareness, and cooperative manoeuvring is technically ready for nighttime/controlled-traffic environments
- Simulation and digital twins are essential to safely prepare CCAM operations and reduce risk for authorities and operators
- Accuracy of data availability and digital services are critical.

MODI objective 2: Define recommendations for supporting infrastructure, vehicle regulation and standards to enable broader CCAM deployment and future large-scale pilots.

- Infrastructure readiness gaps identified, including lack of standardized HD-maps and need for harmonised GNSS reference frames and cross-PLMN roaming behaviour.
- Regulatory learning from real permit processes. The three-year, dual jurisdiction permit effort highlighted concrete needs for shared safety case templates, clear rules for remote operation across borders, alignment on allowable safety measures (e.g., TMA, temporary speed limits), and early involvement of road owners to avoid late redesigns.
- Digitoll analysis produced actionable insights for adapting border procedures to CCAM, including requirements for digital manifests, remote-operator communication pathways, and automated green/red-route handling.
- Cross-border harmonisation is a prerequisite for scalable CCAM logistics: technical, procedural and legal fragmentation imposes operational risk, inefficiency and unpredictability

- Confined-area CCAM depends heavily on terminal digitalisation, including access management, parking logic, standardised trailer coupling, and structured data flows—currently highly manual.
- Authorities need clearer testing and operational frameworks for remote operation, human-in-loop responsibilities, and safety-case expectations.
- Data standards must extend beyond public roads; and transition to terminals, customs and ports are the weak link in CCAM-readiness today.

MODI objective 3: Demonstrate business models and partnerships for CCAM logistics.

- Real multi-actor collaboration was established between OEMs, infrastructure operators and owners, logistics actors, telecom, mapping agencies, and several other suppliers and stakeholders. UC NO shows that no single party alone can deploy CCAM.
- The border–terminal–port chain demonstrated how CCAM fits into existing logistics workflows, including handovers, responsibility chains, charging, terminal operations, and customs processes.
- Input to, and high interest for, automation benefits (efficiency, safety, driver shortage), although limited actual readiness, including low digital maturity in many operations. High value placed on harmonisation, early supply-chain information flows, and structured digital documentation.
- Input to how business models for CCAM hinge on digitalisation maturity in logistics. Without digital workflows, planning tools, and predictable terminal processes, CCAM vehicles cannot operate automated.
- CCAM benefits align with industry priorities (efficiency, safety, driver shortage), the UC exemplify how investments in automation require a clearer return on investment than exists today—particularly for e.g. trailer-handling automation, HD-maps, and digital customs interfaces.

MODI objective 4: Perform technical and socio-economic impact assessments and communicate them in real-world CCAM conditions.

- Impact-relevant operational data was gathered from on-road CCAM driving in mixed environments, connectivity performance measurements pre/post Inter-PLMN fix, simulation-based safety validation, real-time V2X interactions in highway and at terminal/port, quantitative studies e.g. by logistics-operator interviews and surveys
- Contribution to insight on socio-economic and operational perspectives, collected through the "Border-to-Port Story" and stakeholder interviews, showing where automation changes roles, responsibilities, workloads, risk, and legal requirements

References

[1] Storrønning et al. (2024) MODI D4.2 Optimal Designs of Physical and Digital Infrastructure at Public Roads. Available: MODI_D4.2_Optimal-design-of-PDI-for-public-roads_submitted.pdf

[2] Lykkja, O. M., & Arnesen, P. (2024, April). Border Crossing Connectivity for CCAM Vehicles: A Field Test at the Norwegian-Swedish Border. In *Transport Research Arena Conference* (pp. 674-680). Cham: Springer Nature Switzerland. Available: https://www.researchgate.net/publication/396425031_Border_Crossing_Connectivity_for_CCAM_Vehicles_A_Field_Test_at_the_Norwegian-Swedish_Border

[3] Bräutigam, J. et al. (2023) MODI D1.3 Report on border processes. Available: https://modiproject.eu/wp-content/uploads/2024/06/MODI_D1.3_Border_processes.pdf

Annex

Annex 1

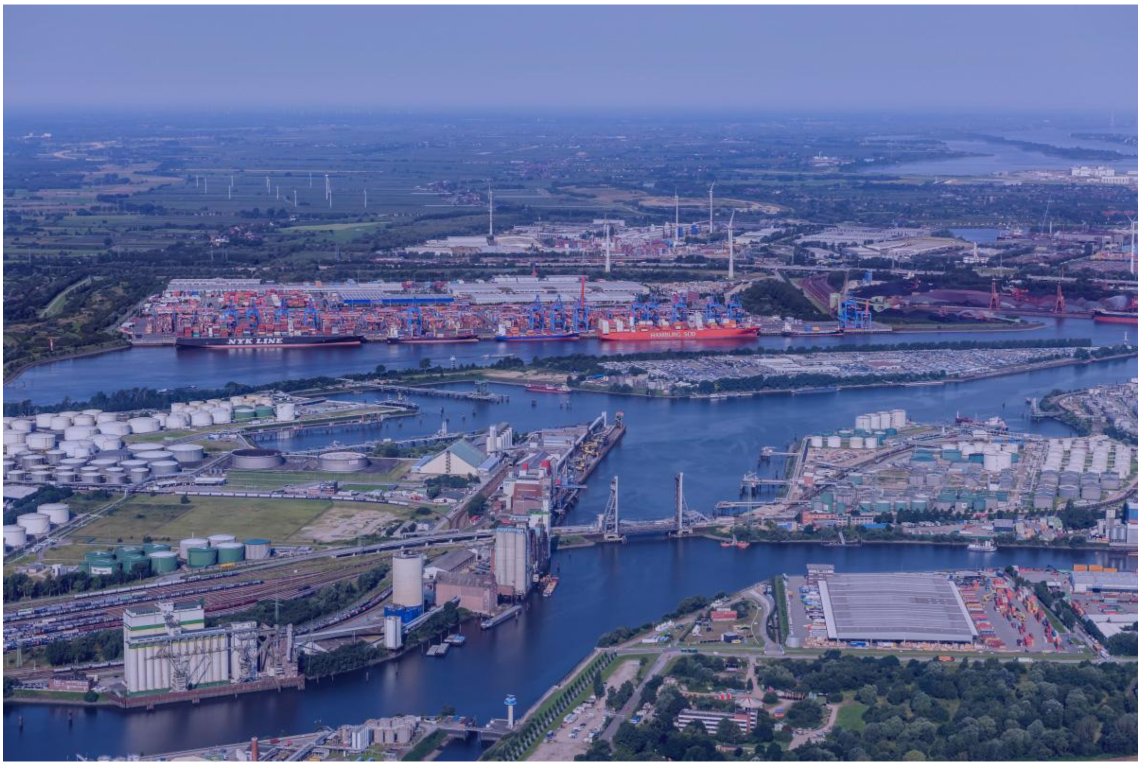
A LEAP TOWARDS SAE L4 AUTOMATED DRIVING FEATURES

A leap towards SAE L4 automated driving features

MODI Task 5.4 UC NO

From border to port – "The story"

Internal document - August 27th, 2025



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1 Introduction

1.1 Purpose and scope of this document

This project memo for MODI Task 5.4 Use Case Norway (UC NO), documents a desktop study exploring the automation of the coherent transport chain from border to port, as outlined in the UC NO description.

1.2 MODI UC NO Sub-Use Cases

MODI UC Norway includes four Sub-Use Cases (SUCs), described in Table 1. These SUCs focus on testing/demonstration of vehicle and infrastructure capabilities in specific infrastructure sections and operations.

Table 1: Overview of sub-UCs in MODI UC NO, and what is going to be tested

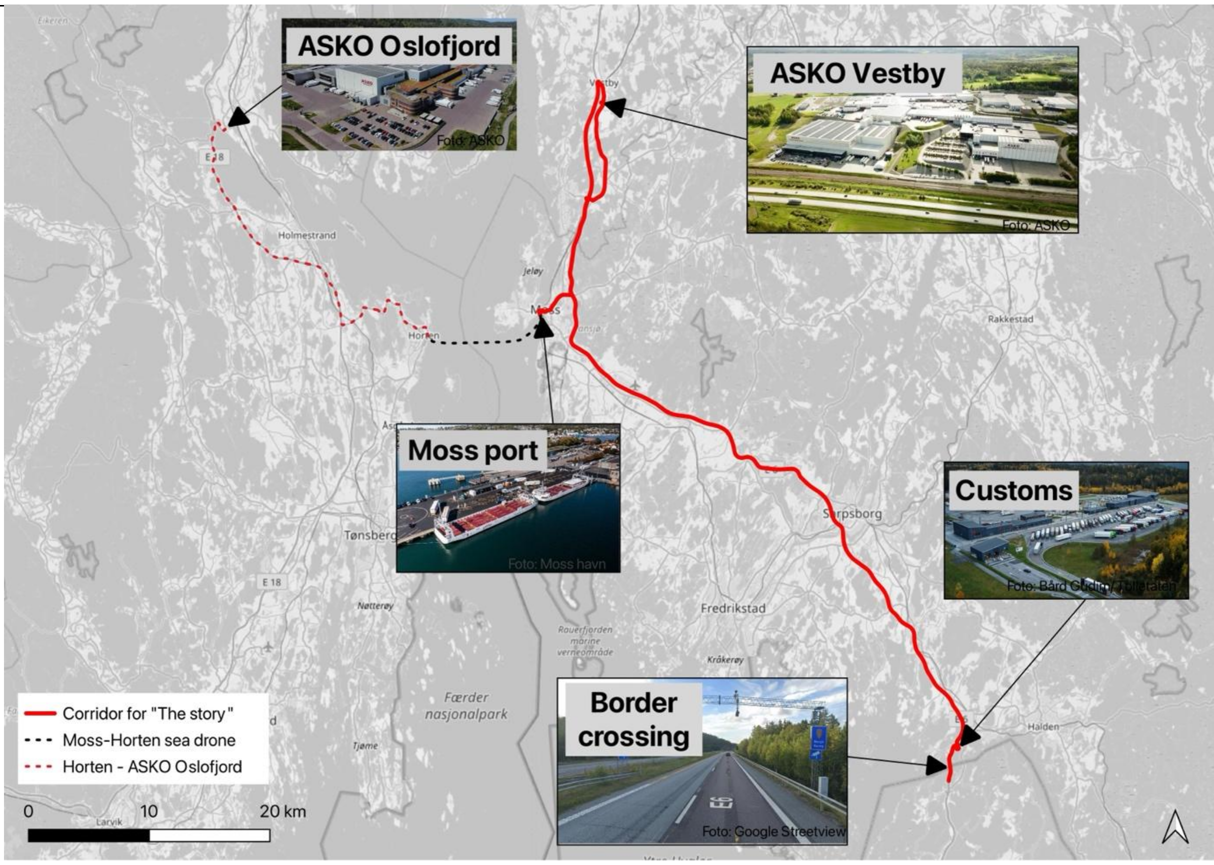
Sub-UC	What is tested
Border crossing	Crossing procedures
Customs	Communication between customs and remote operator (HMI), green/red light scenario
Motorway	Driving on public road from border to customs
Port	Driving to port, also on public roads

1.3 The UC NO frame story

The primary objective of this study is to gain a more comprehensive understanding of logistic perspectives and potential implications of introducing “driverless” automated (CCAM L4) freight vehicles in the logistic transport chain, by complementing the stakeholder studies and technical demonstrations included in the UC Norway Sub-Use Cases, with more in-depth descriptions of current logistic practices, operations and requirements relating to a specific transport chain included as a “frame story” in UC NO:

A heavy vehicle will drive from Sweden, crossing the border and through customs, utilizing Digitoll for automatic green light clearance. The vehicle will continue to ASKO central warehouse in Vestby, where cargo will be unloaded. At the terminal, cargo will be loaded onto another heavy vehicle, which will continue to the ASKO sea terminal at Port of Moss where the semi-trailer will be transferred to the ASKO sea drone.

This story in fact includes two separate transport operations, where the first leg ends, and the second leg starts at the Vestby terminal. The geographical lay-out of this story is shown in Figure 1, and a broader back-drop for this transport chain is given below. Chapter 3 provides a description of current practices and activities included in the frame story, based on interviews with ASKO staff involved in the day-to-day management and operation of transports and terminals in question. These interviews also provided insights into issues and potential for how to perform this transport chain with automated vehicles. This information, combined with input from relevant MODI deliverables, form the basis for chapter 4, where the automated version of the frame story is elaborated on.



Sources: OpenStreetMap (map); ASKO (photos ASKO Oslofjord and ASKO Vestby); Moss havn (photo Moss port); Bård Gudim/Tolletaten (photo Customs); Google Streetview (photo Border crossing)

Figure 1: Corridor for "The story" with points-of-interest

The story takes place against a backdrop which is described in the following sections with respect to main actors involved, what triggers the transport operation in question, and predominant characteristics of vehicles currently used for this operation.

1.3.1 ASKO

According to the ASKO web site[4], ASKO is the largest wholesaler of groceries in Norway, with more than 4 000 employees and 13 regional warehouses, including a consolidation terminal and two automated central warehouses in Vestby. It is the consolidation terminal which is involved in this story. At this terminal, the incoming cargo is being unloaded, cross-docked, sorted and loaded onto other vehicles for further distribution to the regional warehouses.

ASKO Transport is responsible for gathering groceries from ASKO suppliers to the regional ASKO branches. These operations are conducted either as direct transports or by cross-docking at the consolidation terminal at Vestby. Import of groceries is handled through UNIL[5]. ASKO and UNIL are both owned by NorgesGruppen[6].

[4] https://asko.no/en/about-us/ (accessed June 25, 2025)

[5] https://unil.no/ (accessed June 25, 2025)

[6] https://www.norgesgruppen.no/norgesgruppen-in-english/this-is-norgesgruppen/ (accessed June 25, 2025)

The distribution operation involves more than 700 trucks on Norwegian roads. Some 40 different carriers perform road transport on contract with ASKO Transport. Some of these carriers have driven for ASKO in 15-25 years. ASKO hires traction services (driver and road tractor) and any additional loading capacity needed to top up the 185 semi-trailers and some 80 containers owned by the company. ASKO also has a fleet of more than 60 zero-emission vehicles powered by electricity or biogas. At the Vestby terminal, ASKO Transport has 14 chargers for heavy vehicles.

From the terminal at Vestby, ASKO operates a range of fixed routes on a weekly basis, plus extra routes for peak periods (typically before Christmas and Easter).

ASKO Maritime operates electric vessels (sea drones), ferrying semi-trailers and containers without tractors or drivers between the ASKO sea terminals at the Norwegian ports of Moss and Horten. ASKO Maritime works towards full automation of the vessels. The operation of the vessel includes remote control for some functionalities, and the ambition is for these vessels to be unmanned.

1.3.2 "Prequel" to the story

The transport operation described in "The story" is initiated by an order from ASKO Oslofjord which includes groceries from abroad. This order is coordinated through ASKO Transport and UNIL, combining this with other orders from local ASKO branches for a full-load goods delivery to the ASKO consolidation terminal at Vestby. Deliveries to the ASKO Oslofjord location at Sande from ASKO terminal at Vestby, include a sea leg with the ASKO sea drone. These locations are shown in Figure 1, and are also included in the overview in Figure 2.

1.3.3 Vehicles involved in the story

According to ASKO, 99 % of operations relevant for this study today involve articulated vehicles (vehicle type B.II.31 in Eurostat Glossary for transport statistics of 2019 - see Appendix A). Description of current vehicle operation is thus based on this vehicle type. Articulated vehicles include two separate structures; a road tractor (vehicle type B.II.26) and a semi-trailer (vehicle type B.II.30), which can be coupled and de-coupled, allowing the semi-trailer to be pulled by different tractors for operational efficiency and flexibility.

1.3.4 Automation in the context of the UN NO frame story

While L4 driving by definition[7] does not involve a driver, the MODI UC NO frame story includes sequences which are not included in the Operational Design Domain (ODD) of technology currently available. For sequences or activities outside the ODD, utilisation of Remote Operation (RO) has been included in this study, to explore automation of the end-to-end transport chain in question. Although the focus is on automation of freight vehicle operation, potential automation of other operations and processes is touched upon where that has been mentioned by informants for this study.

Connectivity-related issues are described and discussed under vehicle operation sections of this document – in line with how connectivity is included in MODI WP3 Vehicle technology.

In line with MODI D4.2 [1], automated vehicles are mainly referred to as "CCAM vehicles".

[7] https://www.sae.org/blog/sae-j3016-update (Accessed June 3 2025)

1.4 Position in the MODI project

While much of the MODI activities relate to technology issues, this study aims at capturing additional aspects crucial for day-to-day logistic operations, but not so prominent in the main MODI activities. Where possible, terms and classifications applied in the MODI project e.g. to structure work packages, tasks and use cases are being utilised, to highlight links to other parts of MODI.

This frame story provides just one example from the multitude of diverse logistic operations going on every day. Other combinations of actors, cargo types, technology, locations and time frames may produce entirely different, but just as relevant, "stories" about the real-life needs and challenges which need to be addressed in a transition towards automated freight transport.

2 Method

This study examines various elements of the transport chain, including information exchange, physical (manual) handling of cargo and vehicles, and the resources involved in such a transport chain today, using conventional vehicles. Furthermore, it aims to identify potential implications of operating with CCAM freight vehicles, and to explore how automation may impact this transport chain, including changes in activities, roles, or requirements for the various stakeholders involved in the transport operation. Also, we aim to examine how responsibilities and liability is currently assigned and transferred within the transport chain, and to identify responsibility/liability issues if the driver is no longer in the transport chain. A particular focus has been on aspects related to arrival at and activities within terminals and ports, as these aspects are not addressed in other parts of this MODI UC.

2.1 Research questions

The study is guided by the following research questions:

What are the current activities/interactions performed in relation to the transport chain, and how will these be affected by the introduction of an CCAM vehicle in the same context?

The study adopts a structured approach that examines the following aspects:

Current activities and interactions in the transport chain (Chapter 3)
This includes mapping and examining of:

- key activities and interactions within transport operations
- where and when these activities occur
- functions and purpose of each activity
- roles and responsibilities of stakeholders involved in these activities
- methods used to perform these activities, including digital, written, verbal, manual, and automated processes

Feasibility and issues for CCAM vehicles in the transport chain (Chapter 4)
This includes consideration of:

- implications of current activities and practices for a scenario with CCAM vehicles
- where and how results from other MODI activities may add perspectives and potential solutions to specific issues

Enablers and challenges for utilising CCAM vehicles in this context (Chapter 5)
Summary and discussion of aspects touched upon, affecting readiness and potential for automation of the transport chain in this study:

- economic feasibility
- infrastructure readiness
- safety and human behaviour
- tacit terminal knowledge and remote operation staff
- regulatory gaps and need for legal innovation

2.2 Information gathering

The primary source of information has been in-depth interviews with logistic actors involved in day-to-day logistic operations represented by the UC NO frame story. These interviews have been supplemented by information from and references to available MODI documents and additional sources where relevant.

The interviews were designed to elicit detailed information on the day-to-day management and operation of the route, including logistical challenges, operational procedures, and feasibility of integrating automated vehicles. Insights gained from these interviews has provided a nuanced understanding of the practical considerations and potential obstacles to L4 automation, and a basis for identifying relevant dimensions to structure the study by. Supplementary information has been collected from a technology provider (HIVE Autonomy[8]) working with ASKO Maritime at the Moss sea terminal.

MODI documents and resources providing further information related to the route and activities included in the UC NO frame story, is referred to as appropriate. Border crossing and customs clearance are included in the UC NO frame story. As these processes have also been defined as SUCs (see Table 1), they have already been subject to separate studies and documented in MODI D1.3 [1], MODI D4.2 [1] and MODI Project Memo “Logistic operators’ experiences of digital customs processes in Norway Svinesund” [3] respectively. Therefore, these processes have not been prominent topics in the information gathering performed in this study.

Supplementary information has been accessed from relevant websites as appropriate, referenced to the specific links in footnotes.

2.3 Segments in the transport route

The route examined in this study comprises a sequence of segments representing different operational environments, practices and requirements: **Interaction with authorities** (border crossing and customs clearance at Svinesund), **logistic hubs** and **driving in confined areas** (ASKO Terminal at Vestby, ASKO sea terminal at Port of Moss, with onboarding sea-drone) and **urban environment** (Moss city centre). These segments are tied together by trunk roads and lower hierarchy roads: European route E6 from the border at Svinesund to the Vestby terminal, and E6/County Road (Fv 151)/Classified Road (Rv 19)/Municipal Road (Deliveien) from Vestby to Port of Moss, representing **driving on public roads** at different levels.

Each segment is further detailed by a description of a sequence of events or activities taking place at each segment.

2.4 Transport chain dimensions explored

Through stakeholder interviews and document studies, multiple layers/dimensions to the transport chain have been identified:

- **Cargo handling** - Loading, securing, monitoring, unloading of the cargo, including control and confirmations related to this.
- **Vehicle operation** - Driving and other task involving the driver or other personnel along the route: Driving operation along the UC NO route, entering, exiting and manoeuvring at terminal area, trailer positioning at terminal(s), coupling and de-coupling of tractor and semi-trailer, charging at terminal, including control and confirmations related to this

[8] https://hiveautonomy.no/

- **Responsibility** - Identification of responsible/liable part for cargo and load carrier along the transport chain, and procedures for handing over of responsibility/liability from one actor to the next, including control and confirmations related to this.
- **Communication** - Contents and mode/method of information exchange with vehicle/driver before, during, and after completion of the transport operation itself, including mission description, required access information/digital handshakes, in-terminal specifications, and related confirmations.
- **Regulatory aspects** - Identification of legal and operational requirements governing the transport chain, including safe driving of the vehicle

These dimensions are explored for the current situation, as well as for a future scenario with fully automated vehicles operating the same transport chain. Main focus has been on capturing the specifics of operational aspects of the transport chain, while other aspects included mainly rely on what was mentioned by our informants during interviews. This information is thus not exhaustive, but still relevant.

As a tool for this study, the information gathered through interviews and document studies was structured and fed into a matrix providing an overview of respective dimensions and automation issues related to each segment and event along the route. This matrix has also been guiding for the following chapters ,which are structured according to the chain of POIs and related events along the route, with description of the respective dimensions as relevant, based on available information. As the road sections tying the POIs together have pretty much similar properties and requirements, these are joined together in one common section, describing “driving on public road”.

3 «The story» - current situation

This chapter outlines the current step-by-step route in UC Norway, describing each route segment/point of interest, primarily from the logistic operator's point of view. An overview of main features and activities regarding cargo and vehicle is provided in Figure 2. The route segments are analysed across dimensions described in chapter 2.4: cargo handling, vehicle operation, responsibility, communication and regulatory aspects, to provide a comprehensive overview. For each segment, a description of current practices involving conventional vehicles is given. A similarly structured description of issues and requirements identified for completing the same operations/purposes with a CCAM vehicle, is given in Chapter 4.

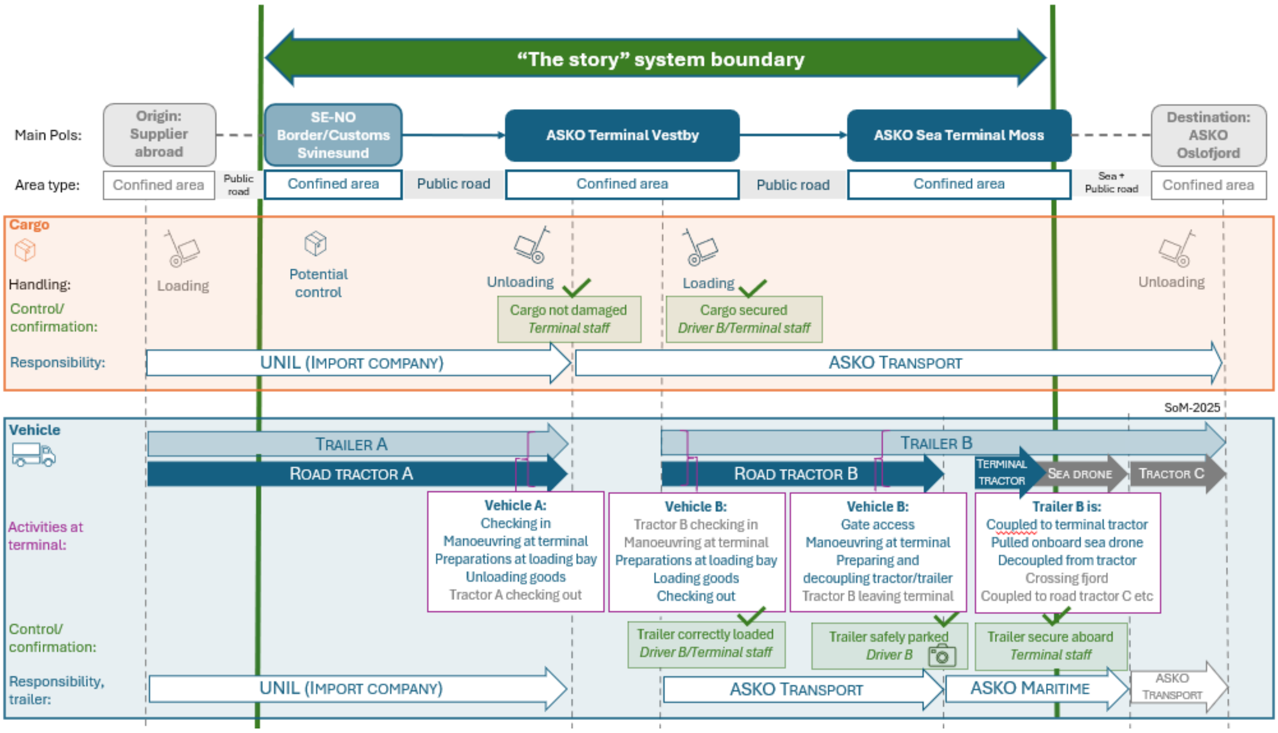
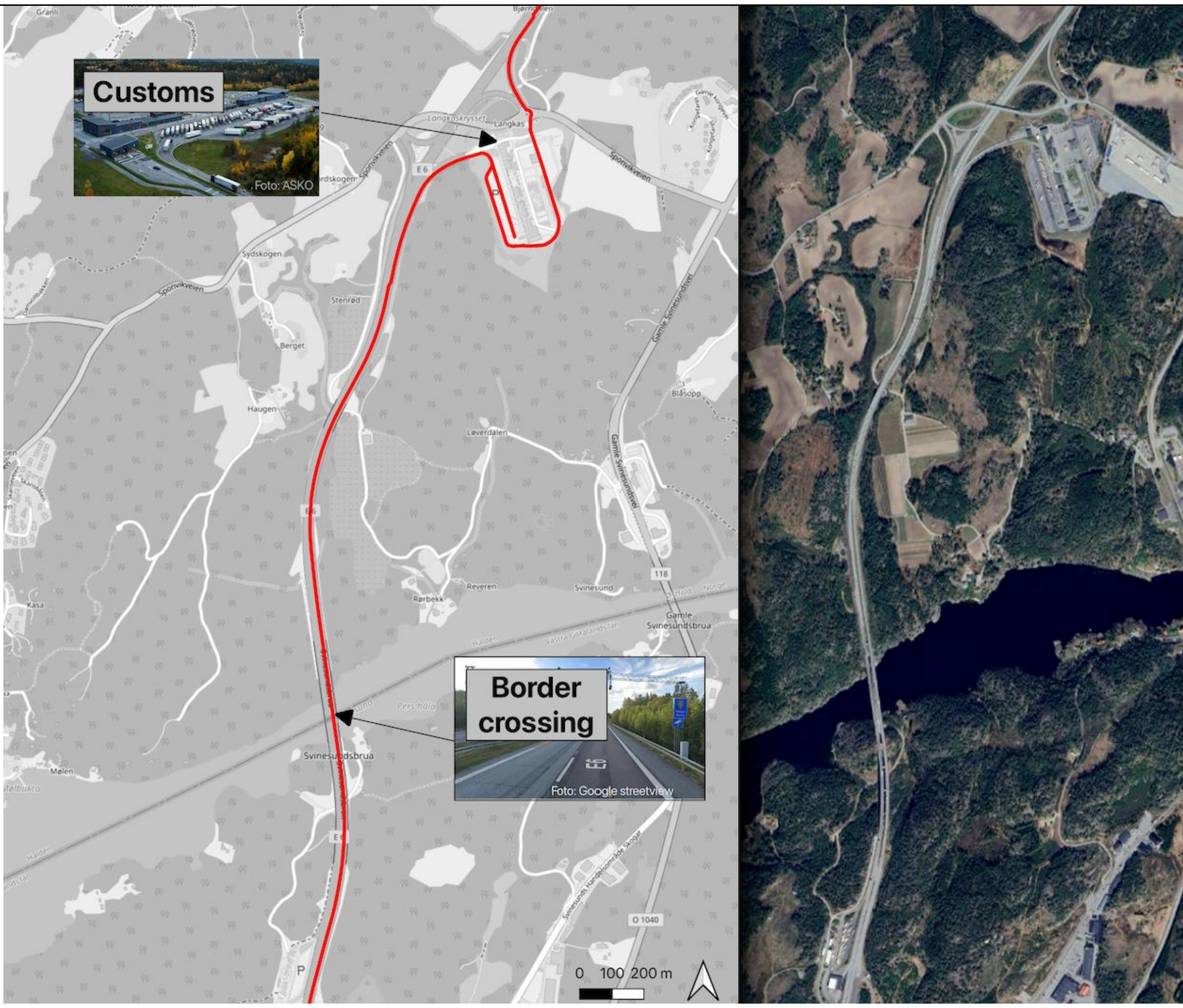


Figure 2: Main current logistic features and activities within and beyond boundaries of "The story" - by dimensions Cargo and Vehicle

The first leg of this operation would currently involve a conventional articulated vehicle delivering cargo to the Vestby terminal. The second leg from Vestby to Moss would also involve an articulated vehicle, but an electric one.

3.1 Border crossing at Svinesund

The vehicle crosses the national border between Sweden and Norway at the Svinesund bridge, which is part of the European route E6. The border is at the middle of this bridge, see Figure 3.



Sources: OpenStreetMap (map); Bård Gudim/Tolletaten (photo Customs); Google Streetview (photo Border crossing); Google maps (Aerial photo)

Figure 3: Svinesund - Border and Customs area

After crossing the national border at Svinesund bridge, the vehicle continues to the Norwegian Customs area a couple of kms further north (see Figure 3), to complete the procedures for entering Norway with cargo.

The Norwegian Customs Authority already has a largely automated custom clearance process in operation at Svinesund: Digitoll. According to the Customs Authority's website[9], Digitoll has three main features:

- Information about the cargo and transport is sent to the Customs Authority before, or not later than when the vehicle crosses the border
- The Customs Authority processes and makes a risk assessment before, or at the latest, upon transport arrival at the Customs area.
- A predominantly automated border crossing, with automated custom clearance procedure.

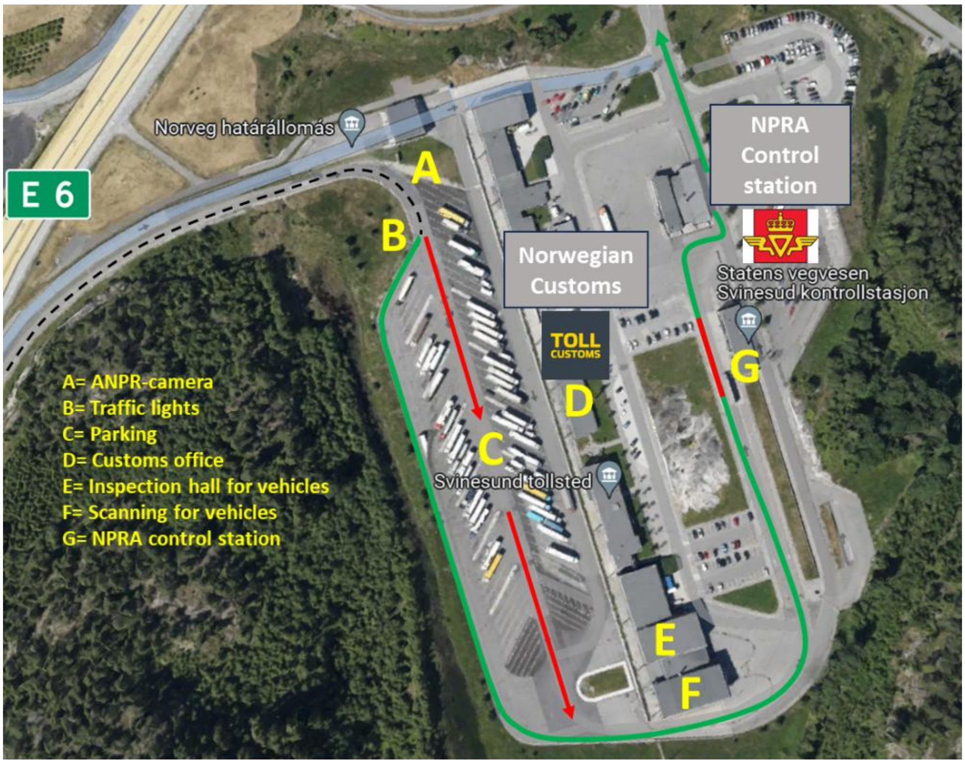
[9] https://www.toll.no/en/corporate/digital-customs-on-importation-of-goods-to-norway (accessed June 27, 2025)

This solution is currently operated in parallel with a conventional, "manual", customs clearance process called "Direct transport scheme", allowing cargo to be transported directly to recipients, and to be declared up to 10 days after border-crossing.

Digitoll will become mandatory in 2026. The transition towards full implementation has two phases: From February 1st, 2026, digital submission of information is mandatory for notification and disclosure of information obligations. From September 1st, 2026, declarations no later than at border crossing will be mandatory, and the Direct transport scheme will be terminated.

UNIL is responsible for the import and all aspects of the transport in question until the cargo is unloaded at Vestby. This responsibility also includes customs clearance. To what degree UNIL utilises the Digitoll option is currently not known to us. However, as Digitoll will be mandatory within a few months' time from this study is completed, use of Digitoll can already now be considered the most relevant representation of current practice for customs clearance process.

The following description of physical layout and functionalities is mainly based on MODI Project Memo "Logistic operators' experiences of digital customs processes in Norway Svinesund" [3].



Sourc: Google Maps (Aerial photo)

Figure 4: Svinesund customs area and NPRA control station.

Figure 4 illustrates the layout of the customs area at Svinesund, which includes Digitoll processing for vehicles entering Norway, and NPRA vehicle control station. Letters in Figure 4 indicating various functionalities, are referred to in the following text.

An automatic number plate recognition (ANPR) camera positioned roadside (A) captures the vehicle's license plate as it approaches the customs station. Vehicle details are cross-referenced with the pre-submitted documentation, and a traffic light (B) will display either a green or red signal, indicating whether the transport is allowed to proceed through the customs area or if further inspection is necessary. This process is automated but can be overridden by customs controllers.

A green light allows the vehicle to enter the express lane (green line) in Figure 4. In case of a red light, the driver must go to a designated parking zone (C), park the vehicle, and proceed to the customs office to interact with a customs officer (D). Should any errors or irregularities be detected in the submitted documentation, the vehicle may be subject to scanning (F) and/or a manual inspection within the control room (E). Finally, if all conditions are met satisfactorily, the vehicle proceeds to exit the customs area. Upon leaving, the vehicle may be directed to the NPRA's control station (G), for a technical vehicle inspection.

A flyer describing procedures for digital border crossing is available in several languages at the Customs Authority web site[10]. An English version is included in Appendix B of this document.

3.1.1 Cargo handling and responsibility

Crossing the national border itself does not include any handling of the cargo. The actor responsible for loading the cargo onto the vehicle is responsible/liable for the cargo until it has been confirmed unharmed and unloaded at the Vestby terminal.

At the customs area, the vehicle may be directed in for a manual customs control. This can include scanning and inspection of the cargo. After the inspection, the driver is responsible for securing the load.

3.1.2 Vehicle operation and driver tasks

This section is mainly based on MODI D1.3 [1]. When crossing the national border using a conventional vehicle today, the driver operates the vehicle according to current road traffic regulations and crosses the border without any additional procedures beyond this.

At the customs area, the driver is responsible for vehicle operation within the customs area and must follow instructions from the customs officers as well as traffic regulations, traffic lights, signage and lane markings. This includes parking at designated parking area and responding to being directed into the NPRA control station before re-entering the E6.

3.1.3 Communication

There is no specific communication related to crossing the national border at the Svinesund bridge.

For the Digitoll customs clearance process, there is mandatory information to be provided to the Norwegian Customs authorities. The obligation to provide information rests with the driver or the driver's customs representative - usually a freight forwarder or a carrier.

The digital information to be submitted includes transport documentation, customs documentation (a so-called Manifest), who is driving the vehicle and its licence plates, and other relevant paperwork, no later than at the time the transport reaches the border. The Customs Authority's web site offers information about procedures and APIs for submitting the required information about the vehicle and the cargo it carries.

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[10] https://www.toll.no/en/corporate/digital-customs-on-importation-of-goods-to-norway/information-for-businesses/border-crossing/print-out-flyer (Accessed July 2, 2025)

The customs officers process and assess the pre-submitted information. As described above, an automated process cross-references the ANPR-based identification of vehicles entering the area with the submitted documents. This process is automated but can be overridden by customs controllers. Customs officers communicate with the vehicle be means of traffic lights, signage, lane markings and manual directions. The driver is responsible for keeping the registration plates clean for the ANPR camera to work properly.

In case the driver/vehicle gets a red light, the driver must enter the customs office in person to communicate face-to-face with the customs officers, and must present a valid ID and vehicle registration number.

3.2 Driving on public roads

The first leg of the route for the frame story is mostly driven on European route E6, with a short drive on Fv 151 after taking the exit at the Vestby junction until arriving at ASKO Vestby terminal. The last short leg is driven on the municipal road Deliveien.

For the second leg of the route, from ASKO Vestby terminal to the ASKO sea terminal at the port of Moss, the vehicle first drives a short leg on Deliveien before it either drives north on Fv 151 to the Vestby junction before entering the E6, or south on Fv 151, and enter E6 by Son. This is a longer drive along the county road but is often used today to avoid crossing the road with an unprotected left turn when entering Fv 151 from Deliveien.

The vehicle leaves E6 in the Patterød junction, before driving on Rv 19 into Moss City centre. Patterød junction is a complex intersection with high traffic volumes, and with a pilot project for ITS G5 technology. The last part before entering the port area, is in an urban area with multiple roundabouts and pedestrian crossings, where the vehicle interacts with traffic going to and from the road ferry service between Moss and Horten.

The routes described above, represent an “uneventful” version of the frame story. However, the vehicle also needs to be able to tackle possible incidents and delays, e.g. accidents, road closures, roadworks or queues, which could occur along the route. There is also the possibility for random checks, e.g. for driver sobriety or vehicle control, or inspections at an NPRA control station. Routines and practices mentioned by our informants in relation to such unplanned events, have been included where relevant.

3.2.1 Cargo handling and responsibility

Cargo is normally not handled during transport between the respective loading and the unloading sites. After random inspections, the driver is responsible for securing the load.

3.2.2 Vehicle operation and driver tasks

The driver needs to be certified to drive on Norwegian roads and is responsible for operating the vehicle according to general road traffic regulations. This includes the ensuring the condition of the vehicle, that the load is correctly secured, and that driving is done in accordance with the current road traffic regulations. A comprehensive overview of requirements applying for professional transport is presented at the NPRA website[11]. Some of the regulations which apply, are very specific, and vary with time of year and geography, as this example shows:

The driver is responsible for the vehicle having sufficient grip. In Norway, there are specific requirements for heavy vehicles[12]: minimum tyre pattern depth (5 mm) for road tractor and semi-trailer between November 1st and the Sunday following Easter day, and general requirements for winter tyres ("Mud and snow" or "3 peak mountain snowflake") from November 15th to March 31st. The regulation also specifies type of winter tyre required for the different types of axles, and rules for when and how studded tyres may be used. Outside the specified periods for winter tyres, the vehicle must still have winter tyres and/or snow chains when snow or icy conditions can be expected, independent of time of year. For the three northernmost counties, the period for the minimum tyre pattern depth is extended, starting earlier and ending later than for the rest of the country.

The driver is responsible for handling events according to traffic regulations and instructions from e.g. the police. The vehicle and driver can be subject to random controls en route. These controls may be performed by a single or joint by several authorities, such as Police, Road authorities, Customs and Labour Inspection. The driver is then required to accommodate the officials upon inspection of the vehicle and/or the cargo, and to provide the required papers.

3.2.3 Communication

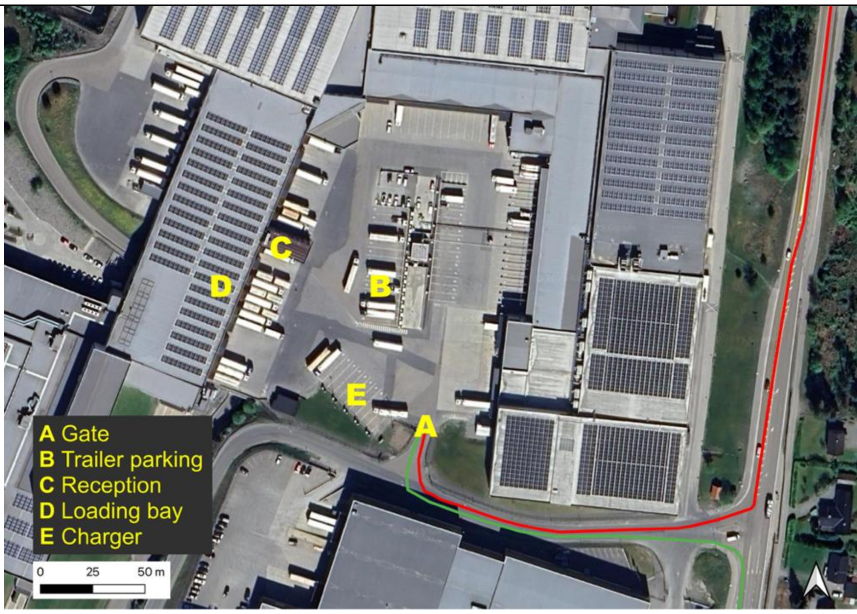
There is normally no communication between the driver/vehicle arriving from abroad and the Vestby terminal. For domestic drivers/vehicles, there is a need for communication related to (re)planning of the route. If something unexpected happens, the driver will mainly communicate with his/her transport company (ASKO sub-contractor), which in turn relays information to ASKO if there e.g. is a delay in delivery time. Today, this communication with the drivers is done via phone, SMS, email or Teams groups. If there is need for communication with officials along the route, the driver will handle this.

3.3 The ASKO Vestby terminal

The ASKO facilities at Vestby consist of two automated central warehouses and a consolidation terminal. It is the latter, and an area called "the horse-shoe", which is involved in the transport operations in this study. This area also includes 14 charging stations for heavy vehicles. The layout of this part of the terminal area is shown in Figure 5. The gates to the terminal area are closed on Sundays, but remain open at all other times, 24/6.

[11] https://www.vegvesen.no/en/vehicles/professional-transport/?lang=en (Accesses July 2 2025)

[12] https://www.vegvesen.no/en/vehicles/professional-transport/tyres-and-chains/ (Accessed May 16 2025)



Source: Google Maps (Aerial photo)

Figure 5: The ASKO consolidation terminal at Vestby.

The terminal has so far chosen to be flexible with regard to accommodating vehicles arriving ahead of schedule. On Monday mornings there can be a queue of vehicles waiting to be unloaded. Some of these may not be scheduled until Tuesday or Wednesday, but have "raced" to arrive early in order to have time to do some cabotage while in Norway, or to pick up a full load of fish for export before leaving the country. The terminal may reconsider this practice for the future.

Vehicles arriving from abroad are unloaded by terminal staff. This is due to HES (Health, Environment and Safety) considerations, and also an aftermath of the pandemic, with restricted access to terminal areas for drivers from abroad. As a safety measure, drivers from abroad must leave the keys to the vehicle at the reception until the loading or unloading process is complete. This measure is implemented for safety reasons to prevent the driver from moving the vehicle while the terminal staff is still busy loading or unloading.

3.3.1 Vehicle operation and driver tasks

Incoming vehicle:

Upon arrival, the vehicle enters through the open gate and parks in one of the designated parking slots. The driver then walks to the reception to register and receive further instructions about which loading bay to use.

Next, the driver manoeuvres the vehicle in the confined area and reverses it into a roofed loading bay at the consolidation terminal. The driver opens the doors of the semi-trailer before completing the reversing into the bay. Terminal staff will open the doors to the bay from the inside, prepare weather-sealing to preserve temperature of frozen or chilled commodities, and lift a "lip" onto the rear of the semi-trailer, for small trucks carrying one or two pallets to access the cargo. These trucks are operated by terminal staff.

Once the preparations for unloading are done, the driver will walk to the reception to hand over the keys to the vehicle, and then to the break room for a coffee.

After unloading, the driver returns to the reception to perform a manual check-out, retrieve the keys, and exit the terminal.

Outgoing vehicle:
Another semi-trailer is loaded for further haulage to ASKO Oslofjord, and is picked up by an electric ASKO road tractor. The driver is involved in the loading process together with the terminal staff, as once the vehicle is on the road, the driver will be held responsible for a potential fine if the cargo is not properly secured.

The driver of this vehicle performs a manual checkout in the reception area. The vehicle can now leave the terminal, heading for ASKO sea Terminal at Port of Moss.

3.3.2 Cargo handling and responsibility

As mentioned, standard procedure at the ASKO terminal is that semi-trailers arriving from abroad are emptied by terminal staff while the driver waits in a break room. Terminal staff also performs acceptance checks of the incoming cargo. UNIL is responsible for the cargo upon arrival at the terminal, and responsibility is then handed over to ASKO Transport, represented by the consolidation terminal, once unloading and acceptance checks have been completed.

Once the incoming cargo has been unloaded (see details in section above), the cargo is cross-docked, sorted and consolidated for the second leg of this story. The goods are put on pallets placed in rows sorted by destination and departure time.

When the semi-trailer carrying cargo destined for ASKO Oslofjord is loaded, the process is supervised by the driver or a loading boss who ensures compliance with safety regulations. Responsibility for the cargo is still held by ASKO Transport, but now represented by the driver/transport operation part of the company.

3.3.3 Communication

Incoming vehicle:
The terminal information system holds information about incoming vehicles and planned arrival time. As described in the intro to this sub-chapter, the actual arrival time may deviate substantially from the planned time, with some vehicles arriving as much as one or two days early.

Signing in at the terminal is an analogue process: the driver meets at the reception, reporting vehicle registration number and handing over the consignment note. The driver is told which loading bay to use. There is no digital check-in, and use of digital consignment letter is not yet widespread. The driver will anyway have to carry a consignment note to show in case he/she is stopped for control en route. The terminal has started to look at digital solutions including pads where the driver can register consignment number and automatically be told which loading bay to use, but this has not yet been implemented.

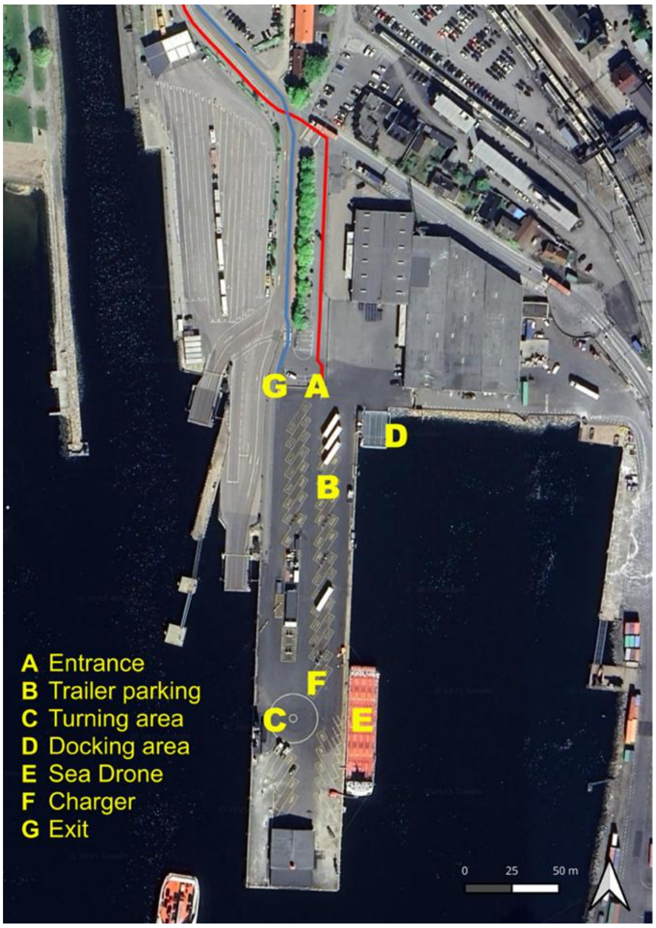
The unloading of the semi-trailer is entered into the terminal information system.

Outgoing vehicle:
In advance of the second leg of the transport chain, a reservation is made for a slot on the sea drone at the ASKO sea terminal in Port of Moss.

The driver for the second leg reports in the reception, and gets information about where to pick up the cargo. The pickup-location will be a specific (numbered) "picking-space" inside the terminal, where the cargo will be placed, palleted and ready for loading, as described in the section above. The driver will also get information about where to deliver the semi-trailer which in this case will be ASKO sea terminal at Port of Moss. For this specific destination, the driver will get all relevant information about the transport and delivery at the next terminal in an app for drivers accessing this sea terminal (See next sub-chapter for details).

3.4 ASKO sea terminal at Port of Moss – ASKO sea drone

Layout of the ASKO sea terminal is shown in Figure 6. Letters and lines referred to in the following text refers to that figure. The ASKO sea terminal at Port of Moss is accessible via a public road (red line), and the entrance gate (A). The vehicles enter and park in designated areas (B) to decouple the semi-trailer from the tractor. Additionally, there is a turnaround area (C) where the tractor can turn around and couple to the semi-trailer it has been assigned to fetch. The terminal accommodates sea drones (E), which are docked at the ramp (D). Terminal tractors retrieve semi-trailers and push them onboard the sea drone. Trucks can also use charging stations (F). There are two chargers available for the vehicles. There is a separate exit gate (G) for vehicles leaving the terminal.



Source: Google Maps (Aerial photo)

Figure 6: ASKO sea terminal at Port of Moss

3.4.1 Cargo handling and responsibility

As the semi-trailer is not opened until it arrives at ASKO Oslofjord, there is no cargo handling at the sea terminal, and the responsibility for the cargo lies with ASKO Transport until the semi-trailer reaches its' destination.

3.4.2 Vehicle operation and driver tasks

Incoming vehicle:
Upon arrival at the sea terminal, the driver presses a button in the drivers' app, for the entrance gate to open.

The driver manoeuvres the vehicle to place the semi-trailer at the designated (numbered, e.g. B4) space given in the app. The driver then manually disconnects the semi-trailer from the road trailer. This includes several operations:

- cranking down the landing gear (retractable legs) supporting the semi-trailer when not connected to the tractor
- pulling a lever to release the kingpin securing the semi-trailer to the tractor
- de-coupling the air-supply and two power-supplies between tractor and semi-trailer

The driver uses the app to report to the terminal system that the semi has been safely parked at the designated space.

If necessary, the driver manually connects the vehicle to a charging station. The exit gate opens automatically for vehicles leaving the terminal.

Issues:
The terminal experiences challenges with some drivers not following the instructions about where to place the semi-trailer at the terminal. Space B4 may already be occupied when the intended semi-trailer arrives, creating trouble for this driver and all arriving later, as well as for terminal staff responsible for onward shipping of the semi-trailers. The terminal staff then has to manually check the location of each semi before starting the loading of the sea drone.

Forwarding the semi-trailer from the sea terminal:
The semi-trailer is pushed onboard the sea drone by a terminal tractor. Coupling these involve manual operations to securely physically connect the two units, air- and power supplies and cranking up the landing gear.

Once the semi-trailer is on board the drone, the de-coupling routines are repeated. Before de-coupling the air-supply, air is let out of the trailer suspension to leave the trailer resting on steel and not on air. This prevents the semi-trailer from swaying on the air cushion during the crossing. For the physical de-coupling of the two units, there is a push-button in the terminal tractor. A lamp at the dashboard indicates the status: locked or unlocked. This functionality is not – and will not – be available in road tractors, due to safety issues.

ASKO Transport holds the overall responsibility for transportation on land. The responsibility for the semi-trailer is handed over from ASKO Transport to ASKO Maritime when the driver confirms that the semi-trailer is delivered to the sea terminal in the terminal operating system. The driver manually takes pictures of the semi-trailer, to document its condition before leaving. The terminal staff also does this, before and after moving the semi-trailer from the parking area to the sea drone.

3.4.3 Communication

Incoming vehicle:

ASKO Maritime operates the sea terminal and has integrated systems for operating the sea terminal, booking slots on the sea drone and planning of loading/unloading of the sea drone. A transportation company, in this case ASKO Transport, books a slot at the sea drone. The booking includes phone number for the driver and planned arrival time for the vehicle The terminal does not get real-time updates of vehicle location en route from Vestby to Moss.

The driver gets all relevant information in an app integrated with the terminal operating system, including the designated numbered space for parking the semi-trailer. The information does not include instructions about driving pattern at the terminal, nor how to position the semi-trailer (direction of the drawbar).

When the vehicle arrives at the gate, the driver opens the gate with the app. The driver can enter at any time during the day, as there is no need for terminal staff to be present for opening the gate.

When the vehicle enters the terminal area, the semi-trailer is parked and secured on the assigned parking space. The driver confirms in the app that the semi-trailer has been safely parked at the sea terminal, and the Terminal system is updated with new status for the semi-trailer: "At the quay".

Issues:

According to ASKO Maritime, Automatic Number Plate Recognition (ANPR) is currently not considered an option for access management at the gate. The ASKO sea terminal in Horten, at the opposite end of the sea crossing, there is a 90-degree road bend in front of the gate, making ANPR for incoming vehicles difficult. Having different access management systems at the two terminals is not considered to be beneficial.

If a semi-trailer has been mis-placed in the terminal area, drivers arriving later may find their designated space already taken, meaning that they cannot correctly confirm in the app that the semi has been placed as instructed at the sea terminal.

Forwarding the semi-trailer from the sea terminal:

The terminal operating system creates a loading plan for the sea drone, based on the confirmed semi-trailers parked at the quay – or the manually corrected information about semis to be loaded onto the sea drone.

When the terminal tractor parks the semi-trailers on the sea drone, this is marked both in the sea terminal operating system and in the sea drone's operating system. This marking is done manually today.

When the loading process is completed, an overview of the load on the sea drone is sent to the operator responsible for receiving the sea drone at the ASKO sea terminal Horten.

3.5 Regulatory aspects

Professional transport is subject to a wide range of regulations and requirements applying for driving on public roads, including the Norwegian Road Traffic Act[13]. A comprehensive overview of requirements applying for professional transport is presented at the NPRA web-site[14]. Some of these requirements concern the driver specifically (e.g. Driving time and rest periods), some the condition of the vehicle (e.g. Tyres and chains), some documentation of operations (e.g. Tachographs and driver cards), and some also the transport operators (e.g. Permits).

Today, regulations "[...] stipulates that the notification and disclosure obligation for arrivals must be submitted electronically to the Norwegian Customs for freight transports."[15]

Within the terminals, general road traffic regulations will apply. At the same time, both drivers/vehicles and other employees are required to adhere to ASKO's safety regulations and comply with the Working Environment Act[16], which ensures a safe and healthy working environment for all employees.

The driver is legally responsible for verifying that the cargo is secure before starting driving.

[13] https://lovdata.no/dokument/NL/lov/1965-06-18-4 (Accessed July 8, 2025)
[14] https://www.vegvesen.no/en/vehicles/professional-transport/?lang=en (Accesses July 2, 2025)
[15] https://www.toll.no/en/corporate/digital-customs-on-importation-of-goods-to-norway/information-for-businesses/faq#legal-aspects (Accessed May 21, 2025)
[16] https://lovdata.no/dokument/NLE/lov/2005-06-17-62 (Accessed July 9, 2025)

4 «The story» - CCAM

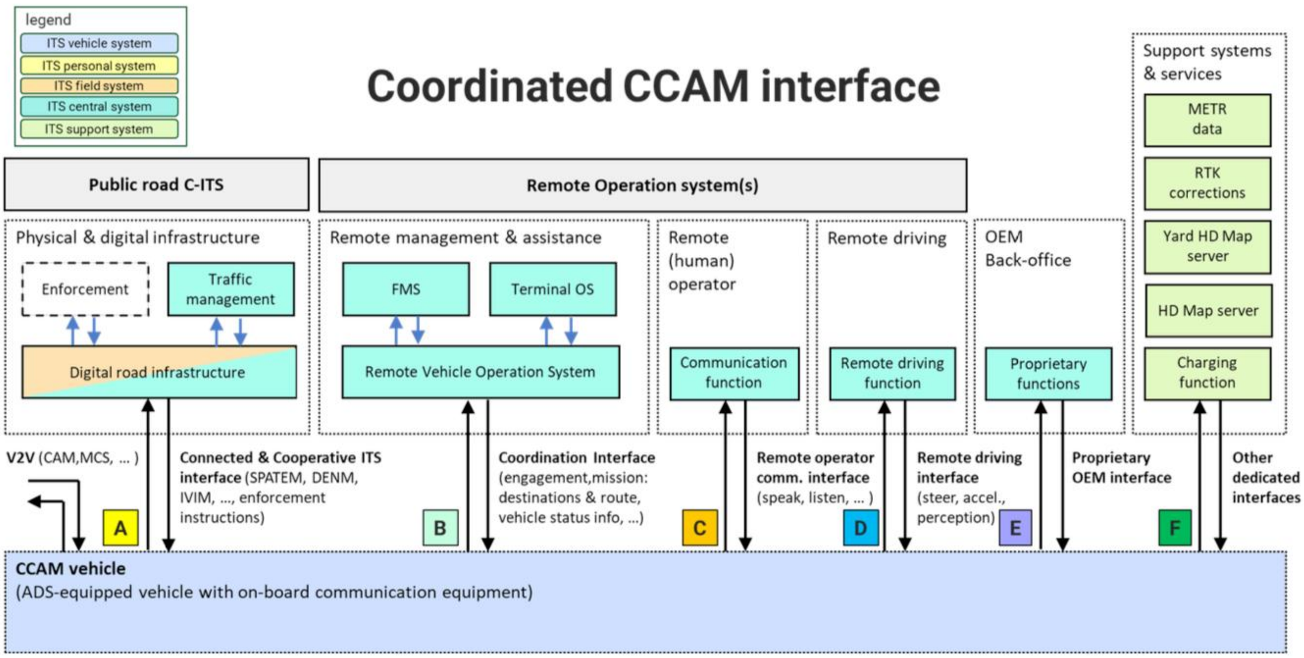
This chapter provides an attempt to describe issues, requirements and potential for completing the operations/purposes described in Chapter 3, with automated vehicles as indicated in the UC NO description. This is not a comprehensive list, but relies on discussions with informants during interviews and information available from MODI deliverables.

The background for the automated story is the same as described in chapter 1.3, but with the freight vehicles now being CCAM vehicles. The story follows the UC NO story, where the cargo is delivered to the ASKO consolidation terminal at Vestby with a CCAM vehicle from Einride, and the leg from Vestby to the sea terminal is driven by a CCAM vehicle from Volvo. For both legs, involvement of a remote operator is assumed for specific points en route.

The Einride vehicle is a rigid CCAM vehicle without a driver's cabin. On the first leg, this would work, even if the leg today is driven mostly with articulated vehicles.

The original UC Norway story uses indicates an L2 CCAM vehicle on the last leg, but for the sake of exploring possibilities and barriers related to removing the driver from the vehicle on the second leg as well, a CCAM vehicle is assumed. The vehicle is articulated.

A technical architecture for interfaces that can be used for communication with a CCAM vehicle has been suggested in MODI D4.1 "Validated interface for Coordinated CCAM" [4]. The different interfaces referred to in this chapter corresponds to Figure 7, which is copied from D4.1 and shown here to ease understanding.



Source: MODI D4.1, Figure 3.1

Figure 7: MODI high-level generic system architecture for defining the coordinated CCAM interface

4.1 Border crossing at Svinesund

The border crossing follows the same route and the same steps as described in chapter 3.1. In the Norwegian Customs area, the green-light scenario could continue as it is today. But the red-light scenario today requires actions performed by the driver. For these actions, different solutions must be used.

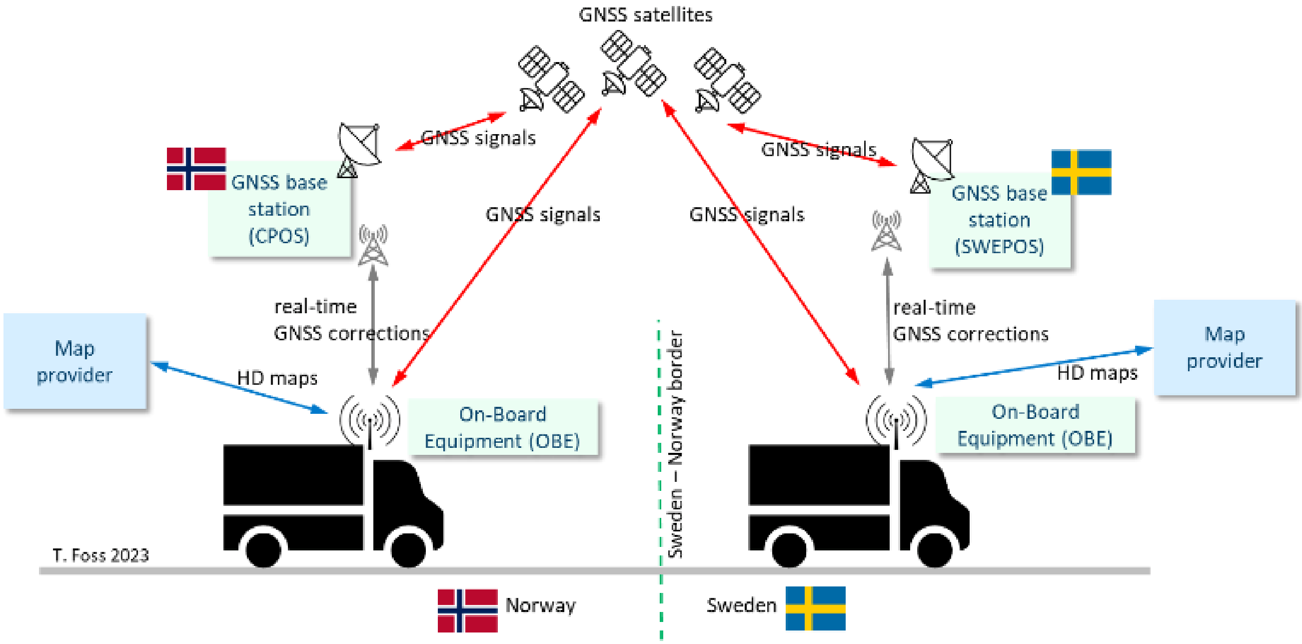
4.1.1 Cargo handling and responsibility

As today, crossing the border itself will not include any handling of the cargo, and there are no changes in distribution of responsibility for the cargo.

The CCAM vehicle may still be directed in for a manual customs control, including scanning and inspection of the cargo. For this to work, some agreement and practical solutions has to be in place for handling and securing the cargo and maintaining the chain of responsibility/liability for the cargo. This needs to involve the actor responsible for the cargo (in this case: UNIL) and the customs. Practicalities with overseeing and confirming that the cargo is properly placed and secured needs to be taken care of. Whether this could involve a representative from UNIL, a third party offering this as a service, or other solutions – even remote - needs to be addressed.

4.1.2 Vehicle operation

According to MODI D1.3 Report on border processes [1], crossing the border is a critical point for the CCAM vehicle, because it needs to switch from Swedish to Norwegian systems while still driving. The most important switch for the operation of the vehicle is switching real-time GNSS corrections from the SWEPOS GNSS base station to the Norwegian CPOS base station. This is required to get the correct reference frame for maps from the Norwegian map provider.



Source: MODI D1.3, Figure 3.

Figure 8: Provision of GNSS corrections and digital maps

For this switch to happen, the CCAM vehicle needs robust connectivity while crossing the border. This is explored in the paper "Border Crossing Connectivity for CCAM vehicles: A Field Test at the Norwegian-Swedish Border" [5], and even though there are technical solutions to address the problem there is currently a period without network connectivity when crossing the border while the handover between the Swedish and Norwegian roaming network is occurring. For the UC NO border crossing use case, Telia has developed a solution that ensures a minimal loss of connectivity, but this is not in ordinary use.

According to [5], CCAM vehicles' Operational Design Domain (ODDs) requires that it must be possible for a remote operator to supervise the vehicle and take control if the vehicle goes outside it's ODD at any time. This also requires robust and reliable connectivity with adequate bandwidth.

Source: Google Streetview

Figure 9: Border crossing from Sweden to Norway at Svinesund

If the vehicle loses connection to the remote operator and needs to perform an MRM (Minimal Risk Manoeuvre), it will possibly stop on the bridge and be unable to get connection again because it would then have to drive further into Norway. As shown in Figure 9, it is not evident that the bridge/border site has suitable locations for performing MRMs. For CCAM vehicles to cross the national border, it must also be made clear if a remote operation centre will operate across borders, or if there needs to be a switch between remote operation centres restricted by country borders.

In the customs area, the vehicle will have to be able to respond to the same kind of directions as the human driver in today's scenario. The customs area can be classified as a confined area, and the requirements for driving in confined areas are discussed more detail in chapter 4.3.2.

4.1.3 Communication

In the green-light scenario with CCAM vehicles, the process could be similar as in the current situation with a Digitoll-process. But as described in chapter 3.1.3, if the vehicle gets a red light, the current procedure is for the driver to walk to customs office to communicate with the officers. With the CCAM vehicle in this story, this is no longer possible, and new ways for this communication to work needs to be explored. Today, the driver is also responsible for making sure the license plate is readable for the ANPR-camera. Some solution to ensure this without a driver should be explored, either for making sure it is readable or for other digital communication to be used to recognise which vehicle is entering the area.

Effective communication between e.g. remote operators or any potential on-site representatives for the transport operator/cargo owner and customs personnel, as well as other control personnel, is crucial for managing the various scenarios inside the customs and control area. These scenarios include vehicle parking, document handling, vehicle scanning, and technical vehicle inspections. How this communication could be performed is discussed in chapter 4.3.3.

4.2 Driving on public roads

The route driven is equal to the one described for the current situation in chapter 3.2.

4.2.1 Cargo handling and responsibility

As today's situation, cargo is normally not handled while driving on public roads. Any random inspections may be handled as described in section 4.1.1.

4.2.2 Vehicle operation

Driving CCAM vehicles on public roads is explored in detail in MODI UC CCAM, with field tests for connectivity and sign and lane detection along the full corridor. The sections of European corridor E6 in "The story" are also included in the MODI UC CCAM, and findings from data collection there shed light on readiness and potential issues for L4 driving in these road sections:

- In the Q-free data collection [6], no cell phone signal loss (and good signal strength) was observed, and GNSS was mostly good (but with problems in tunnels) in the Norwegian part of the route. The Norwegian National Road Database (NRD) is also known to have high-quality data on road infrastructure.
- The sign and lane marking analyses conducted as input to the MODI D5.5 [7], found that Variable Message Signs (VMS) is harder to detect than regular signs, and these are frequent on E6, and no digital representation of the information is currently publicly available (Table 5.2 of MODI D4.2 [1]). E6 has overall good quality lane markings, but the analyses shows that it could still be hard to detect, especially with bad weather conditions, in tunnels and when there are complex lane markings.

The route includes challenging elements like ramps and merging with multiple lanes, exits with roundabouts, tunnels and bridges that the CCAM vehicle needs to handle. The part on Fv 151 also includes pedestrian crossings and junctions with crossing traffic. As stated in MODI D4.2 [1]:

> *"A general perception in the studied literature and from interviews is that the support provided by the physical infrastructure to human-operated vehicles is also expected to be sufficient for automated vehicles, as the industry intends to produce automated vehicles capable of operating in the existing network rather than creating vehicles that can only function on certain roads".*

The CCAM vehicle and/or its support system needs to be able to handle unexpected events, and to respond to instructions from authorities. This could include signs, variable message signs, being directed in for a traffic check or being pulled over by the police. It must also be capable to yield to emergency vehicles when needed. In case of incidents resulting in road closure and rerouting of traffic, it may also be required for the vehicle to be able to drive on smaller roads to avoid having to wait until the situation is resolved.

There must be a clear responsibility for making sure the condition of the vehicle is acceptable and that the driving is done according to the traffic regulations. This includes practicalities regarding tyres and snow chains (see section 3.2.2), and necessary actions related to any incidents or accidents. I.e. snow chains are today fastened by the driver, so there is need for e.g. an automated solution to this if the CCAM vehicle should operate during the winter season.

A more general and comprehensive look at the requirements for L4 driving on public roads can be found in MODI D4.2 [1], and an assessment on the readiness of the MODI corridor will be done in MODI D5.5.

4.2.3 Communication

In a scenario with an CCAM vehicle, current practice with little or no communication with the driver/vehicle does not have to change, but a remote operating centre will know where the vehicles are, so there is a possibility for better communication about arrival times.

In a scenario with CCAM vehicles, the communication from the vehicle to the remote operating centre must be automatic, and the remote operating centre may also have to be able to communicate directly with persons along the route if needed. It may also handle the communication with ASKO terminal, if there are delays.

The vehicle must follow the instructions from the officials, and there may also be a need to provide papers, either digitally or physically, related to the transport. Communication with officials along the route could be done through "Interface C" (from Figure 7), where an audio or video link is opened between the official and the remote operator, or through "Interface B" for more automated checks. If documents must be provided physically, this could be done by having a locked space in the vehicle for paperwork, which can be opened by a remote operator, as mentioned in MODI D3.3 [8].

"Interface A" from Figure 7 is also relevant on this route to be able to exploit the ITS G5 technology in the Patterød junction, and to drive more safely through Moss City centre if V2X technology is deployed to enhance safety for vulnerable road users.

MODI D4.4 [9] discusses how data-sharing between traffic orchestrators and fleet managers could improve the traffic flow and route choices when events occur. MODI D3.2 [10] chapter 2.5 mentions that the coming METR set of CEN/ISO standards could help "[…] the ability of the vehicle to plan and dynamically re-route according to special conditions and dynamic restrictions (weight, height, width, gradient, friction, urban access etc)".

4.3 The ASKO Vestby terminal

The layout of the consolidation terminal at Vestby is assumed to be equal to that described in chapter 3.3. The incoming vehicle is the CCAM vehicle from Einride, which is a rigid truck. The outgoing vehicle is an articulated CCAM vehicle from Volvo.

4.3.1 Cargo handling and responsibility

In a scenario with an CCAM vehicle, the current practices regarding handling of and responsibility for the cargo can be continued. This means that the terminal staff unloads the incoming vehicle and loads the semi-trailer that is being picked up. The loading could be done in cooperation with a loading boss from the transport company driving the outgoing vehicle as well.

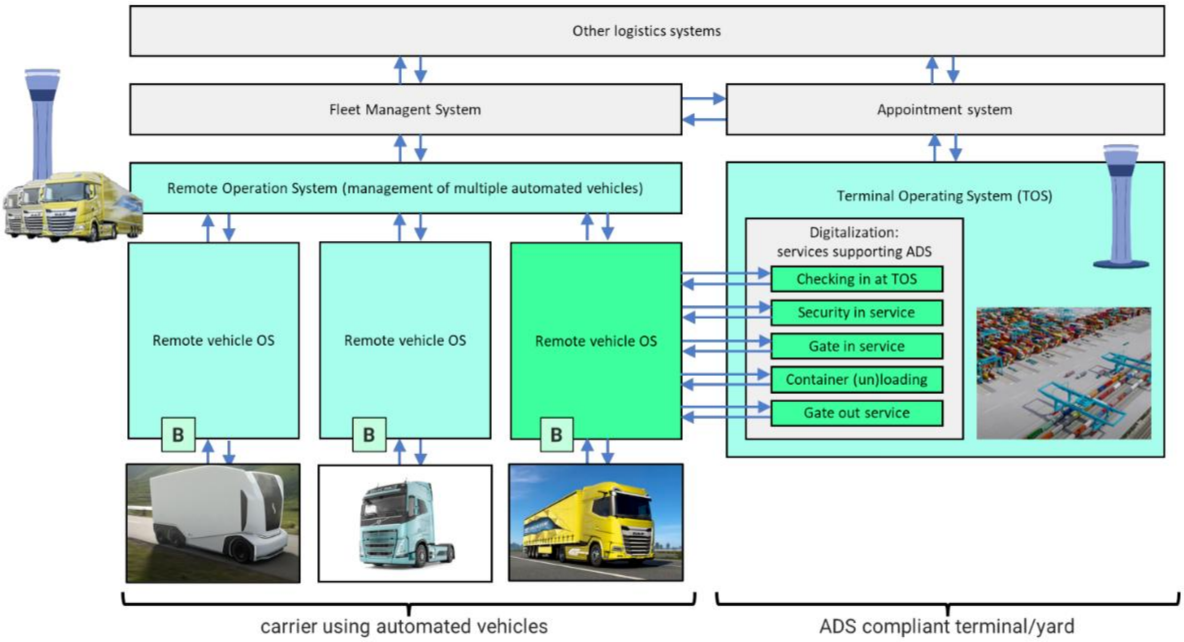
4.3.2 Vehicle operation

The CCAM vehicle must fulfil the same tasks as a human driver today, which includes manoeuvring in the confined area, reversing into the loading bay and parking at assigned parking spaces. A remote operation centre could e.g. be responsible for the driving while in the confined area, while the terminal is responsible for providing the necessary physical and digital infrastructure and giving correct instructions. Driving in confined areas is thoroughly discussed in MODI D4.3 [11]).

For a road-tractor to pick up the semi-trailer for delivery at ASKO sea terminal at Port of Moss, it must be possible to couple the semi-trailer. Coupling and decoupling without a driver present is discussed in chapter 4.4.2. Another critical aspect is reversing and reverse sensors when road tractors are coupled to different semi-trailers. In such scenarios, the semi-trailers need to be equipped with a standardized reverse sensor system that can seamlessly integrate with the road tractor - and potentially also to the remote operator system. This ensures that automated or remotely controlled vehicles maintain full situational awareness, regardless of the semi-trailer in use. Standardization across different manufacturers and logistics providers will be essential to achieve interoperability and reliability.

4.3.3 Communication

There is a potential need for the terminal to provide an HD-map of the confined area (possibly through "Interface F" in Figure 7), and to provide instructions to the vehicle (for example through "Interface B" in Figure 7). These instructions would replace today's manual communication through the reception, on where to park, unload, load and to perform check-in and check-out of the terminal. A suggested systems architecture for this communication is shown in Figure 10.



Source: D4.1, Figure 5.1

Figure 10: System framework for coordination interface (B)

Some communication between terminal staff and the remote operator could be performed through "Interface A" (see Figure 7), but there would still be need for an HD-map to understand the instructions, and there is potentially more room for mistakes and misunderstandings if the communication goes through two human beings before it reaches the vehicle.

In a L4 CCAM scenario, digitalization of the consignment note would be beneficial. An electronic consignment note, eCMR, has been in use since 2008 under a UNECE and IRU protocol[17]. So far, 25 countries have ratified or adopted it. Norway approved the protocol in 2020, officially allowing eCMR usage. As mentioned in section 4.2.3, another possibility is to keep a physical consignment note in a locked space that can be opened by the remote operator. According to the terminal manager, it would also be possible for the terminal to use the information gained from scanning the cargo directly, instead of using a consignment note.

4.4 ASKO sea terminal at Port of Moss – ASKO sea drone

The layout of the sea terminal is assumed to be equal to that described in chapter 3.4.

4.4.1 Cargo handling and responsibility

As today, there will be no handling of the cargo at the sea terminal, and thus there are no changes in distribution of responsibility for the cargo if an CCAM vehicle performs the haulage from Vestby to the sea terminal.

[17] https://lastebil.no/Paa-innsiden/Elektronisk-veifraktmelding-i-internasjonal-veitransport-den-nye-normen

4.4.2 Vehicle operation

The CCAM vehicle must follow the instructions given by the sea terminal operating system and navigate in the confined area. If it needs to charge, the chargers must support automatic connection (this is explored in UC SE), or terminal staff will need to be assigned the task of coupling the vehicle to the charging unit. The aspects on vehicle operations in confined areas described in section 4.3.2, also applies here.

In a scenario with CCAM vehicles, there is no longer a driver present to perform the coupling and decoupling of the semi-trailer. Automated solutions exist but are expensive and not standardized. Options for handling this, may be that all road tractors and semi-trailers used on this route support automatic coupling, decoupling and extracting/detracting of the landing gear for the transport chain to be fully automated, or, alternatively, that terminal staff could take care of these tasks. The latter would however require extended opening hours to continue to allow vehicles arriving outside current opening hours, or to restrict the hours for automated vehicles to enter the terminal, or lastly, that the vehicle is allowed to arrive at any time, but has to wait for the terminal staff to arrive in the morning, to perform the decoupling during regular hours.

There will be a need for an alternative to the current practice of the driver taking pictures to document status of the parked semi-trailer. Whether this task can be assigned to other personnel at the terminal, or this calls for new ways to document the condition of the semi-trailer before handing over the responsibility, should be explored.

4.4.3 Communication

With an CCAM vehicle arriving with the semi-trailer, there is a need for further automation at the sea terminal. The gate must be opened without an action by a driver, and there needs to be more exact information on where to park, and in which direction. Driving pattern in the terminal area may also need to be specified.

The terminal tractors used today are not automated, but in the future this part of the logistics chain could also be performed by CCAM vehicles. This could entail more integration with the sea drone remote operation system as well, if there are no longer any humans manoeuvring the semi-trailer on board.

The sea terminal should also provide an HD-map and be able to provide instructions to the vehicle, as described in chapter 4.3.3.

4.5 Regulatory aspects

When crossing the border with an CCAM vehicle, there is a need for harmonized regulations and permitting processes for cross-border operations. The vehicle must have permits for automated driving in both countries. As described above, there is a need for robust and reliable connectivity when crossing the border, and even though the technical issues are solvable, there are still several commercial and regulatory challenges. As described by Lykkja and Arnesen (2025) [5]:

> *"[...] traditionally, mobile networks near borders have been configured to minimize probability for network reselection to be able to keep network traffic in own network for commercial reasons. Given the complexity of the commercial and technical arrangements needed for seamless roaming it is not always a good business case to invest in seamless cross-border connectivity.*

Furthermore, regulatory requirements on e.g. frequency plans can make this technically challenging".

The vehicle must have permission to drive on both highways, classified roads, county roads, municipal roads and city centres. There is need for regulation regarding the certification of remote operators, and responsibility and liability for making sure the vehicle is in an acceptable condition and is equipped to handle the current weather conditions needs to be clearly defined and assigned to a liable party.

Traffic safety is one of the main objectives of current random controls of vehicle and driver while on the road. In a scenario with CCAM vehicles, there is no physical driver to test e.g. for sobriety. How to reach the same objectives regarding traffic safety for controls related to vehicles with no or a remote operator, needs to be addressed. In confined areas it must be ensured that the CCAM vehicles does not conflict with ASKO's safety regulations or the Working Environment Act.

5 Enablers and challenges for CCAM vehicles in logistic operations

The interviews conducted in this study provide a snapshot of one specific transport chain operated by logistics operators in Norway engaged in wholesale groceries. While this story does not represent the full diversity of the logistic sector, it offers valuable insights in the operational realities and strategic considerations regarding digitalization and automation of different operations in the transport chain. Even though other logistic operators may face different challenges, operate under different routines, or prioritize other aspects of their operation, this story brings attention to issues relevant for broader discussions about future of vehicle automation in logistics. The findings point to several critical considerations raised in the interviews and included in this chapter. However, it is also important to note that these considerations are not exhaustive. Other perspectives, issues and innovations undoubtedly exist within the sector, and further research is needed to capture the full complexity of automation's role in logistics.

In the following sections, key enablers and barriers mentioned in the interviews are added to the specific issues described in previous chapters, associated with the deployment of CCAM vehicles along the logistics corridor from border to port in MODI UC NO. Rather than proposing specific solutions, our aim is to identify and highlight critical obstacles and issues that could require targeted interventions by relevant stakeholders.

5.1 Economic feasibility

A key consideration in the discussion of logistics and automation is the economic feasibility and sustainability of automation efforts. While there are many existing possibilities for digitalization across the logistics sector, several initiatives remain unimplemented – despite being technically achievable. This mainly concerns lower-level digital solutions (such as digital documentation workflows), which are necessary but not sufficient for automation, but still require investment and organizational change. The reluctance to implement such solutions may stem from a lack of clear short-term return on investment, rather than technological limitations.

This challenge becomes even more pronounced when considering the broader digitalization gap between current terminal operations and the envisioned future scenario involving CCAM vehicles. Today, in this study, drivers are required to physically report to a manned reception upon both arrival and departure, and much of the communication along the route is still handled via phone or email. In contrast, the future system anticipates a fully digitalized communication flow, facilitated by fleet management systems, remote operator platforms, and remote vehicle interfaces (see Figure 10). This transition represents more than a technological upgrade. It demands a fundamental restructuring of operational workflows and infrastructure. Bridging this gap will require significant investments in digital systems.

As one terminal manager explained:

> *"We're working with maritime drones as part of our automation efforts, and what we're seeing is how much effort it actually takes to perform even simple automated manoeuvres in a safe manner. […] It often comes down to more fundamental reasons driving the development process, rather than immediate, tangible value, or the payback period is simply too long."*

This statement highlights a crucial point: the development and deployment of digital and automated solutions often require significant upfront investment – both in time and resources – and may not yield clear, short-term returns. This is particularly evident in one of the most common operations in the logistics industry: the coupling and decoupling of road trailers and semi-trailers carrying cargo. At present, this task is performed manually and relies heavily on human labour and experience. Although automated solutions for this operation are available, implementing them would demand significant investments. Thus, logistics operators may view the return on such investments as insufficient to warrant the substantial costs involved.

The potential to automate many manual tasks, such as automatic coupling systems or electronic support legs for semi-trailers, is technically feasible. ASKO has conducted preliminary investigations into the cost of implementing such innovations. However, their findings revealed that semi-trailer connector systems alone were priced at approximately NOK 150,000 (€12,700). Given that each road trailer and each semi-trailer require its own equipment, the total investment quickly becomes prohibitively expensive. As one of the terminal leaders put it: “Basically, you can get what you want - as long as you're willing to pay for it”. This underscores the reality that many such innovations remain untapped, not due to technological limitations, but because current solutions are not yet economically viable when weighed against practical constraints such as staffing needs, safety requirements, reliability, and return on investment.

Moreover, operational realities in the logistics sector remain largely unchanged: terminals still require personnel on-site, and removing certain manual operations does not necessarily result in substantial cost savings. In many cases, the marginal cost of eliminating these manual tasks may in fact outweigh the benefits, making them economically unsustainable. Similar considerations may apply to HD-maps for terminals, which represent added value only if there are automated vehicles at the terminal. This situation is likely not unique to the terminals included in this study, but reflects a broader reality across the logistics industry. As search for efficiency gains is prominent in the logistics sector, a digitalization or automation initiative presenting a clear and compelling business case for the logistic operation in question could be expected to be under consideration or even already implemented.

5.2 Infrastructure readiness

The interviews also touched upon the physical and digital infrastructure that automated vehicles are expected to operate within, and whether this infrastructure is adequately prepared.

HD-maps may be seen as essential for CCAM vehicles (MODI D4.2) [1]. HD-maps exist for public roads included in this study, and the quality of one such is investigated in UC CCAM, but HD maps are not available for any of the confined areas explored in this frame story. The requirements for the infrastructure related to both public roads and confined areas are explored in MODI D4.1 [4] and D4.2 [1], and an assessment in the readiness of the infrastructure will be part of MODI D5.5.

Connectivity at border crossings is especially relevant for this study. For cross-border operation, CCAM vehicles must switch systems between countries without latency or glitches. Also, for a remote operator to be able to monitor the CCAM vehicle, consistent connectivity is crucial. For the UC NO demonstrations, this has been solved using “one-off” solutions. For a full-scale cross-border deployment, this needs to be solved on a permanent basis.

Limited access to road shoulder enabling MRM will be an obstacle for CCAM operations. This has been identified as an issue for the Svinesund Bridge, and that will likely also be the case for large portions of the road network in Norway, especially for regional and local roads. The extent of this issue along the E6-part of the UC NO corridor will be explored in MODI D5.5.

For automation to replicate the flexibility of current logistic operation included in this study, automated vehicles need to be able to operate seamlessly across all levels of the road network – motorways, regional roads, and local access roads. In addition to issues relating to varying road designs and standards, this may also introduce governance challenges, as these roads may be owned and managed by different authorities. In Norway, the main national roads and European routes are typically managed by the NPRA, while county and municipal roads fall under local jurisdictions. This fragmentation may imply issues relating to responsibility, funding and regulatory alignment. For this UC NO study, cross-border operations may add an extra layer of complexity in securing the readiness of physical infrastructure for CCAM vehicles. However, from road-owner perspective, the position may seem to be that automated vehicles must be able to use the physical infrastructure as it is today ([1], Ch.3.4.2), leaving this a challenge for OEMs and other technology providers.

5.3 Safety and human behaviour

Safety is a central issue in the deployment of CCAM vehicles - particularly the need to prevent accidents and injuries. This is prominent in the discussion of potential benefits from automation - namely removing the human, and hence also erratic human behaviour from the equation. This applies to road transport and terminal operations alike.

During the interviews, operators described unwanted driver behaviour potentially leading to incidents and injuries, and measures taken to prevent this. One terminal manager described a recurring safety issue involving some foreign drivers, who, despite clear protocols, have driven off while their vehicles were still being unloaded, and thus posing serous risks to ground personnel involved in the unloading processes. In response, the terminal has introduced a policy requiring foreign drivers to hand in their keys at reception once the vehicle is positioned at the loading bay. However, even this measure had proven insufficient in some cases, as drivers have brought duplicate key sets, circumventing the safety protocol. These examples of procedural non-compliance and incidents underscore that human behaviour is an inherent factor, and that even well-designed procedures can be undermined by individual actions.

This high-risk behaviour from the foreign drivers in question, was tied to their engagement in cabotage operations. This activity may entail competitive pressure, where the goal for the driver is to “beat the competitors” to securing the next assignment. This may involve rushing and potentially speeding from e.g. a ferry to the terminal in order to be first in line there, and next, rushing through and ignoring terminal procedures to be the first back on the road, ready for a new assignment. This race-to-the-next-job dynamic can lead to dangerous situations and reduced compliance with safety protocols, further complicating the operational environment both on the public road and on terminal areas.

In this context, CCAM vehicles may offer a compelling safety advantage. Unlike human drivers, automated systems follow operational routines with precision and consistency. They do not act impulsively, ignore instructions, or attempt to bypass safety protocols. By removing certain human elements from high-risk operations, automation can reduce the likelihood of accidents caused by non-compliance. In this sense, CCAM vehicles represent an opportunity to design safer and more reliable logistics processes.

Nevertheless, the practical implementation to full automation reveals a more complex picture, where hesitation and operational conservatism may play a part (“Better the devil you know than the devil you don't”). The same terminal manager who described these driver-related incidents, expressed limited trust in fully autonomous vehicles, emphasizing instead the value of improving existing semi-automated processes. While human error is a known risk, the threshold for trusting autonomous systems may be higher than that for human operators. As the manager explained:

> *"It needs to be thoroughly tested and account for every possible scenario before we can even begin. You can't start testing in an environment like ours. That said, it's not unthinkable that sensor technology will eventually become good enough – even with forklifts and 60-ton vehicle in motion. I believe it will probably happen at some point...but I'm not sure today's technology supports it. Even if the software is capable. I doubt we have the necessary hardware or practical equipment to handle deviations or component failures without causing a complete stop or triggering an unwanted action. I don't feel we're quite ready to go down that road yet. I don't think we're there with cars in general – let alone trucks."*

This perspective suggests that, while automation may hold considerable potential, expectations toward autonomous systems can be more demanding than those applied to human operators. To gain broader acceptance, autonomous systems are often expected not only to match human performance, but to exceed it, both in reliability and in the ability to integrate seamlessly into complex operational environments.

5.4 Tacit terminal knowledge and remote operation staff

One of the key challenges in automating the logistics chain, particularly from the perspective of terminal operations, is the difficulty of replicating the tacit knowledge and informal communication that currently underpin daily workflows. Daily operations are highly flexible, with on-the-spot decision-making often being a necessity to maintain efficiency and safety, and to handle unexpected events and disruptions. Much of the operational efficiency in terminals today relies not only on formal procedures, but on accumulated experience, local familiarity, and subtle, often unspoken coordination between personnel. Drivers, terminal workers, and loadmasters develop a shared understanding of routines, trailer positioning and tasks through repeated interaction. Instructions may be conveyed through brief verbal cues or gestures, relying on mutual knowledge of the terminal layout and established practices. For example, a returning driver may only need a quick nod or short phrase to know exactly where to park, or which trailer to pick up.

This type of informal, experience-based communication may be difficult to codify and even harder to translate into the structured logic required by autonomous systems. Will CCAM vehicles (to some degree) be able to draw on "memory" from previous visits, like human drivers, or will every instruction have to be precise and machine-readable? The introduction of CCAM vehicles may necessitate a formalization of communication and procedures that could reduce the flexibility and responsiveness that currently characterize terminal operations.

Also, for a remote operation, capturing and transferring this practical knowledge may be a challenge. Recruitment and training experienced drivers with a background in the logistics sectors could be one way to ensure that the practical insight, situational awareness, and ability to handle complex challenges "on the fly", is forwarded into the remote operation room. These professionals bring with them not only technical knowledge but also an understanding of operational flow, safety protocols, and maybe also the informal routines that keep terminal activity running smoothly. During the course of this study, we also spoke to representatives of HIVE Autonomy, working with ASKO Maritime on automation of the terminal tractors at the sea terminal, and remote operation of a crane at Port of Moss. They are also demonstrating automated and remote operation of heavy machinery at a test facility in Kristiansand. Their approach is to require that a remote operator for a specific vehicle/equipment holds a licence for and substantial experience from operating the type of vehicle/equipment in question.

5.5 Regulatory gaps and need for legal innovation

As automation advances, there is a need for regulatory frameworks to evolve to reflect a new operational reality that includes remote controlled or autonomous systems. This requires a careful reassessment of existing regulations. Apart from the Law on testing of self-driving vehicles[18], which is prepared specifically with automation issues in mind, for this study alone, a range of current regulations, such as Norwegian Road Traffic Act[19], the Working Environment Act[20], and the Harbours and Fairways Act[21] for port operations are relevant, and neither were designed with full automation in mind.

Without deeper insights, we expect that ongoing international activities on standards and regulations, e.g. under the United Nations UNECE, will address many of aspects of these issues. Regulations relating to random testing of remote operations staff on e.g. on alcohol and drug abuse, and random controls of automated vehicles and cargo should also be subject to further work at appropriate regulatory level.

Also, there likely are remaining issues relating to legal responsibility of a remote operator in the event of an incident or damages to vehicle or cargo, and need for harmonization of rules across borders to ensure clarity and consistency when automated vehicles/remote controllers operate transnationally.

Local rules and operational protocols may vary between terminals and ports, as operators in confined areas may be allowed to define site-specific regulations, deviating from those applying for public roads. However, in Norway, all testing of automated vehicles, even in confined areas, must comply with the Law on testing of self-driving vehicles and apply for a permit, unless exemption is granted[22]. This is also the case for HIVE Autonomy, who informed us that they comply with these requirements for their automated operation in terminals.

18 https://lovdata.no/dokument/NL/lov/2017-12-15-112
19 https://lovdata.no/dokument/NL/lov/1965-06-18-4
20 https://lovdata.no/dokument/NLE/lov/2005-06-17-62
21 https://lovdata.no/dokument/NL/lov/2019-06-21-70
22 https://www.vegvesen.no/fag/trafikk/its-portalen/automatisert-vegtransport/utproving-av-selvkjorende-kjoretoy/

6 Concluding remarks and main findings

The primary objective of this study has been to gain a more comprehensive understanding of logistic perspectives and potential implications of introducing CCAM freight vehicles in the logistic transport chain – here exemplified by the border to port-frame story included in MODI UC NO. This summary presents some main findings, but is not exhaustive.

6.1 Consequences of CCAM for the transport chain

Some dimensions of the transport chain will be more affected by a transition to CCAM vehicles than others. Main takeaways are presented in the following.

Cargo handling and responsibility – Introducing CCAM vehicles in this transport chain will not impact handling of and responsibility for the cargo in a substantial way. Current practices at terminals can mainly be continued, but where today drivers are involved in loading cargo onto the vehicle, this will have to be taken over by e.g. terminal staff or a representative of the transport company. The handing over of responsibility for the cargo will have to be a part of these considerations. For controls of cargo – be it at customs clearance or random controls en route - there will be a need to find solutions for the practicalities with overseeing and confirming that the cargo is properly placed and secured before the vehicle continues driving.

Vehicle operation – For CCAM vehicles to operate on the entire border-to-port transport chain, requirements for CCAM Vehicles, for PDI in public and confined areas and for corresponding interfaces, needs to be met. These issues are addressed in MODI WPs 3 and 4. Requirements related to digitalisation and automation of more specific logistic-related routines and technology probably needs to be adapted to the individual terminal or logistic operation.

In this study, issues relating to the readiness of PDI and vehicles include the need for coherent and reliable connectivity e.g. at border crossings, varying quality of signs and lane markings and lack of sufficient space for MRMs, and need for vehicles to be capable of operating on the varying types of roads and infrastructure elements, and at speeds comparing to that of the general traffic. The CCAM vehicle and/or its support system needs to be able to handle unexpected events, and to respond to instructions from authorities. This could e.g. include signs, variable message signs, being directed in for a traffic check or being pulled over by the police. For manoeuvring in confined areas such as terminals and customs areas, HD maps will likely be required.

“Out of the vehicle”-processes currently handled by the driver, e.g. for customs clearance or at terminals, will need to be performed by appropriate staff e.g. representing the transport company, or to be transformed into fully digitalised and automated processes. This would require fully digitalised paper trail, detailed coding of manual processes to be automated, and substantial investment in technology for automation of coupling and de-coupling of road tractor and semi-trailer. For the transport chain in this study, indications are that a re-assignment of manual operation at terminals from driver to terminal staff or an on-site representative for the transport operator, would be a relevant solution. For the ASKO sea-terminal this could be a service they could provide to the transport operator.

How to handle and comply with requirements regarding tyres and snow chains must be further explored if year-round operation of CCAM vehicles in Norway is to become a reality.

Communication – In the current situation, there is little or no communication with the driver/vehicle while enroute, but the driver is expected to be directly involved in exchange of communication relating to customs clearances and at terminals.

For the customs clearance involving CCAM vehicles, “red light”-routines, where currently the driver walks to customs office to communicate with the officers, will have to be replaced by fully digitalised/automated communication or be taken over by other representatives for the transport operator.

Current routines for checking in and out of the ASKO Vestby terminal are based on face-to-face-communication between driver and terminal staff at the reception, and preparing for CCAM vehicles will require major changes in technology, organisation and routines at the terminal. Even though the ASKO sea terminal has digital processes for gate entry, this will also have to be further developed, as the driver has to “push the button” to activate gate access. For both terminals, codifying current communication regarding directions for loading bays and how to place semi-trailer, would be a substantial task.

6.2 Enablers and challenges

While the findings offer valuable insights into the operational and strategic implications of automation in logistics, they also underscore the complexity and context-specific nature of such transitions. Importantly, several critical issues remain unresolved and warrant further investigation. a range of thematic areas:

Economic feasibility – Despite the technical viability of solutions for automation, implementation can be hindered by high upfront costs and uncertain return on investment. The reluctance to adopt even lower-level digital solutions reflects a concern about economic sustainability, particularly when automation does not reduce labour costs or improve efficiency in the short term.

Infrastructure readiness – Deployment of CCAM vehicles depends on both physical and digital infrastructure being sufficiently prepared. Fragmented governance across different road authorities may add complexity to infrastructure planning.

Safety and human behaviour – While automation promises enhanced safety by eliminating human error, the transition raises complex regulatory and operational questions. Incidents involving non-compliance with safety protocols highlight the variability of human behaviour, yet trust in autonomous systems remains limited.

Tacit knowledge and operational flexibility – Terminal operations rely heavily on informal communication and tacit knowledge, which are difficult to formalize or replicate in automated systems. A shift to remote operations further complicated this issue, as it demands transfer of experiential knowledge that is not easily codified. This underscores the importance of recruiting experienced personnel in remote operations.

Regulatory gaps and legal innovation – Existing laws provide only partial coverage and were not designed with full automation in mind. Regulation of CCAM vehicles and remote operations needs further work – e.g. on requirements and enforcement.

MODI

References

[4] Storrønning, T., Jetlund, K., Jakobsen, G.C., Wold, H., Eskedal, T.G., Sæther, S.R., Verweij, F., Briele, A.M., Dierke, J, Svensk, P-O, Sirland, T.R., Ekmann, B., Tangrand, K, Lykkja, O.M., Arnesen, P., Meijer, W, Grønnevet, B., Hovland, T., Wijk, P., Arts, G. (2024) Optimal Designs of Physical and Digital Infrastructures for Public Roads. MODI Deliverable 4.2

[5] Bräutigam, J., Foss, T., Jetlund, K., Brunes, M.T., Wijk, P., Rostoft, M.S., Sirland, T. (2023) Report on border processes. MODI Deliverable 1.3

[6] Fagerholt, Randi A., Sande, André B., Mølnvik, G. (2024). Logistic operator's experiences of digital customs processes in Norway Svinesund. MODI project memo, 2024-02-01.

[7] Schmeitz, J., Verhaeg, G., Foss, T., Meijer, W., Wijk, P., Huisman, R., Briele, A.M., Dierke, J., Lykkja, O.m., Arnesen, P., Westling, M., Riedmann, E., Meer, J.v.d. (2025) Validated interface for Coordinated CCAM. MODI Deliverable 4.1

[8] Lykkja, O.M., Arnesen, P., (2025) Border Crossing Connectivity for CCAM vehicles: A Field Test at the Norwegian-Swedish Border. Paper presented at TRA 2024.

[9] Bjelle, E.L., Dahl, E., Arnesen, P., Lykkja, O.M. (2024) Q-Free data collection - input to deliverable 5.5, MODI project memo, 30th June 2024

[10] Heggem, E., Dahl, E., Arnesen, P., (2025) Sign and lane marking analyses, MODI project memo, 10.02.2025

[11] Wijk, P., Walter, A.L., van Waterschoot, B., Jenssen, G., Moen, T., Phillips, R., Saluäär, D., Uyttendaele, A., Vandenhoudt, J. (2023) Report on User/Driver-vehicle interface. MODI Deliverable 3.3.

[12] Spoelstra, J., et al (2023): Collaborative CCAM Fleet- and Traffic Management, MODI Deliverable 4.4

[13] Søråsen, R., Elnes, B., Wijk, P., Schmeitz, A., Seininger, P., Dagerhorn, U., Johansson, V., Moen, T. (2023) Report on automation requirements, MODI Deliverable 3.2

[14] Meijer, W., Spoelstra, J., Das, A., Schmeitz, A., Huisman, R. (2024) Optimal designs of physical and digital infrastructures at confined areas, MODI Deliverable 4.3

Abbreviations

ANPR	Automatic number plate recognition
API	Application Programming Interface
CCAM	Connected, Cooperative and Automated Mobility
CEN	Comité Européen de Normalisation (European Committee for Standardization)
eCMR	Electronic consignment note
GNSS	Global Navigation Satellite Systems
HD Map	High-definition map
HES	Health, Environment and Safety
IRU	International Road Transport Union
ISO	International Organization for Standardization
ITS	Intelligent Transport System
L2 CCAM	Level 2 CCAM
L4 CCAM	Level 4 CCAM
NPRA	Norwegian Public Roads Administration
NRD	Norwegian National Road Database
MRM	Minimal risk manoeuvre
ODD	Operational Design Domain
PDI	Physical and Digital Infrastructure
RO	Remote Operation
RQ	Research Question
RSU	Roadside Unit
SAE	Society of Automotive Engineers
SUC	Sub-Use Case
UC	Use Case
UC NO	Use Case Norway
UC SE	Use Case Sweden
UNECE	United Nations Economic Commission for Europe
VMS	Variable Message Sign
VRU	Vulnerable Road User

A Vehicle definitions from Glossary for transport statistics (Eurostat2019)

B.II-20 GOODS ROAD VEHICLE

Road vehicle designed, exclusively or primarily, to carry goods. Includes categories N and O of the UN Consolidated Resolution on the Construction of Vehicles (R.E. 3).

Included are:

a) Light goods road vehicles with a gross vehicle weight of not more than 3 500 kg, designed exclusively or primarily, to carry goods or to be used by craftsmen, e.g. vans, pick-ups, and two- or three-wheeled vehicles;

b) Heavy goods road vehicles with a gross vehicle weight above 3 500 kg, designed, exclusively or primarily, to carry goods;

c) Road tractors;

d) Trailers and semi-trailers;

e) Agricultural tractors permitted to use roads open to public traffic.

B.II-22 HEAVY GOODS ROAD VEHICLE

Goods road vehicle with a gross vehicle weight above 3 500 kg, designed, exclusively or primarily, to carry goods. Refers to categories N_2 and N_3 of the UN Consolidated Resolution on the Construction of Vehicles (R.E.3).

B.II-23 TYPES OF BODY OF GOODS ROAD VEHICLE

Classification of goods road vehicles by types of their superstructures.

The following classification of types of bodies of goods road vehicles is considered:

a) Ordinary open box:
   - With cover;
   - Flat.

b) Tipper.

c) Tanker:
   - Solid bulk;
   - Liquid bulk.

d) Temperature controlled box.

e) Other closed box.

f) Skeletal container and swap-body transporter.

g) Livestock transporter.

h) Others.

B.II.25 LORRY/TRUCK

Rigid road motor vehicle designed, exclusively or primarily, to carry goods.

B.II-26 **ROAD TRACTOR (SEMI-TRAILER TRACTOR)**

Road motor vehicle designed, exclusively or primarily, to haul other road vehicles which are not power-driven (mainly semi-trailers).

Agricultural tractors are excluded.

B.II-28 **TRAILER**

Goods road vehicle designed to be hauled by a road motor vehicle. With semi-trailers (see B.II-30), refers to category O of the UN Consolidated Resolution on the Construction of Vehicles (R.E.3).

This category excludes agricultural trailers and caravans.

B.II-30 **SEMI-TRAILER**

Goods road vehicle with no front axle designed in such way that part of the vehicle and a substantial part of its loaded weight rests on a road tractor. With trailers (see B.II-28), refers to category O of the UN Consolidated Resolution on the Construction of Vehicles (R.E.3).

B.II.31 **ARTICULATED VEHICLE**

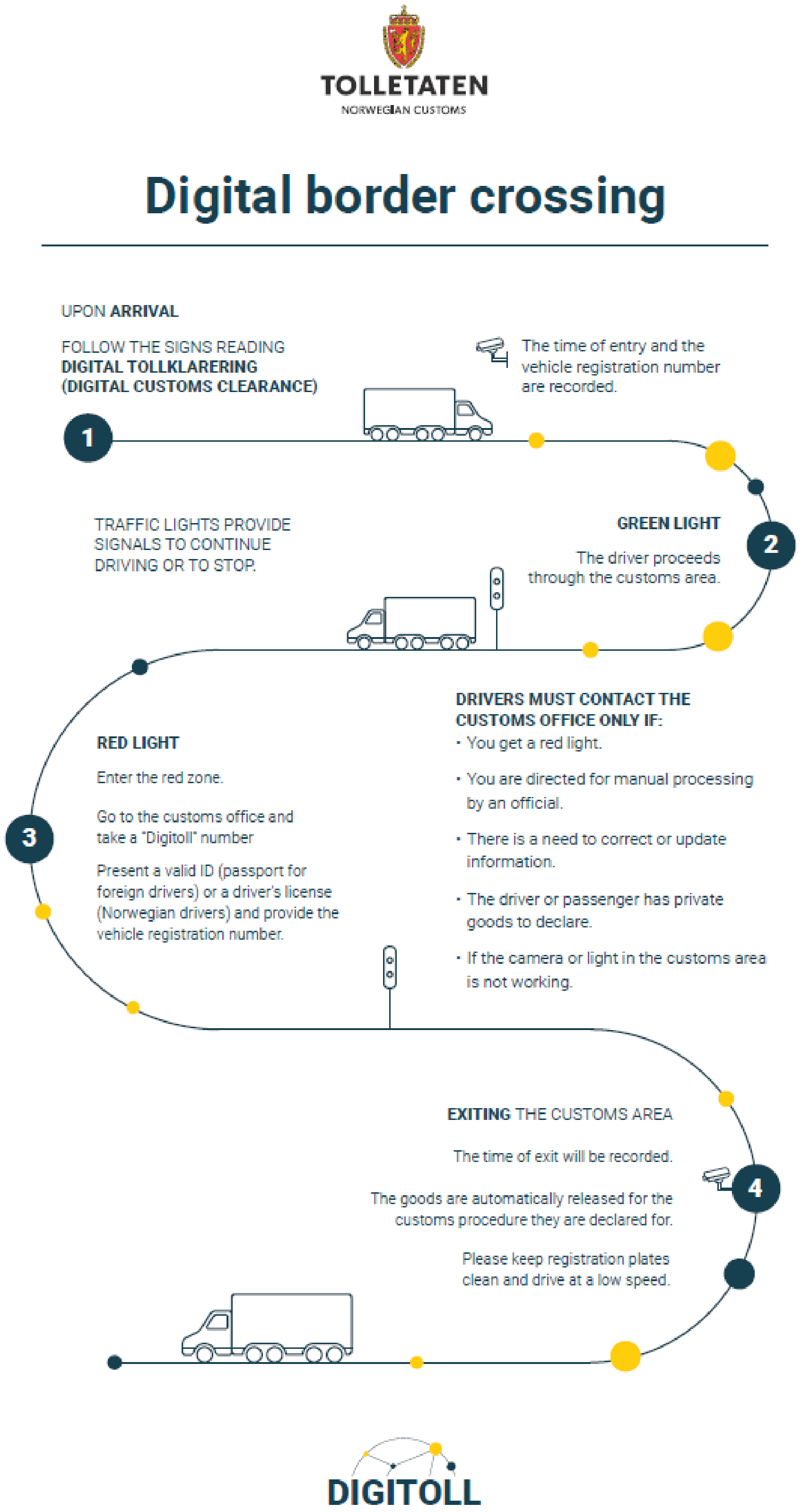
Road tractor coupled to a semi-trailer.

B.II-32 **ROAD TRAIN**

Goods road motor vehicle coupled to a trailer.

Articulated vehicles with a further trailer attached are included.

B Digitoll border crossing – Print-out flyer



Source: https://www.toll.no/en/corporate/digital-customs-on-importation-of-goods-to-norway/information-for-businesses/border-crossing/print-out-flyer (Accessed July 2, 2025)

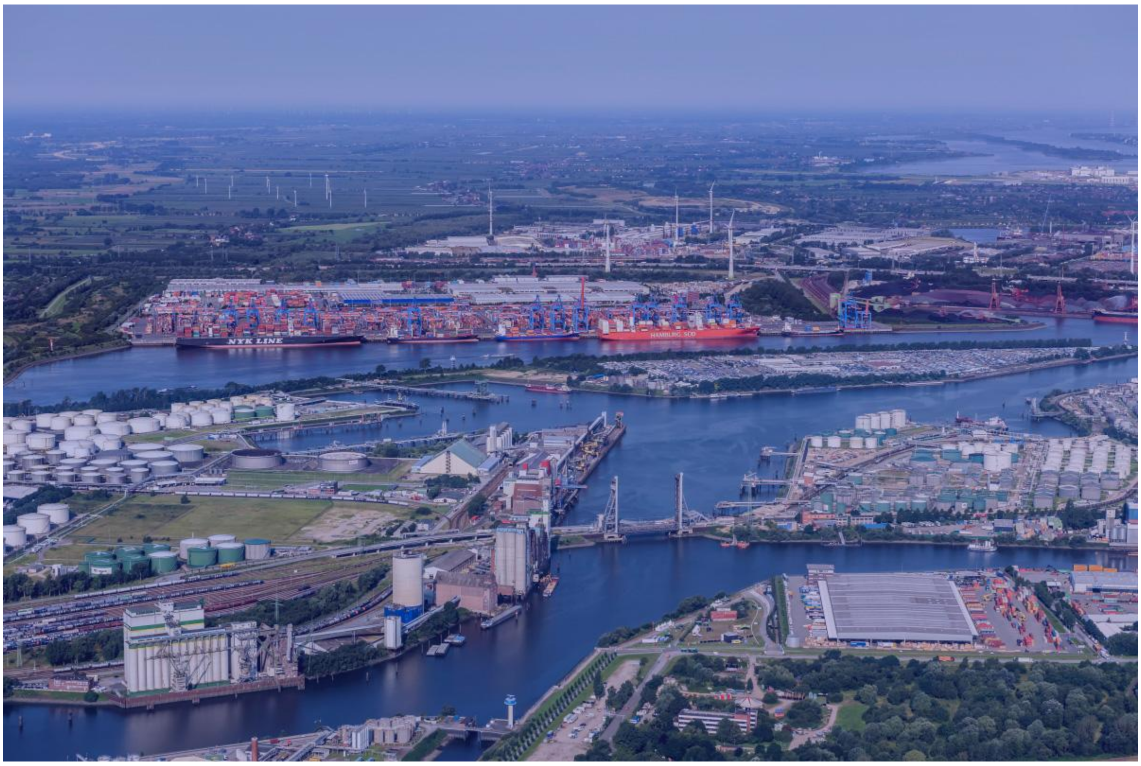
Annex 2

A leap towards SAE L4 automated driving features

Results from logistics survey

WP5.4 UC Norway

23 October 2024



Authors:
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1 Introduction and aim

The MODI project wants to accelerate the introduction of highly automated solutions to improve European logistics chains. When introducing highly automated freight vehicles, stakeholders working within logistics will be the users and hence the ones most affected. For the MODI project to have relevance and be interesting beyond technological development, user perspectives need to be considered. The value chain of logistics is so complex that it is important for the project to gain insights into the industry's own viewpoint.

The aim with this study is to map and consider perspectives on automation among core stakeholders in the European logistics chain. It is being conducted as a part of work package 5.4 in Use-case Norway in the MODI project.

The objective is to map the automation readiness within the different parts of the logistics chain, by conducting a survey targeting the European logistics industry. Some key questions included in the survey are whether the actors in logistics are prepared to welcome automation, if they see it as providing mainly opportunities or obstacles, what kind of new risks it entails and which parts of the logistics chain that have the most potential to benefit from automation. Despite being widely and repeatedly distributed to relevant networks, reaching a significant amount of logistics actors, the final response rate of the survey was very low. With a total of 13 fully completed answers (n=27 being the highest response rate on some questions), the survey results cannot be used for generalisation. These results might, however, provide relevant insight into the future of automation in the logistics sector.

This memo is structured as follows: Chapter 2 describes the method utilised in this study, followed by chapter 3 which presents the survey results. Finally, chapter 4 discusses the survey results and the method.

2 Method

As the focus of this study is how automation will affect the logistics chain, the target group in the survey consists of persons working within the logistics industry. After some consideration, in collaboration with ALICE[23], the study group was divided into the following seven categories: vehicle provider, technology provider, logistics platform provider, shipper, logistic site operator, logistic company, and other.

The survey was created using the web-based tool Netigate. Questions were based on the aggregated requirements from potential users of automated trucks in the MODI deliverable 1.1, "User and stakeholder requirements"[24]. The survey was developed in April-May 2024 and thereafter refined based on feedback meetings with key stakeholders in the MODI project – representing Maersk, the port of Moss and ALICE.

The final survey consists of five main sections. The first section aims at mapping information about the respondent to provide relevant context for the answers. The second asks for the status

[23] https://www.etp-logistics.eu/
[24] https://modiproject.eu/wp-content/uploads/2024/06/MODI_D1.1_user_and_stakeholder_requirements_submitted-.pdf

of automation in the respondent's organisation: where are we at now? The third section wants to get the respondent's position on what are the drivers and barriers for automation, while the fourth section explores benefits and challenges related to the topics of safety, efficiency and driver shortage. In the last section, respondents are challenged to think about the future of automation, through being presented a future scenario of an automated truck driving successfully across the Swedish/Norwegian border, describing a simplified version of Use-case Norway.

The survey has a semi-structured design and consists of some closed questions with multiple-choice and scales, while others are open-ended, not mandatory but encouraging those with opinions to elaborate on them. The option of "I don't know" persists throughout the survey.

The opening day of the survey was 11th of June 2024, and the data collection period lasted until 15th of September 2024. Initially it was distributed to MODI contacts, and thereafter by CLEPA, ALICE, ITS Norway, port of Moss and Maersk to their respective members and/or networks. Methods for distribution was through targeted newsletters, dedicated LinkedIn-posts and by directed emails to the relevant networks/members of CLEPA, ALICE and Maersk. Methodological challenges and possible explanations for the rather low response rate will be discussed in chapter 4.

3 Survey results

This section summarises the main results from the survey. As the total number of respondents are relatively small, with n=27 being the highest response rate on some questions and n=13 as the lowest, we cannot carry out statistical analysis based on these survey data. Therefore, in this section we will rather focus on presenting descriptive statistics, covering the five main categories described above: 1) Background information, 2) Status of automation, 3) Drivers and barriers for automation, 4) Benefits and challenges, 5) Automation in the transport sector. These categories form the structure of this section.

3.1 Background information

The first section in the survey includes background questions on type of stakeholder, country of organisation, geographical distribution, size of organisation and finally segment of goods. As seen in Figure 1, the sample is quite evenly distributed across the different organisational categories. This question received 27 unique responses. However, as several answers were possible, the categories received 37 answers in total. Figure 1 also shows that 9 out of 27 unique respondents answered "Other", indicating that the response categories may not have been comprehensive enough to cover the different organisations. These 9 respondents answered that they belong to the following organisations:

- ONG/OdV
- Research
- Association of logistics companies
- Logistics management system provider
- Network
- Tier 1 Supplier
- Consulting
- Ass
- Association related to logistics

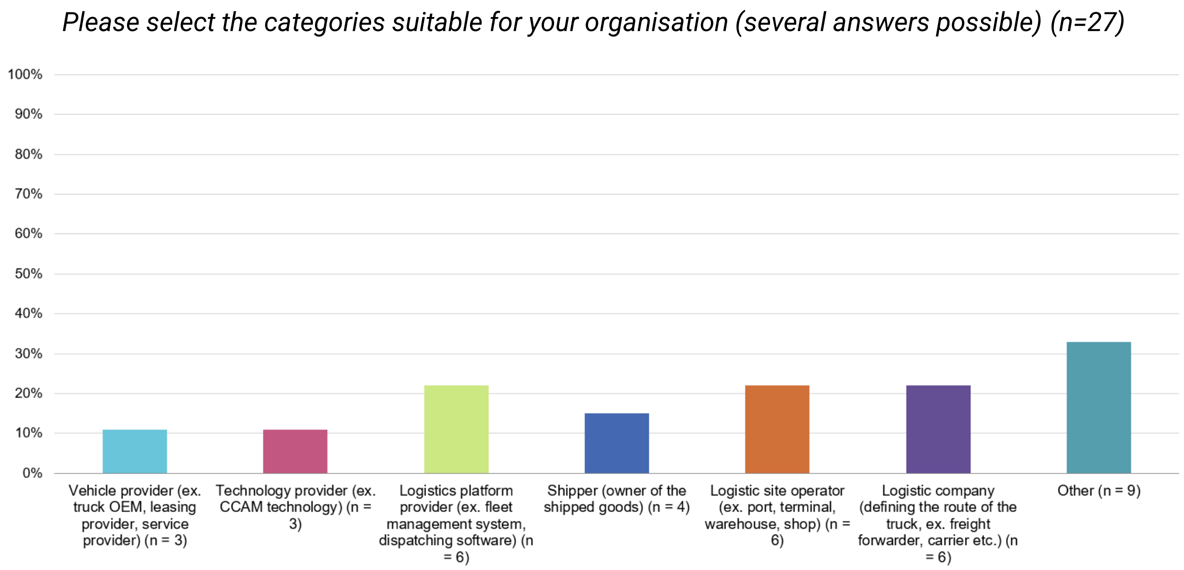


Figure 1: Responses to the question regarding their organisational affiliation

As seen in Table 1, when asked about in which country the headquarter of the respondent's organisation is based, 8 out of 27 organisations represented in the sample are located in Norway, while 5 are located in Belgium, 1 in the Republic of Cyprus, 2 in Denmark, 5 in Germany, 3 in Italy, 1 in Poland and 2 in Sweden.

Table 1: In which country is your organisation based (headquarter)? (n=27)

Categories	Frequency	%
Austria	0	0
Belgium	5	19
Bulgaria	0	0
Croatia	0	0
Republic of Cyprus	1	4
Czech Republic	0	0
Denmark	2	7
Estonia	0	0
Finland	0	0
France	0	0
Germany	5	19
Greece	0	0
Hungary	0	0
Iceland	0	0
Ireland	0	0
Italy	3	11
Latvia	0	0
Liechtenstein	0	0
Lithuania	0	0
Luxembourg	0	0
Malta	0	0
Netherlands	0	0
Norway	8	30
Poland	1	4

Portugal	0	0
Romania	0	0
Slovakia	0	0
Slovenia	0	0
Spain	0	0
Sweden	2	7
UK	0	0
USA	0	0
Asia	0	0
Other	0	0
Total	27	100

Figure 2 shows that 33 % (n=9) of the organisations in the sample operates in “More than 10” countries, while 15 % (n=4) operates in “6-10" countries and 19 % (n=5) operates in “2-5” countries. The remaining respondents answered that their organisation only operates in “1” country (n=7) or “I don’t know” (n=2).

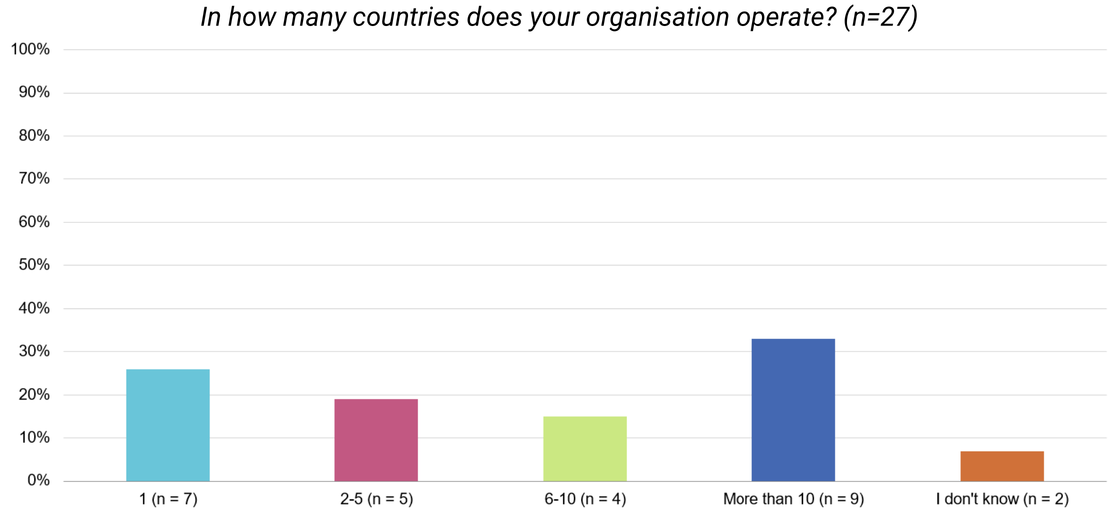


Figure 2: Responses to the question regarding how many countries their organisation operate

When asked about transboundary road transport, as seen in Figure 3, 37 % (n=10) of the sample answered that their organisation is involved in transboundary road transport, while 52 % (n=14) answered “No”. The three remaining respondents (11 %) answered “I don’t know”. Both this question and the question described in Figure 2 was originally included in the survey to investigate if there are any differences between the organisations in their experiences with automation based on how many countries they operate in and if they are involved in transboundary road transport. However, as the sample in this survey is relatively small, it is therefore challenging to perform such statistical analysis and present potential relationships between the different variables.

Is your organisation involved in transboundary road transport? (n=27)

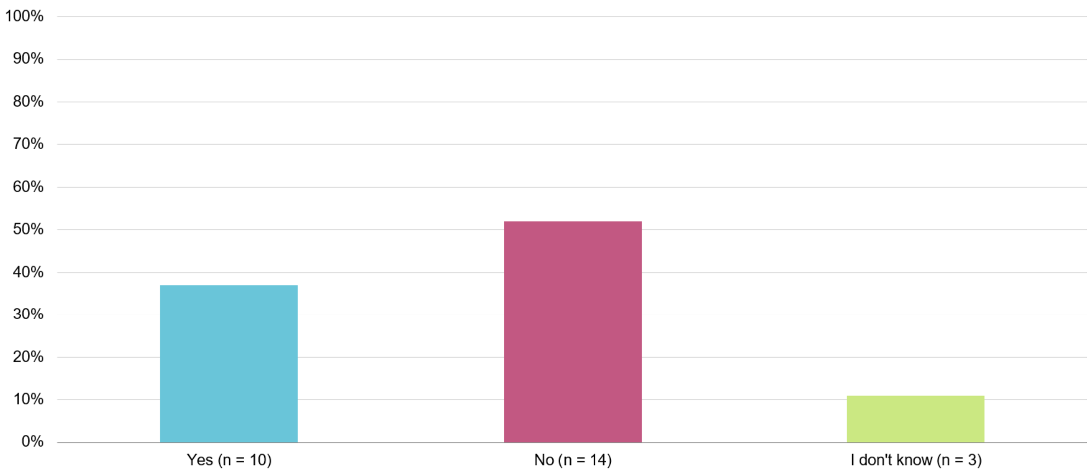


Figure 3: Responses to the questions regarding transboundary road transport

As seen in Figure 4, 44 % (n=12) of the sample answered that they belong to a “Small” organisation with 1-50 employees, while 30 % (n=8) belong to a “Large” organisation with more than 500 employees. The 7 remaining respondents (26 %) belong to a “Medium” organisation, measured in size of employees, with 51-500 employees.

What is the size of your organisation measured in size of employees? (n=27)

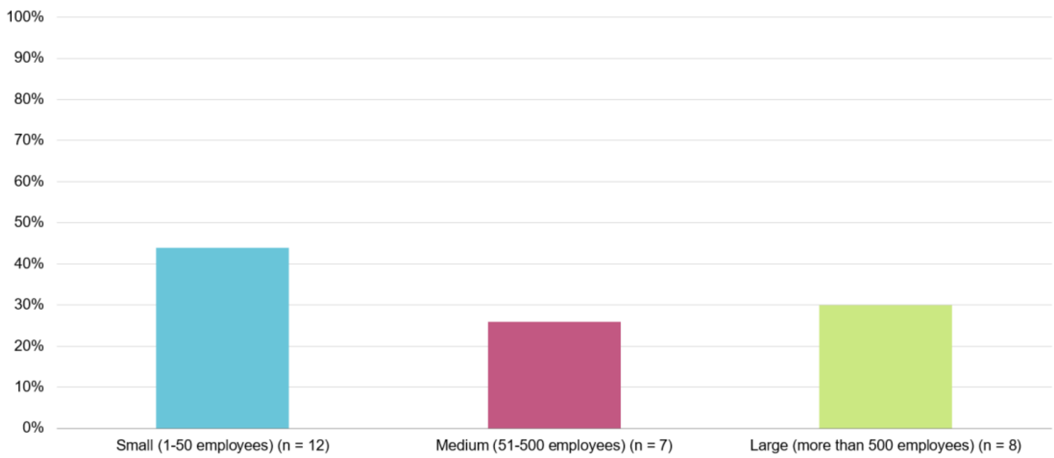


Figure 4: Responses to the questions regarding size of organisation

When asked about what types of cargo their organisation usually handle, several answers were possible. As presented in Figure 5, this question received 27 unique responses, with 57 answers on the different categories in total. The results shows that the majority of the sample (n=14) usually handle “General cargo”, while 10 out of 27 respondents handle “Part loads”. The remaining answers are quite evenly distributed across the different categories. However, 8 respondents have answered “Other, with the following comments in the open text box:

- N/A
- N/A
- As an association, we do not handle flows of goods but we have included the main goods transported by our members. As we will do in the next questions
- N/A
- Technology provider

- Vehicle Parts and Components
- Innovation Policy
- We represent logistics as a whole

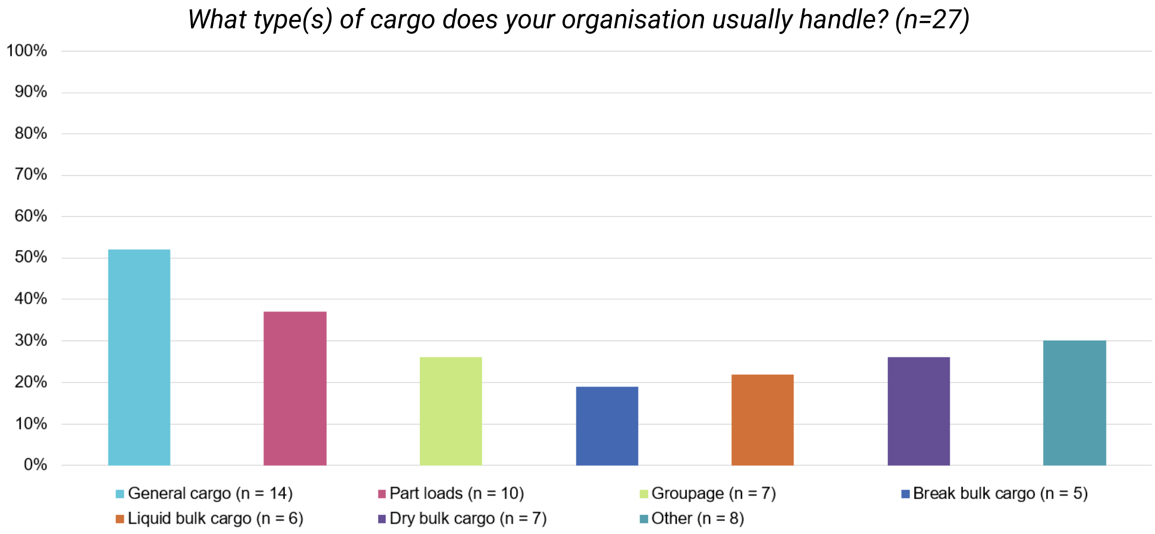


Figure 5: Responses to the questions regarding types of cargo

3.2 Status of automation

The second main section in the survey includes question on the status of automation today, with the aim of mapping the current automation level in different organisations. This includes questions on their attitude towards automation, the extent of automation and digitalisation in their organisation today, strategy and the way forward.

When asked about how positive they are towards automating the transport sector, ranging from 1 (Negative) to 5 (Positive), the average response is 3,85. The results shows that 40 % (n=8) of the respondents answered that they are positive, while none of the respondents answered that they are negative. These results indicate that the sample of this survey is on average quite positive towards automating the transport sector. One possible explanation for this is that the sample is biased, as people positive towards automation in general could be more likely to participate in an online survey where the focus is automation.

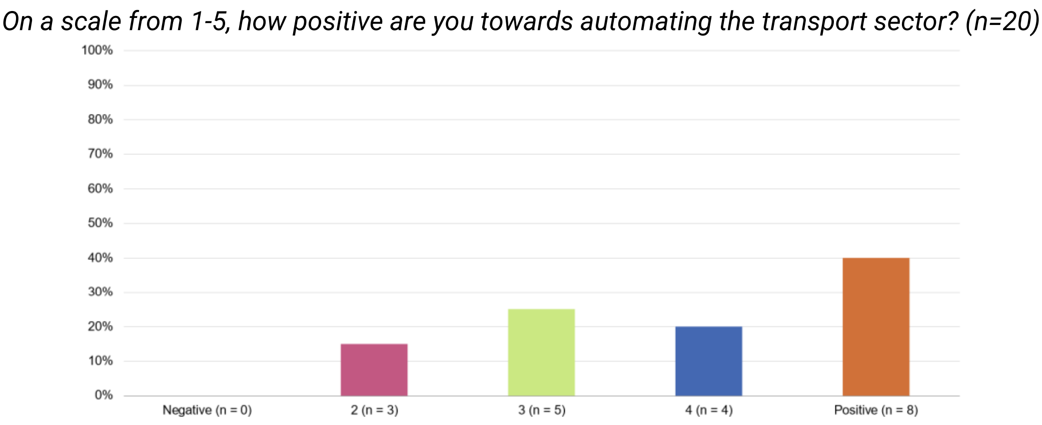


Figure 6: Responses to questions regarding their positivity towards automation

Figure 7 below shows the responses to three questions regarding the status of automation and digitalisation in the respondents' organisations. By taking a closer look at each question, Figure 7 shows that most respondents state that they have, to some extent or more, digitised the internal information flow (80 %), become digitally integrated with external actors and interfaces (70 %) and automated the operations (60 %). These results indicate that most organisations in the sample have started to digitise different processes, but not fully automated the operations (as 30 % state that they "To little extent" or "To no extent" have automated the operations). However, as the number of respondents in the sample is relatively small, it is challenging to assert that this is representative for the logistics industry as a whole.

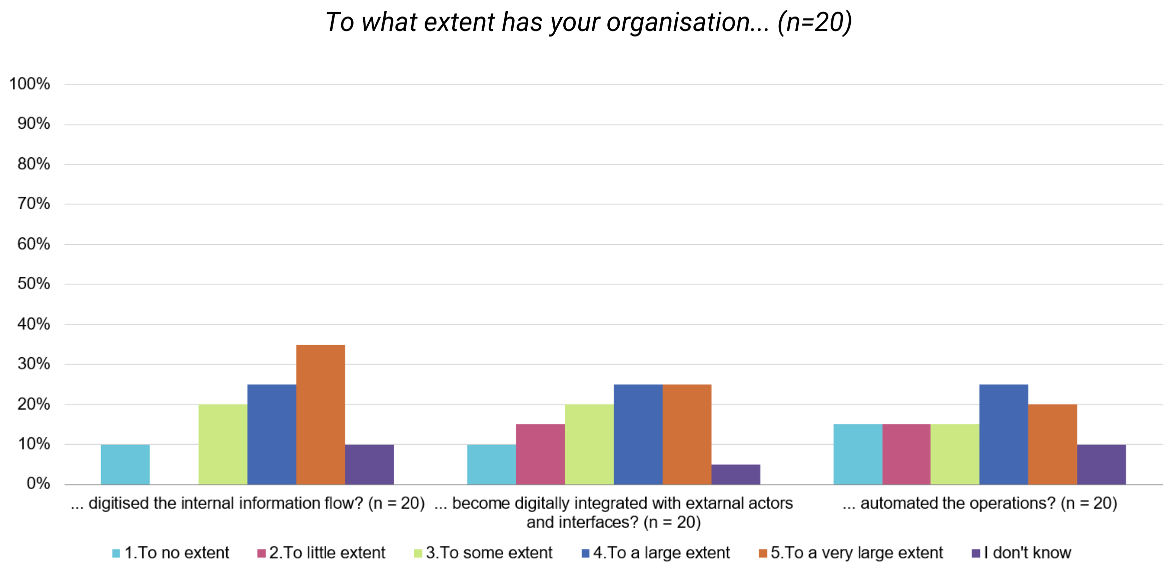


Figure 7: Responses to three questions regarding status of automation and digitalisation in their organisation

The respondents were also kindly asked to provide further details on the specific operations that have been automated. This question received three answers:

- Orders to be shipped are automatically assigned to hauliers depending upon size, destination, and required speed
- I) Digital platforms for customers to track shipments, manage orders, and communicate with our support team. II) Autostore warehouse. III) Automated inventory management, order processing, and shipment tracking
- I) Integration with warehouse customers with purchase orders, sale orders and distribution booking with edi. II) Autostore for B2C orders in warehouse. III) Transport booking with tool, Timpex.
-

As seen in Figure 8, the respondents were asked if their organisation have a long-term strategy for automation. The results shows that 50 % (n=10) of the respondents answered "Yes", while 40 % (n=8) stated that their organisation does not have a long-term strategy. This question was included in the survey to investigate if there are any correlations between having a long-term strategy and to what extent they have digitised and automated their operations. However, as previously mentioned, it is challenging to present such relationships between the different variables, due to a relatively small number of respondents.

The respondents were also asked which operations in their organisation will be automated within the next five years. 11 respondents stated the following:

- All back-office and planning processes
- I) Information flow and sequencing tasks etc. II) Automating gate processes. III) Automated warehouse operations. IIII) Automated container moves
- My organization is not directly involved in operations however, based in our experience with our members, these are the main operations to be automated: I) Yard management and storage areas for manufacturing inbounds and outbounds. II) Movements in terminals within semi-confine areas (e.g. Ports, Logistics Platforms) and open roads for short distance between manufacturing plans and warehouses with a heavy traffic of goods
- Seg
- Storage logistics, shopfloor planning etc.
- Warehouse
- Customer reporting and data sharing
- I) Packing and sorting for distribution autostore. II) Booking transport from harbour. III) AI for use in picking routes
- RTG kranes, sea transport local
- Within the MODI project we investigate the opportunity to make autonomous corridor long-haul transports
- Transport in confined areas.

Does your organisation have a long-term strategy for automation? (n=20)

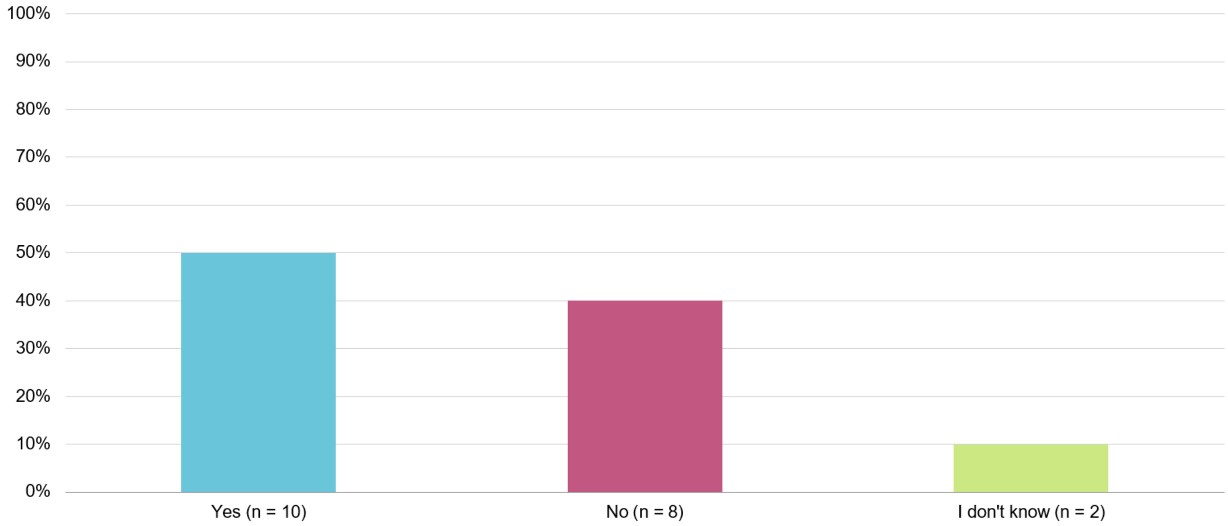


Figure 8: Responses to the question regarding long-term strategy

As seen in Figure 9 below, 76 % of the respondents answered either “Agree” (n=3) or “Strongly agree” (n=10), when assessing if the logistics industry needs to be involved in the development of L4 technology.

The logistics industry needs to be heavily involved in the development of L4 technology for logistics purposes (n=18)

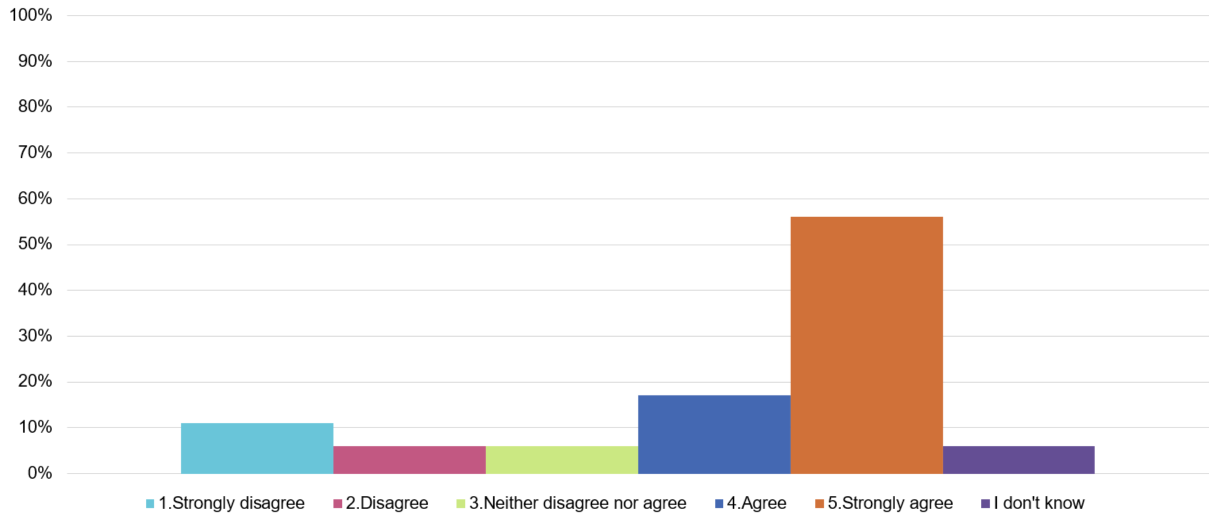


Figure 9: Responses to the statement regarding the logistics industry's role in the development of L4 technology

3.3 Drivers and barriers for automation

The third main section in the survey includes both open-ended and matrix questions regarding drivers and barriers for automation in the transport sector.

When asked about what the main positive benefit with automation would be, 12 respondents stated the following:

- Increase efficiency and less human errors (if properly managed during implementation and maintaining
- Empty miles reduction. Better utilization of asset (vehicles)
- Flexibility, driver shortage, better working condition, reliability, safety
- I) Be able to operate 24/7/365. II) Productivity by ensuring less mistakes. III) Safety as automation will be implemented in operations with risk for employees.
- I) Improved safety. II) Lower costs. III) Integration of value chains
- Less unneeded traffic. Smarter logistics and less drivers needed
- Environmental impact, efficiency
- Reduction of labour cost, increase of productivity, operational efficiency like optimization of routes, high safety standards, 24/7 operations, can be scalability.
- I) Less actors and more professional actors. II) Safe and more secure transport. III) Higher level of planning in the hole value chain
- Efficiency, costs, competitiveness of road transport
- Solve the issue of driver shortage, increase level of safe driving
- Improve traffic safety.

Additionally, the respondents were asked if there are any tasks they believe cannot be automated. 10 respondents answered this question:

- No
- You still need systems support
- Yes, some handover processes of goods
- SDG

➢ Ramming 5 cars into a tiny cube of scrap at the end of a congested lane, when the high of the pills, that get you through your 14-hour driving shift, wears off. Also helping with loading/unloading.
➢ No
➢ Yes, like decision making, human interaction and customer relations, customized services, Emergency responses.
➢ Driving the vehicle
➢ Not in the long term.
➢ Loading and unloading of goods

Regarding barriers for automation, the respondents were asked to assess eight issues highlighted as barriers in the MODI project, ranging from “Strongly disagree” to “Strongly agree”. As seen in Figure 10 below, this includes issues such as “New safety challenges”, “Lack of infrastructure”, “Lack of digitalization”, to name a few. Figure 10 is a compilation of the eight barriers, and 18 respondents in the sample assessed all barriers. Overall, the results shows that the “Lack of standardization” is the issue that most respondents agree is a barrier for automation, where 67 % respondents answered either “Agree” (n=10) or “Strongly agree” (n=2). Nevertheless, 11 out of 18 respondents (61 %) also “Agree” or “Strongly agree” that both “Investment costs”, and “Lack of knowledge and/or capacity” are barriers for automation.

To what extent do you agree that the following are barriers for automation (n=18)

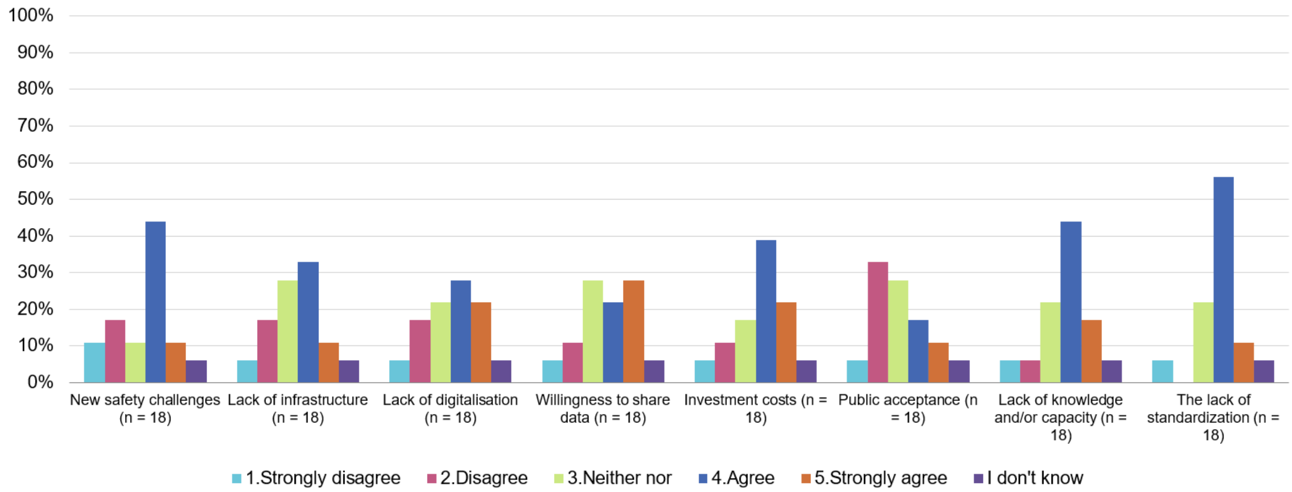


Figure 10: Responses to the question regarding barriers for automation

The respondents were also asked to assess seven issues highlighted as drivers for automation in the MODI project, ranging from “Strongly disagree” to “Strongly agree”. As seen in Figure 11 below, this includes issues such as “Improving safety”, “Operational efficiency”, “Driver shortage”, to name a few. Figure 11 is a compilation of the seven drivers, and 18 respondents in the sample assessed all drivers. The results show that “Improving safety” is the issue that most respondents agree is a driver for automation – 83 % of the sample either “Agree” (n=7) or “Strongly agree” (n=8). Additionally, 13 out of 18 respondents (77 %) either “Agree” (n=7) or “Strongly agree” (n=6) that “Operational efficiency” is a driver for automation. Except for “Customer satisfaction”, where 17 % (n=6) of the sample either “Agree” or “Strongly agree”, more than 55 % of the sample either “Agree” or “Strongly agree” that the other identified issues are drivers for automation.

To what extent do you agree that the following are drivers for automation (n=18)

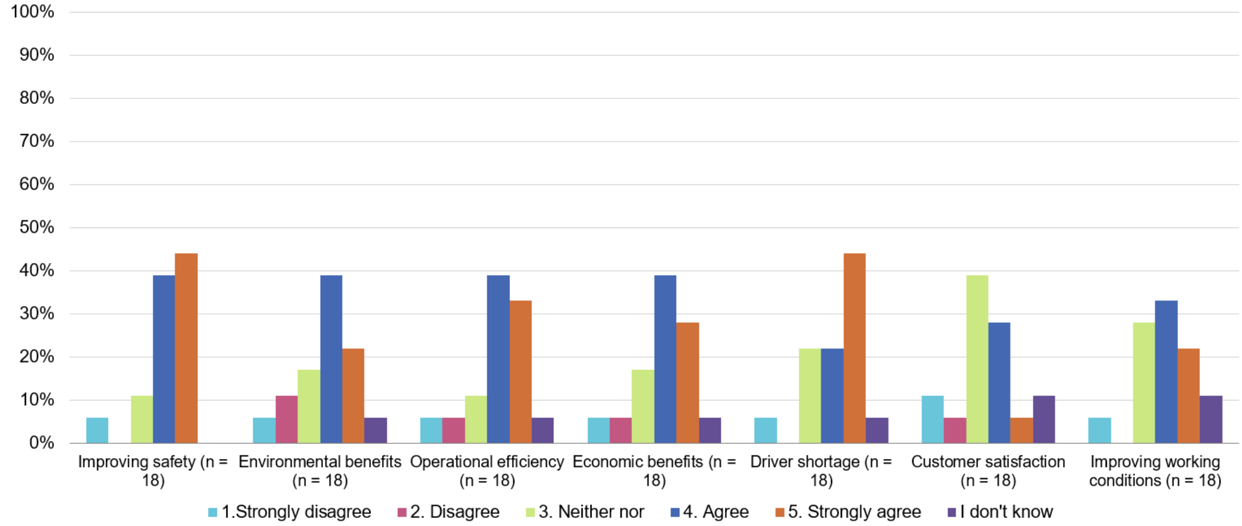


Figure 11: Responses to the question regarding drivers for automation

One assumption is that real time information on unexpected events, such as updated information on road work warnings and accidents, could be useful for the drivers. The respondents were therefore asked to what extent such information will be beneficial for drivers, ranging from “To no extent” to “To a very large extent”. As seen in Figure 12, 15 out of 18 respondents answered either “To some extent” (n=5), “To a large extent” (n=4) or “To a very large extent" (n=6), indicating that real time information would be useful. Only 2 out of 18 respondents answered either “To no extent” or “To little extent”.

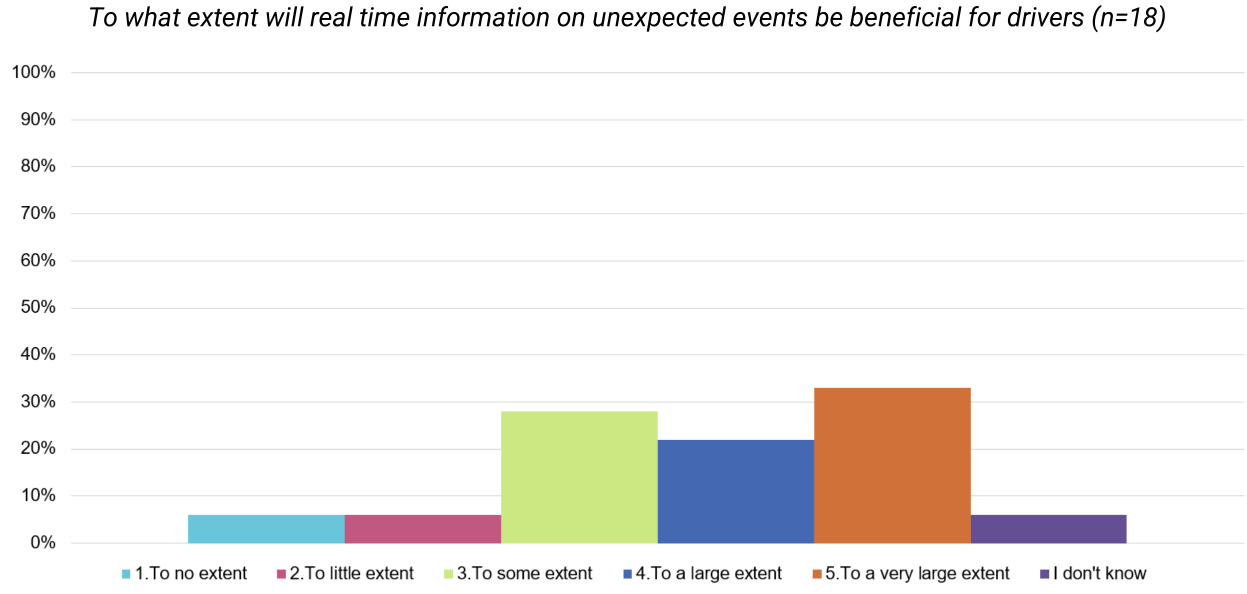


Figure 12: Responses to the questions regarding information on unexpected events

3.4 Benefits and challenges to solve

In the fourth main section in the survey, the questions are structured into three main categories: safety, efficiency and driver shortage.

Safety

First, the respondents had to answer if they have been personally involved in any accidents or near accidents during the last 12 months. As seen in Figure 13, most of the respondents answered "No", while 2 out of 17 respondents answered that they have been involved in an accident.

Have you been personally involved in any accidents or near accidents during the last 12 months? (n=17)

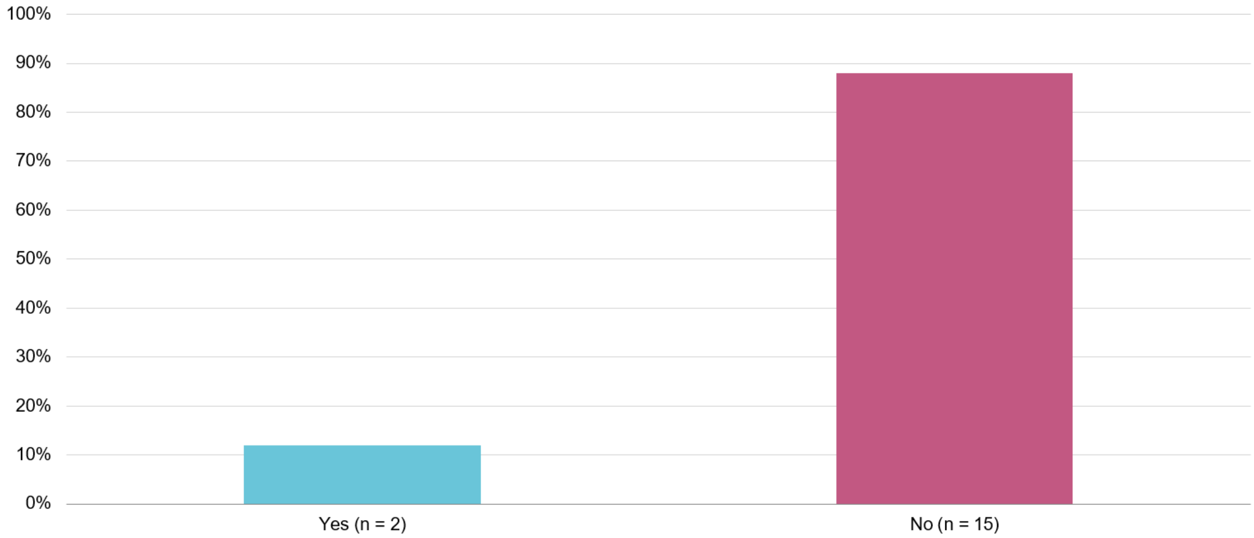


Figure 13: Responses to the question regarding accidents the last 12 months

Furthermore, the respondents were asked to what extent challenges are a challenge within the logistics industry. Figure 14 shows that more than 50 % answered "To some extent", while 5 out of 17 respondents answered "To a large extent" (n=2) or "To a very large extent" (n=3).

In your opinion, to what extent are accidents a challenge within the logistics industry? (n=17)

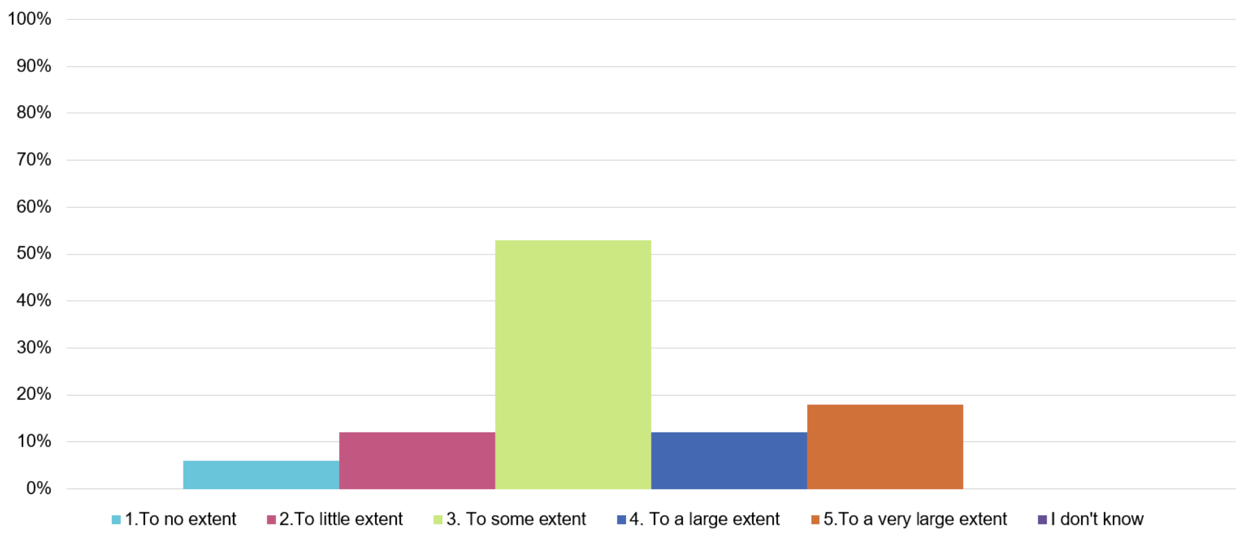


Figure 14: Responses to the question regarding accidents within the logistics industry

When asked about to what extent increased automated can contribute positively to the overall safety, 11 out of 17 respondents answered either "To a large extent" (n=7) or "To a very large extent" (n=4). Only 2 respondents answered "To no extent" or "To little extent".

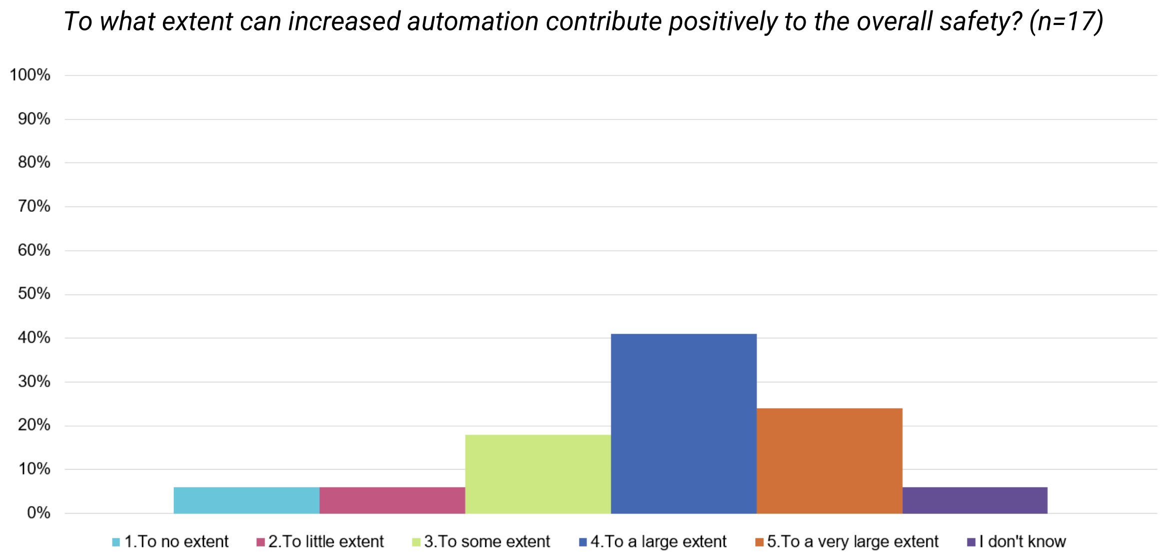


Figure 15: Responses to the question regarding automation and safety

Efficiency

After considering questions related to safety, the respondents had to provide their feedback on two questions regarding efficiency. For the first question the respondents had to rate the overall efficiency of their organisation as of today, ranging from 0 (Inefficient) to 5 (Efficient). The average response is 3,35, when assessing the efficiency of their organisation. As seen in Figure 16, nearly 50 % (n=8) of the respondents answered the middle category, while one respondent answered that their organisations is “Efficient”. None of the respondents answered that their organisation is “Inefficient”.

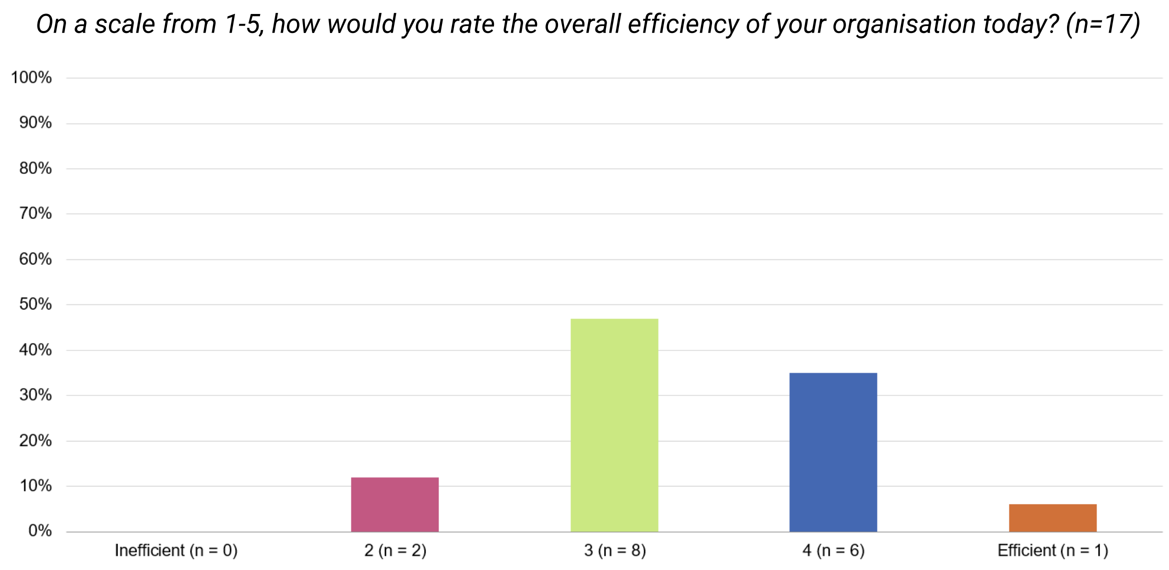


Figure 16: Responses to the question regarding the overall efficiency today

The second question on efficiency was related to automation. More specifically, the respondents had to assess how automation will affect the overall efficiency in their organisation, ranging from “Very negative” to “Very positive”. As seen in Figure 17 below, the majority of the respondents think that automation will have a positive impact on their efficiency. Only one respondent state that automation will be "Very negative" for their efficiency, while almost 13 out of 17 respondents in the sample think that automation will be either "Positive" (n=4) or "Very positive" (n=9) for the overall efficiency in their organisation.

In your opinion, how will automation affect the overall efficiency in your organisation? (n=17)

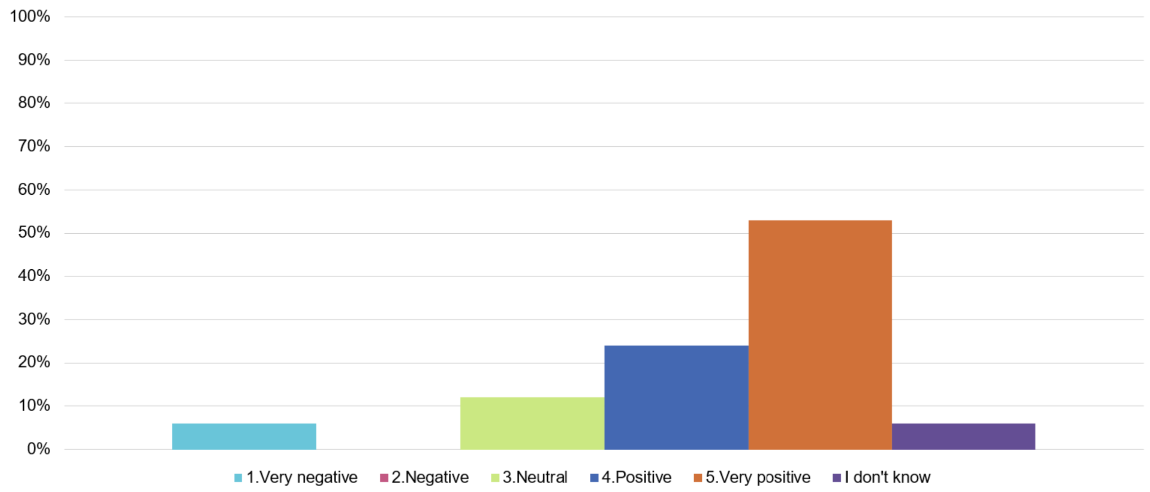


Figure 17: Responses to the question regarding how automation will affect the overall efficiency

Driver shortage

Furthermore, the respondents had to assess three questions related to the challenge of driver shortage. The International Road Transport Union (IRU) reports that in 2023, 7 % of Global truck driver positions were unfilled. When asked to what extent driver shortage is a concern for their business today, their answers are quite evenly distributed across the different response categories ranging from "To no extent" to "To a very large extent" as seen in Figure 18 below. These results indicate that the sample in this survey in general don't necessarily see driver shortage as a big concern, but there are differences among the respondents. This question was originally included to analyse if there are any correlation between either size of organisation or type of organisation, in relation to driver shortage. However, as mentioned previously, such analysis cannot be carried out due to a small number of respondents.

To what extent is driver shortage a concern for your business today? (n=17)

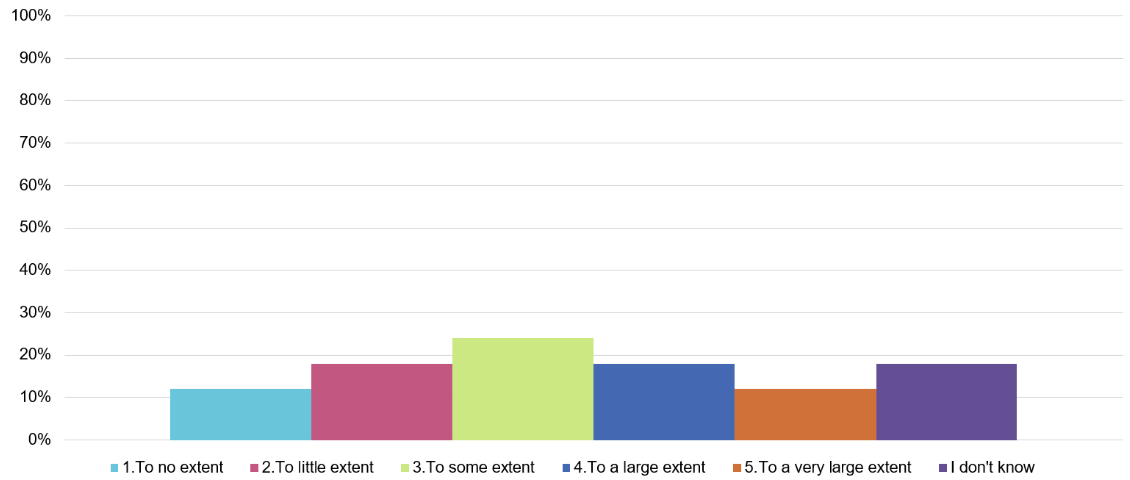


Figure 18: Responses to the question about if driver shortage is a concern today

When asked about if they agree with the report from IRU estimating driver shortage to further increase, the results clearly show that driver shortage will increase in the coming years. 13 out of 17 respondents either "Agree" (n=10) or "Strongly agree" (n=3) with this estimate, indicating that driver shortage could be a more pressing challenge for the logistics industry in the near future.

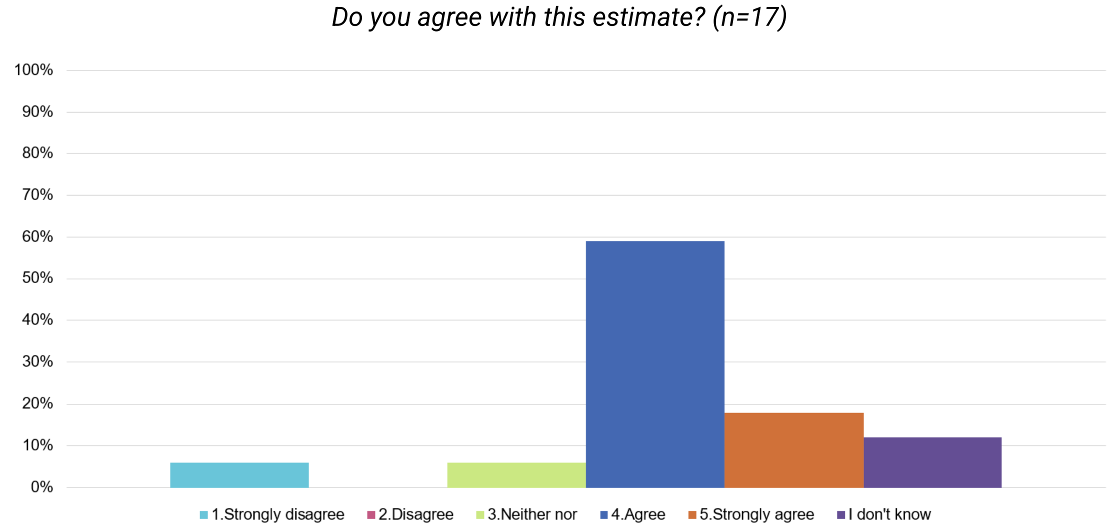


Figure 19: Responses the question about IRUs estimate regarding driver shortage

The next question on driver shortage was related to the introduction of automated trucks. As seen in Figure 20, almost 60 % of the respondents answered either "To a large extent" or "To a very large extent" when they had to assess to what extent automated trucks can be a solution to the challenge of driver shortage.

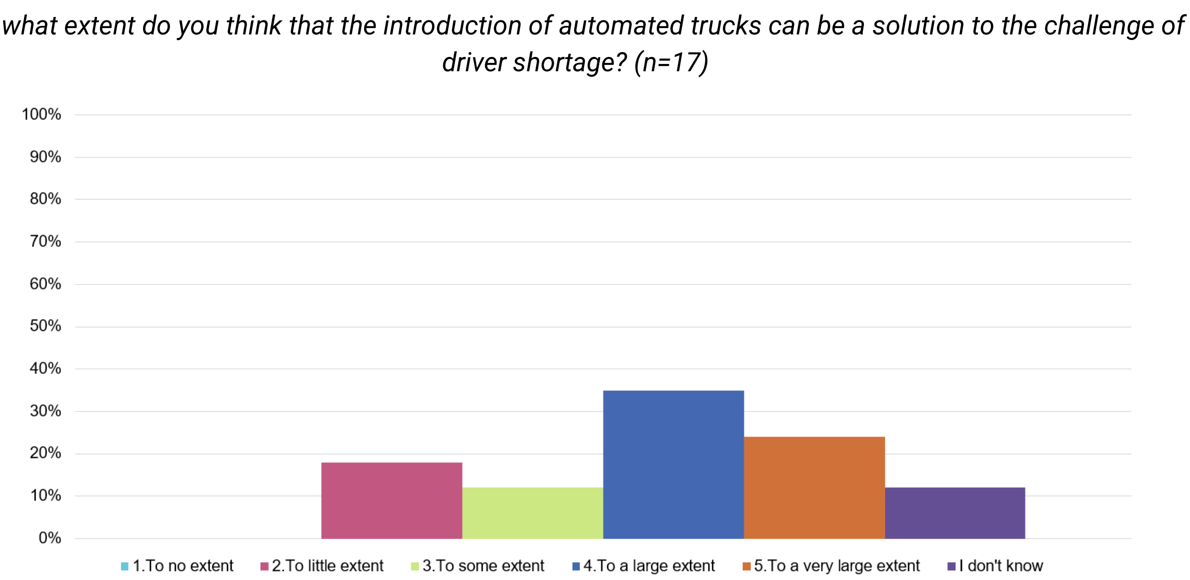


Figure 20: Response to the question regarding automated trucks and driver shortage

The respondents were also asked to elaborate on their answers related to driver shortage. Three of the respondents provided their feedback on this question:

- It's mandatory to plan driver utilization in a way to let them come back home almost every evening
- There are challenges to overcome driver shortage etc, the introduction of automated trucks or other AI system will offer a promising solution to the driver shortage in logistic industries. This will also increase the efficiency, reduce cost and improve safety when technology is matured.
- Automated trucks in Norway will take many years due to safety and roads.

3.5 Automation in the transport sector

The fifth main section in the survey includes question on future automation in the transport sector. More specifically the respondents had to assess four different processes: i) Freight documentation, ii) Loading/unloading, iii) Driving on public roads, and iiii) Driving in confined areas. As a starting point in this section, the respondents were given the following scenario:

- "Imagine that an automated truck is driving successfully on the highway from Gothenburg in Sweden to ASKO's central storage at Vestby in Norway. On the way, the truck crosses the border between Sweden and Norway and has to complete an automated customs clearance process. When arriving at ASKO's location, the goods are unloaded and transferred inside the storage, all through automated processes".

First, the respondents were asked to assess to what extent the four different processes can be automated, ranging from "To no extent" to "To a very large extent". In total, this question received 13 responses. As seen in Figure 21 below, "Freight documentation" and "Driving in confined areas" are the two processes, where most respondents answered either "To a large extent" or "To a very large extent". For "Freight documentation", 10 out of 13 respondents answered either "To a large extent" (n=4) or "To a very large extent" (n=6) when assessing if this process could be automated, while 9 respondents answered either "To a large extent" (n=2) or "To a very large extent" (n=7) when assessing "Driving in confined areas".

To what extent do you think the following processes can be automated? (n=13)

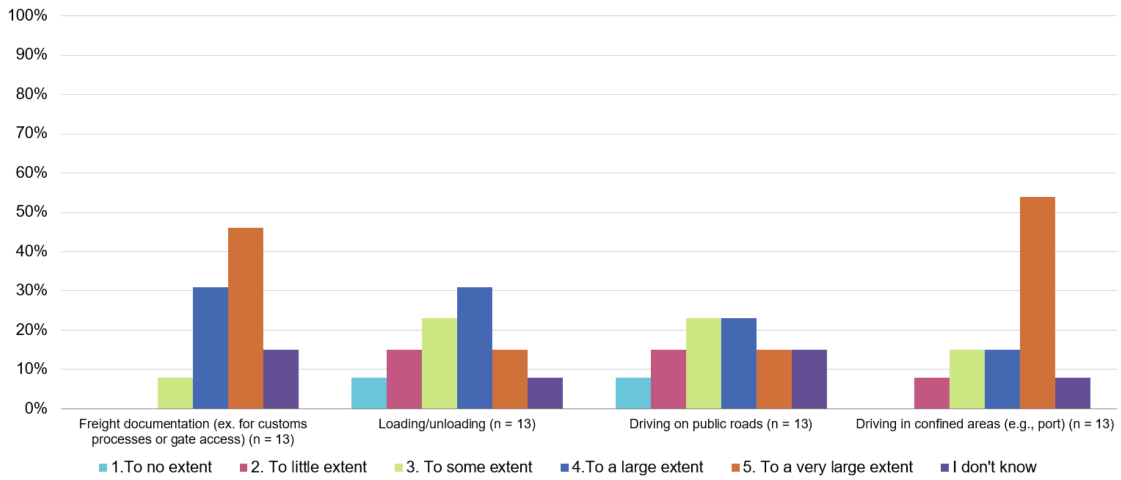


Figure 21: Responses to questions about automation of different processes

Furthermore, the respondents were asked to assess to what extent these processes will benefit their organisations if the processes are automated in the future. As seen in Figure 22, the respondents state that “Freight documentation” and “Driving in confined areas” are the two processes that will benefit their organisation the most, indicating that the processes that are most likely to be automated (as presented in Figure 21) are also the processes that will be most beneficial.

If the following processes are automated, to what extent do you think they will benefit your organisation? (n=13)

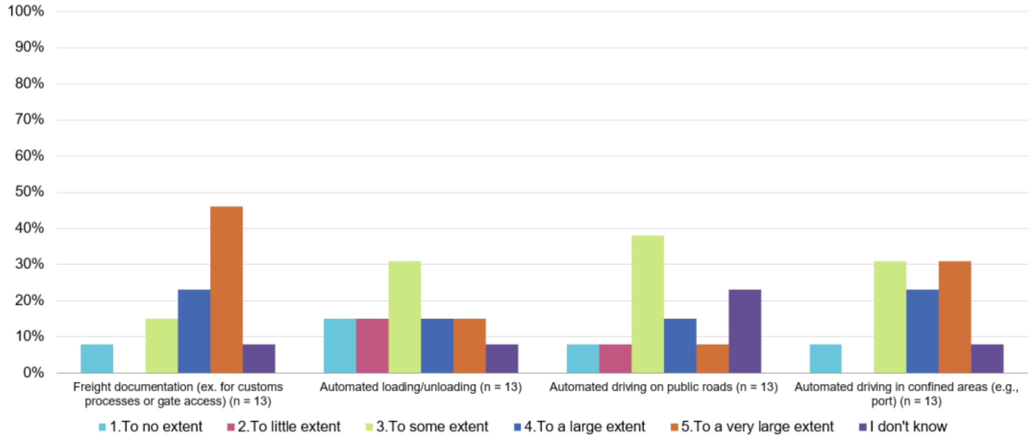


Figure 22: Responses to the questions regarding benefits in their organisation if the processes are automated

Finally, the respondents were asked to assess to what extent these processes will benefit the transport sector in general if the processes are automated in the future. As seen in Figure 23, the results on this question differ slightly from the results in Figure 21 and Figure 22. Overall, more respondents have answered “To a very large extent”. However, “Freight documentation” and “Automated driving in confined areas” are still the two processes that the respondents think will benefit the transport sector the most. For “Automated driving in confined areas”, more than 60 % (n=8) answered that this process will benefit the transport sector “To a very large extent”. However, as the number of respondents (n= 13) for alle these three questions is relatively low, these results have limited reliability.

If the following processes are automated, to what extent do you think they will benefit the transport sector in general? (n=13)

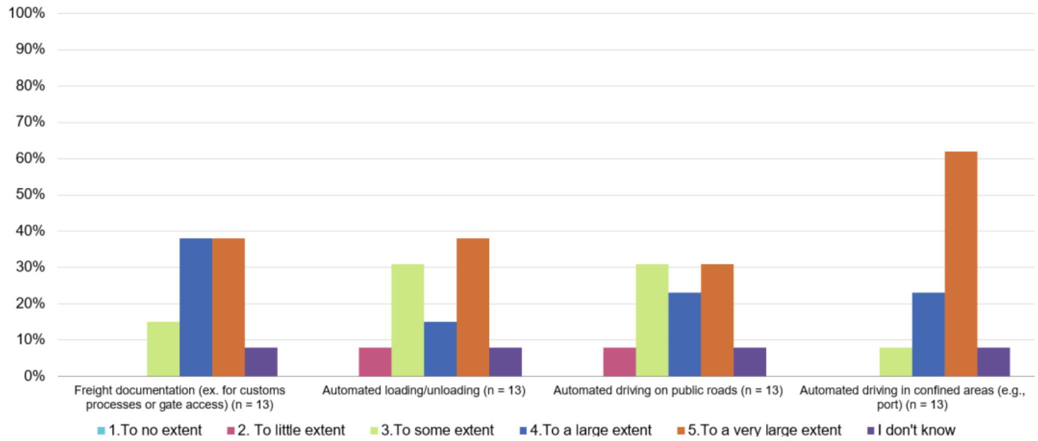


Figure 23: Responses to the questions regarding benefits in the transport sector if the processes are automated

The respondents were also asked to elaborate on their answers. One respondent stated the following:

- Automation of loading/unloading, documentation and other factors mentioned above will surely give positive effects to the logistics industry like the efficiency will be increased by using these technologies, it can scalable, will also be safe when technology is matured.

As a last question in the survey, the respondents were asked to share any final comments. Two respondents provided their feedback:

- Automation and digitalization in transport sector are very important to increase productivity, and competitiveness. This will overcome challenges like driver shortage, and also give positive results for more sustainable future.
- An increased degree of digital communication affects efficiency, safety and planning in the value chain so that all parties get increased value

4 Discussion

4.1 Methodological challenges

Despite being widely distributed as described above, the survey did not get a lot of respondents. In total the survey received 13 fully completed responses, with 27 unique respondents as the maximum. Therefore, the results presented in this memo have limited reliability and there can be drawn no valid conclusions based on the survey.

The aim of the study was to measure automation readiness in the logistics chain. The low response rate might tell something about the logistics industry: thinking about automation might not be a main priority among people in logistics. Few are enthusiastic or interested in the development towards highly automated freight transport. This can indicate that the automation readiness is low when it comes to the potential end users within logistics. The logistics industry might also have other challenges to handle and other concerns in mind. For instance, it is reasonable to think that they are more concerned with financial considerations and their day-to-day operations rather than planning for automated freight transport, as the logistics stakeholders is part of an industry with small margins.

Another explanatory factor for the low response rate is the chosen strategy for distributing the survey. As previously mentioned, the survey was first distributed by email to MODI contacts, and members/networks of both CLEPA, ALICE, ITS Norway, Maersk and the port of Moss. However, as this strategy did not boost the response rate, the distribution was eventually widened, expanding the target group from mainly logistics actors to include a wider range of respondents. By request from SINTEF, both ALICE and CLEPA helped us sharing the survey by publishing a dedicated post on LinkedIn. This strategy was initially chosen to receive more responses from the logistics industry, however, this have potentially skewed the perspectives in the survey, as other stakeholders also provided their responses. Additionally, this have also limited our control over the selection of respondents and the possibility to send follow-up emails to the different stakeholders. The fact that the logistics industry in general is quite difficult to reach with an online survey is invaluable experiences to keep in mind, when planning to distribute future surveys to the logistics sector.

One issue when trying to measure automation readiness in logistics, is that the logistics industry is a very complex and fragmented sector, including everything from ports, terminals, loading/unloading, gate access, highways, city driving, and more. This makes it challenging to gain any sense of overview of the whole sector. Respondents will see their own part of the value chain but might lack the overview needed to confidently represent logistics as a whole. This can have had negative impact on the response rate.

the wide distribution, leading to little control of who the survey reached. The "other" category consisted of associations, researchers and consultants.

4.2 Findings in the survey results

Although the final number of respondents in this survey is relatively law, some points are nevertheless worth discussing.

The open question about the main positive benefit with automation received quite homogeneous responses that aligned with the closed questions. and are therefore worth highlighting. Responses circulated around increased efficiency, safety, improved working conditions and remedies the problem of driver's shortage. A common opinion seems to be that automation will improve safety and efficiency and help decrease the problem of driver's shortage.

The fact that the responses to the open questions align quite well with the closed-end questions, indicate that thematically, the survey's focus area fits the reality well.

The survey results show an average of 3,85 on a scale from one to five on how positive respondents are towards automation. Additionally, most respondents state that they have, to some extent or more, digitised the internal information flow (80 %), become digitally integrated with external actors and interfaces (70 %) and automated their operations (60 %). These results combined show a bias towards respondents being overly enthusiastic to automation compared to the general population. This is reasonable, as these individuals will have a higher interest in responding to a survey like this.

To conclude, this survey is developed in collaboration with core project partners, ensuring relevance and alignment with the overall idea of the project and the reality in the logistics industry. However, it didn't receive the response necessary to make generalisations that could significantly enhance the MODI project's understanding of societal impact. Nevertheless, the individual responses carry interesting feedback and does to some degree validate the need to resolve the MODI objectives within the logistic industry.

Annex 3

MODI A LEAP TOWARDS SAE L4 AUTOMATED DRIVING FEATURES

A leap towards SAE L4 automated driving features

Note on geodetic reference frames for ITS applications

16th December 2024

1.1 Summary

This document presents a detailed analysis of the challenges associated with geodetic reference frames for the MODI project and ITS applications. Theoretical analyses and practical tests highlight the complexities arising from discrepancies between national and global reference frames, particularly at borders along the MODI corridor. The findings confirm a strong alignment between theoretical predictions and real-world observations, emphasizing the critical need for alignment and harmonization of reference frames.

Key results demonstrate horizontal discrepancies ranging from 0.01 m to 0.024 m, corresponding closely to calculated differences of 0.015 m to 0.017 m in the same regions. These differences, validated through GNSS data collected at the Norwegian-Swedish border, confirm that end-users will experience slight misalignments in navigation systems when crossing borders. This underscores the importance of adopting consistent reference frames and minimizing the complexities of cross-border transformations.

Reliable and user-friendly reference frames are essential for both professionals and non-specialists. However, the complexity of geodetic systems should remain the responsibility of geodetic professionals, ensuring accessibility and reducing the risk of errors for end-users. Simplifying reference frames and minimizing the number of available reference frames and transformations are critical steps in supporting seamless navigation and geospatial data usage across borders.

This document outlines recommendations to address these challenges. These include transforming data to a common reference frame before deployment, standardizing metadata, and ensuring alignment between national and global systems. By implementing these solutions, ITS applications can achieve the consistency, accuracy, and simplicity required for effective cross-border operations.

1.2 Background and Introduction

The MODI use case demands high-accuracy geographic data, including maps and GNSS positions. The project aims to accelerate the introduction of automated vehicles navigating across several countries, each with its own reference frame implementation. This introduces complexities, including the need for multiple transformations at borders and challenges in aligning data from various sources.

Reference frames underpin GNSS satellite systems, supporting navigation, positioning, and mapping globally. Effective handling of geospatial data is critical for ITS, navigation, environmental monitoring, and cadastral systems. Collaboration between geodetic professionals, software developers, and geospatial data managers is essential to ensure reliable, standardized systems.

National reference frames adapt global systems like ETRS89 to local conditions, leading to variations at borders. For ITS, minimizing reference frame transformations and simplifying geospatial data handling for non-specialists is critical. Challenges such as outdated reference frames, unclear usage guidelines, and discrepancies between global systems (e.g., WGS84) and national databases (e.g., EUREF89) must be addressed.

This document aims to:

- Highlight the implications of reference frame discrepancies for ITS.
- Provide theoretical and practical analyses of these challenges and validate what the implications are for the end-user.
- Offer actionable recommendations to improve the usability of geodetic reference frames for ITS.

Readers unfamiliar with concepts introduced in this report are encouraged to consult Chapter 4 of the TEAPOT project report [1], which provides an accessible introduction to the topic of geodetic reference frames.

1.3 Geodetic reference frames for the MODI corridor

Countries in Europe refine the general European reference frame, ETRS89, into more precise national variants to meet specific geodetic needs. While this approach ensures improved accuracy within each country, it introduces inconsistencies at borders. This practice aligns with the INSPIRE Directive, which promotes harmonized geospatial data across Europe but does not eliminate regional variations.

For the MODI project, the driving route crosses multiple borders, spanning from Rotterdam to Moss. Each country's use of distinct national reference frames creates challenges, particularly when transformations between global and national systems are inaccurate or inconsistent. Misaligned transformations can lead to errors in navigation systems and mismatches between maps and positioning data.

Table 13-1 summarizes the available transformations from national reference frames to global systems such as ITRF2014/ITRF2020 for the countries along the MODI corridor.

Table 13-1: National reference frames on the MODI corridor

Nation	Source ref. frame	Target ref. frame	Accuracy
Germany	ETRS89 (ETRS89/DREF91/2016)	ITRF2014	0.100 m
Netherlands	RD New – Netherlands - Holland - Dutch	ITRF2014	0.102 m
Sweden	SWEREF99 (ETRS89)	ITRF2014	0.010 m
Denmark	ETRS89	ITRF2014	0.020 m
Norway	ETRS89	ITRF2014	0.020 m

Germany and the Netherlands have transformation accuracies listed as 0.100 m and 0.102 m, respectively. This relatively high error margin reflects the fact that national reference frames are not always fully integrated or updated in geodetic transformation frameworks, for example Proj, limiting their precision. Germany's national variant was only recently added to Proj, and the listed accuracies have not yet been adjusted to reflect this update.

In contrast, Sweden, Denmark, and Norway report significantly higher transformation accuracy, with differences around 0.010–0.020 m, largely due to more mature integration of national variants with global systems.

1.4 Theoretical and Practical Analysis of Reference Frames

This section presents the results of theoretical analyses of discrepancies between geodetic reference frames along the MODI corridor. These analyses are validated by practical tests conducted at the Norwegian-Swedish border, utilizing RTK services from both countries to assess and confirm the calculated discrepancies.

1.4.1 Theoretical analysis

The differences between reference frames used in various countries can vary along the border between two countries and depend on the specific border in question. To analyse the discrepancies between the official national reference frames along the MODI corridor, the following theoretical computations were conducted:

Demonstration 1: Analysis of National ITRF2014-ETRS89 Transformations at Common Borders

The objective of this test is to examine the differences in national ITRF2014-ETRS89 transformations at shared border polygons. The following steps were undertaken:

- Retrieval of country borders in Europe from the EuroGlobalMap [14] dataset.
- Transformation of the shared borders using national ITRF2014-ETRS89 transformations available in the Proj framework.
- Identification and analysis of gaps resulting from the transformations along the borders.
- Plotting of error vectors to visualize the discrepancies identified during the gap analysis.

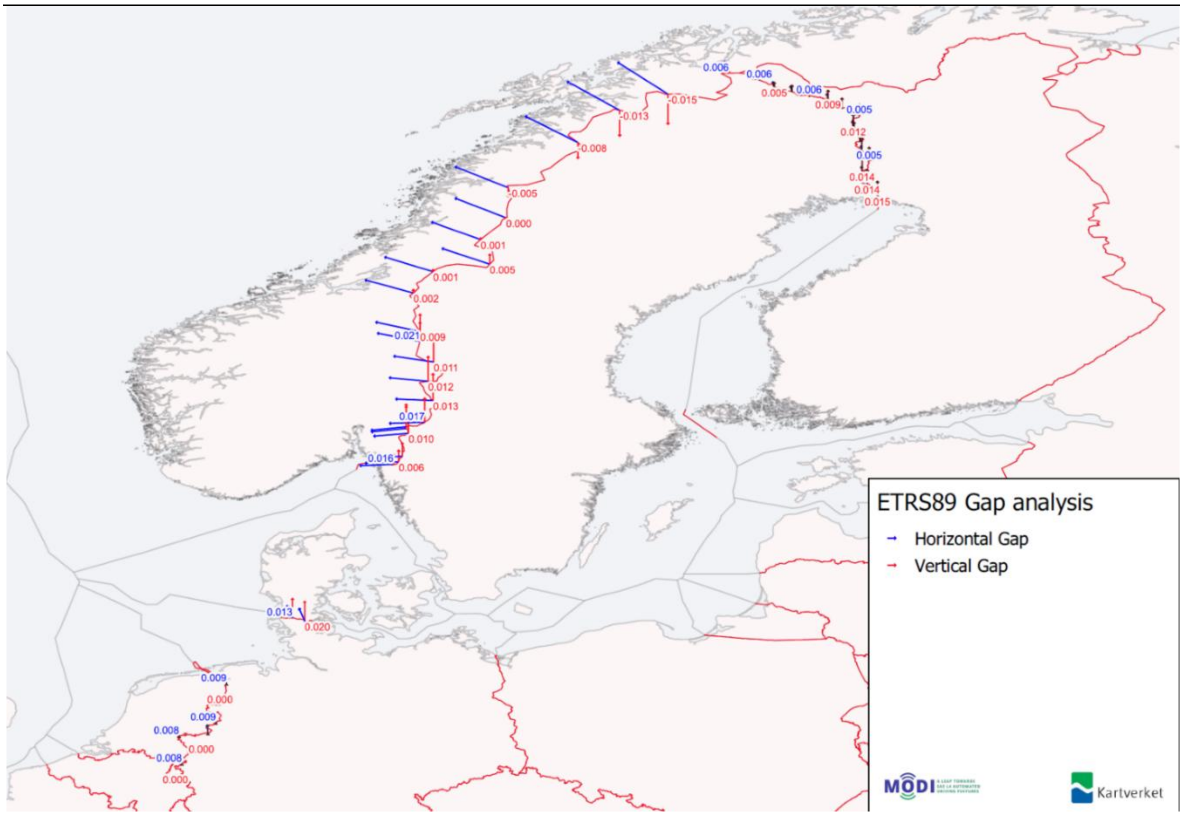


Figure 13-1: Differences between national reference frames in the MODI corridor. Blue arrow is horizontal difference while red is vertical difference.

Figure 1 displays discrepancies in horizontal (blue) and vertical (red) gaps along the borders on the MODI corridor. The long Norwegian-Swedish border shows varying discrepancies due to rotational differences between the Norwegian ETRS89 and the Swedish SWEREF99, which are discussed in more detail later in the second theoretical analysis in this report.

Table 13-2: Average differences on the border crossings on the MODI corridor

From	To	Average north diff	Average east diff
NOR	SWE	0,0047 m	0,0198 m
DEN	GER	0,0124 m	0,0054 m
GER	NL	0,0086 m	0,0008 m

Discrepancies along the MODI corridor are generally lower in the southern regions, reflecting the reduced impact of land uplift and tectonic deformation. In contrast, greater discrepancies are observed in the northern parts of the corridor, due to land uplift and local geodynamic variations in Scandinavia. In other parts of Europe, such as Italy, Greece, and Turkey, seismic activity contributes to larger differences in reference frames, highlighting regional variations caused by local geodynamics.

Demonstration 2: Differences Between National ETRS89 Realizations compared to ETRF2000

This demonstration investigated the differences between national ETRS89 realizations and the European reference frame ETRF2000. ETRF2000 is essentially ITRF2014 adjusted for the continental drift of the Eurasian plate but does not account for intraplate deformation, land uplift, or seismic events.

The following steps were conducted:

- Gap analyses were performed for Norway, Sweden, Denmark, and Germany.
- Error vectors resulting from the analyses were plotted to visualize discrepancies.

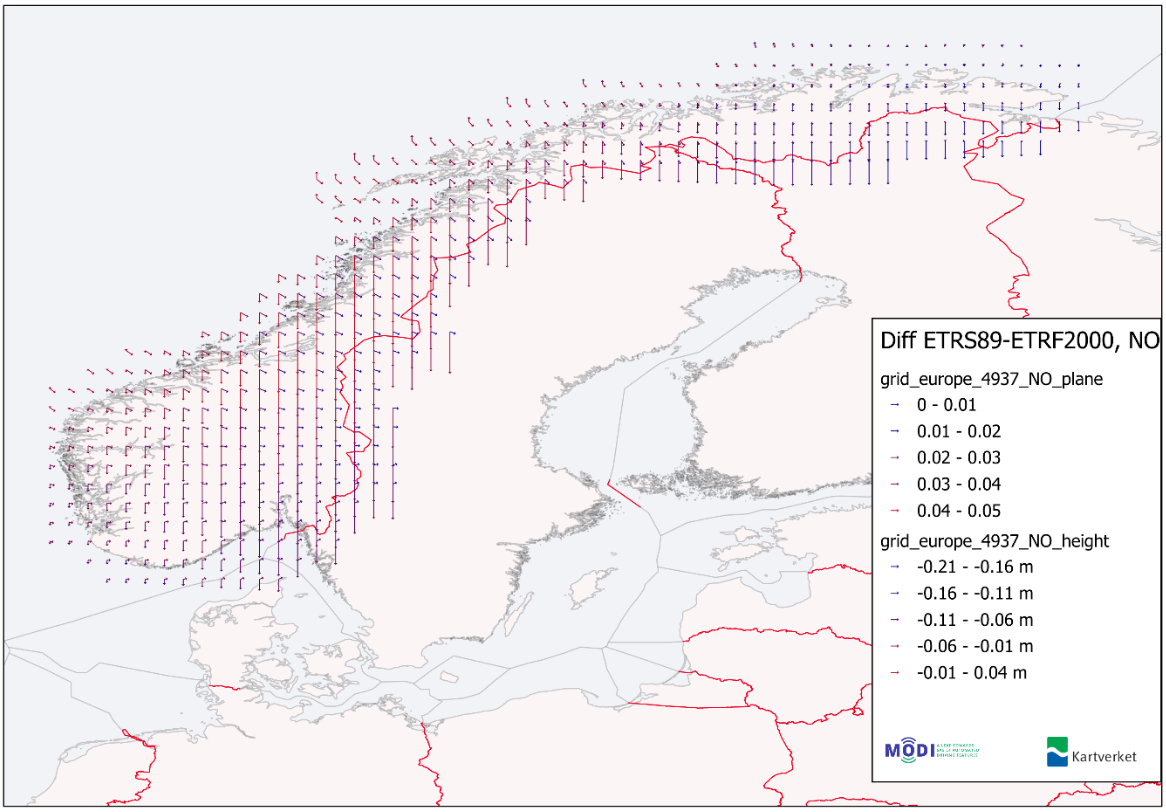


Figure 13-2: Difference between Norwegian EUREF89 and ETRF2000.

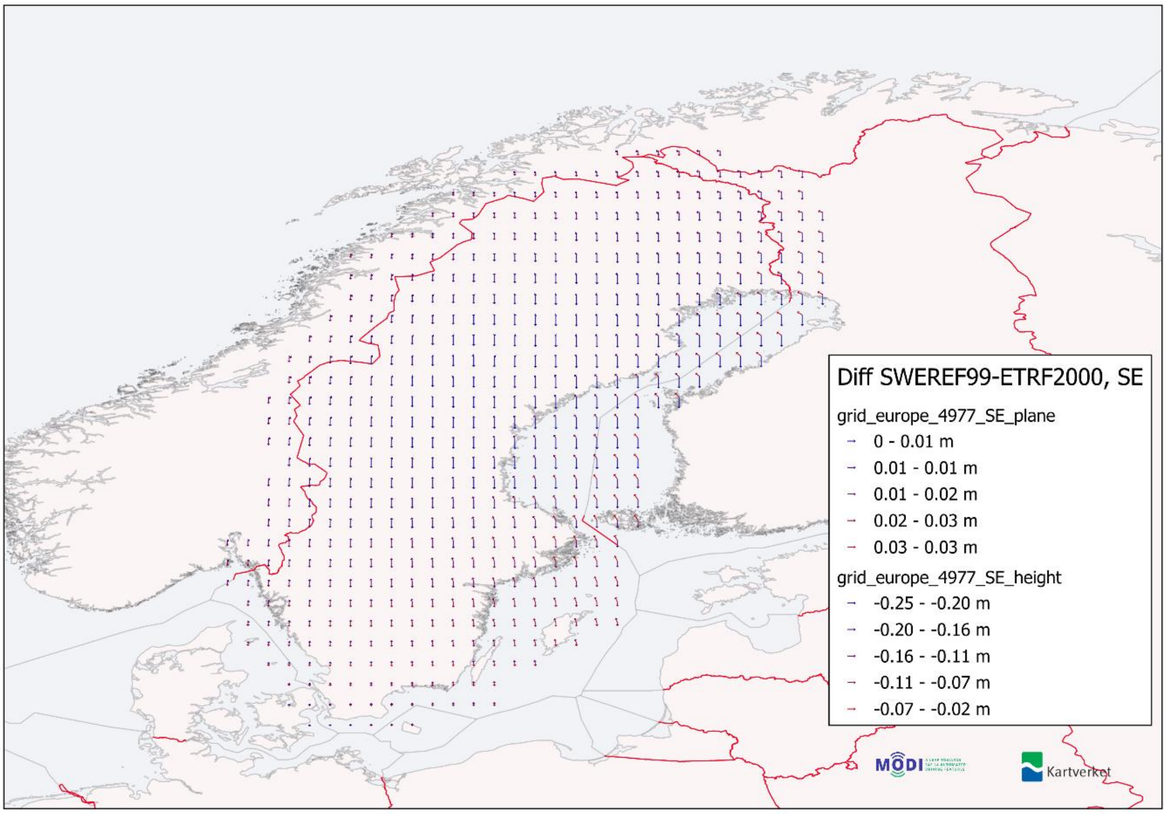


Figure 13-3: Difference between Swedish SWEREF99 and ETRF2000.

Figure 13-2 illustrates differences between the Norwegian national reference frame (ETRS89) and ETRF2000, while Figure 13-3 shows the corresponding differences for the Swedish national reference frame (SWEREF99). The patterns reveal distinct characteristics:

Norway: Figure 13-2 indicates more rotation, as indicated by the varying directions of the small arrows. This rotational difference suggests that the Norwegian realization of ETRS89 includes adjustments that diverge more significantly from ETRF2000 in terms of orientation.

Sweden: The arrows in Figure 13-3 predominantly point in a uniform direction, reflecting translational differences where shifts occur in the east, north, and height directions with minimal rotation. The magnitude of these shifts is represented by colour intensity.

The differences in Norway show a greater degree of rotation, whereas the Swedish example demonstrates more straightforward translational shifts. Further south along the MODI corridor, the pattern aligns more closely with the Swedish example, showing little rotational difference between national translations and ETRF2000.

Similar patterns of translational differences, as seen in the Swedish example, are observed in Denmark, Germany, and the Netherlands. These patterns indicate that adjustments in these regions involve minimal rotation, focusing more on uniform shifts relative to ETRF2000.

There are two primary reasons for the differences observed between national reference frames:

- Each country refines the general European reference frame ETRS89 by incorporating data from additional GNSS reference stations, allowing for more precise modelling of deformations and tectonic plate movements within their territory. However, these refinements are conducted independently by each country, without harmonization across borders or adjustments for neighbouring countries.

- Variations in the realizations of ETRS89. These differences originate from how each country determines its national realization, including variations in the computational approaches, adjustment models, and the epoch (time of realization). These differences can lead to discrepancies such as rotations or translations between reference frames.

1.4 Practical data collection and analysis

A practical demonstration of the theory was conducted through GNSS data collection at the Norway-Sweden border at three different locations:

- Skjeberg - Strømstad, data collected on June 4th 2024
- Ørje - Töckfors, data collected on June 5th 2024
- Magnor - Charlottenberg, data collected on June 6th 2024

GNSS positions were captured using two high-precision NRTK GNSS positioning services:

- CPOS, provided by the Norwegian Mapping Authority, with positions referenced to the Norwegian EUREF89 reference frame.
- SWEPOS, provided by the National Land Survey of Sweden, with positions referenced to the Swedish national reference frame, SWEREF99.

These positioning services are practical implementation of different reference frames and can be used to both demonstrate the practical consequences and verify the theory as described in this document. CPOS and SWEPOS utilize Galileo, GPS, Beidou and GLONASS satellites.

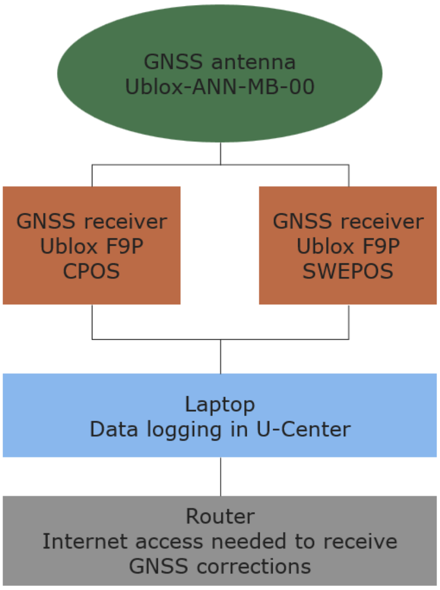
At each location, data was logged twice on both sides of the border, with a time gap between the logging sessions to ensure accuracy and consistency. Equipment used:

- GNSS antenna: Ublox ANN-MB-00
- GNSS receivers: Ublox F9P (one receiver for each positioning service)
- Router: Used to provide internet access for receiving GNSS corrections

The instruments used in the demonstration are illustrated in Figure 5. All GNSS receivers were of the same model, equipped with the same firmware, and paired with the same GNSS antenna. This uniformity ensures that any differences in computed positions can be attributed solely to the different reference frames used by the positioning services.

All data was logged using U-Center software from Ublox to ensure consistency in data capture and analysis.

Table 13-3: Instruments used in data capture.



The tables 13-4, 13-5 and 13-6 present the differences observed between the positioning services at each location. CPOS and SWEPOS denote the respective positioning services used, while NOR and SWE indicate the side of the border where the data was captured. The abbreviations SVI, CHA, and ORJ correspond to the data capture locations (Skjeberg-Strømstad, Charlottenberg-Magnor, and Ørje-Töckfors, respectively). The final number in each identifier refers to the data capture session. Findings from the theoretical study (ref) at the same location is shown in each table.

Table 13-4: Difference between services at Svinesund

From	To	North diff	East diff
CPOS_NOR_SVI_1	SWEPOS_NOR_SVI_1	0.005 m	0.015 m
CPOS_NOR_SVI_2	SWEPOS_NOR_SVI_2	0.002 m	0.012 m
CPOS_SWE_SVI_1	SWEPOS_SWE_SVI_1	0.001 m	0.016 m
CPOS_SWE_SVI_2	SWEPOS_SWE_SVI_2	-0.002 m	0.015 m
Calculated values at Svinesund		0.006 m	0.016 m

Table 13-5: Difference between services at Ørje.

From	To	North diff	East diff
CPOS_NOR_ORJ_1	SWEPOS_NOR_ORJ_1	-0.006 m	0.010 m
CPOS_NOR_ORJ_2	SWEPOS_NOR_ORJ_2	-0.004 m	0.013 m
CPOS_SWE_ORJ_1	SWEPOS_SWE_ORJ_1	0.013 m	0.019 m
CPOS_SWE_ORJ_2	SWEPOS_SWE_ORJ_2	0.008 m	0.021 m
Calculated differences at Ørje		0.010 m	0.016 m

Table 13-6: Difference between services at Charlottenberg

From	To	North diff	East diff
CPOS_NOR_CHA_1	SWEPOS_NOR_CHA_1	0.014 m	0.024 m
CPOS_NOR_CHA_2	SWEPOS_NOR_CHA_2	0.008 m	0.016 m
CPOS_SWE_CHA_1	SWEPOS_SWE_CHA_1	0.000 m	0.018 m
CPOS_SWE_CHA_2	SWEPOS_SWE_CHA_2	0.001 m	0.019 m
Calculated differences at Charlottenberg		0.013 m	0.017 m

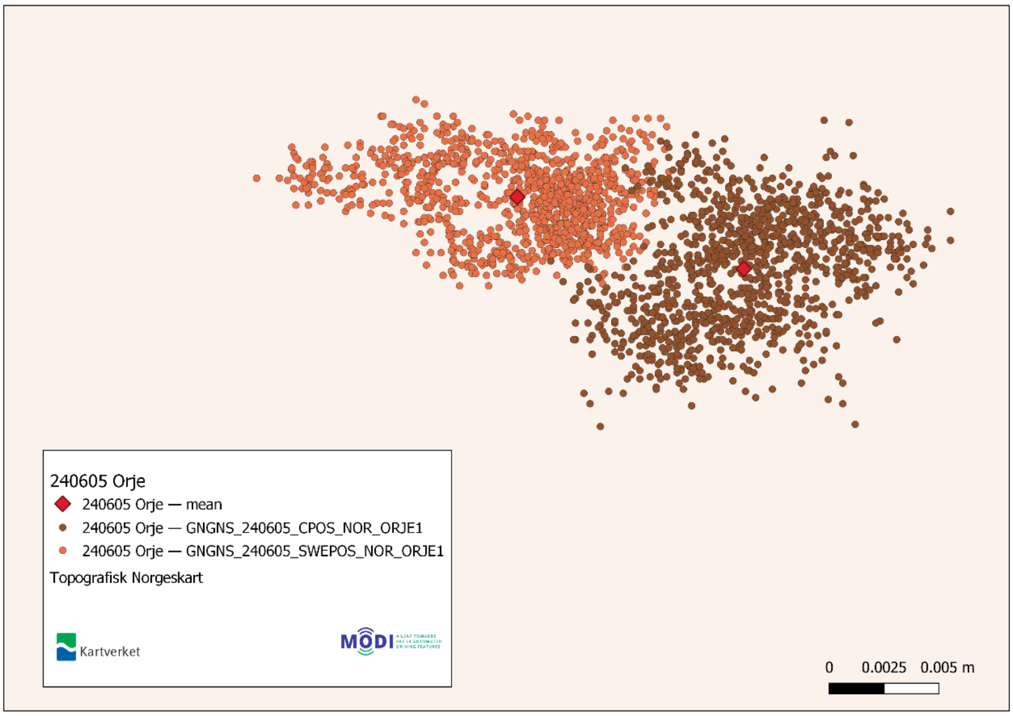


Figure 13-4: Scatter plot from practical test

Figure 13-4 shows a scatter plot of CPOS, SWEPOS at Ørje, Norway. The red squared dot symbolizes the meamvalue from both services.

1.5 Conclusion

The results from Tables 2–4 and Figure 4 demonstrate that the discrepancies between the Norwegian positioning service CPOS and the Swedish positioning service SWEPOS closely correspond to the calculated differences between the Norwegian ETRS89 and the Swedish SWEREF99 reference frames. Implicating that there is a strong alignment between theoretical calculations and practical observations.

The findings confirm that end-users relying on positioning services will experience discrepancies close to what is shown in Table 1 when crossing borders, resulting in slight misalignments between navigation systems and geographic data.

1.5.1 Discussion

Reliable and user-friendly reference frames are essential for both professionals and non-specialists. However, managing their inherent complexity should remain the responsibility of geodetic professionals and relevant organizations, reducing risks for end-users and ensuring accessibility.

Collaboration among geodetic professionals, geospatial data managers, software developers, and standardization bodies is critical for achieving interoperability. Reference frames and metadata must be properly handled in software and sharing platforms. Simplifying reference frames and minimizing transformations should be a priority to avoid unnecessary complexity. These steps are vital for enabling non-specialists to work effectively with geographic data, maps, and positions sourced from multiple providers.

The responsibility for developing future reference frames rests primarily with public-sector institutions, which play a key role in maintaining the global geodetic infrastructure. These reference frames are foundational for GNSS satellite systems, supporting positioning, navigation, and mapping for critical applications such as transportation, environmental monitoring, defense, and cadastral systems. Simplified, standardized, and updated geodetic frameworks are essential for ensuring reliability and usability across diverse applications.

1.5.2 Recommendations

To address the challenges of reference frames in the MODI project and ITS applications, actionable solutions are required to ensure consistency, accuracy, and simplicity for end-users. By harmonizing data transformations, adopting widely recognized reference frames, and standardizing metadata, the complexities of cross-border operations can be significantly reduced. Below are key recommendations to support the effective use of geodetic reference frames in the MODI corridor and beyond:

Table 13-7: Recommandations on how geodetic reference frames should be handled

Recommendation	**Rationale**
Transform all geographic data to a common reference frame before deployment, using an EPSG code to define the reference frame.	Ensures consistent and accurate geographic data alignment across providers.
Perform real-time transformations of GNSS positions during operation to align with the reference frame of geographic data.	Maintains accurate positioning throughout operation, especially when crossing borders.
Use the WGS84 (G2139) reference frame, defined by EPSG code 9755, as the standard for automated vehicles operating across multiple countries.	WGS84 (G2139) is widely recognized, closely related to ITRF2014, and integrates well with EGM08. *NOTE: G2296 was released in Nov 2024, defined by EPSG code 10606*
Adopt the EGM08 geoid model, defined by EPSG code 3855, for height referencing, as it provides sufficient accuracy (5–10 cm) and simplifies data handling.	EGM08 is globally available and simplifies processes by avoiding complex national models while maintaining acceptable accuracy.
Standardize reference frames and metadata, including time stamps, to ensure seamless integration of geospatial data.	Standardized metadata reduces complexity for users and ensures consistency across systems.
Rely on official registries, such as the ISO Geodetic Registry, IOGP's EPSG registry, and OGC standards, for published and continuously updated transformations.	Official registries provide reliable, authoritative data and transformations for use in ITS systems.

References

[1] Arnesen, P., Brunes, M. T., Schiess, S., Seter, H., Södersten, C. J. H., Bjørge, N. M., & Skjæveland, A. (2022). TEAPOT. Summarizing the main findings of work package 1 and work package 2. Project report: 2022:00170. ISBN: 978-82-1407546-5. URL: https://hdl.handle.net/11250/2981432

[2] Nordic Geodetic Commision, URL: https://www.nordicgeodeticcommission.com/ - 09.08.2023

[3] Kierulf_Geodesidagene_DRF_Island, conference proceedings at Geodesidagen 2018.

[4] NCGEO, Offical refererence frames in the Netherlands. URL: https://www.ncgeo.nl/index.php/nl/ncg/archief/geodetische-infrastructuur-referentiesystemen/item/2192-officiele-cooerdinatenstelsels-van-nederland –25.08.2023

[5] Geodetic infrastructure and reference systems in Nederlands. https://ncgeo.nl/index.php/nl/ncg/archief/geodetische-infrastructuur-referentiesystemen/item/2192-officiele-cooerdinatenstelsels-van-nederland - 30.08.2023

[6] ISO 19111, Geographic information – referencing by coordinates, URL: https://www.iso.org/standard/74039.html - 09.08.2023

[7] EPSG Geodetic Parameter Dataset, URL: https://epsg.org/home.html - 09.02.2023

[8] ISO Geodetic Registry, URL: https://geodetic.isotc211.org/ - 09.08.2023

[9] Open Geospatial Consortium, URL: https://www.ogc.org/ - 30.02.2023

[10] Guide to Coordinate Reference System (CRS) Resources, URL: https://committee.iso.org/files/live/sites/tc211/files/Resources/GuideToCRSRegistries3.pdf, 30.09.2023

[11] Referanserammer og transformasjoner. ISBN: 978-82-7945-476-2

[12] GeoE3 project. URL: https://geoe3.eu/geoe3-paved-the-road-for-better-access-and-utilisation-of-location-data-in-europe/ – 06.08.2024

[13] PROJ. URL: https://proj.org/en/9.4/ – 07.08.2024

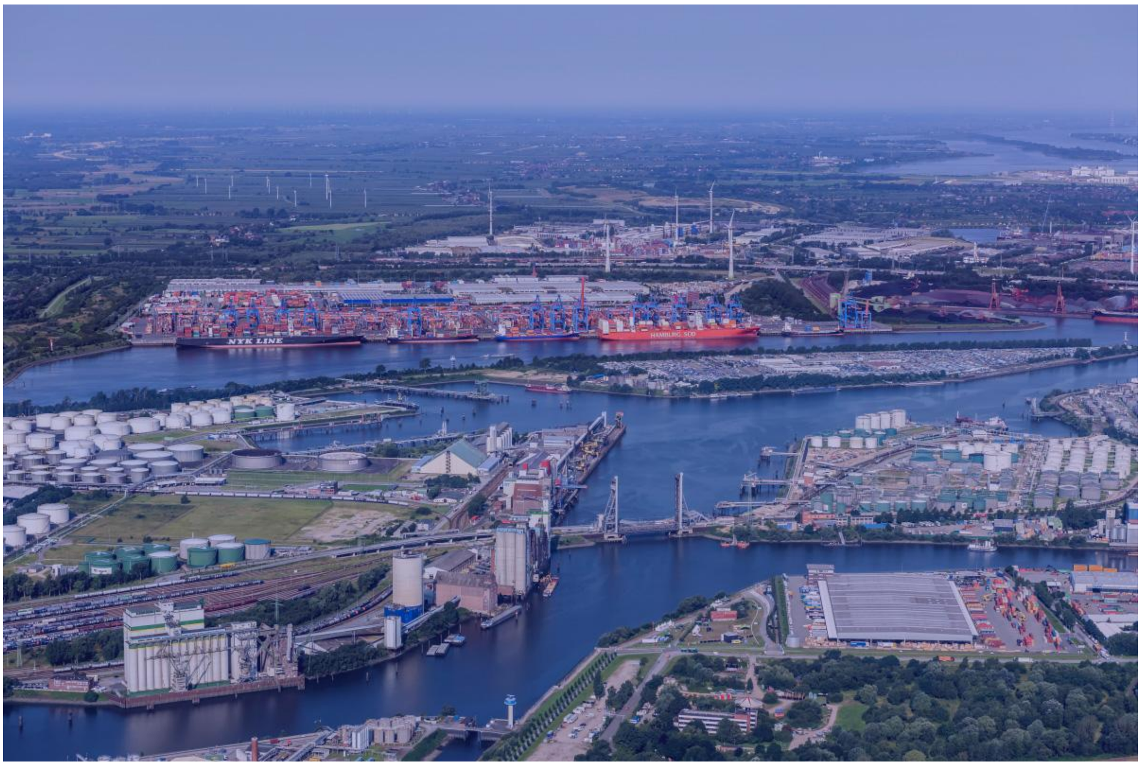
[14] EuroGlobalMap. URL: https://www.mapsforeurope.org/datasets/euro-global-map - 07.08.2024

Annex 4

A leap towards SAE L4 automated driving features

Logistic operators' experiences of digital customs processes in Norway Svinesund

01 February 2024



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Executive summary

This note explores the utility and barriers of digitising the customs processes. The memo focuses on understanding the experiences and viewpoints of logistics operators engaged in border-crossing between Sweden and Norway at the Svinesund checkpoint, using a digital customs process (Digitoll). In addition, the study aims to provide input for the execution of the demonstration of CCAM vehicle border crossing at Svinesund in the MODI project, as well as to inform future endeavours concerning border crossings for CCAM vehicles. The study employs a comprehensive approach, utilising interviews with logistics operators and other relevant stakeholders as the primary research method. Of specific interest is the initial engagement with logistic operators and others who have interacted with the Digitoll system. This study highlights Digitoll's role in enhancing customs monitoring and efficiency while outing challenges such as complexity, cost implication, and early-stage challenges in the transition to a new system. Through close collaboration with the logistics industry, the customs authorities aim to address these barriers and ensure successful adoption by the 2025 deadline. The study emphasises the need to address long-term challenges like allocation of legal responsibility and the lack of alignment to the proposed EU Customs Reform. A system compatible with the rest of Europe would benefit implementation and sustain the effectiveness of digital customs clearance and border control. Weather conditions, effective communication between remote operators and control personnel, and unresolved legal responsibilities for goods transported by CCAM vehicles are key barriers to the demonstration of CCAM border crossing involving customs or technical control, requiring insights from logistic operators' experiences with Digitoll and the Norwegian UC demonstration in MODI to inform future processes.

1 Introduction and aim

MODI aims to explore a challenge involving the necessary adaptions in border processes to accommodate advanced vehicle automation. One of the primary challenges associated with implementing CCAM pertains to ensure the provision of CCAM services when vehicles traverse national borders. However, cross-border mobility with CCAM vehicles necessitates more than merely ensuring the seamless functionality of these systems on the other side of a national border (such as 5G border crossing connectivity [1]). In the case of CCAM goods transport, this also entails addressing challenges related to border control mechanisms: an unstaffed goods vehicle will, for instance, demand an automated and digital customs process. A digital custom system, called Digitoll, is implemented at Svinesund, situated on the Swedish-Norwegian border. Understanding the perspectives of logistic operators, who are actively adopting automation, is essential. However, there is currently a lack of insights from the users' perspective, highlighting the need for attention in this area. Understanding their needs and experiences, including their approach to testing new technologies, is crucial for the successful implementation of digital and automated solutions. Moreover, given that the transport sector is the first to undergo and embrace automation, there is an opportunity to leverage digital customs processes as a catalyst for initiating and accelerating the automation process further. With the substantial traffic and volume of goods crossing borders, there is significant potential for efficiency improvements through the integration of digital customs processes, which can streamline border procedures and increase supply chain efficiency.

This memo aims to provide a comprehensive analysis of the utility and barriers of digitised processes within the transport chain, explicitly focusing on digitised customs clearance processes at international borders for logistic operators. The memo investigates digital customs processes in border crossings at Svinesund, where a CCAM vehicle, at a later stage in the project, will demonstrate border crossing with focus on customs and demonstrate driving through the Norwegian customs area using Digitoll (Use Case Norway). This demonstration will provide learning points about the gaps and future needs of custom declaration for CCAM vehicles with remote operators including legal aspects, technology, digital data flow and human-machine interaction. The memo contributes to the knowledge gap on the implication of L4 automated driving features in the transport chain, by presenting findings derived from a study that investigates the impacts and barriers associated with digitised border control prior to the demonstration.

This memo asks: **What are the key benefits and barriers associated with the digitising of the customs process at Svinesund seen from a logistics perspective?**

This contribution is achieved through interviews conducted with experts from the logistics industry and customs authorities. Consequently, this memo aspires to offer valuable and novel insights to policymakers, border management authorities, industry stakeholders, and researchers, aiding in effectively navigating the evolving landscape of CCAM mobility, customs, and border control.

2 Method

Given the lack of pre-existing research on the benefits and barriers of automating the customs process, our study takes an explorative and abductive approach. We employ a flexible stepwise deductive induction research design as described by Tjora [2] to generate insight from empirical data. This methodological choice aligns with our aim to explore new ideas emerging from the data. Our data collection methods encompass:

- **Document study:** We conducted an in-depth examination of consultation notes, existing public strategies, and other relevant documentation related to the automation and digitalisation of the customs process
- **Semi-structured interviews:** We conducted eight semi-structured interviews with key stakeholders, which included
    - Scandinavian logistic operators (5 interviews)
    - Interest organisations (1 interview)
    - Customs authorities (1 interview)
    - Road authorities (1 interview)

We aimed to involve a diverse range of stakeholder informants in our study. We specifically recruited logistics operators with Digitoll experience who could provide insight into their involvement in the process. Our intention was to engage large and small logistics operators within various types of transportation to encompass a substantial portion of Digitoll's user base. Our logistic operator informants held different customs and logistics management positions in their respective companies. Additionally, we sought to engage with the Customs Authority due to their central role in executing the customs process and Digitoll. Further, we interviewed the National Public Roads Administration (NPRA) because of their control stations at the borders and their role as regulatory authority and strategic stakeholder. Lastly, we interviewed interest organisations to obtain a broader perspective on the interests of transport and logistic companies in this matter.

Each interview was conducted via Teams, lasted approximately 45-60 minutes, and was recorded by permission of the participants. The interviews were semi-structured and explored topics such as use, utility, and limitation of automated customs in addition to future scenarios where CCAM vehicles are crossing borders.

Collectively, we believe these stakeholders provide relevant insights related to the Digitoll case study and possess the requisite experience, expertise, and knowledge to assess and reflect upon future scenarios associated with further automation of various processes within the transport chain.

3 Results

3.1 Customs clearance at the Svinesund border between Sweden and Norway

In Norway, there is an arrangement called the direct driving scheme (also known as the "10-day rule"), which is an exception in the customs regulations allowing for declaration of goods within 10 days after crossing the border. The aim has been to reduce queues at the largest border crossings. This scheme implies that the goods can be delivered directly to the consignee and declared within 10 days after the goods have been registered at the customs warehouse. This arrangement will be discontinued with the full implementation of Digitoll, valid from April 1st, 2025.

Digitoll, developed by Norwegian Customs, is a concept for digital customs clearance[25]. It has legal basis in new customs regulations (Movement of Goods Act and Customs Duty Act) that entered into force on January 1st, 2023. Digitoll is a concept developed to support the digital submission of information and to ensure that the commercial actors crossing the border (e.g., logistics operators) fulfil their four obligations: 1) advance notification of goods, 2) declaration obligation, 3) reporting and information, and 4) presentation of the goods for inspection [3,4]. The Digitoll solution is already available for road transport and has been introduced at several border crossing points. From February 1st, 2024, Digitoll is available at all Swedish border points that perform duties on behalf of the Norwegian Customs. In addition to road transport, Digitoll will be available for all modes of transport during 2024 and 2025, including ferry, air freight, sea, and railway. However, as we are interested in automated road transport, and the logistics operators and their experiences with the digital customs procedures at Svinesund, this note will highlight the Digitoll solution for road transport (and not for the other transport modes) with a main focus on the Svinesund customs point.

The Norwegian Customs' introduction plan for Digitoll aims to ensure that the commercial actors have enough time to adapt to the new systems and processes and make necessary adjustments. Therefore, Digitoll is currently voluntary and will be introduced gradually towards 2025. To include the commercial actors in the implementation phase and to get insights into the first experiences with Digitoll, the Norwegian Customs has established a working group consisting of logistic

[25] https://www.toll.no/en/corporate/digitoll

operators, interest organisations, and the Norwegian Customs itself. This resource group has frequent meetings to discuss different challenges with the new digital customs process. In addition, there have been two consultation rounds, with associated consultation notes and documents, where affected commercial actors have made suggestions for adjustments to Digitoll and the implementation plan. The Norwegian Customs are now working on the third consultation and are preparing for the fourth and last consultation round in spring 2024. As of now, and according to the current implementation plan, Digitoll will be mandatory for all transport moving goods into Norway from April 1st, 2025. However, as our interview results shows, the logistic operators highlighted that this timeline is too ambitious.

By making Digitoll the norm for customs clearance, the Norwegian customs aims to remove time-consuming and manual processes at the border crossing points when importing goods into Norway. To succeed, they need digital information before or at the latest when crossing the border. This implies that from April 1st, 2025, the current direct driving scheme will be discontinued, and digital reporting and disclosure obligations will be mandatory[26].

In the following, we will outline how the customs process unfolds in both the conventional customs process (including use of the direct driving scheme) and through the new Digitoll process. We will elucidate the steps involved in each process, starting before the transport arrives at the border, detailing the stages at the customs station, and concluding when the goods are fully customs cleared.

See MODI deliverable D1.3, chapter 3.2 [5], for more technical details on the digital and conventional customs clearance processes and technical recommendations for CCAM border crossing. This memo's description of the Digitoll process integrates elements of previously discussed information in D1.3 with our data collection.

3.1.1 Conventional customs clearance process

When transport is to be cleared through the conventional customs process, few preparations are needed prior to the transport's arrival at the border, other than bringing necessary documents for reporting and information[27]. Upon reaching the customs area, the vehicle is required to stop and park within the designated parking zone (C in Figure 1). Subsequently, the driver is obligated to enter the customs office (D) and present their documents to a customs officer to fulfil their reporting and information obligation. If the goods are imported on the direct driving scheme, the commercial actors are not obliged to fulfil their declaration obligation at the border, as the goods can be declared within 10 days. This scheme is an exception from the Customs Act. However, according to the Norwegian Logistics and Freight Association [6], more than 80 % of all goods imported to Norway are imported on the direct driving scheme, making it the primary method for import declaration, despite original intentions of it being an exception rule. Hence, the

[26] See: https://www.toll.no/en/corporate/digitoll/what-happens-next/

[27] New rules for advance electronic information are forthcoming, e.g., ICS2 (Import Control System 2), where anyone transporting goods into the EU, Norway, and Switzerland from a third country must submit advance electronic information regarding the goods. https://www.toll.no/en/corporate/transport-and-customs-warehouse/prenotification/advance-cargo-information--import-control-system-2-ics2/advance-electronic-information-regarding-cargo-fram-third-countries/

discontinuation of the direct driving scheme by April 1st, 2025, will have major consequences for the commercial actors, as the goods must be declared before reaching the border.

Assuming all is in order after presenting the documents, the drivers receive document stamps, allowing the vehicle to proceed through the customs area. However, should any suspicions, errors, or irregularities arise, the vehicle may undergo scanning and/or a controlling procedure (respectively located at E and F in Figure 1). This could be due to the vehicle appearing suspicious, having undergone prior inspections with irregular findings, or displaying other shortcomings that prompt the Customs Authority to conduct additional control of the vehicle, its documents, and/or goods.

Following the customs clearance process, the vehicle exits the customs area. Yet, the vehicle may be subject to an inspection at the NPRA control station (located at G in Figure 1). The control station may not always be staffed, and inspections are contingent upon staffing availability and transport patterns (Bräutigam et al. 2023). However, the vehicle might stop and undergo a technical vehicle inspection if there is control. If the vehicle has been stopped by the Customs authority, the NPRA often conducts a vehicle inspection as well. After a successful control, the vehicle concludes the process, continuing straight ahead through the roundabout to rejoin the E6.

3.1.2 The Digitoll process

The Digitoll concept involves three key premises [7]:

1) Digital information (including transport documentation, custom documentation, and other relevant paperwork) must be submitted 2 hours[28] before or, at the latest, upon reaching the border.
2) The Customs authority undertakes the processing and assessment of information before or, no later than upon, the vehicle's arrival.
3) A thoroughly digitised border crossing is implemented, allowing for automatic release based on the selected procedure to the greatest extent possible.

All digital information must be submitted 2 hours before or, at the latest, upon reaching the border, as described above. This implies that the logistic operators send all customs documents (a so-called Manifest[29]) in advance. The customs officers process and assess the information upon the vehicle's arrival. The exact arrival time is written in the submitted documentation. Therefore, all goods are declared in advance, before the vehicle arrives, or at the latest, upon arrival.

Figure 1 illustrates how the Digitoll process is carried out after the transport arrives at the border and enters Norway. An automatic number plate recognition camera (ANPR) roadside (A) registers the vehicle's license plate when exiting the E6, heading towards Svinesund Customs station. The vehicle will then be cross-referenced with the submitted documents. This process is automated but can be overwritten by custom controllers. A traffic light (B) will then display a green or red

[28] The commercial actors must cross the border and the customs area within 4 hours after the expected arrival time written in the Manifest. If they submit the documents two hours upon arrival, this means the documents are valid for 6 hours.

[29] The manifest contains relevant information for conducting border control, such as details about the vehicle and its transported goods.

signal, indicating whether the transport is permitted to proceed through the customs area or if further inspection is required, whether it be for document verification, vehicle inspection, or both.

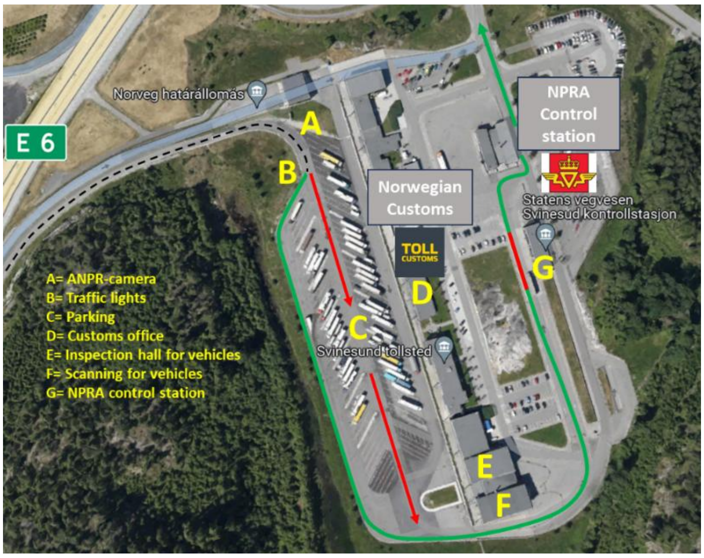


Figure 1: Execution of a Digitoll process where the vehicle is either given a green or red light at the respective customs and NPRA control station.

In case of a green signal, the transport can utilise the express lane, marked in green in Figure 1[30]. If the vehicle receives a red signal, as illustrated in Figure 2 below, the driver is required to locate a designated parking zone (C), park the vehicle, and proceed to the customs office to engage with a customs officer (D). This process aligns with the conventional customs clearance process. In instances where errors or irregularities are identified in the submitted documentation, the vehicle may undergo scanning (F) and/or a manual inspection within the control room (positioned at E in Figure 1 and seen below in Figure 3).

Figure 2: ANPR-camera at the Svinesund customs station and the light signal at the Digitoll express clearance lane (B in Figure 1).

[30] However, the customs authorities can still choose to bypass the green light and inspect the vehicle.

Finally, if all conditions are satisfactory, the vehicle proceeds to exit the customs area. On their way out, there is a possibility of being subject to inspections at the NPRAs control station, located at the outer edge of the customs area (G in Figure 1), replicating the procedure outlined in the earlier description of the conventional customs process above.

Figure 3: Vehicle scanner at Svinesund Customs station.

3.2 Benefits and barriers

This memo seeks to investigate key benefits and barriers associated with digitising the customs process at Svinesund border, seen from a logistics perspective. To address this issue, we have categorised the findings into distinct themes. Certain aspects of Digitoll could concurrently serve as both benefits and simultaneous barriers, depending on the perspectives of various logistic operators. Therefore, we have chosen to organise the results into thematic categories based on the experiences of these operators.

3.2.1 Advancing digitalisation at roadway border crossings

From the perspective of the customs authority there exist a need for digitisation due to an unmet need for control, particularly in terms of capabilities to verify goods crossing the border compared to what is offered by the direct driving scheme and 10-day rule. An informant from the customs authorities describes the current arrangement as follows:

> "The companies register their goods, and then they have ten days to declare it to customs. In principle, they should not release the goods until after these ten days, or until they have submitted the customs declaration. However, in practice, the goods are often released immediately, and it has already been consumed by the time we receive the customs declaration, with minimal opportunity for verifying its contents." (Customs authorities)

Additionally, to facilitate the control function, Digitoll eases practical considerations. A quick pass through the express lane prevents a buildup of vehicles in the parking lot and thereby reducing queues. Furthermore, through digitalisation and eventual use of AI to analyse large amount of data about a vehicle's history, goods, and other relevant factors, algorithms can identify patterns and deviations that may indicate potential risks or irregularities. This can help optimise resource allocation by focusing inspection efforts on vehicles with the highest likelihood of violating regulations or smuggling illegal goods. Consequently, this could also lead to a more efficient and targeted inspection process for the customs authority.

The logistics industry, on the other hand, is moving towards increased automation, recognising significant opportunities to enhance efficiency. With narrow profit margins, there are opportunities to improve profitability, efficiency, and the management of cross-border mobility. However, there are considerable differences among logistics companies in terms of size and the extent to which they have initiated internal automation and digitalisation processes. In our study, we interview both large global companies that have made considerable progress, and medium-sized logistics companies that have yet to embark on major modernisation initiatives.

Our research finds a desire and necessity for efficiency gains through the digitalisation of customs clearance processes, as articulated by all respondents. There is a consensus that Digitoll will have significant importance and consequences for the Norwegian business sector and the authorities controlling the border. Logistic operators demonstrate a favourable disposition towards the digital transition of customs clearance procedures, recognising its potential to optimise capacity utilisation. Additionally, there is recognition of a demographic shift among customs experts in Norway, characterised by a relatively high average age, joined by a growing demand for digital competence in the customs field. Consequently, the logistics industry needs recruitment of personnel possessing digital competencies to effectively navigate customs-related responsibilities.

- Digitoll addresses the customs authority`s need for enhanced monitoring of inbound freight transport, while also potentially enhancing efficiency and digitising the customs processes for logistic operators.

3.2.2 Implementing and use of Digitoll

The majority of the logistics operators are satisfied with the authorities’ inclusive and collaborative approach and see the establishment of a resource group as a success. Consisting of authorities, interest organisations, and the industry, the resource group ensures a constructive process between the different stakeholders. Through regular meetings and several consultation rounds, the logistics operators raise relevant challenges and present suggestions for adjustments to the Customs Authority. Several logistics operators describes that their feedback has been taken into account and included in the further development of Digitoll. As one of the informants describes it: “ [The resource group] has worked in a good way. It is a good relationship between the industry and the Norwegian Customs Authority”. This strong collaboration and close dialogue between the authority and the industry is quite unique in a European context and is highlighted as a success factor.

> "We have attended many meetings regarding this digitisation project, and there is openness to express our opinions. They include us in the process, and not all customs authorities in the world do that. So, we have a very good dialogue, which has impressed me. We also

don't give up, and they know that, but I now see that they understand that we genuinely want to succeed together with them.”

Even though the process has been constructive, there are still several challenges that must be resolved before Digitoll is fully implemented and mandatory by April 1st, 2025. An example brought forward by one of the logistics operators is the complexity of Digitoll and the possible negative consequences for Norwegian import.

> "We are terrified that it will become so complicated to send goods to Norway that they don't want to. Look at Brexit or England; they have lost a lot because of everything that has happened there, right?"

This complexity is, among other things, connected to the need for a transition and implementation of new systems (e.g., API) offered by the Customs authority to connect to the Digitoll platform. In the interviews, the industry shares their concerns regarding the lack of time for testing these new solutions due to tight deadlines. Hence, several of the informants clearly states that the final deadline for the full implementation of Digitoll is too ambitious and underscores the need for enough time to test and adapt to the new processes. One of the logistics operators states that:

> "Those of us working at [company name], we are 90,000 employees, and our IT operations are managed from Copenhagen. It's common for systems to experience glitches and come to a halt. What do we do in such situations? This occurs for everyone operating digitally. Customs authorities need to find effective solutions, which they currently lack."

Many of the challenges raised by the industry during the implementation phase could have been avoided if the process and the plan had started the other way around, according to the informant from the Customs Authority: “Ideally, we should have started at the other end, and anchored what concrete information [in the documentaetion] we will require from the industry, and how we intend to do it, before we got started”. The Customs authority started to develop solutions and an implementation plan for Digitoll before establishing a resource group and dialogue with the industry. By starting with legal authority and anchoring within the industry, they might have achieved a more complete implementation of Digitoll. However, to solve some of the issues and concerns raised by the industry in the consultation rounds, the Customs authority will present an action plan to ensure that the goods can be imported even if everything in the documents is not ready prior to the border crossing. This implies a) a temporary customs storage (as in the EU), b) conditional permit for entry, and c) simplification of the digital reporting and information obligation.

- Close collaboration between authorities and logistics operators through the establishment of a resource group has facilitated inclusive dialogue, allowing for the incorporation of industry feedback into the development of Digitoll, which is perceived as a success factor and unique in the European context.
- Challenges such as complexity and tight deadlines for implementation remain, necessitating effective solutions and adjustments to ensure the successful adoption of Digitoll by the 2025 deadline.

3.2.3 Revising work processes and time management with Digitoll

The most prominent shift experienced for the businesses in the transition towards Digitoll revolves around alterations in the workflow and working hours of customs and logistics management staff in the logistic companies:

> "For our part, it becomes an entirely new way of working. Previously, we've operated under the premise of having everything ready by the time the truck reaches the border. Now, everything must be prepared two hours before the truck reaches the border, introducing a shift in the timeline."

For the Digitoll solution to work as intended, meaning that the vehicle gets the green light and can pass through the customs area in an efficient way, it is required that the industry collect and submit a large amount of information in a manifest in advance. If there are any errors or irregularities in the manifest, the vehicle gets the red light and has to stop. Therefore, to avoid a stop at the customs station, both the industry and the Customs authority underscores the importance of having accurate information in the documents. The amount and type of information required has been oneof the main discussion topics in the resource group meetings. As the representative for the Customs authority stated in the interview:

> "There is a big value of getting all the information before the vehicle reach the border. This requires major adjustments when having to operate in a different way and obtain the necessary documentation. We have worked a lot on what information we will require about the drivers".

Nevertheless, it could be quite challenging for the industry to collect all the necessary information two hours prior to the border crossing. It is especially challenging for the logistic actors doing multiple consignments, as they need to collect customs documents from several businesses and signatures from their customs representatives:

> "In a hypothetical scenario, Schenker assigns us the task of preparing the information. Then they subcontract the transportation to a subcontractor. They may further sublease capacity, leading to challenges in obtaining accurate information. Additionally, there is a time aspect involved; the manifest must be submitted at least two hours before the planned border crossing time."

Hence, the combination of a short time span and the need for substantial information represents a significant adjustment for the logistics operators, necessitating industry-wide adaptation. For instance, they need to collect more information concerning the driver than before:

> "Previously we only wrote customs documents, but now we also need to have information about who is driving, the name of the driver, the nationality of the driver and also which transport company is driving across the border. We often need to collect more information earlier, quite simply".

However, despite the increased need for information, one of the logistic operators underscored that this not necessarily mean increased workload. Rather, the margin for errors in the information provision has diminished: "It will be exactly the same, but the time we have at our disposal for error corrections has drastically diminished. The timespan is so short that we cannot accept that kind of errors”.

One of the logistic operators perceive this issue from a broader perspective and emphasises the significance of information flow across Europe, to gain a comprehensive understanding of the entire value chain, spanning from the consignor to the recipient. They stated:

> "We must involve the whole of Europe, so to speak, because otherwise, we stand no chance whatsoever, and we have tried to convey this to the customs authorities. It doesn't help how nice and impressive it looks on paper on the Norwegian side if we don't have the necessary information in advance. With digitalisation, early information flow and crucial information are vital. Providing clear and accurate information is important, and unloading this as soon as the right means of transport is available will be crucial."

As we have observed, the workload using Digitoll is front-loaded, and customs work is carried out at different times of the day than previously, utilising larger portions of the day. The shift in workflow represents both advantages and challenges for the logistic operators. First, Digitoll can lead to more efficient customs clearance that enables greater efficiency for the logistic operators: "Things run quite smoothly when we submit the correct information, and the vehicles arrive. It's excellent, and it means that we, as an industry, can invoice for the assignments earlier." However, it also involves setting a time constraint on the transport, which may be a challenging task to accomplish and relates to the logistics involved in planning the arrival at the Svinesund border: "In the transportation world, especially in local transport, a two-hour shift poses a challenge." Another informant reflects more comprehensively on this challenge:

> "There is a time aspect here as well. You must submit the manifest at least two hours before the planned border crossing time to allow customs enough time. It might not be an issue if the transport is coming from Europe, but if it's coming from Gothenburg, for example, where a lot of the goods in Norway originate, it becomes a bit challenging. We also need to sign paperwork outside of those two hours in advance. Additionally, the transport must cross the border within four hours of the specified time, which can be more challenging if coming from Europe, as you have to specify within four hours when you're at the border, and unforeseen events can occur on the road".

A third informant articulates the following regarding the challenges associated with loading the final goods in Gothenburg:

> "And if we have the last loading in Gothenburg, for example, then it's barely two hours to the border, and what should we do with the truck? Should it wait at the sender's location, or should we let the truck drive to a possibly unsupervised parking lot? That's not a good alternative. Or should it drive to the border, only to find a halt because the customs authorities are not ready, and the gates are not open? In any case, we would have to resort to manual handling. So, there are some things to work on to get it completely perfect”.

The logistics companies need to rethink planning, strategizing logistics to a much greater extent than before. The seamless use of Digitoll is contingent upon several elements earlier in the supply chain. This change in the workflow is nevertheless crucial for Digitoll to achieve its goal of more efficient customs clearance. One informant describes it as follows: "What we see as incredibly important from the beginning is that there is an early and accurate flow of information from our partner countries. If we don't achieve that, success in this project will be difficult."

Collectively, this demands a considerable amount of new coordination and restructuring in term of information acquisition compared to prior practices, in order to realise efficient customs clearance processes with Digitoll. Considerable refinements are still requisite for the system to operate at its utmost efficacy and seamlessness.

- Transitioning to Digitoll necessitates significant adjustments in workflow and time management for both customs and logistics personnel, with an emphasis on early submission of accurate information to ensure efficient customs clearance.
- The front-loaded workload of Digitoll presents both advantages, such as earlier invoicing and streamlined processes, and challenges, including tighter time constraints and complex logistics planning, highlighting the need for extensive coordination and refinement to optimise system efficiency.

3.2.4 The cost of Digitoll implementation for logistic operators

The implementation of Digitoll evidently entails costs for the logistics industry. The transition to operating in a different manner and during different timeframes than previously requires both expenses and some reorganisations for the companies: "The aspect of working 24/7 is indeed a significant cost driver that we cannot avoid. We need to have a portion of people [physically] at work, and it is a major challenge." Moreover, Digitoll necessitates the adoption of specialised software, entailing procurement expenses for the companies: "Of course, there is a cost associated with adopting the interface. Because you have to purchase the software developed by various software providers and implement it. That is, of course, a cost."

However, a crucial cost aspect is the internal restructuring needed to align with the requirements set by the authorities: "[W]hat businesses highlight as the most significant cost is the restructuring they themselves have to undergo to meet the requirements of the Customs Authority." This restructuring poses a considerable financial burden, with concerns raised about the potential impact on the survival of certain companies, particularly smaller ones:

> "[T]his is going to be tough for many companies, and I also believe that it's going to be the end for some companies. And that's something we really don't want because we need jobs in Norway. But I've talked to a lot of people in the industry, and many are very worried about whether they'll be able to survive. Because there will be huge costs that we don't have today."

The absence of upfront cost analyses by the Customs Authority has caused uncertainties in the industry regarding additional expenditures, particularly related to labour costs. Furthermore, the transition presents significant disparities among companies, particularly concerning their size and capacity to navigate the changes effectively. Larger companies, often at the forefront of adopting Digitoll, incur substantial initial costs and bear the brunt of system-related challenges, thereby paving the way for smaller entities.

- The implementation of Digitoll imposes significant costs on logistics operators, encompassing expenses for operational adjustments, procurement of specialised software, and internal restructuring to meet regulatory requirements.

- Concerns are raised about the financial viability of smaller companies and uncertainties surrounding upfront cost analyses.

3.2.5 Enhancing efficiency while encountering time constraints

The primary aim and outcome of Digitoll is to enhance the efficiency of border transit. At the Svinesund border crossing, approximately 1600 heavy goods vehicles pass through daily[31]. However, the conventional tolling process has resulted in the formation of extensive queues due to capacity constraints. Utilising Digitoll and the express lane, transport vehicles qualified for passage on green light, experience markedly reduced border transit time. As described by one informant, the drivers can "wait for only 5 minutes instead for an hour". This demonstrates significant efficiency gains for both the Customs Authority and logistic operators traversing the border. It helps ease large build-ups of vehicles at the toll station, resulting in shorter queues, thereby allowing transports to get back on the road more quickly to deliver their goods. However, the vast majority of Digitoll users today transport uniform goods, often bulk goods and other shipments requiring only one customs declaration. This trend emerges because logistic operators find it easy to obtain documentation for these specific types of shipments in advance. Nevertheless, what significantly demands expeditionary capacity at the border are transports containing multiple shipments. These typically involve freight forwarders who transport goods that originated from multiple shippers and has numerous different goods recipients. A transport containing, for instance, 200 different consignments necessitate 200 individual customs clearances, thereby requiring extensive document collection and time for this endeavour. An informant elaborates the time-demanding nature of document retrieval in this case: "A freight truck with 200 customs clearances might take an entire day for one person, so it is evident that there is a significant disparity".

The time-consuming customs clearance process for multiple consignments may lead to an unintended negative impact seen from a sustainability perspective. Freight forwarders dealing with multiple consignments often exploit the opportunity to fill up vacant spaces in their transport, fostering collaboration among competitors to facilitate the transportation of goods across borders while avoiding running partially empty transports: "Suddenly they have an incentive not to fill the extra capacity because the risk becomes greater than the potential gains, which is very unfortunate. Therefore, they are not using the full capacity" (Interest organisation). When customs clearance for such shipments suddenly becomes highly time-consuming, as described above, it may disincentivise the utilisation of additional capacity in transport. This may result in reduced sustainability because of an increase in the number of transports on the roads. The current configuration of Digitoll fails to adequately incentivise the optimisation of available capacity for multiple shipments in a seamless manner.

- Digitoll aims to enhance border crossing efficiency, notably reducing wait times for qualifying vehicles at the Svinesund border crossing, thereby easing congestion and expediting goods delivery.

[31] Based on data obtained from annual average daily traffic 2022, from NPRA: https://vegkart.atlas.vegvesen.no/

- Challenges arise, particularly for transports with multiple consignments, necessitating extensive document collection and potentially preventing capacity optimisation, impacting sustainability efforts.
- While Digitoll streamlines customs processes for uniform goods, it poses significant time constraints for transports with multiple consignments, potentially hindering sustainability goals by discouraging capacity optimisation and increasing road traffic.

3.2.6 Overcoming long-term obstacles in Digitoll

In addition to the short-term challenges encountered in the implementation of Digitoll, there are long-term challenges related to digital border crossings that necessitate resolution. These challenges encompass legal responsibilities and ongoing efforts at the EU level.

The allocation of legal responsibility for the goods is not tailored for the state of modern transport and need a revision. This is further actualized with the introduction of Digitoll. The Norwegian law gives responsibility of notifying and presenting the goods to the 'person who lodges the customs declaration', in other words the declarant. This is in line with the current European Union Customs Code. In Norwegian law, however, the responsibility is shared with the driver of the vehicle, a practice with long tradition nationally. However, this allocation of responsibility is widely contested as unfair, given the detachment of the driver from the goods being transported. The driver often is not involved in the loading or unloading of goods on the vehicle. Additionally, the cargo is frequently sealed. In this manner, the driver is entirely disconnected from the goods being transported:

> "It's actually completely crazy that the driver is still primarily responsible and has personal liability for this. It should at least have shifted up a notch to the carrier. But this is a result of using the same structure for responsibility allocation in this law [Customs Act] of 2023 as they did in the first customs law of 1850; they've simply continued that allocation of responsibility without reassessing it, because that would be a much bigger job, right? But they've chosen not to do that all the way, so then we're left with a legal structure meant for a completely different volume than what we have now."

Our informant advocates for shifting the legal responsibility from the driver to the carrier or logistic operators, aligning it with modern practices and realities. This shift is particularly pertinent for CCAM vehicles crossing borders, raising questions about accountability in the event of an inspection. As such, there is a pressing need to redefine the legal responsibility structure to ensure alignment with modern transport practices and technological advancements.

Another potential barrier for the development of Digitoll is the proposed EU Customs Reform, as noted by several informants from major logistic companies. The reform package emphasises a data-driven approach to customs management, leveraging advanced technologies like machine learning and AI to streamline processes and enhance risk management, much alike Digitoll. The reform aims to establish the EU Customs Data Hub, enhance collaboration between customs authorities and businesses, and modernise customs procedures for e-commerce. This includes simplifying reporting, improving risk assessment, and ensuring online platforms to comply with customs regulations, thereby creating a more efficient and transparent customs framework for the EU [8].

The first draft from the Commission addresses the problem of the declarant or the carrier being legally responsible for goods. It problematises today's situation where several actors take care of the customs, and it is not easy to know who the importer and exporter is. It suggests a clarification in the level of roles, making importers and exporters solely responsible for ensuring compliance with procedural and legislative requirements and paying applicable duties and taxes. The responsibility of the carrier will be to *provide* the right information to the customs office in advance, including the information of the importer responsible. As EU members, the MODI countries Sweden, the Netherlands and Germany will have to comply with the customs reform upon adoption, implying clearer delegation of liability for importers and exporters. Norway, on the other hand, will not automatically take part of the reform as the EEA is not a customs union.

Several logistic operators express a desire for closer integration between the development of Digitoll and the EU Customs Reform. Some fear that the efforts invested in Digitoll may become futile in a few years when the EU Customs Reform comes to effect, necessitation a transition to a new system:

> "And then the question arises, how do we integrate this new EU Customs Data Hub with Digitoll? I mean, everything costs money to develop, everything takes time to develop, and so on, so... perhaps one should also bear in mind that a change is coming with the EU Customs Reform."

The interest organisation also expresses scepticism regarding the development in the forthcoming years, emphasising that the implementation of the new EU Customs Reform will necessitate alterations in the Digitoll process:

> "They didn't know much about how the EU's system would turn out when Digitoll was developed, and it has been developed to a small extent and has been little influenced by EU processes. When the EU system arrives in 2028, it will most likely necessitate significant modifications to Digitoll."

An informant in a logistic company underscores the need for closer collaboration between the Norwegian customs authorities and the EU Customs Reform:

> "[W]e wish that the customs authorities had perhaps collaborated more with the EU regarding what we are about to embark on. It's great that Norway is leading the way, and the idea is excellent, but we see that things would have been smoother and simpler if the EU had joined in. Therefore, we recommend the customs authorities to be present in international arenas and communicate what it truly entails."

In sum, it is not currently feasible to implement measures to address these two barriers. However, they represent significant challenges that will eventually have implication for both logistic operators and border control authorities, necessitating long-term solutions. One observation is that the issue of legal responsibility and the lack of integration with the EU are interlinked. If Norway were to aim for closer harmonisation with the EU customs reform, it could simultaneously rethink and modernise issues of legal liability for goods.

- Long-term challenges in Digitoll implementation include addressing legal responsibility for goods, with calls for updating regulations to reflect modern transport practices, and navigating the relationship between Digitoll development and the proposed EU Customs

Reform, highlighting the need for closer integration and collaboration between Norwegian customs authorities and EU initiatives to ensure alignment and avoid redundancy in future customs frameworks.
- Pressing issues such as redefining legal responsibility and aligning Digitoll with the EU Customs Reform underscore the importance of proactive planning and collaboration between national and international entities to ensure the effectiveness and longevity of border control systems, requiring long-term solutions to address evolving regulatory landscapes and technological advancements.

3.3 Relevance for CCAM vehicles

The effectiveness of CCAM relies on the dependability and strength of its components [9]. Hence, it is crucial that key operations, such as border crossings, are tailored and feasible for CCAM vehicles. Therefore, ensuring that essential processes are optimised to accommodate and facilitate CCAM vehicles is necessary for their effective integration into the transportation system. Digitoll represent a first step towards digitised and more automated customs solutions, and a progressive step towards automated transport in general, contributing to the resolution of key challenges such as border crossings. The experiences and insights from the users' perspective are of great importance for preparing the transport sector for further digitalisation and automation. These learnings are not only of relevance for other border crossing scenarios, but also for other terminal operations (e.g., access control).

In the following chapter, we will highlight key findings from the study that are relevant for future CCAM vehicles using a digitised customs clearance solution (such as Digitoll) and other automated terminal operations where CCAM vehicles might be involved in the future. We will present the current barriers hindering CCAM vehicles taking use of Digitoll when demonstrating automated border crossing, as well as the long-term barriers that must be addressed to integrate fully automated border crossings. These findings should be considered in the GAP analysis of the MODI project for further follow-up and resolution.

3.3.1 Demonstrating CCAM vehicle border crossing with Digitoll

UC Norway will demonstrate a border crossing and customs process with a CCAM vehicle at the Svinesund border between Sweden and Norway. The border crossing and customs demonstration in the Norwegian Use Case ensure that the UC-partners learn about future needs and gaps of a digitised and automated customs clearance process involving a CCAM vehicle and a remote operator. This includes both the human-machine interface and the communication between the vehicle and the personnel, in addition to technical solutions on how to navigate inside the customs area.

In the UC demonstration, in the event of a green light and clearance for passage, there are few pronounced barriers for the vehicle to cross the border. One informant mentioned weather as a possible disrupted factor in the event of snow and dirt that can impede the registration of the vehicle's number plate for the ANPR camera. Harsh weather conditions, typical of those encountered in Nordic countries, can also influence the capabilities of the CCAM vehicles' sensor technologies, such as LiDAR, Radar, and cameras (see [10]). Snow, sleet and rain, can limit the technologies' abilities, making it challenging to navigate and operate in a safe way, for instance inside the customs area and other terminals. Aside from that, there are few external disruptions for a CCAM vehicle to cross the border via the Digitoll express lane.

Barriers may arise on the route if the transportation is given a red light, for example in the event of unreadable number plates. First, the CCAM vehicle must perceive that the light turned red, for instance communicated via C-ITS, before proceeding to the customs station for inspection. The CCAM vehicle must then handle mixed traffic and possible VRUs when manoeuvring to an available parking lot (C in Figure 1). In such a scenario, the communication interface between the remote operator[32] for the CCAM vehicle and the customs personnel will play a significant role. For instance, the CCAM vehicle and the remote operator will most likely require information regarding suitable parking locations at the customs station[33]. This necessitates effective communication between the customs personnel and the remote operator, for instance communication over the phone or other contact methods.

Subsequently, after parking the vehicle, there is a need for a representative of the transportation to be available for document management, either physical, remote or both, to the customs authority to provide information about vehicle and the goods. Who will be responsible for document handling in the future where CCAM vehicles are involved, need to be investigated in greater detail to find reasonable solutions and roles of responsibility, as discussed in the preceding chapter. The customs authority reflects on a hypothetical scenario where a vehicle is driverless and how this would appear when conducting a Digitoll customs process:

> "Presumably, there must be some sort of responsible entity in this context. Someone who is accountable for ensuring that everything is reported and who can be approached or held accountable depending on the circumstances, if there is any wrongdoing. And of course, it also requires some regulatory adjustments, I assume. When the [physical] papers are replaced by messages through our interface, then it will not be any worse than it is today."

Currently, it is unclear who should bear the legal responsibility, but the customs authority does not view CCAM border crossing with pessimism if the legal responsibility is placed on an appropriate entity and if the documents required are further digitised, allowing the customs process to become more automated and digitised than it is today.

However, in addition to parking and document handling, there are several other scenarios inside the customs area where the interface between the remote operator and the customs personnel is decisive. Effective communication will be essential if the CCAM vehicle must undergo a scanning, if the vehicle must manoeuvre to the inspection hall, or if the vehicle has to be relocated due to technical issues. In such cases the remote operator needs to be able to communicate with the personnel from the customs authorities, and vice versa. Another issue that needs to be investigated is how the personnel can unlock the doors in case of cargo inspection. This communication interface is also relevant for the NPRA and their personnel located at the control station, where the CCAM vehicle might be stopped for a technical inspection. In such a situation it

[32] Remote operator involves a human controlling a vehicle or machinery from a separate location, often using wireless communication and human-machine interaction. Typically, a human remote operator interacts with the vehicle through a dedicated interface in a remote operating center (ROC).
[33] This is investigated and detailed in MODI deliverable D3.3 *User and vehicle interface*.

is essential for remote operators to be able to communicate with the vehicle, facilitating the receipt of necessary information and documentation. This coordination is also crucial in scenarios involving relocation of vehicles, particularly during challenging weather conditions. Ensuring effective communication between the remote operator and control station staff is imperative for the seamless execution of operations.

As of communication, several of our informants highlighted the importance of having a concise language, as they were concerned that a different use of terms and languages could pose some challenges to the communication between the customs personnel and the remote operator for the CCAM vehicle. One possibility can be to look towards the air traffic controllers and their standardised communication, as they use communication known as "aviation phraseology" or "ATC phraseology". It comprises standardised communication procedures and specific terminology designed to ensure clear and concise communication between pilots and air traffic controllers. This standardised language helps prevent misunderstandings and contributes to the overall safety of air travel. This may serve as inspiration for the communication between remote operators and personnel stationed at various points, such as customs and technical control stations. It is pertinent to highlight that training in effective communication protocols is not exclusively directed towards remote operators but extends to personnel stationed at customs and control stations as well.

Another highly central aspect for the CCAM vehicles is the legal responsibility for the goods. As stated previously, in Norway today it is the driver that is legally responsible for the goods inside the vehicle. This is based on a framework established by the 1850 customs law and is highly criticised for being outdated and unfair, as the driver has little detailed knowledge of the goods transported in the vehicle.

Hence, one of our informants advocate for shifting the legal responsibility from the driver to the logistic operators or the carrier. Such a shift may also be of great importance for CCAM vehicles, as these vehicles will have no driver. How to solve these legal aspects for a CCAM vehicle remains unanswered but is clearly something that needs to be examined in greater detail, echoing previous research done in the MODI project (see recommendations in [5]). Although the EU Customs reform don't explicitly address the issue of CCAM vehicles, it goes far in simplifying and digitising the customs process for trustworthy operators. These can get status as 'authorised economic operator' and 'trust and check trader'. For CCAM vehicles, the latter is interesting because it allows for the vehicle to cross the border via 'green lanes', free of administrative burden. These operators need to provide a high level of transparency and monitoring, including making available real-time data on the movement of their consignments. This data is a prerequisite for operating CCAM vehicles, making these actors key candidates for operating within the 'trust and check traders' scheme.

The experiences of logistic operators with Digitoll, and the insights gained from the Norwegian Use Case demonstration in MODI, are expected to be significant for future digitised and automated processes in the transport sector. These experiences offer valuable insights to the perspective of end-users regarding functionality and challenges of a digitised customs clearance process. Such insights will be valuable for the MODI project as a whole, and to other stakeholders involved in automated processes within the transport sector. Hopefully, the Norwegian Use Case will further investigate legal considerations, such as the allocation of legal responsibility for the goods in scenarios where the vehicle lacks a physical driver.

- Weather conditions can impact the performance of CCAM vehicle sensor technologies, potentially hindering navigation during the Svinesund Digitoll customs clearance process and within other terminals.
- Effective communication between remote operators and customs personnel and other control personnel is crucial for managing various scenarios inside the customs and control area, including vehicle parking, document handling, vehicle scanning, and technical inspections.
- Legal responsibilities for goods transported by CCAM vehicles pose unresolved challenges, with potential shifts in responsibility from drivers to logistic operators or carriers requiring further examination.
- Insights from logistic operators' experiences with Digitoll and the Norwegian UC demonstration in MODI will be valuable for addressing these barriers and informing future digitised and automated processes in the transport sector.

4 References

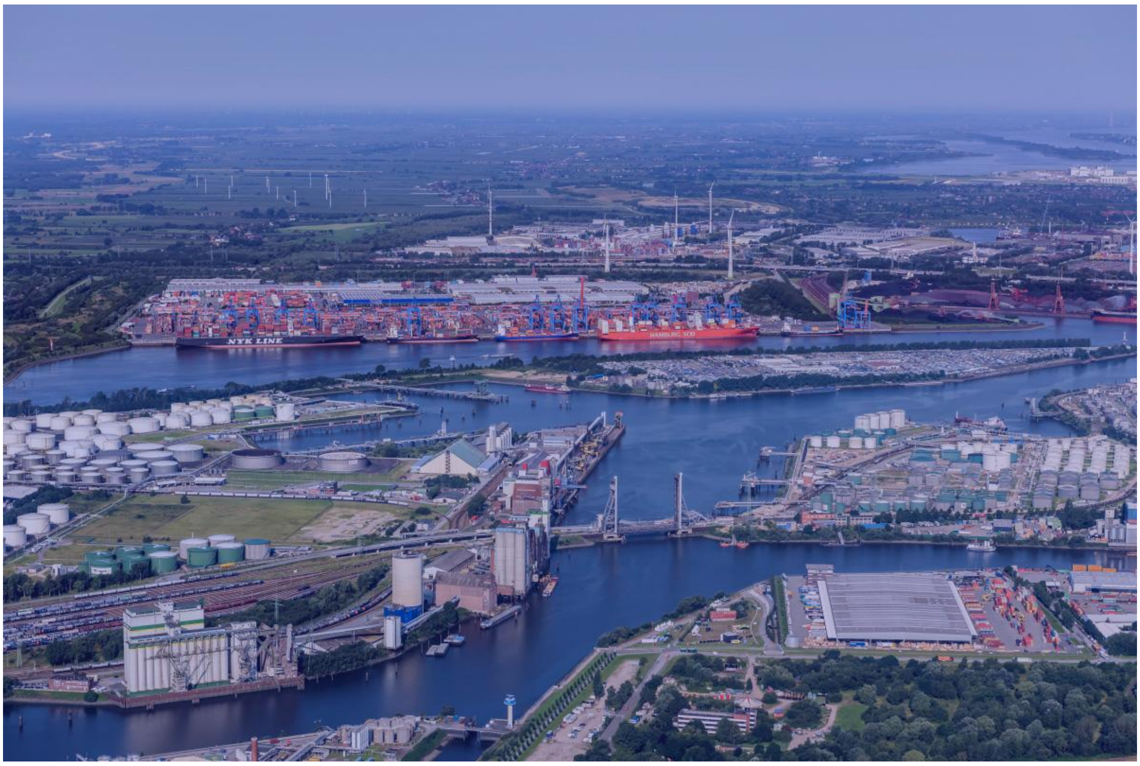
1. Lykkja OM, Arnesen P. Border Crossing Connectivity for CCAM Vehicles: A Field Test at the Norwegian-Swedish Border. To be Present TRA2024 to Appear Lect Notes Mobil. 2024;
2. Tjora A. Qualitative Research as Stepwise-Deductive Induction. 1st ed. Abingdon, Oxon; New York, NY : Routledge, 2018. | Series: Routledge advances in research methods ; 26: Routledge; 2019. 182 p.
3. Tolletaten. Ny vareførselslov og tollavgiftslov [Internet]. 2023. Available from: https://www.toll.no/no/bedrift/digital-tollbehandling/lover-regler/ny-vareforsels-tollavgiftslov/
4. The Customs and Excise Act [Customs Act) [Internet]. 2007. Available from: https://lovdata.no/dokument/NLO/lov/2007-12-21-119
5. Bräutigam J, Foss T, Jetlund K, Bruanes MT, Wijk P, Rostoft MS, et al. (2023). D1.3 Report on border processes. MODI-report.
6. NHO-LT. Et eksempel på godt samarbeid [Internet]. 2023. Available from: https://www.nholt.no/artikler/2023/nyheter-fra-tollverden/
7. Norwegian Customs. Digitoll [Internet]. 2022. Available from: https://www.toll.no/en/corporate/digitoll/
8. European Commission. EU Customs Reform [Internet]. 2023. Available from: https://taxation-customs.ec.europa.eu/customs-4/eu-customs-reform_en
9. Gruyer D, Orfila O, Glaser S, Hedhli A, Hautière N, Rakotonirainy A. Are Connected and Automated Vehicles the Silver Bullet for Future Transportation Challenges? Benefits and Weaknesses on Safety, Consumption, and Traffic Congestion. Front Sustain Cities. 2021;2(January):1–24.
10. Venæs J, Sande AB, Tangrand K, Seter H, Arnesen P. MCSINC Summarising hte main findings of WP1: Demands and requirements for machine sensing infrastructure [Internet]. 2023. Available from: https://sintef.brage.unit.no/sintef-xmlui/bitstream/handle/11250/3104278/Report_MCSINC_WP1_final.pdf?sequence=1&isAllowed=y

Annex 5

A leap towards SAE L4 automated driving features

The Norwegian Public Data Infrastructure

29th Mar 2023



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Introduction

In MODI, identifying physical and digital infrastructure (PDI) needs, is an important task. Both from a general L4 perspective and for developing and conducting the MODI demonstrators. In this project note we focus on available data sources from the authorities in Norway, in particular for the Norwegian use case, E6 Svinesund – Oslo, including Patterød junction to the Port of Moss.

Existing data could be valuable digital infrastructure for the future of automated vehicles, but they need to be available, accurate and reliable. In addition, support from the infrastructure could provide redundancy for the in-vehicle sensors, extending the ODD (operational design domains) of the vehicles. For this to happen, there needs to be dialogue and collaboration between authorities, data providers, and vehicle industry on what is needed and the requirements. In MODI, this is a topic in several other tasks, in addition to UC Norway, including task 4.2 and the CCAM corridor use-case. This note is from the Norwegian authorities (The Norwegian Public Roads Administration, Viken County Council and The Norwegian Mapping Authority) perspective input to these discussions, providing an easy-to-read overview and guidance on how to access the available data sets.

The data described here can have multiple usage, including planning of demonstration, simulation of scenarios, and analysis of gaps that needs to be closed for future implementations, both the availability of data, data collection processes, meta data descriptions and attribute inclusions. In essence this note aims to describe what is available now, including a section describing available measuring vehicles that can be utilized for a more targeted data collections within the MODI-project.

Static Data

NVDB – National Road Database

National Road Database is a database that contains information about national and county roads, municipal roads, private roads, and forest roads. The database is actively used in Norway's road management and contains the following information:

- Road network with geometry and topology that forms the basis for online mapping solutions and route planners.
- Overview of equipment and drainage along the road.
- Accidents and traffic volumes.
- Basic data for use in noise calculation and traffic modelling.

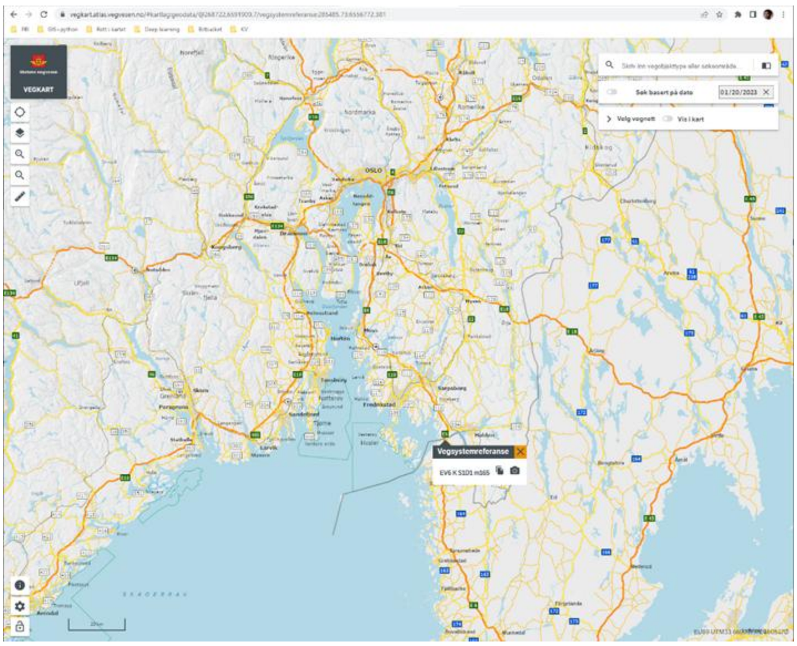
The API is based on REST and can be used to retrieve most of the basic data in the National Road Database (NVDB). The data is delivered in XML or JSON format. As the NVDB API Read is open under the Norwegian license for public data, it does not require a user account. However, you need a user account with write access to register and modify data in the NVDB.

Examples of content in the NVDB include *signs, culverts, lighting points, manholes, guardrails, landslides, rest areas, tunnels, ferry terminals, and traffic accidents*.

Currently, there are more than 16 million objects available for retrieval, divided into over 400 object types. All object types in the NVDB are described through a separate data catalog. Note that it is the object types' ID, not their name, that is used in queries against the API. Most of the data is associated with the European, national, and county roads. A few object types are registered on other roads, such as speed limit. All object types have a coordinate for display on the map.

The information is also available on vegkart, the Norwegian Public Roads Administration's map application for presenting data from the NVDB.

Vegkart:



Road and traffic data, road closures and weather condition are supported in DATEX II format, which may be useful for the trucks. REST based API's can be used to connect to NVDB, for more information visit: Dataut. More detailed information about NVDB, NVDB API, and related datasets can be found at NVDB atlast, which is in Norwegian.

API documentation for NVDB:

- NVDB-API

Pypi module for working with NVDB api-v3 and a github page for documentation:

- Pypi – Module – Python
- Github - Documentation & example code

The following is an example of how to extract speed limits *(geometry included)* on European roads for all municipalities between Svinesund and Moss.

```
# Create a variable for speed limits data with Fagdata ID 105
# The object catalog for Fagdata 105 can be found here: https://labs.vegdata.no/nvdb-datakatalog/
fart = nvdbapiv3.nvdbFagdata(105)

# Filter the data to include only the following municipalities: Halden, Sarpsborg, Fredrikstad, Råde, Moss
fart.filter({
    'kommune' : [3001, 3003, 3004, 3017, 3002]
})

# Further filter the data to include only European routes
fart.filter({
    'vegsystemreferanse' : 'E'
})
```

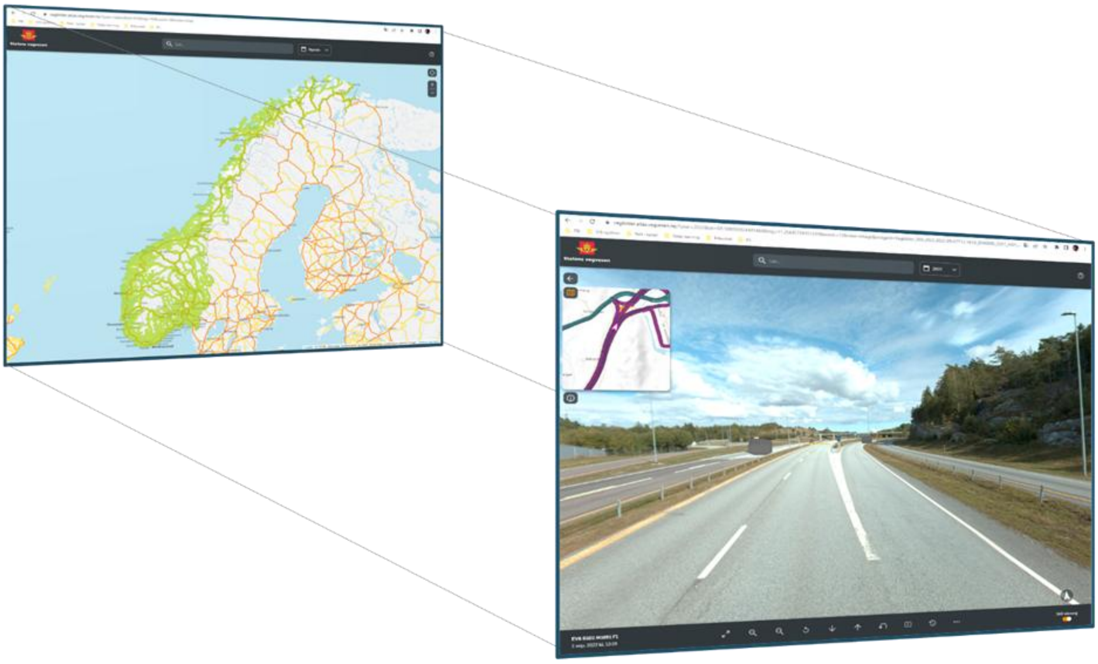
Contact who can provide further information and assistance:

Vinith Balasingam, Vinith.Balasingam@kartverket.no

Vegbilder – Road Images

Vegbilder is a web-based application developed and maintained by The Norwegian Public Roads Administration (NPRA) for displaying images of the Norwegian road network. The purpose of this application is to provide a visual representation of the road network in Norway to the public. The data presented in the application may contain errors.

Vegbilder allows users to view images of the Norwegian road network, which are taken on a yearly basis and continuously made available in the application. The user can click on the map to initiate a search for the most recent image taken at the selected point. If an image is found, a preview of the image is displayed. In cases where no images are found within 300 meters of the selected point, the map will zoom in to make the selection process easier. Additionally, at most locations on the European road, there is an option to turn on 360-degree view for a given location.



The search bar in Vegbilder can be used to look for specific location names or road references. Users can also select a specific year to narrow their search. The year selector can also be used to look for images from other years in a selected image point. NPRA is working on an API solution to make it easier for people to get road images from Vegbilder.

Contact who can provide further information and assistance:

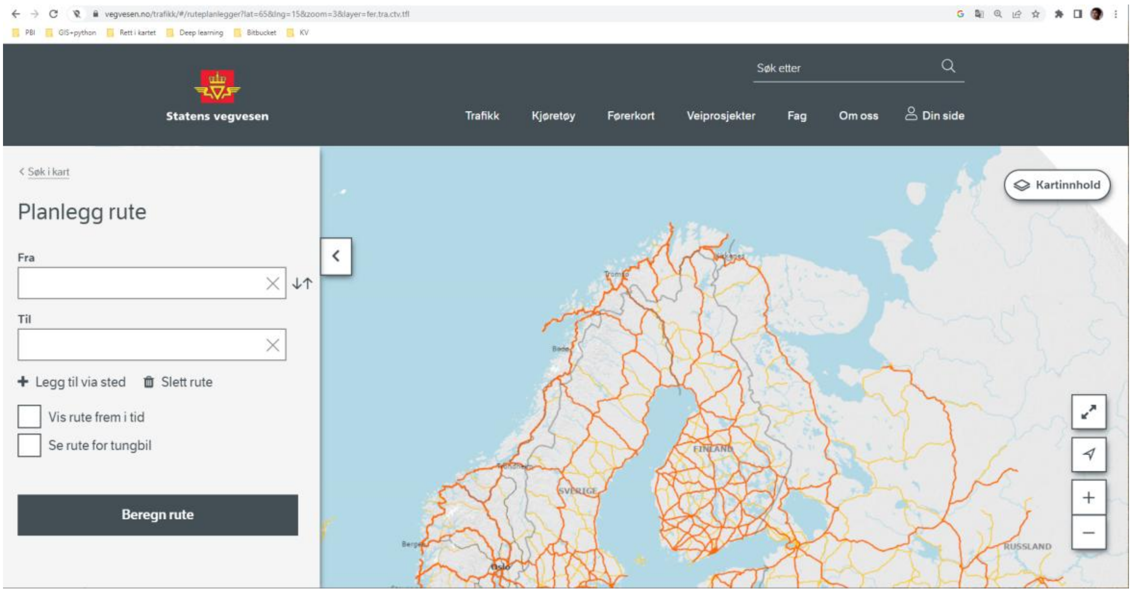
Doreen Siebert, doreen.siebert@vegvesen.no

Route planning for cars

Navigable road network from NVDB, and API that provides travel routes between two points with detours.

The routing service for driving calculates up to three different travel routes between two points. You can also define up to eight detour points. The service is intended for developers who want to use the route calculator in their web or mobile applications. The service is a REST-inspired API and should be sufficiently well-documented to be used if you have sufficient programming knowledge.

A web-solution for route planning:



Data is available in open formats such as XML and JSON. Coordinates are delivered by default in the proprietary but publicly available ESRI compact geometry standard, but with the geometry format parameter, more conventional formats such as GML and ISO can also be chosen. Add z (GMLZ, ISOZ) to include altitude coordinates in the route proposals' geometry.

To use the service, you need to get in touch with the NPRA (ruteplan@vegvesen.no) and request the creation of a username and password. The URL for accessing the service is: https://www.vegvesen.no/ws/no/vegvesen/ruteplan/routingservice_v2_0/routingservice/

Documentation for the route planner is available here:

https://labs.vegdata.no/ruteplandoc/

Contact who can provide further information and assistance:

Jan Kristian Jensen, jan.kristian.jensen@vegvesen.no

Høydedata – Elevation Data

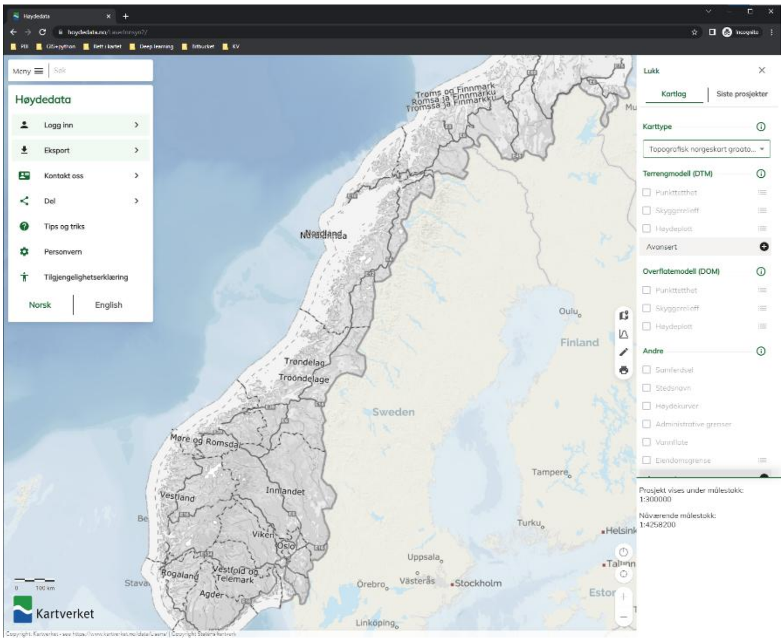
All height data is accessible at høydedata.no. It was collected through the National Detailed Height Model project, which started in 2016 and was completed in 2022. The project has now ended, and the result is a comprehensive height model for the entire country with one-meter resolution. In addition to the laser data collected through the project, høydedata.no also contains data from other Norge digitalt partners. Norge digitalt is a partnership between all public entities with responsibility for geodata or who are major users of such data.

Terrain data can be downloaded in the following formats:

- Original point clouds in LAZ or ZLAS format
- Terrain models (DTM) in grid format (Geotiff)
- Surface models (DOM) in grid format (Geotiff)
- Depth data can be downloaded in ENH (East North Height), NED (North East Depth), and XYZ formats.

The maps are also available as APIs: WCS, WFS, and WMS. We also have REST services for machine-based data downloads and metadata searches from høydedata.no. An overview of all APIs can be found here: https://www.geonorge.no/verktoy/APIer-og-grensesnitt/

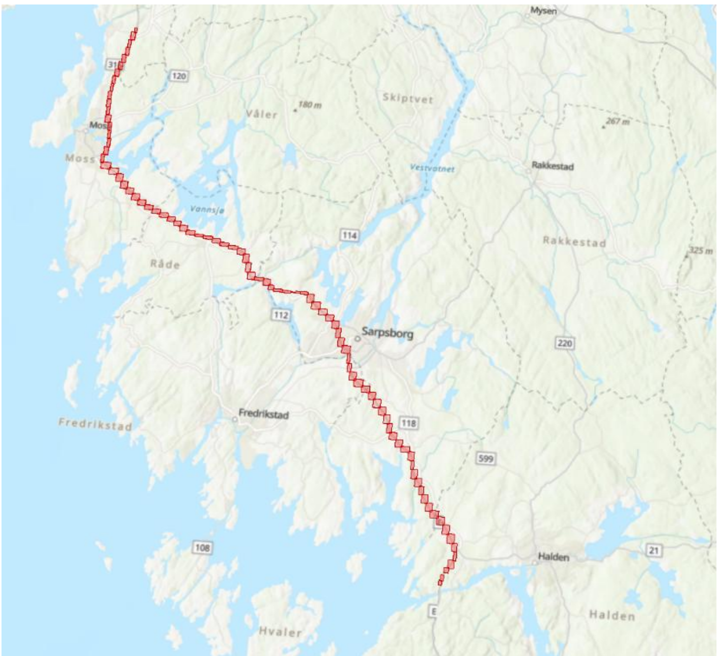
URL link to høydedata: https://hoydedata.no/LaserInnsyn2/



Point clouds relevant for UC Norway:

E6, Svinesund – Moss

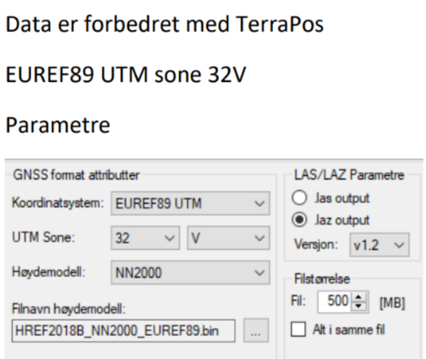
The point cloud for the stretch Svinesund-Moss is collected by The Norwegian Public Roads Administration. These points were gathered on 25.08.2022 using a mobile mapping scanner. Images were taken while the vehicle was scanning the road, providing a model of the terrain with images and point clouds. The figure below provides a visual representation of the mapped route.



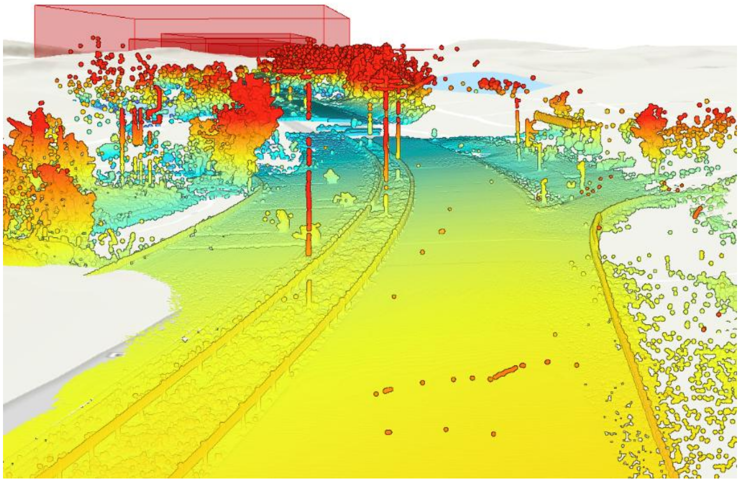
The following features are available from the point cloud:

> *[X, Y, Z, intensity, return number, number of returns, scan direction flag, edge of flight line, classification, synthetic, keypoint, withheld scan angle rank, user data, point source id, gps time]*

Parameters from the scan:



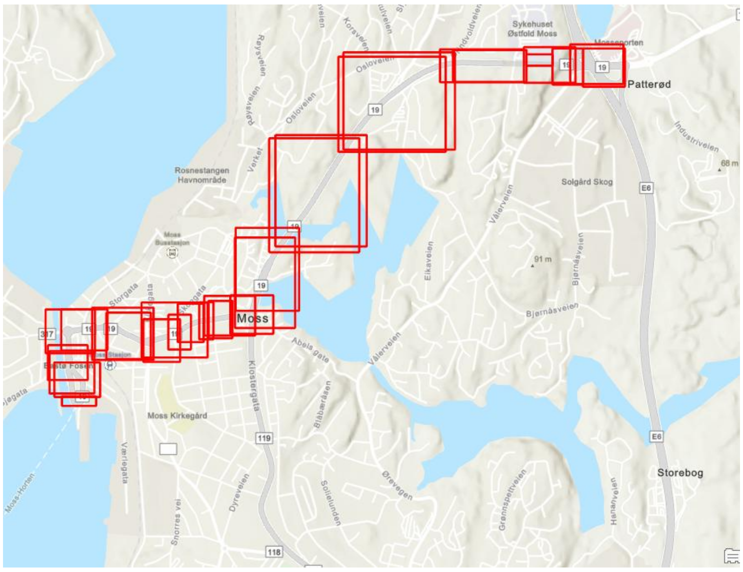
Visualization example:



RV19, Patterødkrysset – Port of Moss

The point cloud for the stretch Patterødkrysset – Port of Moss is collected by The Norwegian Public Roads Administration. These points were gathered on 26.08.2022 using a mobile mapping scanner. Both images and point clouds were collected simultaneously.

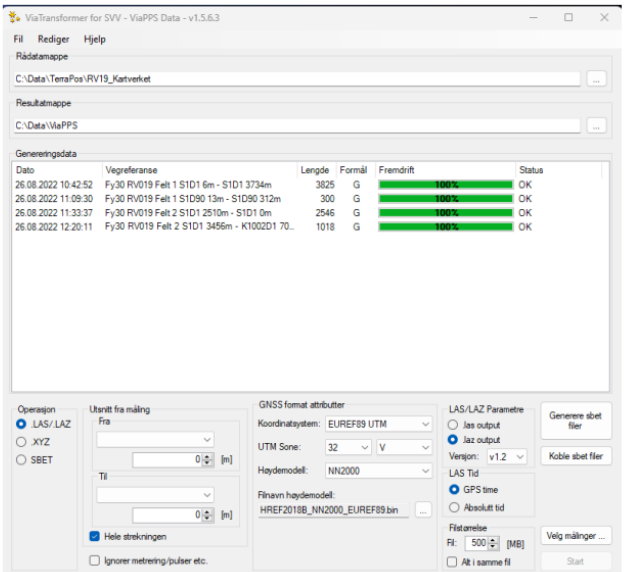
These areas show the coverage of overlapping point cloud collection on RV19:



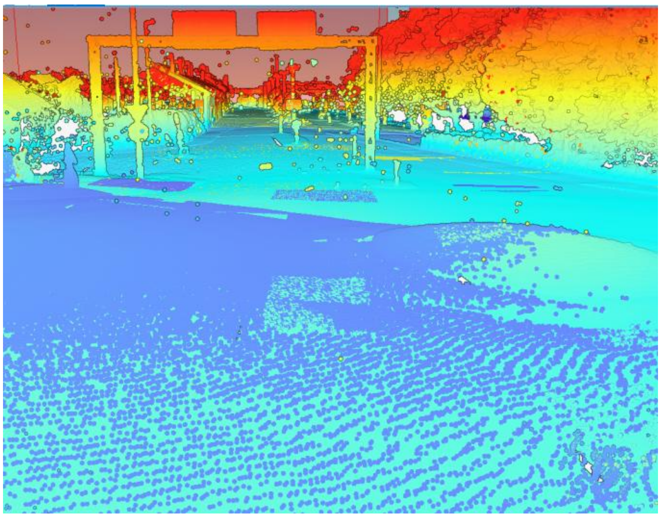
The following features are available from the point cloud:

> *[X, Y, Z, intensity, return number, number of returns, scan direction flag, edge of flight line, classification, synthetic, keypoint, withheld scan angle rank, user data, point source id, gps time]*

Parameters:



Visualization example (Road images and Lidar point clouds):



Contact who can provide further information and assistance:

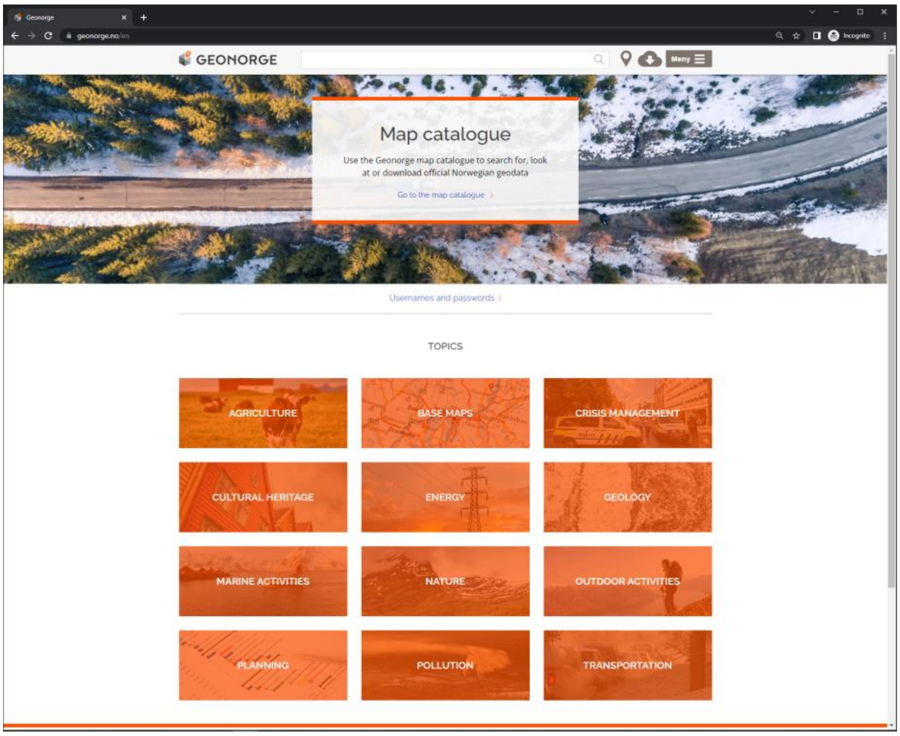
Jon Moe, Jon.Moe@kartverket.no

Geonorge – Geospatial Data Portal

Geonorge is the national website for map data and other geospatial information in Norway. Users of map data can search and access available information.

Geonorge is a part of Norge digitalt, a collaboration between public entities responsible for establishing and managing map data and other geospatial information. Geonorge is developed and maintained by The Norwegian Mapping Authorities on behalf of the partners in the Norge digitalt collaboration. Geonorge has numerous kinds of data and information sources. These can be accessed through APIs. Software developers can use APIs for direct access to data sources, and to make applications more functional and user-friendly.

URL to Geonorge: https://www.geonorge.no/en



These APIs are a collection of rules on how to execute requests relating to data and information sources, and they describe how different requests may give responses with different data selection variants. APIs can usually be linked, making it possible to join data requests and ensure richer use of the information and data available in the Norwegian spatial data infrastructure.

The following Geonorge APIs are available:

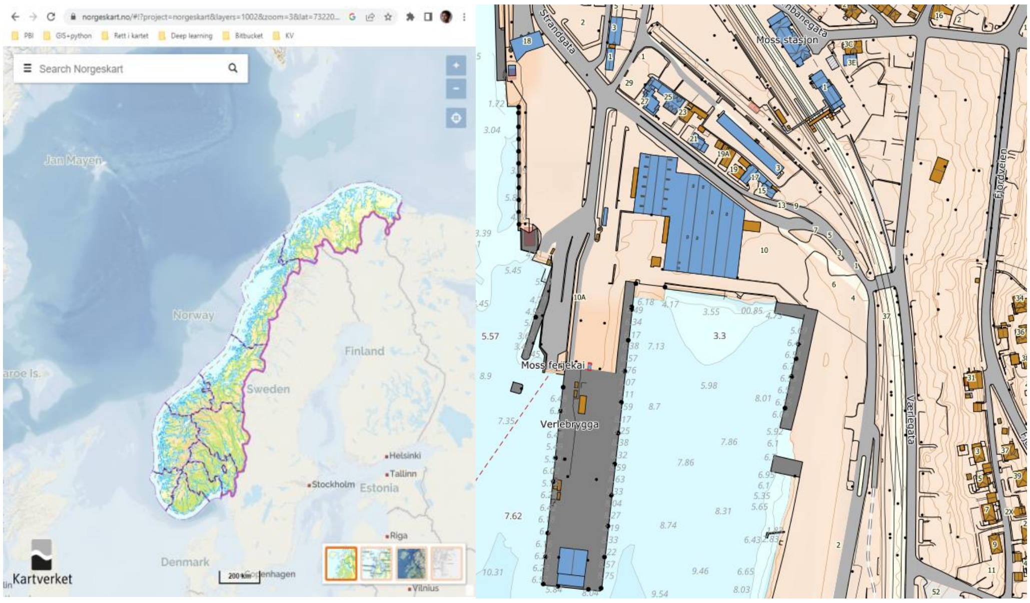
- APIs for the Norwegian metadata catalogue
- APIs for the Norwegian Feature Catalogue
- APIs for the Geonorge/Norwegian NSDI registers – registry services
- API for the Geonorge/Norwegian NSDI service validation and status function
- Norwegian Geoportal Atom Feed
- Norwegian Geoportal metadata service – CSW (catalogue service web)
- Norwegian Geoportal metadata API – rest
- ID references and linked data

- Norwegian Geoportal download API

FKB – Common Map Database

The Common Map Database (FKB) is a collection of data sets with some of the most detailed and accurate geospatial information about the country's terrain, buildings, and infrastructure. FKB data is managed by the Norwegian Mapping Authority (Kartverket) and is widely used by various public and private organizations for mapping, planning, and analysis purposes. The FKB data includes both vector and raster data and is updated frequently to ensure that the information is up-to-date and reliable. The data is largely constructed based on periodic aerial photography and continuously updated.

The Norwegian Mapping Authorities has developed a web-map solution to visualize FKB data. Link to the web mapping solution, Norges kart. FKB data for Port of Moss as an example:



FKB data is adapted for use at scales of 1:500 to 1:30,000. The FKB database is classified into four standards, namely FKB-A, FKB-B, FKB-C, and FKB-D. The different standards of the FKB database address varying degrees of map detail, with FKB-A containing the most comprehensive and in-depth information, followed by FKB-B, FKB-C, and finally FKB-D. FKB data can be downloaded for a fee and is available through Geonorge.no. NMA can provide FKB data free of charge for the MODI project.

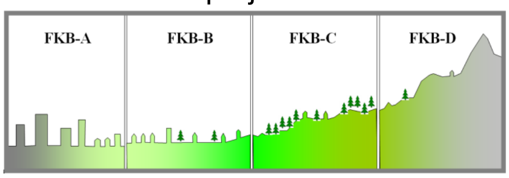


Figure 1: The different Standards of FKB data

Contact who can provide further information and assistance:

Vinith Balasingam, Vinith.Balasingam@kartverket.no

Dynamic Data

DATEX II

The Norwegian Public Roads Administration (NPRA) offers weather data, travel times, camera images and traffic information via DATEX II.

Traffic information (DATEX-format) - Dataset - Dataportalen (vegvesen.no)

The Norwegian Public Roads Administration offers **real-time weather data**, **travel times**, **camera images**, and **road messages** containing information on incidents, roadworks, and driving conditions via DATEX II version 2.3 and 3.1. DATEX *(specification for DATa EXchange between traffic and travel information centers)* is a European standard for exchanging traffic information between different actors and is based on XML messages.

Access to DATEX is provided at this page: Request DATEX NPRA

Weather data

This publication contains meteorological measurements from weather stations along national and county roads. We update it every 10 minutes. The road weather data publication publishes updated information every 10 minutes.

The publication consists of meteorological measurement values from weather stations located along the national and county road network. All weather stations have a connected web camera that shows a regularly updated still image, possibly video. The weather data publication is updated every 10 minutes.

You must order access to the Norwegian Road Administration's DATEX node before you can connect to the publication.

Webcams

The webcam publication transmits updated images from roadside cameras. These provide an impression of traffic flow, weather and road surface conditions.

The Norwegian Public Roads Administration has deployed a number of webcams along the road network. They are mostly located in places with challenging weather, at ferry quays, mountain passes and in urban areas with heavy traffic.

The images from the cameras are updated with varying frequency. This has to do with the type of camera and how communication with the cameras is set up. Some cameras are set up to alternate between different directions and lanes. This means that they can change image details between updates

Travel times

This publication contains travel times in seconds between two measurement points. We update travel time for all road sections every five minutes.

The publication contains travel times for

the main road network around Oslo, Bergen, Stavanger, Kristiansand and Trondheim

- E18 from Oslo to Aust-Agder
- E6 from Ås to Kolomoen
- E8 from Skibotn to the Finnish border

Road traffic information

This publication shows information about situations on or along roads that may cause delays or increased risk of accidents in traffic.

Roadworks, temporary traffic control measures such as closures, traffic accidents, storms, slides and floods are among the things that may affect traffic flow. Information we receive about such issues is continuously published as traffic messages in the DATEX II format.

Relevant pages about DATEX from NPRA:

- What is DATEX? | Statens vegvesen
- How to use DATEX | Statens vegvesen
- DATEX publications | Statens vegvesen
- Information and news | Statens vegvesen

Contact who can provide further information and assistance:

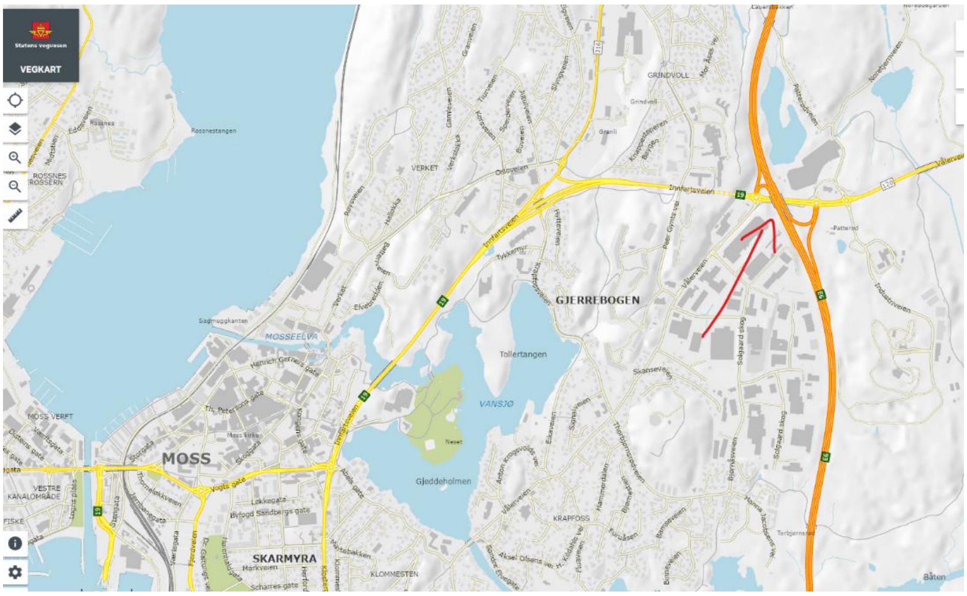
Martin Andreas Fredriksen, martin.fredriksen@vegvesen.no

ITS G5

The ITS Pilot initiative, situated at Patterødkrysset (E6) and highlighted on the Vegkart website of Vegvesen.no, represents an intersection solution. The system boasts two roundabouts and a fully articulated two-level intersection, between the E6 and RV19.

Patterødkrysset with the exit to Moss has a large amount of traffic and challenges with back-blocking on the E6. Combined with high speed (110 km/h) on the E6, this leads to the risk of serious accidents. This also applies to vehicles driving in the opposite direction up the ramps. In order to prevent accidents and provide road users with better information, ITS-G5 solutions have been developed and installed which are being tested at the intersection, while a traditional queue warning system using inductive loops has also been installed.

This is not publicly available, but access and use of the physical and digital infrastructure can be arranged after further discussions with NPRA, Aventi and Qfree.



- 4 permanently mounted RSUs (roadside units) with ITS-G5 (from Aventi)
- 4 fixed RSUs with ITS-G5 (from QFree), hang from the same masts as Aventi's but lower
- 2 mobile RSUs with ITS-G5 technology that can be used in trials and placed where you want to test
- About. 40 OBU (onboard units) with ITS-G5
- Inductive sensors on the exit ramp from the south
- Camera owned by VTS - Fiber network and cabinets in which equipment can be stored

Contact who can provide further information and assistance:

Christina Skaftnes Nicolaisen, christina.nicolaisen@vegvesen.no

Traffic Data

Trafikkdata (vegvesen.no)

Visual map solution Trafikkdata (vegvesen.no)

The Norwegian Public Roads Administration's Traffic Data API contains traffic data from public roads in Norway. Traffic data is registered in traffic registration points from around the country on state and county roads, and some points are located on municipal roads.

The Norwegian Public Roads Administration's aim is to be able to deliver traffic data of known quality and the right level of detail, and that this data is requested and collected from the correct road network.

All available data are on an aggregated level, where one hour is the shortest time interval. Vehicle by vehicle data is not available to the public.

As of now, all data is for traffic volume. The spatial resolution is per lane, direction or registration point, where each point is limited to one unique road reference. The vehicles are classified according to their measured length.

Speed and distance are also recorded for each lane.

All data has quality parameters associated with it, indicating their uncertainty and relevance. All use of the data must take the quality parameters into account.

Traffic data API:

- Traffic data

Read more on traffic data and data quality under Om trafikkdata (Norwegian only).

Contact who can provide further information and assistance:

Espen Sveen, espen.sveen@vegvesen.no

Traffic management & information:

Vei- og trafikkinformasjon | Statens vegvesen (Information only in Norwegian)

The Norwegian Public Roads Administration has national preparedness on roads The road traffic centers (five each with their own area) are an example of a national area of responsibility) The Vegtrafikksentralene (VTS) is the NPRA's operational unit to look after traffic management and traffic information on European, national and county roads. They are the hub of traffic preparedness. VTS continuously monitors using cameras and other installations - which provide support for traffic management They warn and convey information about status and events on the road network, in road traffic and in the road's immediate surroundings

Vehicle with sensor platform

NPRAs measuring vehicle:

The Norwegian Public Roads Administration (NPRA) has several measuring vehicles with advanced equipment to collect data on the condition of roads. These vehicles are equipped with lidar, GNSS, and cameras for accurate and comprehensive data collection.

Lidar:

- One of the lidar systems used by NPRA is the Z+F PROFILER® 9012, a compact high-speed phase-based laser scanner that offers great precision, a 119 m range, and a 360° field of view. It has a high scan rate of over 1 million points/ sec. and a scanning speed of up to 200 profiles/sec. This makes it possible to achieve very short distances between profiles even at high platform speeds.
- NPRA also uses ViaIRI texture laser to collect data on road surface irregularities and provide accurate measurements of the International Roughness Index (IRI).

GNSS:

- The NPRA's measuring vehicles use Applanix POS LV, a fully integrated and turnkey Position and Orientation System that utilizes integrated inertial technology to generate stable, reliable, and repeatable positioning solutions for land-based vehicle applications. It also utilizes CPOS service for added accuracy.

Cameras:

- The measuring vehicles are equipped with two camera systems: ViaPhoto Wide and Ladybug 360. These camera systems help in collecting visual data for detailed analysis of the road condition, including wear and tear, cracks, and other damages.

Contact who can provide further information and assistance:

Ingrid Høydal, Ingrid.Hoydal@vegvesen.no

NMAs measuring vehicle:

The vehicle equipped with a sensor platform provides advanced mapping capabilities with the help of its high-end navigation equipment and lidar. NMAs vehicle with a sensor platform is an excellent tool for accurate and efficient data collection and analysis.

Figure 2: The Norwegian Mapping Authority vehicle with sensor platform

Sensors on vehicle platform:

- GNSS receiver: Septentrio AsteRx 4
- GNSS antennas: Trimble Zephyr Geodetic 2
- IMU: SBG Systems Apogee-D
- Odometer: Pegasem WSS2
- Lidar: Ouster OS1-128

Navigation and georeferencing of point cloud are post-processed to ensure optimal accuracy.

Contact who can provide further information and assistance:

Morten Taraldsten Brunes, morten.taraldsten.brunes@kartverket.no.

Annex 6

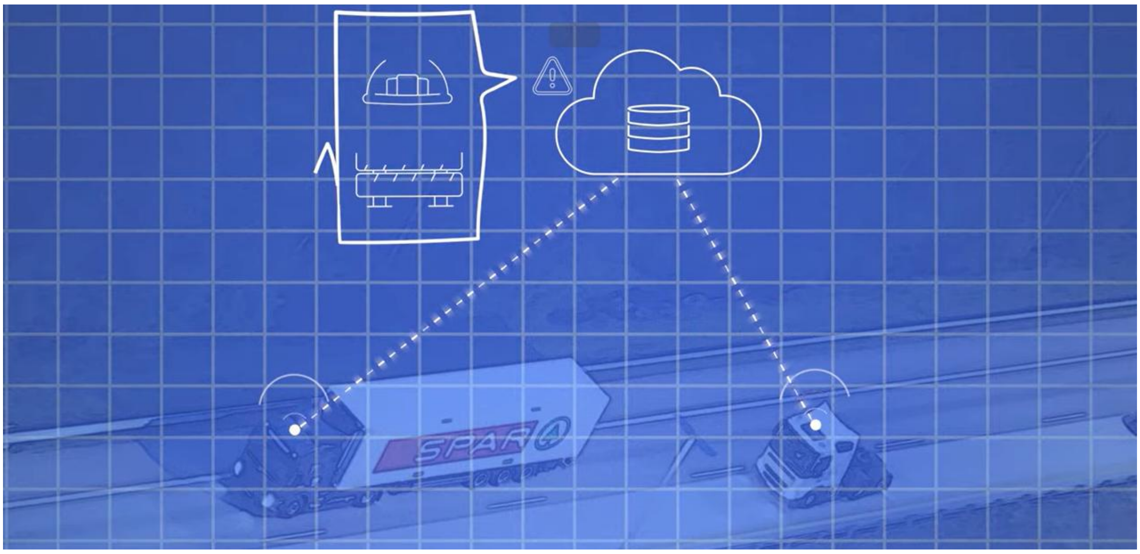
A LEAP TOWARDS SAE L4 AUTOMATED DRIVING FEATURES

A leap towards SAE L4 automated driving features

UC NO

C-ITS service RWW and

Volvo vehicle



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Introduction

The Norwegian UC (UC NO) explores and demonstrates parts of the following scenario:

V2X Safe merging

Figure 1 Demo section (area for work along the road)

This demonstration was conducted the E6, north of the Patterød junction.

The demonstration site will be located midway between two motorway entry and exit points, 8.3 km apart (from the Patterød junction to the Uno-X station at Sonsveien station) E6, which takes about 6 minutes to drive one way.

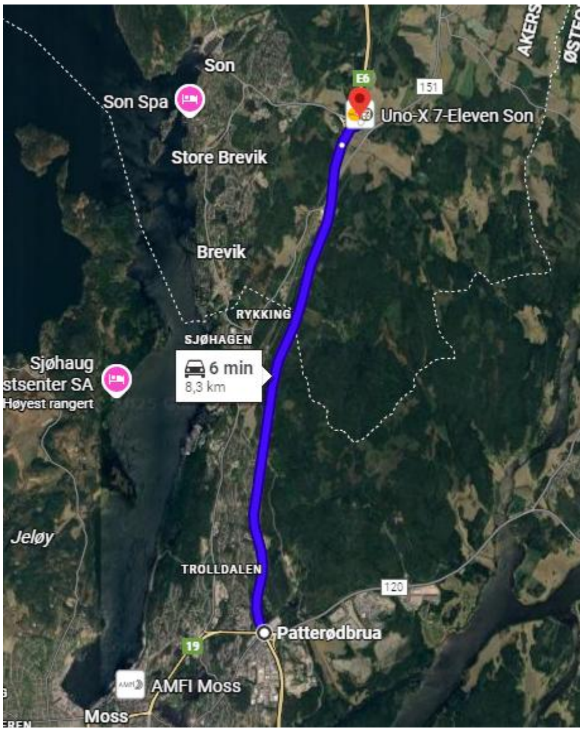


Figure 2 Demo section (area for driving route)

For this demonstration, we established a physical barrier in the right lane and mark it as a roadwork warning, by using a setup like the one shown in the figure below.

Figure 3: Example of physical barrier.

This means that all traffic was merge at this point during the demonstration period. The solution to avoid traffic jam was therefore to carry out this demonstration outside rush hours, at night.

In the demo, the following scenario was presented:"

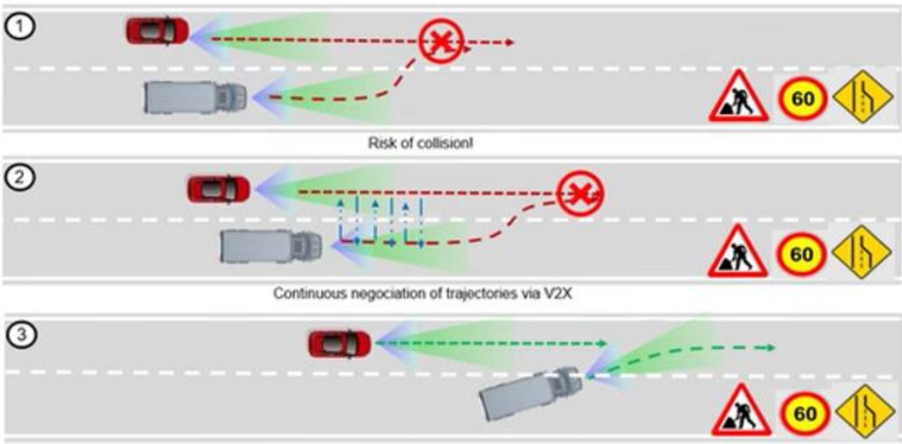


Figure 4 The merging scenario.

Volvo brought two test vehicles equipped with C-ITS to this demonstration. Where C-ITS V2X direct communication between the vehicles was used for activing lane negotiation, both vehicles automatically adjusted their speed and steered laterally by themselves, resulting in an automated safe merging. Volvo

Data flow

The vehicles was notified of the geographical location of the RWW, retrieved and decoded from the RWW message published via the NordicWay Interchange using the mobile network. The Norwegian Public Roads Administration was responsible for publishing this message.

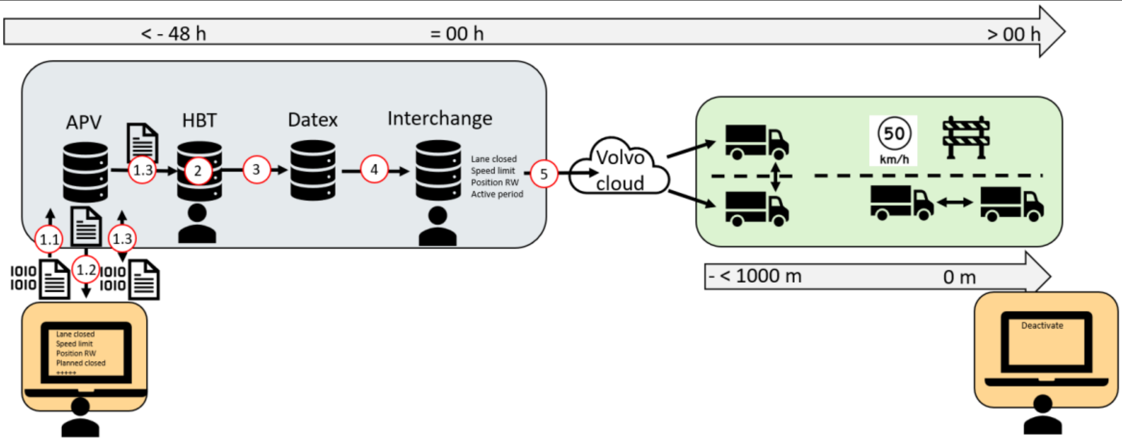


Figure 5: Message flow from contractor to vehicle. Numbering in the figure corresponds to the chapter division in the document.

1. APV (Arbeid På Veg): Road works application process.

A company that is going to work on or near a national or county road must apply to the Norwegian Public Roads Administration for permission to provide warning and secure the work.

If the work takes place on or near a municipal road, the company must apply to the relevant municipality for permission.

1.1 Application for work zone warning from the contractor

The contractor logs in and completes several steps in the process. At the end this was the main information registered (Only in Norwegian):

General information:

Søknadsinformasjon

Prosjekttittel

E6 Kambo retning Sverige venstrefelt stengt

Plantype

Spesiell

Kontaktperson for søknaden

Fornavn	Etternavn	Telefonnummer	E-postadresse
SANDER	MIDTBØ	97737195	sander-rog@hotmail.com

Figure 6: General information data registrert for demo.

Area definition containing: 1) first define the link of the actual work area, from start to finish, and 2) register the advance warning point

Område

Arbeidsområde

Arbeidssted	Punkt	Vegreferanse	Fartsgrenser	Høyeste ÅDT
Arbeidssted 1	Fra	EV6 S8D1 M10227 (K)	110	38308
	Til	EV6 S8D1 M10256 (K)		

Vegarbeidsområde

Varslingspunkt	Vegreferanse	Fartsgrense	ÅDT
Varslingspunkt 1	EV6 S8D1 M10976 (K)	110	38308

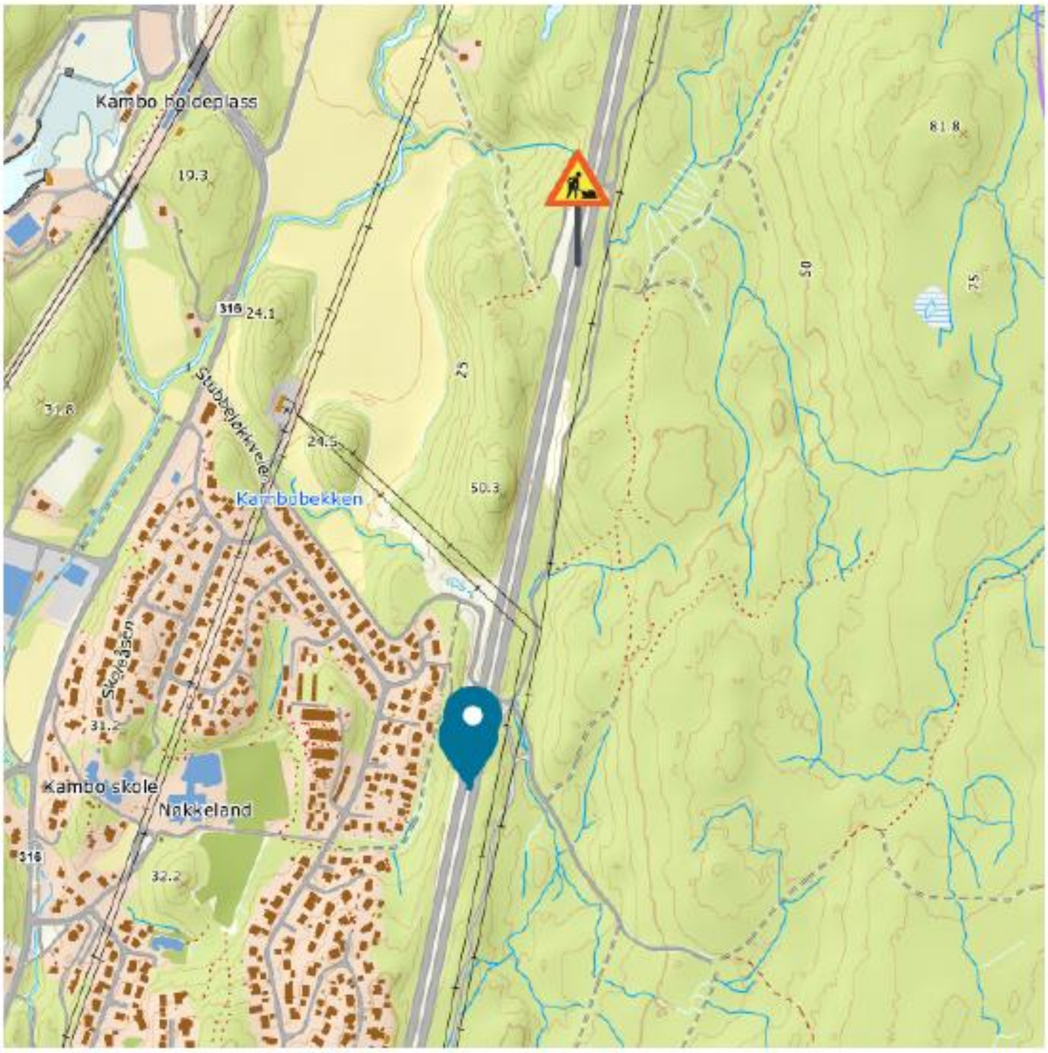


Figure 7: Data registered for Area definition

Time period for planned RWW

Periode

Merk! Dette er kun ønsket arbeidstid. Tillatt arbeidstid blir definert i tillatelsen.

Fra	Til	Arbeidets varighet	Arbeidsdager	Arbeidstider
17. 06 .2025	18. 06 .2025	1 dager	Alle dager	Natt kl. 22 : 00— 05 :30

Figure 8: Data registered for time period of the RWW.

Risk management:

Risikoforhold

Kartlegging av risikoforhold skal gjøres for å avdekke faremomenter i trafikken forbi arbeidsområdet. Denne kartleggingen skal supplere risikovurderingen som entreprenør skal gjøre for forholdene internt på arbeidsområdet.

Hvilke arbeidstyper skal utføres på området?

Vedlikehold / drift

Testkjøring av systemer til automatiserte kjøretøy. Kjøretøyene skal kjøre gjennom et stengt kjørefelt. Kjøretøyene er bemannet.

Hvilke trafikanter ferdes i området?

Bilister

Tungtransport

Hvilke risikoreduserende tiltak skal utføres?

Stengt veg – Delvis stengt veg

Venstrefelt stenges for å kunne utføre testkjøringen.

Gjelder i arbeidstiden

Fart – Midlertidig fartsgrense

Fartsgrense reduseres til 50 km/t

Gjelder i arbeidstiden

Varsling – Varselpanel

Varselpanel med lyspil for å lede trafikken over i høyre kjørefelt.

Gjelder i arbeidstiden

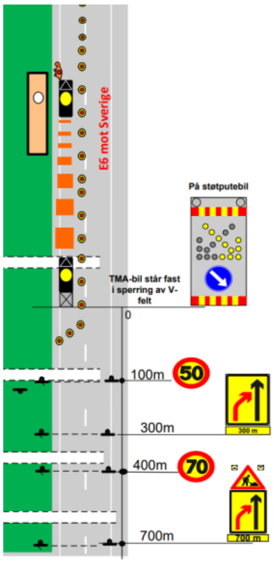
Sikring – Tversgående

Tversgående sikring i form av støtputebil.

Gjelder i arbeidstiden

Figure 9: Data registered for risk management

Sketch of working area:



Skisse 1 – Skisse_1_E6 arbeid i venstrefelt stengt 110 sone.pdf
- Midlertidig fartsgrense – Gjelder i arbeidstiden
- Varselpanel – Gjelder i arbeidstiden
- Delvis stengt veg – Gjelder i arbeidstiden
- Tversgående – Gjelder i arbeidstiden

Figure 10: Sketch attached to the application, uploaded as an attachment.

Contact persons

Kontaktinformasjon

Byggherre

Bedrift	Kontaktperson	Telefonnummer	E-postadresse
STATENS VEGVESEN (971032081)	Kim Kongshaug	94279373	kim.eirik.kongshaug@vegvesen.no

Utfører av arbeid

Utførende entreprenør	Ansvarlig for arbeidsvarsling	E-postadresse til varslingsansvarlig
MESTA AS (992804440)	MESTA AS (992804440)	martin.gulliksen@mesta.no

Ansvarshavende

Navn	Mobiltelefonnummer	E-postadresse	Kompetansebevis (gyldig til)
Martin Gulliksen	98697052	martin.gulliksen@mesta.no	kurs_Martin Gulliksen_martin gulliksen arbeidsvarsling.png (05. 01 .2029)

Stedsansvarlig

Navn	Mobiltelefonnummer	E-postadresse	Kompetansebevis (gyldig til)
Thomas Gulliksen	90605731	thomas.gulliksen@mesta.no	kurs_Thomas Gulliksen_Thomas Gulliksen kurs 2 26.10.28.jpg (26.10 .2028)

Figure 11: Data registered for contact persons

The data from the registration forms the basis for an application document in PDF, which is archived under its own case in MIME: 25_121270-2 arbeidsvarsling-soknad-s2 29206105.

The registered data in the application process is stored in a dedicated APV database. Shown here as a JSON file.

apv20255167_vegarbeid.json


```
{"results":[{"columns":[{"name":"SOKNAD_ID","type":"NUMBER"},{"name":"VEGARBEID_ENDRET","type":"VARCHAR2"},{"name":"VEGARBEID_OPPRETTET","type":"VARCHAR2"},{"name":"VERSJON","type":"NUMBER"},{"name":"VEGARBEID_DATA","type":"CLOB"}],"items":
[
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]}]}
```

1.2 Approval of application

The case officer approves the application. A PDF file containing information about the granted permit is produced.

Statens vegvesen

MIDTBØ SERVICE
Skogliveien 15
4380 HAUGE I DALANE

Behandlende enhet:	Saksbehandler	Vår dato:
Transport og samfunn	Tore Johansen	26.05.2025

Tillatelse til arbeidsvarsling - E6 Kambo retning Sverige venstrefelt stengt - spesiell - EV6 - Østfold - Moss - APV20255167-T1

Vi viser til søknad av: **22. mai 2025**

Ansvar for utførelse og oppfølging av arbeidsvarslingsplanen (vedlagte dokumenter) etter skiltforskriften § 33 nr. 2 tillegges ansvarlig for arbeidsvarsling: **MESTA AS**

Vedtaket vil være gyldig i tidsperioden **17. juni 2025 - 18. juni 2025** og i henhold til angitt tidsperiode under spesielle vilkår.

Vedtaket er gyldig fra det tidspunkt skilt/utstyr/vegoppmerking er satt opp og avdekket.

Figure 12: The PDF document of the permit is sent to the applicant.

1.3 Activation of the permit

When actual wortk being the permit must be activated.

Aktivering: APV20255167-T1

Aktiverer: MARTIN GULLIKSEN

Aktiverers selskap:

Rolle: Ansvarshavende

Telefonnummer: 98697052

Epost: martin.gulliksen@mesta.no

APV-nummer: APV20255167-T1

Aktivering utført: 27.05.2025 11:07

Gyldig fra: 17.06.2025

Gyldig til: 18.06.2025

Aktiveringsbeskrivelse

Arbeidsvarsling som vedtaket beskriver.

---Stengt vei---

Deler av veien skal stenges i løpet av perioden.
Tiltak valgt: delvis

---Håndtering av utrykningskjøretøy---

Utrykningskjøretøy kan passere arbeidsstedet både i og utenfor arbeidstid

Kontaktinformasjon stedsansvarlige

Navn	E-postadresse	Telefonnummer	Kompetansebevis
Thomas Gulliksen	thomas.gulliksen@mesta.no	90605731	26.10.2028

Tidfesting

Tirsdag kl.	Onsdag kl.
22:00–23:59	00:00–05:30

Trafikkpåvirkning

Liten (under 15 min forsinkelse)

Figure 13: Data input for activation. Additional info needed in case of partly closed or fully closed road.

The data registered in the activation process is stored in a dedicated APV database. Shown here as a JSON file.

apv20255167_aktivering.json


```
{"results":[{"columns":[{"name":"ID_AKTIVERING","type":"NUMBER"},{"name":"SOKNAD_ID","type":"NUMBER"},
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{"name":"HAR_OPPDATERT_AV_MOBILNR","type":"NUMBER"},{"name":"AKTIVERINGSBESKRIVELSE","type":"VARCHAR2"},
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som vedtaket beskriver.\\n\\n---Stengt vei---\\n\\nDeler av veien skal stenges i løpet av perioden.\\nTiltak valgt:
delvis\\n\\n---Håndtering av utrykningskjøretøy---\\n\\nUtrykningskjøretøy kan passere arbeidsstedet både i og
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"aktivering_aktiv_til":"18-06-2025 00:00:00","aktiveringsnummer":1,"har_oppdatert_av_mobilnr":1,
"aktivering_forsendelsesversjon":"5"}
]}]}
```


A notification of activation is sent to the Traffic Management Centre (VTS) for registration of the event in Event System (HBT).

2 Registration of the permit in HBT (Event System)

To produce a traffic message, the VTS must register data from the application for work on the road. When a notification is sent to VTS about a new activation, it will be added to the traffic operator's work list.

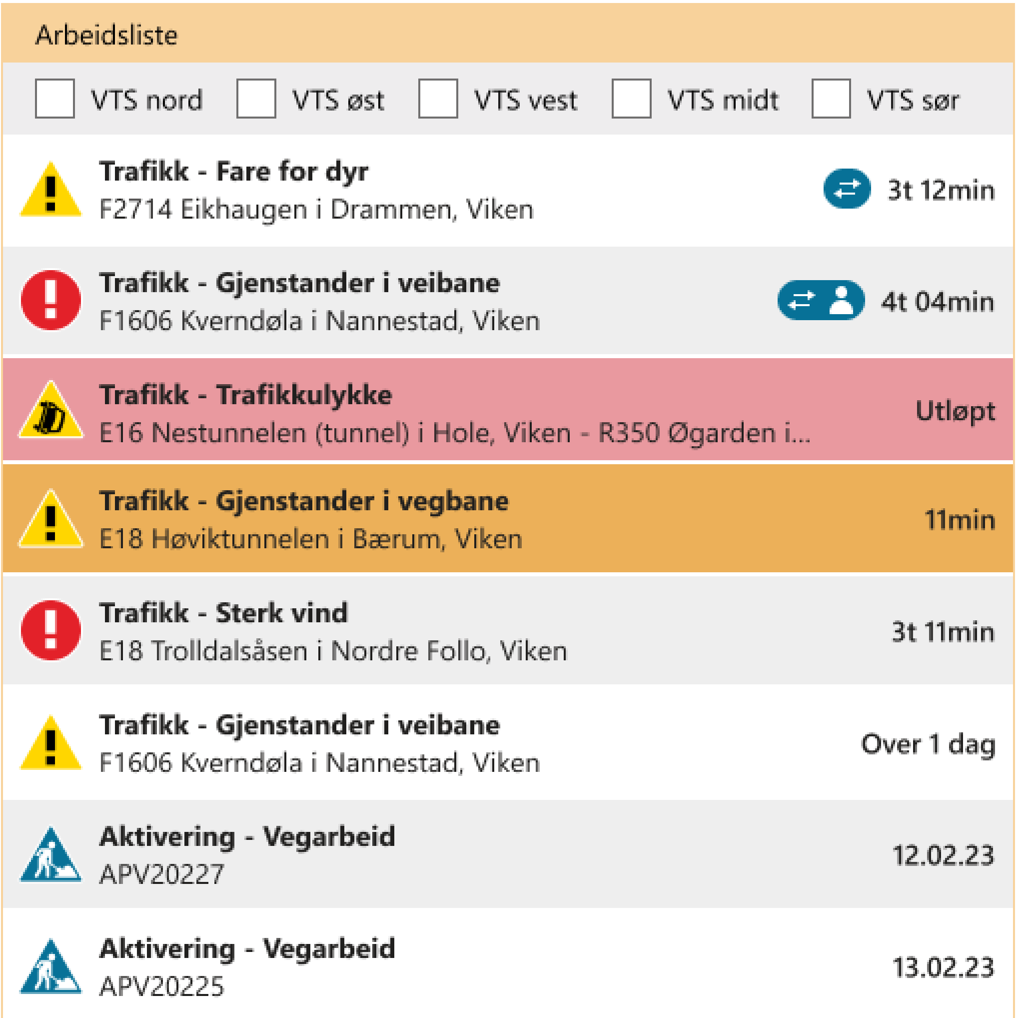


Figure 14: Worklist VTS

Activation and deactivation of the permit appear in this list.

The traffic operator is then provided with a further link to the necessary PDF files related to the case

The traffic operator must then register data from the PDF documents into HBT, which is done through a digital dedicated interface.

This is a manual task that ought to be automated. The data registered in the application/activation process is stored in a dedicated APV database, and this data should be automatically retrievable in HBT via an API towards the APV database.

Today, the traffic operator spends up to 5–10 minutes to re-register and verify the APV permits, which results in unnecessary additional workload in an already busy working day.

After the registration in HBT, traffic messages will be produced and retrieved by, among others, the Vegvesen Traffic App and 175.no.

Traffic impact for traffic-related incidents
In the HBT registration one must indicate what impact the incident will have when traffic is at its heaviest (during rush hours or outbound traffic), due to waiting time or detour routes. This is mandatory for traffic-related incidents and must be completed by the operator.

Traffic impact governs how traffic information is displayed to the public on 175.no and for notifications sent from HBT to the road owner and contractors. It is therefore important that one always focus on setting the correct traffic impact. This may be changed during the course of the incident.

Traffic impact for road work
Traffic messages in the Vegvesen Traffic App and on 175.no must include information about traffic impact. This is to be set by the contractor when the work is activated in APV. The same criteria apply for setting traffic impact here as for traffic-related incidents.

If changes in the work lead to a different traffic impact, we as operators must go in and update the traffic impact. The scale for traffic impact ranges from "No delyas, small delays (<15 min), large delays (15-60 min) and very large delay (>60 min).

3 HBT to Datex

The data stored in HBT is then sent to the NPRA Datex node via an XML format.

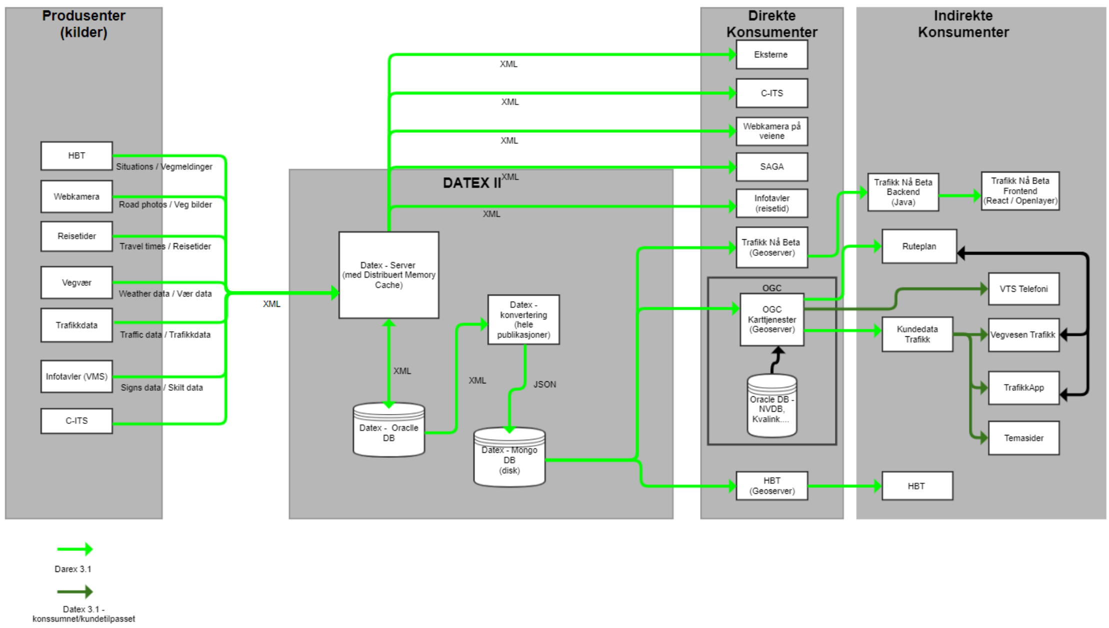


Figure 15: Architecture diagram of NPRA traffic data.

4 Datex - Interchange

Publication of standardized messages (DENM format) takes place in a separate ecosystem referred to as the Interchange.
The Interchange "listens" to the DATEX node to extract relevant messages that should be forwarded to third-party providers, which may be specialized service providers or OEMs' own solutions.

In short, the process works as follows (see also Figure 16):

- Selects relevant traffic information by "listening to" the DATEX node.
- Converts traffic information from DATEX to JSON format, which is readable by a C-ITS station.
- The C-ITS station produces an RWW message in accordance with the DENM standard and adds signature data to ensure message integrity.
- The Interchange client makes the data available for external actors such as service providers or OEMs.

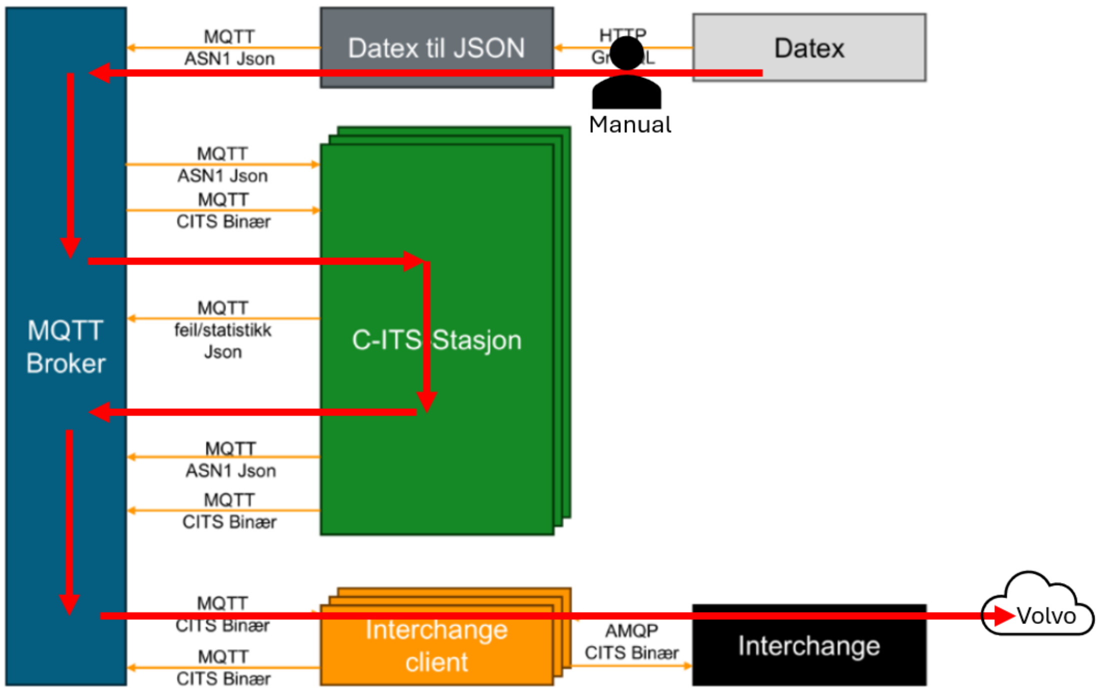


Figure 16 Architecture diagram for the production and dissemination of C-ITS messages.

After a long value chain, a DENM message for RWW has now been produced.

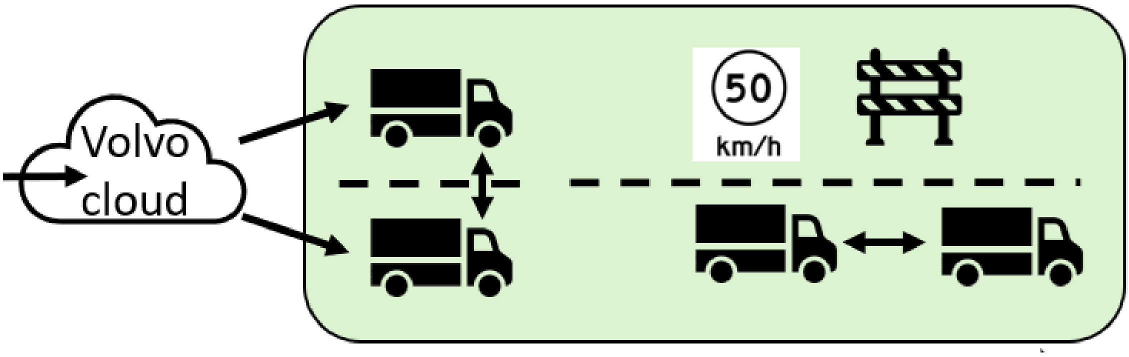
Management	actionID (DENM ID)	Datex
	detectionTime	Datex
	referenceTime	Datex
	termination	N/A
	eventPosition	Datex
	relevanceDistance	N/A
	relevanceTrafficDirection	Datex
	validityDuration	Datex-JSON
	transmissionInterval	Datex-JSON
Situation	informationQuality	Datex
	eventType	Datex
	-causeCode	Datex
	-subCauseCode	Datex
	linkedCause	N/A
	eventHistory	Datex
Location	eventSpeed	N/A
	eventPositionHeading	N/A
	traces	Manual
	roadType	N/A
alacarte	lanePosition	N/A
	impactReduction	N/A
	externalTemperature	N/A
	closedLanes	Manual
	restriction	N/A
	speedLimit	Datex
	incidentIndication	N/A
	recommendedPath	N/A
	startingPointSpeedLimit	N/A
	trafficFlowRule	Manual
	referenceDenms	N/A
	positioningSolution	N/A
	stationaryVehicle	N/A

Figure 17: Data content in the DENM message with an indication of the data source for the various elements. DATEX, DATEX-JSON, and Manual are the sources shown in Figure 16

DENM cause code description (we use this)	Direct cause code	TPEG-TEC Description (for info only)	Sub cause code	DENM sub cause description
Roadworks	3	Road works	0	Unavailable
			1	Major roadworks
			2	Road marking work
			3	Slow moving road maintenance
			4	Short-term stationary roadWorks
			5	Street cleaning
			6	Winter service

Figure 18: Cause codes for roadworks.

5 Interchange - Volvo



Volvo's process for accessing and using the C-ITS message RWW is described as follows:

5. The truck's software digitally subscribes itself to the interchange of NPRA (the NPRA's data platform), in order to be notified by traffic events in Norway (such as RWW).
6. The truck then have access to the available messages on the interchange of NPRA.
7. The truck will fetch those messages and process the ones that are immediately relevant (in close proximity or near future).
8. For example, when we are testing the "Cooperative Merging" driving towards the RWW, the RWW is then considered as relevant when it is within 1000 meters from the truck.
9. The truck's software will then further process the RWW, i.e., extracting information of positions, lanes and speed limits, which would be used by vehicle functions like "Cooperative Merging".

Note 1: All the communication above is over cellular network.

Note 2: All the steps/processing/actions above is automated (by the truck's software).

6 Summary

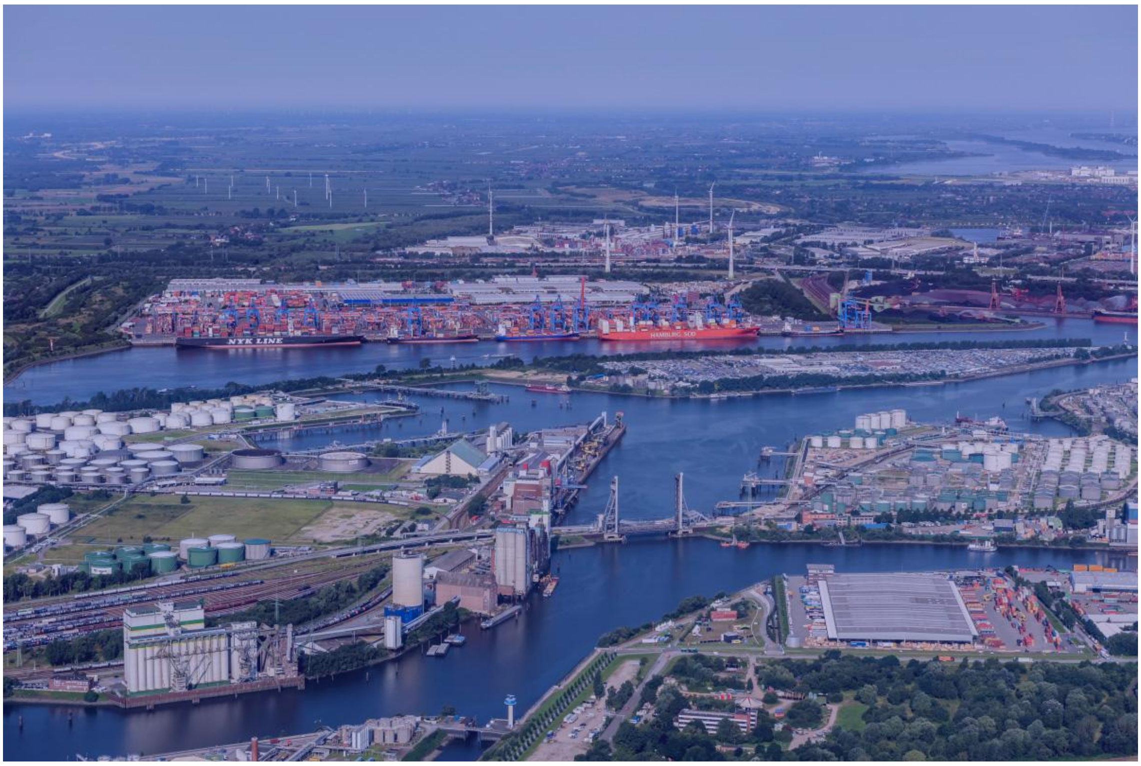
The process of digitalization and automation of the whole data chain for establishing and publishing traffic events, such as RWW, from entrepreneur to interchange and finally to driving traffic, still has untapped potential. However, within this work the processes are mapped out, and shown that the sub systems are in place and data information is sufficient in end for the safe merger functionality. The remaining work is to automating the interfaces and implementing a more efficient human in the loop approach to some of the steps.

Annex 7

A leap towards SAE L4 automated driving features

MODI Task 5.4 UC NO

“The border-crossing permit story”



Authors:
Solveig Meland (@SINTEF)

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1 Introduction

1.1 Background

MODI Task 5.4 Use Case Norway (UC NO) includes the sub-use case Border crossing, where an automated vehicle will cross the border between Sweden and Norway [1]. The vehicle manufacturer therefore needs a permit from each of the two countries to test an automated vehicle on public roads. The permit process for Norway has been tightly linked to and coordinated with the corresponding permit process in Sweden for MODI Task 5.3 Use Case Sweden (UC SE), as the same vehicle is involved in both use cases.

1.2 Scope and purpose of this document

This project memo documents the process leading up to required permits for Einride to perform L4 test driving on public roads in the UC NO Border crossing demonstrations. This includes the specifics of the cross-border permit process, as well as the respective permit processes, regulations and requirements in Sweden and Norway, and the interplay between these in a border-crossing permit perspective. Learnings, insights and challenges identified by the involved actors through this process are summarised, with the intention to benefit the MODI project and future work on cross-border permit processes for trials with automated vehicles on public roads. For this purpose, the perspectives of both authorities and applicant are relevant and needed.

1.3 Actors and stakeholders involved in the permit process

The process involves actors providing and applying for permit to test Automated Vehicle (AV), authorities assessing whether these technologies adhere with safety requirements defined in laws and regulations, and - depending on the specific trial plans – also local authorities and stakeholders.

The Swedish Transport Agency[34] - (Transportstyrelsen): The Swedish Transport Agency (hereafter referred to as TS) is responsible for issuing permits for trial operations with automated vehicles on public roads. The role and mandate regarding automated vehicles is described at the website[35]:

> *«The Swedish Government has decided on an ordinance on trial operation with automated vehicles. The ordinance states that trial operations with automated vehicles may only be carried out with permission from the Swedish Transport Agency. We also have the right to assign a permit with terms and conditions.»*

The Swedish Transport Administration[36] - (Trafikverket): The Swedish Transport Administration (hereafter referred to as STA) is responsible for the transportation system, and that all transport and travel is performed efficiently, safely and with consideration for environment and health.

Other authorities and stakeholders, Sweden: Before a decision is made on trial permit, *road owners* are consulted to get their view on the trial plans, and any conditions they have to accept the trial. *Local police* and *emergency services* may also be consulted by the applicant.

[34] https://www.transportstyrelsen.se/en/ (accessed October 5, 2025)
[35] https://www.transportstyrelsen.se/en/road/Vehicles/self-driving-vehicles/ (accessed October 5, 2025)
[36] https://bransch.trafikverket.se/en/startpage/ (accessed October 5, 2025)

The Directorate of public roads: The Directorate of public roads (DPR) is responsible for issuing permits for trial operations with automated vehicles.

The Norwegian Public Roads Administration[37]: The Norwegian Public Roads Administration (NPRA) is responsible for the national transportation system, and through DPR, also for issuing trial permits.

In this document, for clarity of roles, NPRA refers to the transport system and road owner role, while DPR refers to the permit authority role.

Other authorities and stakeholders, Norway: Before DPR make a decision on trial permit, relevant *police districts*, *road authorities*, *road owners*, *sign authorities* and *owners of any railway infrastructure* shall be given the opportunity to comment before permission is granted for testing.

Einride Autonomous Technologies AB[38]: Einride Autonomous Technologies AB (hereafter referred to as Einride) is the applicant in the permit process(es). Einride is the manufacturer of the purpose-built vehicle and the developer of the Automated Driving System (ADS), and is responsible for both supplying and operating the ADS in the demonstration.

1.4 UC NO demo plans

According to MODI D2.1 Report on UC details [1], the UC NO Border crossing demonstration would involve *«driving from Sweden on E6 to Norway crossing the Svinesund bridge … without the need to stop. This includes switching between different positioning services … and connectivity providers. The driving will likely include an overtake by other vehicle, exit/enter highway, and handling of safety critical failures. The speed will be approximately 60 km/h … The safety case needs to be thoroughly planned with discussions concerning the ability to create a more controlled environment with mitigating actions e.g., dedicated lane, possible to lower speed limit etc. »*

This description formed the starting point for planning and discussions on the realisation of the demonstration, and hence also for the permit process explored in the present document.

1.5 Trial permit process timeline and milestones

The UC NO Border crossing demonstration was performed in September 2025. This was in accordance with the initial plans, which stipulated Q2-Q3 2025. The demonstration was the result of a nearly three-year long process, which began late 2022 (Table 1).

From the first dialogue meeting starting discussions on how to realise the UC NO Border crossing demonstration in November 2022, nearly two years of preparatory meetings, alignment of processes and detailed planning and preparations for the AV trial followed, until the formal Swedish permit process commenced with Startup-meeting between Einride and TS in December 2024. At this point, six months of preparatory work were required before the permit applications were submitted to the Norwegian and Swedish authorities in April and May of 2025, respectively. Permits were granted from Swedish and Norwegian authorities in August and September 2025, respectively, and it took approximately three weeks from the final permit to the realisation of the demonstration.

[37] https://www.vegvesen.no/en/ (accessed October 5, 2025)

[38] https://www.einride.tech/autonomous (accessed October 5, 2025)

Table 1: MODI UC NO Trial permit activities and timeline

Phase/step	When	Activity
Permit preparations	November 2022	Dialogue meeting, UC NO
	February 2023	Permit process discussion meeting
	March, June, Nov, Dec 2023	Planning meetings
	Jan 2024	Demo discussion meeting
		Detailed trial planning and preparations
Formal permit process	December 18, 2024	Start-up meeting, TS and Einride
		Meetings between Einride, DPR and TS Detailed trial planning and preparation of application, including Safety case
	March 11, 2025	**Advice from TS/STA to change demo site/route**
		Identification of alternative site/route (Ørje) Detailed trial planning Preparation of application
	March 20, 2025	FAT/Pre-SAT at AstaZero
	March 26, 2025	FAT of AV and remote station approved
	April 15, 2025	**TS indicative positive to the alternative demo site/route**
	April 23, 2025	Data collection at Ørje
	April 25, 2025	**Permit application submitted by Einride to DPR**
	May 15, 2025	**Permit application submitted by Einride to TS**
		Permit processing by TS and DPR Supplementing documentation provided by Einride
	August 27, 2025	**Permit granted, SE:** **Duration: September 22-25, 2025** **Site: Ørje**
	September 4, 2025	**Permit granted, NO:** **Duration: September 22-25, 2025** **Site: Ørje**
Trial realisation	Target: Q2-Q3 2025	UC NO Border crossing demo
	Actual: Sept 24-25, 2025	**Trial at Ørje, border crossing and customs** **Public demo: September 25, 2025**

1.6 Information gathering

This memo builds on information gathered from varying sources:

- Available presentations and notes from MODI meetings
- Web sites, with reference to specific links in footnotes
- Laws, regulations and guidelines related to the permit process
- Dialogue/interviews with main involved national authorities and applicant.

1.7 Structure of this document

Chapters 2 and 3 provide an overview of current regulations relevant for the permit process, and practices related to getting a permit for testing automated vehicles on public road in Sweden and Norway respectively. The demonstration relied on getting a permit for the test vehicle from both counties, and how to align and make these processes as efficient as possible, has been on the agenda throughout the UC activities. Discussion points relating to this, and how these were resolved, are described in chapter 4. Key safety issues and consequences for the demonstration activities are presented in chapter 5, and the resulting permits in chapter 6. Finally, chapter 7 presents key takeaways from the process, and reflections provided by the main actors: applicant and permitting authorities.

2 Laws and regulations for trial permits

This chapter provides an overview of national laws and regulations regarding permits for trials involving automated vehicles in Sweden and Norway, as well as international regulations and guidelines referenced in the national regulations.

The national authorities involved in the MODI UN NO process presented main aspects and perspectives of the respective national regulations of Sweden and Norway, and differences in these, in a joint UC NO meeting in February 2023:

- The Swedish permit process applies only to public roads, not confined areas, while in Norway a permit from road authorities is required no matter where a test is performed, public or fenced area.
- Swedish authorities grant permit after Site Assessment Test (SAT), while Norwegian authorities give permit before the SAT, but with an option to withdraw this based on condition evaluation.

2.1 National regulations - Sweden

In the joint UC NO meeting in February 2023, Swedish authorities highlighted the following main aspects and perspectives of the national regulations:

- Regulations are developed with "safety by design" in focus
- The vehicle needs exemption from vehicle regulations, but must comply with traffic regulations
- Safety case: proof that the vehicle is safe and that the trial is safe.
- Assessment aspects: Sufficient planning; Scope of safety case; A common thread (everything provided is connected and has a purpose); Risks mitigation

The remainder of this section is based on information about automated vehicles at the authorities' website[39].

Förordning (2017:309) om försöksverksamhet med automatiserade fordon [2] regulates testing of automated vehicles on public roads.

This Ordinance provides definitions of some central terms:

- **automated vehicles** (AVs) mean vehicles that have an automated driving system (ADS) that can independently control and drive the vehicle for all or part of its journey
- **experimental activities** mean activities that involve the driving of automated vehicles to test and evaluate automated functions that are not included in a type approval, an individual approval or a registration inspection under the Vehicles Act (2002:574). (2§)
- The person who activates the automated driving shall be considered to be the driver of the vehicle until the automated driving is deactivated.

This Ordinance establish that experimental activities with automated vehicles may only be carried out after a permit, and that a permit may only be granted if the applicant demonstrates that traffic safety can be ensured during the trial and that the activity does not cause any significant disturbance or nuisance to the environment. (4§)

[39] https://www.transportstyrelsen.se/en/road/Vehicles/self-driving-vehicles/ (Accessed October 9th, 2025)

This Ordinance refers to other laws which are not further described here:

- the Swedish Vehicle Ordinance (2009:211)
- the Swedish Vehicles Act (2002:574)
- Swedish Ordinance (2020:754)
- The Swedish Traffic Ordinance (1998:1276)

TSFS 2021:4 Transportstyrelsens föreskrifter och allmänna råd om tillstånd att bedriva försök med automatiserade fordon [3] regulates the permit process. This is described in more detail in the chapter 3.1.

2.2 National regulations - Norway

In the joint UC NO meeting in February 2023, Norwegian authorities highlighted the following main aspects and perspectives of the national regulations:

- Dispensations from regulations within the Road Act can be granted, based on description/documentation of technology, system capability, necessary dispensations with risk assessment and mitigating measure per exception
- Conditions for permit is based on what has been tested and verified. E.g. if brakes have been tested for speed of 20 km/h only, this is the speed the permit will be limited to.
- Assessment criteria: Risk must not be higher than for an average driver driving an ordinary approved vehicle
- Permit will be temporary, and not a national type-approval
- Road owners and municipalities need to approve road stretch to be included in trial.

The remainder of this section is based on information available at the NPRA website, on Testing of automated vehicles[40] (in Norwegian).

LOV-2017-12-15-112 Lov om utprøving av selvkjørende kjøretøy [4] (Act on testing of self-driving vehicles) regulates testing of automated vehicles, and gives rules on permission, conditions and responsibility for the trial, as well as dissemination of information, processing of personal data, supervision, responsible driver and penalties.

The Act allows the Directorate of Public Roads to grant permission for testing of automated vehicles. The aim of the Act is for testing to evolve gradually, in line with technological developments and within a framework that safeguards traffic safety and privacy.

FOR-2017-12-19-2240 Forskrift om utprøving av selvkjørende motorvogn [5] (Regulations on testing self-driving motor vehicles) supplements LOV-2017-12-15-112 to ensure that such testing takes place within a framework that safeguards traffic safety, accessibility, data security and privacy. This is described in more detail in chapter 3.3.

[40] https://www.vegvesen.no/fag/trafikk/its-portalen/automatisert-vegtransport/utproving-av-selvkjorende-kjoretoy/ (Accessed October 2, 2025)

2.3 International regulations, supporting documents and standards

The respective national regulations, permit processes and relevant authorities of Sweden and Norway also refer and relate to international regulation and standards:

EU Regulation 2022/1426 [6] describes procedures and technical specification for the type-approval of the automated driving system (ADS) of fully automated vehicles. Information to manufacturers on how to interpret and guide on how to comply with requirements in this regulation is provided in supporting documents [7],[8].

Guidelines on the exemption procedure for the EU approval of automated vehicles, Version 4.1 [9]. According to the press release[41] these guidelines help coordinate national ad-hoc assessments of automated vehicles at SAE levels 3 and 4 and aim to clarify to manufacturers what they can expect from regulators, harmonise regulation with international partners and start a discussion on the necessary adaptation of some national legislation for these vehicles (e.g. traffic rules). Swedish authorities refer to these guidelines for related information regarding need for exemptions from the Swedish Vehicle Ordinance (Ch 8, §18).

The Commission Expert Working Group on Motor Vehicle (MVWG), subgroup on automated/connected vehicles (ACV) has provided a final draft of *Guideline on a uniform EU-wide procedure for the subjects of pre-type approval assisted (ADAS) and automated vehicle (ADS) testing and recognition of testing approvals among member states* [10]. The stated ambition for this guideline is to have pragmatic provisions to allow R&D and pre-Type Approval testing of ADAS and ADS, including testing performed in different EU member states. Based on a review of national processes and practices, the guideline suggests a common procedure for obtaining permits for type approval and development testing. Swedish authorities have contributed to developing this guideline.

UN Regulation No157 [11] on Automated Land Keeping Systems (ALKS) is presented as a first regulatory step for an automated driving system in traffic, containing administrative provisions suitable for type approval, technical requirements, audit and reporting provisions and testing provisions. The regulation includes general requirements regarding system safety and failsafe response, requirements on safe hand-over of driving task from ALKS to driver, and requirements on the Human-Machine Interface (HMI).

UNECE Inland Transport Committee's *Framework document on automated/autonomous vehicles* [12] identifies key principles for the safety and security of automated/autonomous vehicles of levels 3 and higher as a guidance for i.a. World Forum for Harmonization of Vehicles Regulations.

UNECE Working Party on Automated/Autonomous and Connected Vehicles (GRVA) draft for a UN Regulation regarding *Uniform provisions concerning the approval of vehicles with regard to Automated Driving Systems* [13] aims at establishing uniform safety provisions and a harmonised methodology for validating ADS safety, requiring «the ADS to deliver a level of safety in mixed traffic at least equivalent to that of a competent and careful human driver».

ISO 34503:2023 [14] provides requirements for specification of operational design domain (ODD) for automated driving systems, primarily at levels 3 and 4, for the use of organisations conduction trials,

[41] https://single-market-economy.ec.europa.eu/news/guidelines-exemption-procedure-eu-approval-automated-vehicles-2019-04-09_en (accessed October 6, 2025)

testing and commercial deployment, as well as for manufacturers to define the operating capabilities of the ADS in question.

UL 4600 Standard for Evaluation of Autonomous Products[42] provides lists of issues to address in Safety case.

[42] https://ulse.org/focus-areas/travel-safety/autonomous-vehicles/ (accessed November 11, 2025)

3 National trial permit processes

This chapter provides an overview of the respective national processes regarding permits for trials involving automated vehicles in Sweden and Norway, along with the authorities' perspectives on the respective processes.

3.1 National trial permit process - Sweden

The Swedish Transport Agency (TS) provides information and description of the process for obtaining permits for trial operations with automated vehicles on public roads on their web site[43], and states that *"Anyone who seeks permission must be able to prove that the operation can be conducted in a traffic-safe manner."* TS provides (links to) supporting documents to aid the applicant in the process, but also states that *"... the applicant is completely free to rely on the documents and the information that is relevant for the handling of the case."* Supporting or related documents include:

- TSFS 2021:4 [3], regulation for the permit process
- Supplementary information for trial operation permits with automated vehicles (Guidance for TSFS 2021:4) [15]
- Compliance with the traffic regulation (1998:1276) [16] Supporting document - trial operation with self-driving vehicles, for the applicant to show how the vehicle complies with applicable traffic rules during the trial operation.
- Application for a permit for automated vehicles [17]
- Guidelines on the exemption procedure for the EU Approval of Automated Vehicles. [9]

TSFS 2021:4, regulation for the permit process

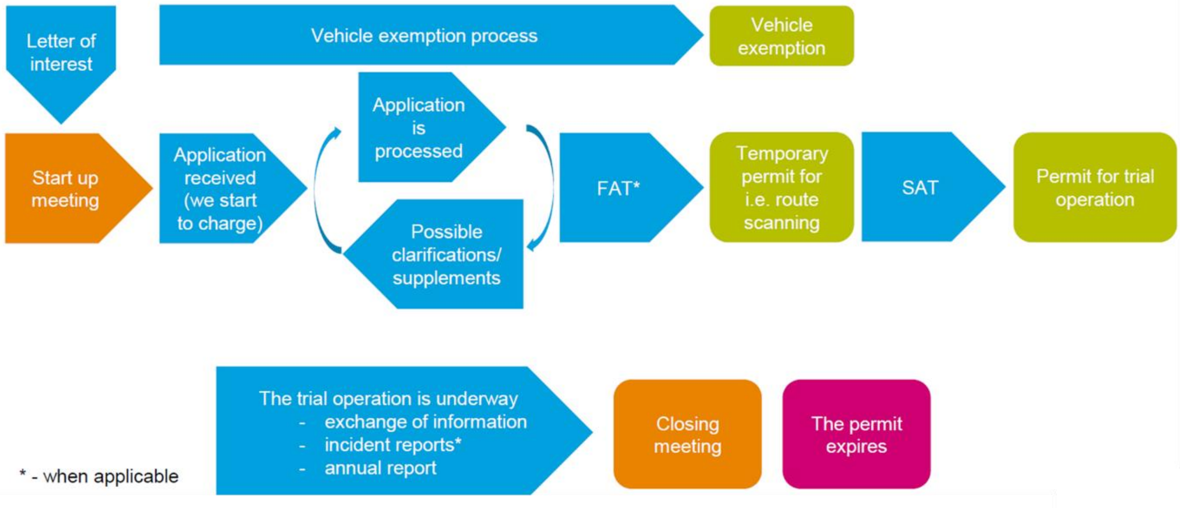
This regulation applies to trial operations with automated vehicles on public road and describes e.g. minimum contents of an application; management and control routines; reporting and evaluation of the trial operation. The regulation does not cover trials performed off-road or in confined areas.

Guidance for TSFS 2021:4

The document *Guidance for TSFS 2021:4* outlines a stepwise process, aiming at ensuring *"... equal treatment between applicants and to give the applicant a better understanding and an overview of the stages that are included in the process of obtaining a permit."*

There is an hourly charge involved for the authorities' processing of submitted applications.

[43] https://www.transportstyrelsen.se/en/road/Vehicles/self-driving-vehicles/ (accessed October 5, 2025)



Source: Guidance for TSFS 2021:4

Figure 1: Flowchart of the application process in Sweden

As indicated in Figure 1, the vehicle exemption process and the trial-permit process are separate and independent processes. The vehicle exemption process, which includes a background check, approval of exemptions and finally a registration, is not further elaborated in this memo.

Table 2: Steps in the permit application process in Sweden

Step	Initiated/performed by	Also involves
1. Letter of interest	Applicant	
2. Start-up meeting	Authority	Applicant
3. Application completion and submittal	Applicant	
4. Processing of application	Authority	
5. Factory assessment test (FAT)	Authority	Applicant
6. Temporary permit and decision on exemption from vehicle requirements	Authority	
7. Site assessment test (SAT)	Authority	Applicant
8. Permit for trial operation	Authority	
9. Execution of trial operations	Applicant	

These steps are further described below. Unless otherwise stated, the description of each step is based on and includes more or less direct quotes from the document Guidance for TSFS 2021:4 [15].

3.1.1 Letter of interest, SE

The applicant completes and submits a letter of interest for permit for automated vehicles, using the form[44] provided by the Swedish Transport Agency. This form requests information listed in Table 3.

Table 3: Information requested in form for Letter of interest

Topic	Detailed information requested
Name of the trial operation	
1. Applicant	• contact details of applicant and persons, • name of person legally responsible for the trial • company registration number • desired start and end date for the trial operation
2. Management and responsibility	• how the trial operation will be managed • how responsibilities, tasks and powers are distributed for the person or persons who will be responsible for the trial operation
3. Purpose of the trial	• purpose and objectives of the trial operation
4. Automated functions	• which fully or partially automated functions are to be tested and evaluated in the trial
5. Implementation of the trial operation	• overall plan for how to carry out the trial • how it will be evaluated • why the trial must be done in real traffic
6. Geographical area	• the geographical area and • on which streets or roads the trial will be performed • who is the road owner
7. Risk management	• how risks will be identified • activities to minimize these to an acceptable traffic safety level and • how risks will continuously be handled during the trial
8. Ownership of the vehicles	• who owns the vehicles included in the trial
9. Technical description of the vehicles	• a technical description of the vehicles included in the trial
10. Vehicle exemption	• account for the need for exceptions according to chapter 8. § 18 of the Vehicle Ordinance (2009:211)
11. Other information	• any other information of importance for the permit processing

3.1.2 Start-up meeting, SE

Upon receiving the letter of interest, the Swedish Transport Agency adds a case number and books a start-up meeting with the applicant – physical or digital. According to the authorities' web site[10], the purpose of the meeting is to ensure that the following permit process will be as efficient as possible.

Table 4: Typical items in start-up meeting

Meeting items	Responsible
1. Presentations of trial plan in questions	Applicant
2. Information about the application process, safety requirements, etc	Authority
3. Questions	

[44] https://www.transportstyrelsen.se/globalassets/global/blanketter/vag/english/tsv7100-letter-of-interest-permit-for-automated-vehiclest2.pdf (accessed October 6, 2025)

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3.1.3 Application completion and submittal, SE

The applicant completes and submits an application for permit for automated vehicles, using the form[45] provided by the Swedish Transport Agency (TS). This form requests information structured in accordance with that of the Letter of interest (Table 3), but with accompanying documents providing more detailed information under each topic. The following sections sums up examples given in the Supplementary information document [15] of more specific and detailed information requested (beyond what is given in the Letter of interest) for specific topics addressed in the application.

Management and responsibility

This includes describing management of responsibilities and skills, handling of documents and communication, and actions to prevent and handle any accidents, incidents or deviations from plans.

Table 5: Examples of questions to be answered re. management and responsibility

Question
• **Is there a specific driver education?**
• **Are there incident/accident procedures in the trial operation, and how is it followed up?**
• **Is there a deviation management procedure for the trial operation, and how is it followed up?**
• **When and how is the Swedish Transport Agency informed regarding, for example, accidents or changes affecting the permit?**
• **Is the trial operation insured?**
• **Is there a clear and communicated distribution of responsibilities for the trial operation?**
• **Are there risks in the risk management plan that are managed via one or more organizational routines?**

Automated functions

The applicant must give a description of the technical system, its functionality and limitations. For any driving tasks not fully covered by the automated system, the description must show how relevant traffic rules are observed during test operation.

The document *Compliance with the Swedish Traffic Ordinance (1998:1276)* [16] provides a detailed list of 100 questions related to specific requirements embedded in the traffic regulations. The applicant can use this for describing how the system to be tested complies to each requirement. The requirements are grouped according to the chapter structure of the traffic ordinance (number of requirements per chapter in brackets):

- Chapter 2 - Requirements for all road users (9)
- Chapter 3 - Requirements for the operation of vehicles (75)
- Chapter 4 - Requirements for traffic with motor vehicles (14)
- Chapter 8 - Requirements for traffic on the pedestrian street and the living street etc. (1)
- Chapter 9 - Requirements for traffic on the motorway and expressway (1)

[45] https://www.transportstyrelsen.se/globalassets/global/blanketter/vag/english/tsv7099-application-for-a-permit-for-automated-vehiclest2.pdf (accessed October 6, 2025)

Geographical area

For testing on public roads, the route must be clearly defined, e.g. by means of a map, with specification of where the route starts and ends. Road owners must be identified, and road owners and municipalities need to approve road stretch to be included in trial.

Risk management

The applicant must provide a safety case, including a risk assessment showing that risks and disturbances related to the trial have been identified, categorized and managed to acceptable levels. In the Supplementary information Ch. 6 [15], TS states that the "methods and risk acceptance criteria are up to the applicant to choose based on the scope and complexity of the trial operation". It further says that the documentation shown in Table 6 below are considered examples of a minimum level of safety evidence that the trial operation is "at least as safe as today" on the intended test site.

Table 6: Examples of safety evidence

Topic	Detailed information requested
Basic documentation	
Safety plan	• safety work, roles, responsibilities and methodology used to ensure safe trial operation
System and trial definition	• the technical system, essential functions and interfaces to internal and external adjacent systems. • intended operating conditions for the trial (e.g. maintenance and environment) • limitations relating to the technical system • identification of which parts of the technical system are included in automated functions, and the degree of maturity for each part
Risk analysis	Minimum contents: • Description of hazard • Initial probability (with clearly defined and weighted levels of probability) • Initial consequence (with clearly defined and weighted levels of consequence) • Initial risk classification (based on acceptance criteria/risk matrix) • Mitigation with reference to action taken • Final probability • Final consequence • Final risk classification
Fulfilment of requirements	

For risks identified:	• specification of acceptance criteria for sufficient safety level
	• evidence that the risk-reducing measures have been implemented, e.g.
	  ○ technical documentation, verification and validation of a technical solution
	  ○ demonstration of a routine
	  ○ demonstration and documentation of relevant requirements for driver training

Independent assessment (for trial operations relying on technical systems to ensure traffic safety)	
Report from independent assessor hired by applicant	• documentation of assessor's competence Minimum contents of assessor's report: • Description of assessed system (functions, intended use, interface, limitations) • Description of assessment method (basis and implementation) • References (account of documents and sources used, and review of these) • Results (including any deviations or observations) • Conclusions with final statement on whether the system can ensure traffic safety, and any limitations or conditions applying for the system.

Technical description of vehicle/Vehicle requirements

Vehicle approval:

Vehicles which have been modified to facilitate automated driving, need an exemption from the vehicle regulation. To obtain such exemption, the applicant must provide:

- a technical description of the vehicle, and
- a certificate of compliance.

This documentation is required for the TS to perform the sequence of steps included in the vehicle exemption process.

Table 7: Steps in the vehicle exemption process

Step	
1.	**Verification of origin**
2.	**Classification of vehicles**
3.	**Fulfilment of vehicle requirement**
4.	**Assessment of exemptions**
5.	**Decision and registration**

For testing on public roads, the vehicle must also be registered in the Road Traffic Register.

Principles of the automated vehicle:

The TS also specifies a number of principles regarding automated vehicles (Table 8) which the applicant must consider when planning the test operation. These principles address and detail requirements for safety-critical technical systems the trial relies on, depending on system status and maturity, and for remote controlled operations, with reference to national and international regulations. It is further emphasized that these regulations do not cover exclusively remote driving, and that remote controlled operation is considered an emergency control option only, and not a primary modus operandi.

Table 8: Principles of automated vehicle to be considered when planning trial

System status	Detailed requirements
Safety-critical technical systems the trial relies on	
such systems must be ...	• verified and validated with relation to function and reliability • reviewed by independent assessor (ref. Table 6)
for already certified systems	The applicant must: • provide safety certificates or similar • demonstrate that trial application falls within intended area of use
for novel systems or with new area of application	The independent assessor must: • assess whether the development and construction of the system follow guidelines, applicable standards and best practices.
Driver outside the vehicle – applicable regulations for remote control	
Remote control (UN R70)	• max speed of 10 km/h (+2) • fault diagnosis must be available • vehicle must always stop in front of any obstacle in the vehicle's direction of travel – and it must not be possible to remotely deactivate this functionality while vehicle being remotely operated • vehicle must stop unconditionally and immediately in case of communication interruption • distance in a remote connection must not exceed 6 meters. In case of exemption: the driver must be able to observe/manage the traffic situation as if they were in the vehicle and its drivers' seat (if any).

System status	Detailed requirements
Traffic ordinance (1998:1276)	• the person activating the automated driving is to be considered the driver until the automated driving is deactivated, and must fulfil the driver's responsibilities according to the traffic regulation. • this is the case whether activation of automated driving is done in-vehicle or remotely. • the applicant must show how the driver's responsibilities can be fulfilled when the driver is at a distance from the vehicle.
Vision requirements for drivers	• good view of surrounding traffic environment, putting demand on design of driver's environment and technical systems, including video resolution, viewing angles and frequency.
Technical limitations of automated system	
Operational boundaries	• The vehicle must not be able to operate outside its technical limitations without explicit consent from the driver. • Without such consent, the vehicle must be placed in a safe state • The vehicle may continue operation after confirmation from the driver.
System – driver interaction	
Driver as risk reducing factor	If the driver is used to reduce an identified risk, the applicant must: • provide evidence or arguments that the driver can act as such a barrier, by considering control strategies (e.g. pressing emergency stop button) and driver's reaction time.

3.1.4 Processing of application, SE

TS's processing of the application is based on documents enclosed in the application. During the processing, TS may ask for more detailed information or additional meetings with the applicant, as indicated in Figure 1. At this stage in the process, the charging of a processing fee commences.

3.1.5 Factory assessment test, SE

TS may request a Factory assessment Test (FAT) to be performed, if they deem that on-site demonstrations are necessary.

3.1.6 Temporary permit and decision on exemption from vehicle requirements, SE

Once TS considers that the application provides sufficient proof that the trial can be conducted in a safe and non-disturbing manner, they issue two decisions:

1. Exemption from regulations on requirements for vehicles
2. Temporary permission to conduct trials – usually valid for two weeks.

These decisions enable the applicant to prepare operations at the intended site, before the final on-site inspection. This could e.g. involve route scanning with the vehicle, adjustments to the vehicle's automated functions, etc. The temporary permit usually has a validity period of around two weeks.

3.1.7 Site assessment test (SAT), SE

TS performs a Site Assessment Test (SAT) before issuing a permit. This is an inspection of the vehicle at a location relevant for the trial operation, checking that:

- the vehicle meets relevant traffic rules,

- the operation does not cause significant disturbances or inconveniences,
- the test is carried out in accordance with the application.

A planning meeting involving applicant and TS is held a few weeks ahead of the SAT.

Additional SAT(s) may be requested in case the initial SAT generates questions or remarks from TS.

3.1.8 Permit for trial operation, SE

Once the SAT results are deemed satisfactory, the TS will issue a time-limited permit for trial operations with automated vehicles. This permit is issued with a number of conditions which shall be met by the applicant during the trial operation. The set of conditions depend on design and content of the trial.

3.2 Authorities' practices and perspectives - Sweden

The contents of this section are based on interview with Swedish authorities.

<u>Process layout:</u>

Online information from Swedish authorities to applicants describes nine well-defined steps in the application process for test-permit, including tests (FAT and SAT) to be performed by the authorities. These are steps in a generic process, used for test-permit processes involving AVs ranging from small robots to large vehicles. In practice, the permit processes can have a more dynamic character, as the authorities identify control needs and specific conditions for each unique case. E.g. in case of an extension of an approved test program or where the applicant is "known" and has completed tests previously, FAT may be seen as unnecessary, and registration inspection can be carried out by other actors. SAT is always included, but can be based on video recordings. This practice was introduced during the pandemic. A digital SAT supplements a site inspection. SAT is always carried out physically with a new vehicle or a new operator.

<u>Dialogue between authorities and applicant:</u>

Dialogue is essential, and the process always includes a start-up meeting aiding the applicant to direct scope of documentation towards safety. An extensive list of questions regarding Compliance with the Swedish traffic ordinance is provided to make the applicant aware of relevant topics/problems. This is supporting documentation, but not required, and is not completed for all applications. The applicant can also include videos, simulation results etc. as part of the documentation accompanying the application. The authorities mainly base their assessment on description of the ODD/TOD and chosen location, as well as the risk analysis and planned ways to resolve deviations from ODD.

After the start-up meeting, there is not much dialogue between the Swedish permit authorities and the applicant. Where there is a need for additional "points of contact" to address different aspects of the application, the TS provides the applicant with contact information to other public bodies, to facilitate access to the relevant competences. It is the applicant's responsibility to utilise this information.

<u>Authorities' main concerns:</u>

Main concern of the authorities is that AVs in a trial must be safe, follow traffic rules and not obstruct traffic. The SAT can thus be compared to the driving tests an individual has to pass to get a driver's license. The applicant must provide convincing evidence that traffic conditions at the test site will be "just as safe as today" during the trial. Exemptions from this cannot be granted. The AV must have sufficient capabilities and overview of its surroundings, and RO must be able to judge the situation continuously during the trial. Exemptions may be granted e.g. for requirements regarding distance between AV and RO (UNECE: «Max 6 m»), but not for fault diagnostics, loss of connectivity, etc.

Road owners' role:
Road owners (local as well as national (STA)) can set conditions for where and when a test can be carried out, and may ultimately deny a permit for a proposed trial activity at a given location based on the combined characteristics of vehicle, functionalities, time and site for the trial. TS has no supervisory authority over the trial as such, but can withdraw or adjust the permit.

Vehicle requirements:
A trial permit also requires registration and individual approval of AVs to be used in a trial.

3.3 National trial permit process - Norway

The Norwegian permit process is described on the NPRA web site (in Norwegian)[46]. Supporting documents include:

- FOR-2017-12-18-2240 [5] (Regulations on testing of self-driving motor vehicles)
- Veiledning til søker om utprøving av selvkjørende motorvogn [18] (Guidance for applicants for testing self-driving motor vehicles) – in Norwegian
- Søknad om utprøving av selvkjørende motorvogn [19] (Application for testing of self-driving motor vehicles) – in Norwegian

FOR-2017-12-18-2240, Regulations on testing of self-driving motor vehicles

A permit is required for all testing of automated vehicles, also if this is performed in a confined or private space.

The Regulations cover testing of motor vehicles…

- with a driver in a traditional driver's seat equipped with an automated technical system that drives the motor vehicle where the driver is no longer to be regarded as the responsible driver in whole or in part.
- that drive completely without a responsible driver, or with a responsible driver in a position other than a traditional driver's seat.

The Regulations cover testing of self-driving motor vehicles, whether it takes place on or off road.

The Regulations describe conditions for a permit, with requirements for:

- contents of the application, including duration of trial
- motor vehicle(s) included in the test
- vehicle registration
- the automated system, with documentation of system and technology capabilities and maturity, including electromagnetic compatibility (EMC) and information security

[46] https://www.vegvesen.no/fag/trafikk/its-portalen/automatisert-vegtransport/utproving-av-selvkjorende-kjoretoy/ (accessed October 2, 2025)

- road section or test area, with applicant's assessment of suitability for testing of specific vehicle and system, and need for informing local police about tests on public road
- reporting of risks, including assessment of conditions beyond ODD and TOD for tests on public road
- operators, including documentation of certificates and training

This Regulation refers to other laws which are not further described here:

- Road Traffic Act (Vegtrafikkloven, LOV-1965-06-18-4)
- Commercial Transport Act (Yrkestransportloven, LOV-2002-06-21-45)
- Personal data Act (Personopplysningsloven, LOV-2018-06-15-38)

Guidance for applicants for testing self-driving motor vehicles

This guidance [18] provides additional information on the application and the authorities processing of this, on conditions which apply for a permit, including a statement that *"Road safety during the trial must be at least as well taken care of as it would have been without self-driving motor vehicles"*. The guidance also informs that the road owner is not ordered to implement any traffic regulations suggested in the application. The guidance therefore advice that road owner and other relevant stakeholders (e.g. local police, road- and sign authorities) should be consulted during the permit process, to clarify any issues related to measures suggested in the application, and need for exemptions from existing regulations.

The guidance further provides detailed information about expected contents of report to be provided within six months after end of trial, and item by item guide on information expected in the application form [19]. This includes references to EU regulations on procedures and technical specification for the type-approval of the automated driving system (ADS) of fully automated vehicles [6].

Relevant parts of the permit process are further described below. Unless otherwise stated, the general description of each step is based on and includes more or less direct quotes from the document Guidance for applicants for testing self-driving motor vehicles [18].

3.3.1 Application contents, NO

Table 9: Information requested in application, NO

Topic	Detailed information requested
1. Type of application	• New application; extended period; extended route; change(s) of vehicle
2. Applicant	• contact details of applicant and persons, • name and date of birth for person(s) responsible for safety • company registration number
3. Purpose of the trial	• purpose and objectives of the trial operation
4. Description of vehicle(s)	• description of vehicle(s) included in the trial (type, class, VIN) • vehicle registrations status and need for exemption • documentations of compliance with, or description of need for exceptions from, technical requirements • vehicle insurance
5. Operator(s)	• name, contact info and date of birth • description of role, including relations between operator, responsible driver and responsible for safety • documentation of training and skills

6. Automated system	• automated system to be included in trial, including description and documentation of:
	  ○ functionality, system, technology and technology maturity
	  ○ how data security and privacy is safeguarded

Topic	Detailed information requested
	○ risks related to automated functionalities and data security, and consequences for privacy ○ electromagnetic compatibility (EMC)
7. Implementation of the trial operation	• overall plan for how to carry out the trial • time and location for the trial operation • type of location and its suitability for trial • indication of need for (and description of) any: ○ additional traffic management (sings, markings, signals) ○ additional barriers, rails of fences ○ roadside equipment (ITS) • documentation of, or plan for collection of, opinions from police, road authorities, road owner, sign authorities etc regarding traffic safety, passability and need for specific regulations
8. Exemption from current regulations	• indication of need for (and description of) need for exemptions from road traffic act or "vocational transport act" (yrkestransportloven)
9. Risk management	• description of risks related to trial • documentations of risk assessment, including, if performed in general traffic, for situations beyond normal situations (e.g. road works, weather, re-routing or accidents). • activities to minimize or remove risks • how risks will continuously be handled during the trial
10. Other information	• any other information of importance for the permit processing

3.3.2 Processing of application, NO

Applicant's guidelines [18] provides information about the application and process:

- where to send the application
- expected response time: one month, but potentially longer if more information/clarifications are needed
- format of response: in writing, with reasoned decision (granted, in whole or partially, or rejected) and complaint form enclosed.

3.3.3 Permit for trial, NO

Permit for trial are granted for a limited period of time, with possibilities for extensions.

Road safety during the trial must be at least as well taken care of as it would have been without self-driving motor vehicles.

3.4 Authorities' practices and perspectives - Norway

The contents of this section are based on interview with Norwegian authorities.

Process scope:

The Norwegian legislation is a response to the industry's challenges in being able to do tests of AVs. The legislation is designed to provide basis for exemptions from current regulations, e.g. the Professional Drivers Act, rather than permissions for something.

Process purpose and layout:

The purpose of the legislation is to facilitate testing of new technology, without loss of safety. The process is based on documentation of the maturity of the technology, inspections and discretionary assessments. What and how to assess is individually adapted to each application, depending on e.g. vehicle, functionality and chosen location. The process is iterative, and number of iterations required tends to reflect the how well the applicant does understand what the authorities are looking for in the documentation. Documentation requirements are quite open and leaves some interpretation to the applicant. This may represent a challenge in the communication, predominantly with new applicants, and with actors who do not develop their own technology.

Dialogue between authorities and applicant:

Norway has a similar process as Sweden. There is one main contact at each side of the process (authority/applicant), but both sides can involve additional staff in the process as they deem necessary and relevant. OEMs are familiar with providing detailed safety assessments for the Automated Driving System (ADS), Operational Design Domain (ODD), functional safety as well as Hazard and Risk Analysis (HARA). The NPRA may request an assessment from a third party if less experienced applicants do not understand/deliver what SVV is asking for.

Controls and permits:

Inspections are performed by authorities based on assessed need: Authorities usually make a site visit to check that things are as described in application. Permissions granted may start quite limited and be adjusted over time.

4 MODI UC NO border-crossing permit process – principles and ambitions

To determine what would be a feasible and as efficient trial permit process as possible, handling of process-related issues had to be discussed and resolved. The following provides an overview of (some of) these. Unless otherwise stated, this chapter is based on available presentations and notes from meetings relating to this process.

4.1 Border-crossing process for trial permit

To cross the national border between Sweden and Norway, the vehicle must have a trial permit from authorities in both countries. How to go about this in an efficient manner, while respecting the individual national requirements has been a process throughout the UC.

<u>Authorities' previous experience with cross-border permit processes</u>

According to information from dialogues with respective authorities, Norway had been involved in cross-border permit processes earlier (Norway-Finland), while this was a first for Sweden. However, Swedish authorities have been involved in EU-process on approving approvals from other countries.

<u>Einride permit history in Sweden</u>

Swedish authorities have granted Einride trial permits to operate in Sweden since 2019. The authorities have expressed that the dialogue with Einride has been good during these years, and that Einride has demonstrated that they understand the permit process and prerequisites involved.

<u>Ambition for the UC NO permit process</u>

There was early on a question about the ambition or intended character of the process: was the aim to make it as simple as possible, or as close to a type-approval as possible? In the January 2024 Demo discussion meeting, it was made clear that even though it is not the end goal of the MODI project to have type approved vehicles, it was desirable from Einride point of view to align parts of the MODI work with the type-approval methodology, as this could provide important insights and learning points.

<u>Outline of the process</u>

In January 2024, it was agreed that the permit process should be iterative, starting with information and assessment of the organization and safety work, and ending with verification of tests performed. STA recommended a stepwise submitting of application.

<u>One or two processes and permits?</u>

From point of view of Swedish and Norwegian authorities, a parallel process would be desirable to avoid doing the same work twice.

The national authorities initiated a discussion among themselves, addressing:

1. what a permit application for this one-off demo should include
2. suggested milestones for this (at least a start meeting and final deadline of documents)
3. Number of applications (one for each country?)
4. Or, can one country be the receiver of the permit application, but the permit is valid for both countries?

Norwegian authorities commented that if the vehicle is already approved by Swedish authorities, the permit process in Norway will be less time-consuming, as the safety assessment for the Norwegian sections of the trial site will be most important part of the process for Norwegian authorities.

4.2 The vehicle

In UC NO discussions in January 2024, it was emphasized that the vehicle needs to be constructed to be able to handle the speeds at which the demo will be performed, and that road owners that needs to approve the tests are the Swedish customs (for the staging area), police, STA, NPRA and the Norwegian customs.

Vehicle registration:

The AV to be used in UN NO was a new one. Einride decided to register the vehicle in Sweden, and hence the process of vehicle approval for trials would be performed by SE authorities.

All involved parties wanted to avoid parallel and redundant processing, and once Einride had decided to register and process the AV in Sweden, the NPRA saw no major challenges in building on SE assessments and approvals. For the eventual trial location, NPRA would check that the Norwegian part of the demo site satisfied all prerequisites identified in the trial permit provide by Swedish authorities.

4.3 Human in the loop and remote operator

The trial vehicle would be L4 with a human in the loop - a remote operator (RO) that provides supervision and targeted support, enabling the system to safely manage rare or ambiguous situations without placing a human inside every vehicle.

Additional clarity was required for the specific roles and responsibilities of the RO due to a lack of regulatory precedents, and having the RO located in a different country could had the potential to be an additional complicating aspect of the trial. This is reflected in perspectives on this topic presented in dialogues with respective national authorities:

Authority perspectives, SE:

Swedish authorities have previous experience with trials where the RO is located outside Sweden: A test involving a delivery robot in Stockholm with the RO in Estonia. This requires that the RO must have a valid European driver's license. The interviewee states that they do not know if this is comparable to requirements related to an RO for heavy vehicles.

Authority perspectives, NO:

For Norway, lawyers have problematized that the driver is not in the vehicle, but less so that the RO is not in Norway. A location in Europe is considered OK, with reference to Interpol and the possibility to enforce regulations. However, legal implications of cross-border RO will be further explored in an upcoming report [20] commissioned by NPRA, going more into depth on jurisdictional issues related to RO being a foreign person in a foreign country.

The vehicles must comply with national traffic regulations, and among other requirements the RO must not be able to exceed the speed limit.

- Regulations accommodate Remote Operation, but not Remote Driving
- Norway has allowed remote operation, but not in cases where it is critical for traffic safety or of nuisance for/hindering other road users

4.4 Safety aspects to be addressed

General safety issues to be addressed in AV trials have been specified by the national authorities (Chapter 3). Additional perspectives/concerns raised by the authorities in MODI included passive safety (the AV may be hit by other vehicles), and driving in mixed traffic (other vehicles may not comply with traffic regulations). Authorities do not express concerns about cyber security for trials with few vehicles, unless the applicant itself identifies this in their risk assessment. Swedish authorities recommend the applicant to use third party assessment of software from a functional safety-perspective if they rely on safety critical technical systems as a risk mitigator.

4.5 Road authority involvement in demonstration preparations and facilitation

<u>Permitting authorities' relations to the MODI project</u>

The Swedish Transport Agency has deliberately not been active in MODI, in order to keep the roles separate, and also did not take part in social activities related to the trial.

The DPR in Norway did have the same approach, keeping out of discussions and activities related to planning and facilitating the cross-border trial to be performed in UC NO.

The permit authorities have been clear about issues they could <u>not</u> be involved in, specifically how to handle ODD-related issues such as defining ODD or splitting route into "micro-ODDs" to identify requirements related to each section.

<u>Transport system/road owners</u>

The executive part of NPRA (transport system/road owner) took part in exploring possibilities and practical facilitation of the trial, including signage and potential safety measures identified (section 5.1).

The applicant is recommended to contact the road owner – in this case the Swedish Transport Administration – in order to identify concerns and issues related to the proposed trial site as early as possible. For the MODI UC NO Border crossing demonstration, indications are that the process would have benefitted from an earlier and direct dialogue with staff representing the road-owner role for the demo site. This could have prevented a late change of trial location (chapter 5.4 and 7.3.3).

4.6 Dialogue and exchange of information during the permit process

<u>Authorities' roles and participation</u>

Main parts of the end-to-end permit process were administered by TS.

According to DPR in NPRA, the Norwegian permit authorities participated in some joint meetings and conversations related to location of trial, but not on discussions and assessments related to vehicles and technology to be tested. DPR did receive detailed information and documentation when Einride submitted documents for the permit process.

<u>Dialogue with applicant</u>

As described in chapter 3, there is not much dialogue between the permit authorities and the applicant after the start-up meeting.

Confidentiality and access to documentation

Technical specifications and risk analysis provided by the applicant are confidential. A parallel permit process would require both authorities to have access to all relevant documents from Einride. A first suggestion for how to accommodate this was for Einride to provide a written permit to share documents between the national authorities. In the end, the chosen procedure was that Einride made double sets of all documentation for the permit process and provided the same documents to both national authorities.

AV trial permissions granted by the authorities are publicly available.

4.7 Startup meeting and application

The formal **startup meeting** for the permit process was held in Q4 2024. The purpose of the startup meeting is to ensure that the following permit process will be as efficient as possible.

The **permit applications** submitted to Swedish and Norwegian authorities were dated May 15, 2025, and April 25, 2025, respectively.

The following chapter presents core safety issues, activities and pivotal points during the months leading up to the submitting of the application for permit.

5 Making a safety case for the MODI UC NO demonstration

As pointed out in chapter 3.2, assessment of applications for trial permits are mainly based on description of the ODD/TOD and chosen location, as well as the risk analysis and planned ways to resolve deviations from ODD. Main concern is that AVs in a trial must follow traffic rules and not obstruct traffic. The applicant must provide convincing evidence that traffic conditions at the test site will be "just as safe as today" during the trial. Shortcomings on this may ultimately result in a denial of permit for a proposed trial activity at a given location.

The following sections describe core safety-related issues pivotal for permits to perform AV trials on public roads, and thus the realisation of the UC NO border-crossing demonstration. Again, this is based on available information in meeting notes and presentations and public official documents relating to the permit process. Specifics of technical descriptions and other issues considered confidential by Einride, are not included.

5.1 Border-crossing demo site at Svinesund – plans and preconditions

As indicated in the UC NO plans for border crossing demo (chapter 1.4), the demonstration would use E6 from Swedish side of the border to the Norwegian toll station (some 3.3 km in total).

More specific preconditions for the trial and expected contributions to demo preparations were indicated in a presentation provided by Einride on MODI UC Norway demo in January 2024:

Trial preconditions include:

- off-peak hours (preferably)
- no roadworks
- visible lane markings
- network service and GNSS to the threshold levels
- no overtakes or change of lanes performed by the AV on the motorway (prohibited on large part of the stretch)
- good visibility (no snow, fog or heavy rain)
- temperatures above 4 degrees
- not too windy

Expected contributions to/roles in demo preparations include:

from project partners:

- NPRA: supporting the demo providing the motorway on the Norwegian side, safety measures and permit for conducting the demonstration
- STA: supporting the demo providing the motorway on the Swedish side

from additional stakeholders:

- TS: approving permit for conducting the trial (vehicle registration and trial permit)
- The Swedish customs: supporting the demo providing the control road at the Swedish side

5.1.1 Traffic conditions and infrastructure, TOD

More detailed exploration of properties at the intended demo site commenced in November 2023 and continued into 2024:

- Speed limits at the stretch of E6 intended for the demo is 90 km/h.
- Traffic levels at the site are quite high also during off-peak hours, and with modest variations during the day/week. The lowest traffic levels occur at nighttime and very early morning hours.
- There is no road shoulder to perform a minimal risk manoeuvre (MRM) if needed.
- Good connectivity is a requirement.
- The trial will use C-ITS provided by Q-Free for the communication with the Digitoll[47].
- Weather statistics indicate that September is the latest month to guarantee temperatures above 4 degrees.

5.1.2 Extent of trial – number of drives

In January 2024 it was clear that the trial would extend to one single drive of the planned route.

5.1.3 Remote operation

The Remote Interface will be connected and located in Gothenburg, at Einride facilities.

5.2 Safety measures and tools available for border-crossing trial at Svinesund

Discussions about possible specific safety measures for a trial at Svinesund started in November 2023. The main strategy was to identify potential mitigations based on what would be needed to maintain a level of safety required to confidently undertake such a demonstration for the first time, and to tailor corresponding measures to the test and the documented capabilities of the vehicle.

Possible tools identified included:

- Reduce the speed limit on the road (entire or part of the road)
- Close one or both lanes for traffic for a period on E6
- Schedule the test for a less busy period
- Blue lights
- Escort vehicle
- TMA-truck (Truck-Mounted Attenuator)

Main risks for the trial were expected to be interaction with other road users, specifically due to the delta speed. The preferred option would be to close all lanes for the duration of the trial. Subchapters 5.2.1 to 5.2.5 describe the most relevant of these measures in more detail.

[47] https://www.toll.no/en/corporate/digitoll/this-is-digitoll (accessed January 21, 2026)

NPRA perspectives:

Measures would have to be implemented on both sides of the border. NPRA would need a detailed plan for safety measures, and sufficient time to conduct the relevant processes, especially for any road closures:

- For the most invasive measures (closing one or both lanes at E6 for traffic), NPRA would start looking into the possibilities, what permits need to be in place and who must be involved.
- NPRA would also initiate/continue dialogue with Swedish authorities about coordination of joint safety measures
- Regarding the use of TMA vehicle(s), the respective authorities would have to look closer at the regulations of using such a vehicle.

5.2.1 Speed limit

Plans were developed for implementing a reduced speed limit (down to 50 km/h) at the Svinesund demo site for a limited period of time, by using variable message signs (VMS).

5.2.2 Closing of lanes

Feasibility and implications of closing lanes as a safety measure for a limited period of time were explored. This was envisioned to be a one-off action, only to be required for the time of the demo.

The discussions included duration (number of minutes), time of day (early morning hours most relevant), number of lanes (one lane/one direction/both directions), potential combination with TMAs, as well as more general issues and implications related to closing the national/European border.

5.2.3 TMA-trucks

Einride suggested that TMA trailing vehicles could be used to address the delta speed between AV and general traffic, as well as other critical system malfunctions which might arise during the trial, and referred to such use of TMAs e.g. in the USA. In Q1 2025, utilisation and positioning of three TMAs were planned and described for a sequence of road sections included in the Svinesund demo site.

In Sweden, TMAs are primarily intended for roadwork activities, and not as a mobile barrier, as suggested for the trial. The legal basis for this use would have to be ensured.

There was also a need to check whether TMAs are allowed to enter a confined area for customs clearance.

5.2.4 MRM

In case the AV would experience any critical malfunctions, it would conduct an MRM (stop in lane).

5.2.5 Information to other road users

Information about demonstration/slow moving vehicles and safety measures to be applied, were to be communicated to the road users by means of VMS.

5.3 Vehicle speed

In the initial UC NO plans for border crossing demo (MODI D2.1 [1], September 2023), the expected AV speed was aligned with the posted speed limit. However, given the combination of parameters of the set operational design domain (ODD). safety considerations, and the level of complexity of the first-of-its-kind border crossing, in October 2024, the decision was to operate the trial at 15 km/h.

5.4 Feedback from Swedish authorities on plans for trial at Svinesund

By March 2025, Transporttyrelsen (TS), asked staff at Trafikverket (STA) representing the road owner role at the Svinesund trial area for their views on the operational plan for the UC NO Border crossing trial. They had until then not seen the full operational plan for the trial.

Conclusion from this consultation was communicated to Einride on March 11, 2025:

Based on their assessment of the full operational plan for the trial, TS recommended that Einride and the UC Norway team shift to an alternative demo site. They concluded that the defined ODD would result in unavoidable negative impacts to traffic and traffic safety.

This conclusion was based on a series of issues, many of which related to lack of legal basis in Swedish regulations for the proposed safety measures:

- **15 km/h is too slow for a highway.**
  Vehicles allowed on the highway must be constructed for and be capable of driving at 40km/h.
- **There is no legislation that allows using signs for reducing speed limit for this purpose**
  To use the dynamic speed signs you must have a T14 decision which cannot be issued for this type of use case.
- **There is no legislation that allows TMA to be used for this purpose**
  TMAs should be used for road works and protect road workers. The planned use is not allowed.
- **Traffic safety**
  Even if using TMAs, traffic safety cannot be confirmed. In the end of the tail, there will still be too big a delta between the regular traffic and the queue of vehicles.
- **Traffic flow**
  This demonstration is assessed by the authorities to have too big negative effect on the traffic flow.

For the Norwegian part of the trial, the safety measures considered would be allowed within the national regulations. NPRA had also made simulations of how the demo would affect traffic flow at the intended demo site, and considered it to be acceptable for the short period of time the demo would be conducted.

5.5 Plan B for location of UC NO Border crossing trial: Ørje

Once it was clear that Svinesund was not a viable trial location, a search for acceptable alternatives started. Within lunchtime the same day, exploration of Ørje as a plan B demo site was ongoing. Characteristics of this site indicated a more suitable environment for the trial than at Svinesund, while still providing the required digital toll handling at the Norwegian customs station:

- Short stretch of road on the Swedish side
- Speed limit of 30 km/h at the border crossing
- Less traffic
- Low likelihood of connectivity issues at the border, as everything could go on the Norwegian net

Ørje appeared to be able to fulfil most of the requirements and functionalities planned for the UC NO Border crossing demo. A more suitable infrastructure and lower traffic flows would make several of the safety measures considered for Svinesund (chapter 5.2), unnecessary or less intrusive, and thus ease the process of getting a permit for a one-off trial from Swedish authorities.

This was the basis for revision of demo plans and applications for trial permit.

5.6 Vehicle testing

The formal trial permit process in Sweden includes two official tests: FAT and SAT. Neither of these are required in Norway.

5.6.1 Factory assessment test

For MODI UCs and demonstrations involving Einride vehicles, a FAT for AV and remote station was performed at AstaZero in March 2025, and approved a week later for vehicle speed of up to 15 km/h.

5.6.2 Site assessment test

The base application for Einride's gen 2.1. vehicle was for Morgongåva, and the SAT was performed for Morgongåva as part of MODI UC SE. According to TS, the MODI-application was seen as an extension of this application: Same type of vehicle but new route (TOD, target operational domain). As this was a very limited trial (one time demonstration + set up), TS decided that no SAT was required for MODI UC NO. TS was however present at the official UC NO border crossing demonstration to observe and to provide feedback to Einride for upcoming deployments.

The Norwegian permit process does not require a SAT. DPR performed a risk assessment for the Norwegian part of the demo site, but also indicated that a one-off trial would require a less comprehensive risk assessment.

5.7 Permit applications

First batches of documents for the permit applications were submitted to Norwegian and Swedish authorities on April 25, 2025, and May 15, 2025, respectively. Einride created the same set of documents for both applications - the only thing that was different between the two countries was their respective templates. This was done for efficiency, but also due to the fact that the demonstration on the Norwegian side cannot be seen only from a Norwegian context and vice versa. One must understand both sides to be able to assess if the entire demonstration can be conducted in a safe manner.

The contents of the application for AV trial permits are not publicly available. However, both permit letters issues by the respective national authorities (Chapter 6) include information about trial location, timing, extent, setup, preconditions etc. The most detailed and comprehensive information about the trial is given in the permit letter issued by the Norwegian authorities.

6 Resulting setup and permits for MODI UC NO Border crossing demonstration

This chapter presents contents of the AV trial permits issued by the respective national authorities facilitating the performance of the MODI UC NO border crossing. Included in the permits are detailed descriptions of the setup of the demonstration performed at Ørje.

6.1 Permit from Swedish authorities

In a letter dated August 27, 2025, [21], TS issued a trial permit for the Swedish part of the UC NO border crossing demonstration, with description of conditions, presentation of the request and basis for the decision. Main points from the letter are summarised in the following.

Presentation of the request

On 15 May 2025, the company submitted an application in accordance with the Ordinance (2017:309) for experimental activities with automated vehicles.

- The experiment will take place on the E18 and aims to carry out border crossings between Sweden and Norway.
- Eurotax PayBack AB and the Swedish Transport Administration are the road operators.
- Drivers will be at the driving station located at the company's premises in Gothenburg or in the direct vicinity of the vehicle.
- The company has previously received a permit for experimental activities with the same type of vehicle in Morgongåva. The safety of the vehicle and its external systems have been reviewed and approved in case TSV 2025-705.

Basis for the decision

- The company has submitted site-specific documentation showing that the trial can be carried out safely on this new stretch of road as well.
- After reviewing the submitted documents in the case, the Swedish Transport Agency considers that the company has shown that the risks associated with the trial have been managed in a satisfactory manner.
- Eurotax PayBack AB and the Swedish Transport Administration, as road operators, have commented on the experiment and have nothing to remark.

Scope and conditions for the permit

The permit is geographically limited to travel between the Eurotax PayBack AB area on Hän 1 in Töcksfors and the E18 road to the Norwegian border.

The permit is valid from 22 September 2025 to 25 September 2025 and is subject to the following conditions:

- The vehicle that may be used in the trial is a truck with registration number OBH 03S with the company as owner.
- The vehicle must be equipped with an LGF[48] plate.
- The vehicle must not be driven at a speed higher than 15 kilometres per hour.

[48] LGF: LångsamtGåande Fordon (Slow moving vehicle)

- There must be staff on site in the vicinity of the vehicle who must fulfil the obligations described in the Road Traffic Ordinance (1998:1276) that cannot be fulfilled with drivers at a distance.
- The company shall assist authorities with information and assistance in interpreting collected data from the vehicle in connection with any investigations of accidents.
- In the event of an incident or accident, the company must report by e-mail to the@transportstyrelsen.se without delay.
- The company must receive visits from the Swedish Transport Agency and then assist by showing that the trial activities are run within the framework of the permit.

The permit can be revoked if the Swedish Transport Agency assesses that the vehicle cannot be transported in a safe manner in accordance with applicable traffic rules or if there are other reasons for doing so.

6.2 Permit from Norwegian authorities

In a letter dated September 4, 2025, [22], the Directorate of Public Roads (DPR) at NPRA issued a trial permit for the UC NO border crossing demonstration, with description of conditions and basis for the decision. Main points from the letter are summarised in the following.

Basis for the decision

According to § 4 of the Regulations relating to the testing of self-driving motor vehicles [5], a permit may be granted when road safety during the testing is at least as well safeguarded as it would have been without self-driving vehicles.

The NPRA assessment is based on:

- the permit on the Swedish side of the border granted by the Swedish Transport Agency
- access to the risk assessments and other technical documentation
- a risk assessment carried out for the section on the Norwegian side of the border.

NPRA placed decisive emphasis on:

- accounts of the risk associated with the trial
- measures implemented to reduce the risk associated with the limitations of the automated system used in the trial. Particularly important measures are
  - speed limitation
  - continuous monitoring by the remote operator or operator of the vehicle, who monitors the vehicle's movements at all times and can stop it immediately by remote control.
- observers deployed to monitor and warn of upcoming activities in traffic towards the test area

NPRA assessments:

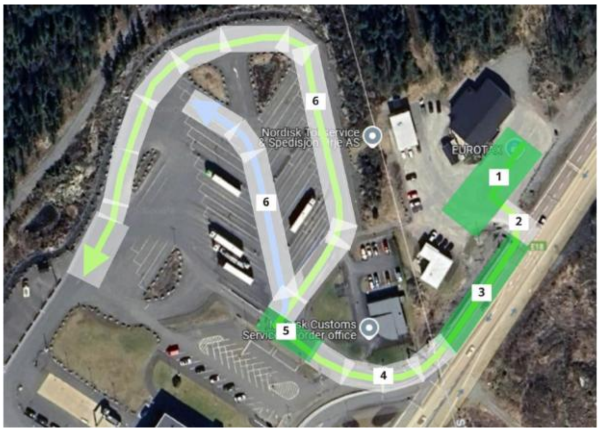
- risk of hard collisions is considered to be low, as speed is low for both the automated vehicle and other road users
- it is made probable that traffic safety will be sufficiently ensured in, provided that the trial takes place under the conditions and frameworks described.

Scope and conditions for the permit

- The permit is only valid within the framework described in the application
- The permit is valid from 22 to 25 September 2025
- The permit applies to one vehicle of the type Einride Gen 2.1 with Swedish registration number OBH 03S
- The permit is only valid within the relevant area that is risk assessed in the application's appendix: ERA-D61-005: Deployment TOD Örje
- The vehicle is continuously monitored by a remote operator (on-site or from the operations centre), who is responsible for assessing the traffic around the vehicle and the vehicle's movements
- Operation of the vehicle shall only take place in conditions with sufficient visibility
- Safety operators receive special training from the manufacturer Einride AB
- Passengers must not be carried in or on the vehicle
- The speed shall not exceed 15 km/h, based on the manufacturer's risk assessments

More detailed description of scope and requirements for the trial

The chosen route (Figure 2) starts at the parking lot at Eurotax (1) on the Swedish side, continues on the E18 (3) until the border crossing and exit (4) into the Norwegian customs territory (5,6). After the customs clearance, the truck turns left on the E18 and returns back across the border to Sweden and the parking lot at Eurotax (Figure 3). The maximum speed limit on the road section is 30 km/h.



Source: NPRA permit letter [22]

Figure 2: Trial route

Source: NPRA permit letter [22]

Figure 3: Return route

System training: Multiple rounds will be run to adapt the automated system on the line, starting with low speeds which will gradually be increased. This training of the system will take place at times of the day with little traffic to disturb other traffic as little as possible. The training of the automated system is estimated to take 2-3 days, while the demonstration itself will take place on September 25.

Operator requirements: The vehicle's automated system can evade and stop for obstacles in the pre-programmed path at speeds of up to 15 km/h. The automated system cannot handle traffic lights, intersections or road signs. The system must therefore be supported by a remote operator who observes the traffic through cameras mounted on the vehicle, and instructs the system to move the vehicle when there is free sight. Driving tasks which cannot be handled by a remote operator must be supported by operators in the vicinity of the vehicle. The vehicle can also be remotely controlled at walking speed by remote operator and local operator. NPRA emphasize that the vehicle can only be operated by people who have undergone the manufacturer's operator training and can document this.

Vehicle approval: The vehicle is an Einride Gen 2.1 truck with no cab and no space for the driver. This prototype version has been registered by the Swedish authorities (TS) who have granted a number of exemptions from the current requirements for such vehicles, including the system-level requirements for electromagnetic compatibility. The vehicle can only be used with special permission.

Reporting: Einride Autonomous Technologies AB shall ensure that a continuous log is kept as described in Section 12, second paragraph, of the Regulations relating to the testing of self-driving motor vehicles [5]. If the safety measures do not work as intended or other conditions arise with regard to safety and accessibility, the applicant must notify the local authorities and the Directorate of Public Roads immediately. This also applies if the trial reduces passability for other road users.

Data security and protection of personal data: Einride Autonomous Technologies AB assures that they will process all data and personal data in line with the Personal Data Act and GDPR.

Supervision and reactions: The NPRA is supervising the trial. The Directorate of Public Roads may revoke or temporarily suspend the testing of self-driving motor vehicles if the rules or conditions of the permit are not complied with.

7 Takeaways from the border-crossing permit process

In November/December 2025, a couple of months after the demonstration had been successfully performed, Einride, DPR and TS provided their reflections on the permit process and learning points from this in separate interviews. Main points from this are presented in chapters 7.1 and 7.2. The final section 7.3 sums up some main takeaways from this activity.

7.1 Applicant perspectives and reflections

In an interview in November 2025, a couple of months after the demonstration had been successfully performed, Einride provided some reflections on the process and interaction between the main actors, especially regarding the rejection of the intended demo site:

> *«The authorities did not want to turn an application down; they, as well as the UC Norway team, wanted the demo to happen. It was however important to find a site that was a better match between the vehicle ODD and TOD so that safety and traffic efficiency could be upheld.»*

Further reflections on the process:

- It is important to have a close and early dialogue with all necessary parties, including the road owner.
- The UC Norway team held on to the demonstration site that was defined in the permit application for too long. The MODI project risk analysis clearly states that if a site is deemed to be too complex, the mitigating measure is to find a new, less complex site. This should have been discussed earlier for the Norwegian border crossing demonstration.

Reflections on use of mitigating measures:

- Use of TMAs to increase safety could be interesting during a deployment phase, for a day or so, but will not be suggested for longer trials of autonomous vehicles.
- Use of variable speed could be interesting, e.g. for lowering the speed on a stretch when an autonomous vehicle is there and increasing it again when the vehicle has passed.

7.2 Authorities' perspectives on differences in national regulations and processes

Both Swedish and Norwegian authorities state that differences in regulations are known, and that they don't think these differences have affected the MODI process in a significant way. For both countries, trial regulations require that vehicle capability (most prominently regarding speed) must be suitable for the test site, and that it does not obstruct other traffic.

However, one can argue that some differences in regulations may have a consequence for a general cross-border trial permit.

7.2.1 Role of local authorities

Local authorities have a more decisive role in Sweden, where they can stop a permit, than in Norway, where local authorities have a right to be heard, but can possibly be "overrun" by the NPRA. However, the Norwegian trial permit process requires the applicant to consult the local Police forces. This is not a formal step in the Swedish application.

In this case the TS and STA were of the same opinion that Svinesund was not suitable for this trial. However, TS state that even if STA would have been positive, TS probably would still have required the change of location.

According to the DPR, it is still an open question whether a permission could have been granted for the Norwegian part of a cross-border demo at Svinesund.

7.2.2 Regulation of traffic safety measures

Relevant measures/instruments to increase traffic safety during trial, such as "buffer vehicles" and variable signs, could not be used:

- The use of Buffer vehicles (TMA) in addition to warning vehicles is regulated differently: This is allowed in Norway, but not in Sweden.
- Use of variable signs to lower speed during trial: Not regulated for this use in Sweden – allowed in Norway.

Differences in regulation of relevant measures to increase safety during a trial does not seem to have been decisive in the issues related to demo location in UC NO. In a case with a smaller delta speed at the trial site, this could however potentially be important. In a situation where these measures could provide the required safety for the demo situation, regulatory differences would make these measures unavailable on Swedish side of the border.

7.2.3 Regulations on Remote Operations

Swedish authorities see a need for regulations on AVs in general, including trial regulations, to be updated. They also state that large-scale experiments (geography and number of vehicles) and the development of more permanent services require change, e.g. with regard to today's requirements for drivers in vehicles.

From the Norwegian side, there are questions related to the role of the operator. The RO must be able to assess and handle what happens around the vehicle, and can if needed remotely control at walking speed, but should not be driving the vehicle. Legal implications of cross-border RO will be further explored in an upcoming report [20] commissioned by NPRA, going more into depth on jurisdictional issues related to RO being a foreign person in a foreign country

The manufacturer must describe RO functions – the more the activities the RO will need to perform, the more challenging the safety case will be.

7.2.4 Harmonisation of legislation

It is seen as important to find a common ground for harmonization across countries. This will make it easier for authorities and the industry alike.

Many activities address harmonisation of the technology, but less so for traffic regulations, although there appears to be some processes at UN level. Until this is more developed, OEMs need to take into account different national regulations.

Harmonisation activities for trials are going on at European level [10], but not for permanent schemes. Legislation for permanent schemes would include a broader range of topics, e.g. responsibilities, roles etc.

Differences in process layout and test requirements between Sweden and Norway may be seen as a consequence of the presence of an automotive industry and thus need for type approval processes in Sweden. This may also be the case for other countries.

7.2.5 Vehicle registration and permit in Norway?

EIN could have chosen to register and to process the AV in either of the two countries. According to NPRA, registration in Norway instead of in Sweden could have resulted in more paperwork. On the other hand, in Norway, the permit process is free of charge, while in Sweden, there is an hourly fee of SEK 1 700 for all processing following the initial meeting.

According to Einride, Sweden was chosen as they have previous experience with registering autonomous vehicles in Sweden.

All involved parties wanted to avoid parallel and redundant processing, and once EIN had decided to register and process the AV in Sweden, the NPRA saw no major challenges in building on SE assessments and approvals.

According to TS, a "mirrored" process, with vehicle registration and permit approval process performed in Norway, would have been possible, and most likely with TS performing a SAT themselves for the Swedish part of the demo site.

Einride comment to this is that for a longer trial with collaboration between two countries, it makes sense that both authorities provide a joint SAT on the entire route.

7.3 Main observations and conclusions

7.3.1 Permit process and requirements

The general impression is that the permit processes in Norway and Sweden are based on very similar focus, mindsets and requirements for documentation to accompany applications for AV trial permits.

Although the Swedish permit process is described as what appears to be a more formalised stepwise structured process than the Norwegian counterpart, the role and relevance of (some of) the steps are assessed to the individual case, and the process adapted accordingly.

The most prominent difference are the test requirements in Sweden (FAT and SATs and requirement for a third party assessment). This may be seen as a consequence of the presence of an automotive industry and thus need for type approval processes in Sweden.

The information requested in the application forms provided by the respective national authorities [17] and [19] are largely the same.

7.3.2 Legal basis for use of safety measures

What was made evident in the assessment of the initially intended trial location at Svinesund, is that the legal basis for safety measures such as TMAs or VMS to temporarily reduce speed limits at trial site, is not the same in the two countries. This illustrates challenges related to lack of harmonisation of regulations between countries.

For future cross-border trials, this prompts the need to explore these issues as early as possible in the permit process.

7.3.3 Early communication is of the essence

As indicated by reflections from Einride (Chapter 7.1), the permit process would have benefitted from an earlier start of direct dialogue with staff representing road owner on the Swedish side of the border. This could possibly have prevented a late and stressful change of trial location. Early and explicit mapping of who will have a role, how they will be kept informed, and by whom, can be one way of ensuring a better control of information flows.

References

[15] Sæther, S.R. (2023) MODI D2.1 Report on UC details.

[16] Förordning (2017:309) om försöksverksamhet med automatiserade fordon. https://lagen.nu/2017:309 (accessed October 6, 2025)

[17] TSFS 2021:4 Transportstyrelsens föreskrifter och allmänna råd om tillstånd att bedriva försök med automatiserade fordon; https://www.transportstyrelsen.se/TSFS/TSFS%202021_4k.pdf (accessed October 6, 2025)

[18] LOV-2017-12-15-112 Lov om utprøving av selvkjørende kjøretøy. https://lovdata.no/dokument/NL/lov/2017-12-15-112 (accessed October 2, 2025)

[19] FOR-2017-12-19-2240 Forskrift for utprøving av selvkjørende motorvogn. https://lovdata.no/dokument/SF/forskrift/2017-12-19-2240?q=forskrift%20utpr%C3%B8ving%20av%20selvkj%C3%B8r (accessed October 2, 2025)

[20] Commission Implementing Regulation (EU) 2022/1426, Official Journal of the European Union, 2022 regarding procedures and technical specification for the type-approval of the automated driving system (ADS) of fully automated vehicles. https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32022R1426 (accessed November 24, 2025)

[21] Rusciano, E., Dona, R., Maggi, D., Ciuffo, B., Galassi, M.C. (2025) "Interpretation of EU Regulation 2022/1426 on the Type Approval of Automated Driving Systems. Addendum for Safety Management System and Remote Management" Publications Office of the European Union, doi:10.2760/1764206, JRC140978.

[22] Ciuffo, B., Dona, R., Galassi, M. C., Giannotti, W., Sollima, C., Terzuoli, F., & Vass, S. (2024) "Interpretation of EU Regulation 2022/1426 on the Type Approval of Automated Driving Systems." Publications Office of the European Union, doi:10.2760/86028, JRC136417.

[23] EU (2019) Guidelines on the exemption procedure for the EU Approval of Automated Vehicles. https://ec.europa.eu/docsroom/documents/34802 (accessed October 6, 2025)

[24] Commission Expert Group MVWG, ACV (2025) Guideline on a uniform EU-wide procedure for the subjects of pre-type approval assisted (ADAS) and automated vehicle (ADS) testing and recognition of testing approvals among member states. Final draft. https://circabc.europa.eu/ui/group/4273d650-b8a9-4093-ac03-18854fbba4b5/library/632b00fa-2d34-4977-844f-fa3c42ed59ae/details (accessed December 2, 2025)

[25] UN Regulation No157 - Automated Lane Keeping Systems (ALKS) https://unece.org/transport/documents/2021/03/standards/un-regulation-no-157-automated-lane-keeping-systems-alks (accessed October 2, 2025)

[26] UNECE (2022) Framework document on automated/autonomous vehicles. Inland Transport Committee, World Forum for Harmonization of Vehicles Regulations. https://unece.org/transport/publications/framework-document-automatedautonomous-vehicles-updated (accessed October 9, 2025)

[27] UNECE GRVA (2025) Uniform provisions concerning the approval of vehicles with regard to Automated Driving Systems, Outcome of Tenth Workshop on ADS, 30th September 2025. https://unece.org/sites/default/files/2025-10/GRVA-WS10-04r1e.pdf (accessed October 31, 2025)

[28] ISO 34503:2023 Road Vehicles – Test scenarios for automated driving systems – Specifications for operational design domain. https://www.iso.org/standard/78952.html (accessed October 31, 2025)

[29] Supplementary information for trial operation permits with automated vehicles. Guidance for TSFS 2021:4. Swedish Transport Agency, Ref. TSG 2023-6693 https://www.transportstyrelsen.se/globalassets/global/vag/fordon/automatiserade-

fordon/supplementary-information-for-trial-operation-permits-with-automated-vehicles-1.0t.pdf (accessed October 6, 2025)
[30] Compliance with the Swedish Traffic Ordinance (1998:1276) Supporting document - trial operation with self-driving vehicles, dated 24 February 2020. https://www.transportstyrelsen.se/globalassets/global/vag/fordon/automatiserade-fordon/compliance-with-the-traffic-regulation.docx. (accessed October 6, 2025)
[31] Application for a permit for automated vehicles, Swedish Transport Agency. https://www.transportstyrelsen.se/en/road/forms-for-road/vehicle/application-for-a-permit-for-automated-vehicles/ (accessed October 6, 2025)
[32] SVV (nn) Veiledning til søker om utprøving av selvkjørende motorvogn (PDF). (Guidance for applicants for testing self-driving motor vehicles) – in Norwegian. https://www.vegvesen.no/globalassets/fag/trafikk/its-portalen/veiledning-til-soker-om-utproving-av-selvkjorende-motorvogn.pdf?v=49d56c (accessed October 2, 2025)
[33] SVV (nn) Søknad om utprøving av selvkjørende motorvogn (Word, bokmål) (Application for testing of self-driving motor vehicles) – in Norwegian. https://www.vegvesen.no/globalassets/fag/trafikk/its-portalen/soknadsskjema-utproving-av-selvkjorende-motorvogn-bokmal.docx?v=49d647 (accessed October 2, 2025)
[34] Haavind (2026) Criminal responsibility for remote operators in self-driving vehicles. Memo dated January 2026.
[35] Transportstyrelsen (2025) Tilstånd enligt förordnignen om försöksverksamhet med automatiserade fordong (2017:309). Letter dated August 27, 2025
[36] SVV (2025) Tillatelse til utprøving av selvkjørende lastebil – grensepassering E18, Ørje. Letter dated September 4, 2025.

Terms and abbreviations

Term / Abbreviation	Description
AD	Autonomous Drive
ADS	Automated Driving System
AV	Automated vehicle
AZ	AstaZero AB
CCAM	Connected, Cooperative and Automated Mobility
DPR	Directorate of Public Roads at NPRA
EIN	Einride AB
ERA	Einride Autonomous Solution AB
GNSS	Global Navigation Satellite Systems
HARA	Hazard and Risk Analysis
ISO	International Organization for Standardization
ITS	Intelligent Transport System
LGF	Långsamt Gående Fordon (Slow moving vehicle)
L2	SAE Levels of Driving Automation according to SAE J3016, and Level 2 is Partial Driving Automation
L4 CCAM	Level 4 CCAM
L4	SAE Levels of Driving Automation according to SAE J3016, and Level 4 is driving automation within a defined ODD.
MRM	Minimal risk manoeuvre
NPRA	Norwegian Public Roads Administration
ODD	Operational Design Domain
OEM	Original Equipment Manufacturer
RA	Remote Assistant
RO	Remote Operation
SAE	Formally SAE International (formerly named the Society of Automotive Engineers) is a professional association and standards developing organization.
STA	Swedish Transport Administration (Trafikverket)
TS	Swedish Transport Agency (Transportstyrelsen)
TOD	Target Operational Domain
UC	Use Case
UC NO	Use Case Norway
UC SE	Use Case Sweden
UNECE	United Nations Economic Commission for Europe
VMS	Variable message sign
WP	Work Package within the MODI project