MIND THE GAP! MOVING CONNECTED AUTOMATED TRANSPORT IN THE NETHERLANDS FORWARD FOR IMPROVING SAFETY, EFFICIENCY, AND SUSTAINABILITY IN ROAD TRANSPORT

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Summary

Connected Automated Transport (CAT) for heavy road transport is expected to have substantial benefits on business, environmental and societal level. Based on observations and experiences in the CATALYST Living Lab, this discussion paper presents the gaps between various stakeholder groups that constitute barriers for further development of CAT in the Netherlands. The paper concludes with a roadmap of how to close these gaps to move CAT forward to ensure its contribution to safe, efficient, and sustainable road transport.

First, logistics companies face uncertainties with respect to the efforts and requirements for integrating CAT into logistics practice. As such, they are not able (yet) to formulate clear requirements towards the OEMs in the automotive sector and hence both stakeholder groups are looking towards each other and only take next steps to a limited extent. Second, road infrastructure managers are not certain about their role, resulting in 'wait and see' behaviour. Their role heavily depends on the vehicle functionalities that OEMs develop and whether intelligence is located in autonomous vehicles or infrastructure (or both). Third, a gap is observed between government policy and legislation and expectations from both logistics parties and the automotive sector. Procedures, risks, and responsibilities for conducting experiments and admission for deployment of autonomous vehicles are unclear, which hampers the realization of real-world experiments in the Netherlands.

Given these gaps, this discussion paper describes the next steps to move CAT forward. First, more insight is needed regarding the requirements for integrating Connected Automated Transport in logistics practice. Second real-world experiments at yards should provide practical insights of the boundary conditions for and value of CAT innovations. Lastly, real-world testing of CAT expanding from yards to more complex environments – such as industrial (port) areas, regional (hub-hub) transport and long-haul transport and the connection other modes of transport – is needed to step-by-step work towards an integrated and seamless logistics system.

1. Introduction

1.1 Dutch Road freight transport faces several challenges

Transport volumes are expected to grow, while at the same time the Paris Climate Agreement and the Dutch Climate Agreement urge the transport and logistics sector to cut (CO_2) emissions to zero by 2050. As agreed, in the Dutch climate agreement hinterland transport (road, rail, waterway) needs to reduce 1.4 Mton CO_2 by 2030. Heavy duty road transport constitutes ~3% of all CO_2 emissions in the Netherlands and ~22% of all traffic emissions (PBL, CBS, TNO, RIVM, RVO, 2020). With growing transport volumes, challenges regarding traffic safety and accessibility become even more pressing. In the Netherlands, 1100 trucks were involved in accidents in 2020, and nearly 6,000 were stranded (Stimva, 2020). The EU vision zero program wants to improve traffic safety throughout Europe by aiming for zero fatalities and serious injuries by 2050 (European Commission, 2018). Regarding accessibility congestion is a major burden for logistics companies. It is estimated that Traffic jams cost ~ EUR 1,5 billion per year according to transport companies (TLN, 2020) and truck drivers frequently encounter waiting times at major logistics nodes such as the ort of Rotterdam and Schiphol airport (Verheggen, 2020), resulting in inefficient and unreliable transport. Lastly, the transport and logistics sector faces major labour shortages, that are expected to worsen with an aging workforce and new cabotage regulations (EU Mobility package).

1.2 Automated driving technologies hold potential of improving road transport

There is not one silver bullet measure that can overcome all these challenges in road transport. There is a need for a combination of technical, organisational, and social innovations to improve road freight transport such as alterative fuels and power trains, application of new vehicle technologies and logistics optimization and organizational and behavioural change (Van Zyl et al., 2017). In this paper we focus on the contribution of new technologies, and specifically on *Connected Automated Transport* (CAT) innovations as there is an increased interest in how emerging technologies can mitigate road transport challenges (Dong et al., 2021).

Connected Automated Transport (CAT) is an umbrella term for transport with increasing levels of automation facilitated by communication among vehicles (vehicle-to-vehicle or V2V) and infrastructure (vehicle-to-infrastructure or V2I) (Van Kempen, Gerritse, & Van Meijeren, 2022). SAE International (2021) developed international standards to distinguish vehicle automation levels; from level 0 (no automation) to level 5 (fully autonomous). CAT applications can be envisioned for both public roads and confined areas – such as port areas and distribution centers. In the short term, CAT innovations with high levels of automation are more likely to be implemented in contexts with lower complexity.

Therefore, it is expected that autonomous freight vehicles are more likely to be deployed in yards rather than for hub-hub transport in the near future (ERTRAC, 2019).
CAT innovations are interesting both from a (logistics) business and a societal perspective as these hold the potential of improving amongst others logistics efficiency and sustainability (by more efficient use of vehicles and control of the logistics chain), safety and traffic flow (by reducing human error), and improved business continuity and economic growth (by reducing the dependency on drivers in tight labour markets) (Dong et al., 2021; Graf & Anner, 2021; Sivanandham & Gajanand, 2020).

1.3 International testing and Dutch experiments are taking off

Internationally, several countries already experiment with Connected Automated Transport, amongst others Scania tests a SAE Level 4 vehicle on a highway trajectory of approximately 290 kilometres (Scania, 2021) and TuSimple executes 20 weekly highway trips with a SAE Level 4 vehicle for UPS in the USA (TuSimple, 2020). Also, CAT innovations directed at yards and (semi-)confined areas are tested, amongst others Volvo successfully piloted its Volvo Vera on a trajectory from a DFDS distribution center to an APM terminal in the port of Götenborg (Leonard, 2019). And Einride delivered the first Einride T-Pod models to clients in 2021 (Randall, 2020).

Also in the Netherlands, CAT pilots on confined areas are being conducted; for example Living Lab Autonomous Transport Zeeland successfully tested its Terberg-Easymile proof of concept at the Lineage Logistics terminal in Flushing in 2022 (Zeeland Connekt, 2022) and Aviko is deploying an automated vehicle to transport frozen products from its production plant to its warehouse (Nederland Elektrisch, 2021). Next to that, European funded projects MAGPIE and MODI will demonstrate automated SAE L4 driving at a terminal in the Port of Rotterdam area in the near future. These experiments have a rather limited scope from a logistics point of view since there is a strong focus on technology validation and improvement. Despite these initiatives in the Netherlands, developments are not progressing as could be expected in relation to the envisioned benefits of Connected and Automated Transport. This paper aims to present underlying 'chicken-egg' issues for the realization of CAT and proposes a concise roadmap of how to move forward. Therefore, this paper has the following aim:

- Analysing the gaps between several stakeholders in realizing Connected Automated Transport that were observed in the CATALYST Living Lab.
- Presenting the next steps that the CATALYST Living Lab identified to move CAT forward in the Netherlands to contribute to efficient, safe, and sustainable road transport.

We use experiences and observations in the CATALYST Living Lab for conducting the analysis. The Living Lab approach is elaborated on in section 2. Subsequently, section 3 further elaborates on the observed issues that hamper development of Connected Automated Transport in the Netherlands. Then, in section 4, we propose a concise roadmap with next staps and we to conclude in section 5 with a discussion.

2. Living Lab approach in CATALYST

A Living Lab is a test environment and ecosystem for cyclical development and evaluation of complex innovative concepts and technology in a real-world environment, where different stakeholders work together towards a common goal (Quak et al., 2016). Aligned with this definition, the CATALYST Living Lab was formed in 2019 to develop and accelerate Connected Automated Transport innovations for more sustainable, safe, and efficient heavy duty road transport. CATALYST is a public-private partnership of more than 40 parties from industry, governments, and knowledge institutes, investigating CAT innovations that create both social and business value. Improved connectivity and automation enable innovations such as Advanced Driver Assistance Systems (ADAS), truck platooning, in-truck information (such as iVRIs or signalized intersections) and autonomous vehicles for both confined areas and public roads. Using the so-called 'Orchestrating Innovation' approach, project leader TNO gives shape to the Living Lab (TNO, 2021). By working cyclically, the Living Lab is adaptive and, based on evolving insight, the sequencing and form of activities can be adjusted to ensure the likelihood of successful implementation of CAT innovations for sustainability, safety, and efficiency.

In 2022, the applied research part of the Living Lab was completed, and this resulted in several insights regarding emission reduction potential of CAT innovations. Amongst others CATALYST provided insight regarding Signalized Intersections (Deschle, van Ark, van Gijlswijk, & Janssen, 2022), Adaptive Cruise Control (ACC) driving (van Kempen et al., 2021) and autonomous and electric yard tractors (van Kempen et al., 2022). Next to that, various other analyses have been conducted, amongst others regarding the impact of Connected Automated Transport on skills of future truck drivers (van Kempen et al., 2020), required infrastructure for CAT (Madadi & Verduijn, 2022) and admission and approval of new vehicle concepts (Van Meijeren & Van Kempen, 2022). For the full overview of results we refer to the Lessons Learned (Van Kempen, Gerritse, & Van Meijeren, 2022). From 2022 untill 2024 onwards, the fundamental research part of the Living Lab continues through 3 PhD projects of which first results are already presented (Brunetti, Mes, & van Heuveln, 2020; Gosar et al., 2022; Mohammadi, Zuidwijk, & Schmidt, July 2021). The analyses that we present in the next sections, result from observations and discussions in consortium meetings and work sessions, interviews and conversations with project partners that took place in the period 2019-2022.

3. Mind the gap! Barriers for further development of CAT in the Netherlands

Resulting from observations and discussions in consortium meetings and work sessions, interviews and conversations with the CATALYST stakeholders, we identified the following barriers as presented in Figure 1. As is visualized, all barriers are interrelated and some result in different groups of stakeholders waiting for one another to take the next step. In the subsequent paragraphs we highlight 3 important gaps between several groups of stakeholders in the ecosystem (see numberd items in Figure 1).

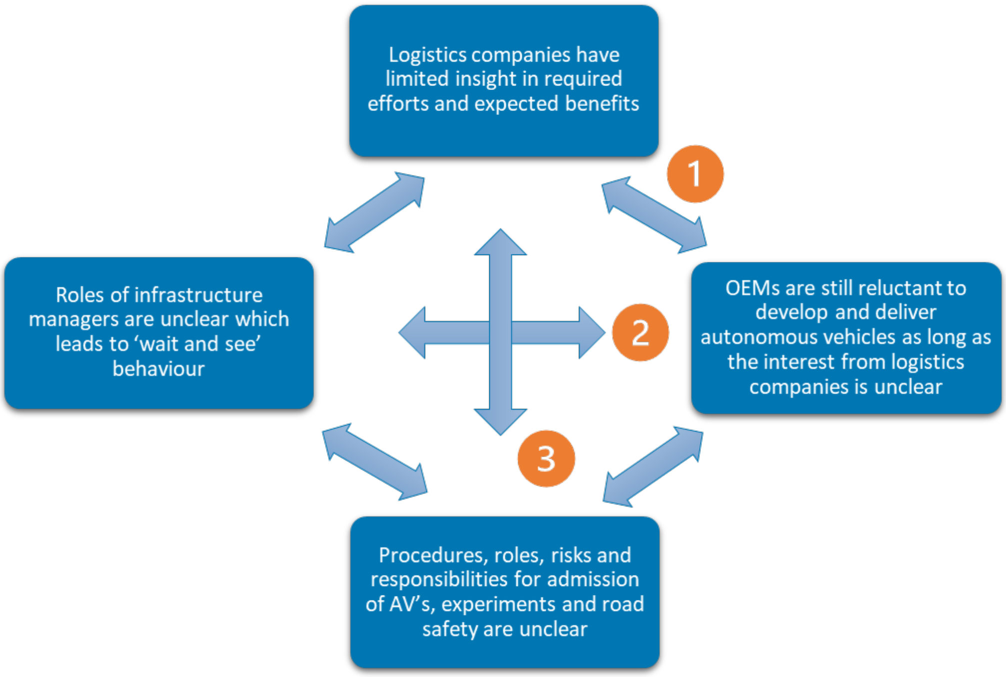

Figure 1 Overview of barriers for the further development of CAT in the Netherlands (adapted from: Van Kempen, Gerritse, & Van Meijeren, 2022)

3.1 Gap 1. Logistics companies and automotive sector

First, a gap can be observed between logistics companies and the automotive sector or OEMS. Among the involved stakeholders in the CATALYST living lab, there is a strong need to take the next step towards implementation of CAT by preparing and executing more real-world experiments. Logistics companies, however, cannot yet foresee the impact of autonomous systems on their logistics operation as they have a lack of certainty about amongst others the integration of the vehicle in current ICT systems, infrastructure, and safety requirements. The implementation of CAT at a specific location can have an impact on quite a lot of aspects: related to the yard (a.o. physical and digital infrastructure, work processes), the vehicle (a.o. functionality, safety), control of the vehicle (e.g., network, data and IT, control tower, remote control), and people (a.o. skills, acceptance, human-machine interaction). A good understanding of what implementation of CAT means related to all these (interdependent) aspects can be complex. Especially since there are possibly multiple options for these aspects and there are still uncertainties related to time and budget needed for realization. In many cases, logistics parties cannot realize a solution independently and companies will have to jointly explore and learn how they can best set up an operation with autonomous vehicles. Because of the above uncertainties, logistics companies – even the ones that are really interested in preparing and executing real-world experiments – perceive a barrier to formulate the right questions and requirements towards automotive suppliers of Connected Automated Transport solutions.

On the other hand, OEMs are – to some extent – only prepared to participate in implementation-oriented projects on a commercial basis in which logistics parties have already made the investment choice for the deployment of autonomous vehicles. But the lack of insight into the impacts on the design and execution of logistics operations, hinders logistics companies from making this investment decision. This in turn blocks the further development towards implementation of CAT as well. This means that the required insights about efforts, requirements and benefits of CAT implementation are not only needed by logistics companies, but by OEMs as well to get a good understanding about the interest of logistics companies to operate autonomous vehicles. This has been stressed by several OEMs because there is no market to sell autonomous trucks if logistics companies are not interested because they have no full understanding of the implications.

3.2 Gap 2. Automotive sector and road infrastructure managers

Secondly, road infrastructure managers (both national and regional) in the CATALYST living lab indicate that their roles and responsibilities regarding preparing road infrastructure for Connected Automated Transport is unclear (Madadi & Verduijn, 2022). There are no standards yet for digital or data infrastructures facilitating autonomous or connected transport. Road infrastructure managers can now choose themselves whether they provide digital infrastructure, and if so in what form. There is a trade-off between the level of intelligence in the vehicle versus the level of intelligence of the infrastructure. Once OEMs develop autonomous vehicles as such that these have a high-level intelligence, possibly less investments and adjustments need to be made by road infrastructure managers on the road infrastructure – and vice versa. Madadi and Verduijn (2022) highlight three schools of thought that sketch various options for road infrastructure managers. The first approach suggests that OEMs are fully responsible for guaranteeing that their vehicles can cope with the environment and consequently road infrastructure managers do not have any liability for adapting their infrastructure (for example making lane markings clearer or resolving contradicting priority signs). Second, road infrastructure managers could take a more reactive stance by facilitating automated vehicles to a certain extent – but only after there is certainty about technological developments and then committing to new investments (or not). Third, road infrastructure managers can take on a proactive role by facilitating testing and pilot projects and collaboratively define standards with technology providers. What makes the trade-off between OEMs and road infrastructure managers of where to put intelligence (infrastructure, vehicle or both) even more complicated is that road infrastructure managers often have to make investments for a long time horizon, while there are to date still many uncertainties regarding the future development path of Connected Automated Transport innovations and automated vehicles (Madadi & Verduijn, 2022). Currently in the Netherlands, CATALYST observed that road infrastructure managers are showing 'wait and see' behaviour, because of these uncertainties.

3.3 Gap 3. Automotive, logistics companies and national government

The last gap that we want to highlight in this discussion paper is the gap between automotive and logistics companies on the one hand and legislation and policy by the national government on the other hand. Since 2019, the Netherlands has regulation in place via the *Experimenteerwet zelfrijdende voertuigen* which allows testing of self-driving vehicles without a driver in the vehicle if monitoring of the vehicle takes place remotely, for example in a control room. Under strict conditions, testing with self-driving vehicles on public roads is allowed (RDW, 2023). However, to date no approval has been granted for experiments under this law. In 2019 an analysis was conducted to assess the robustness of the Dutch system of exemption and several tensions were identified (Groenendijk, Kalfsbeek, Arends, & Wolters, 2019). These turn out to be still of relevance based on experiences regarding approval of the Super Ecocombi (SEC) and the TNO-DAF EcoTwins (vehicles that can drive as a truck platoon) (Van Kempen & Van Meijeren, 2021):

- Safe versus inviting testing environment - Because the Netherlands consciously chooses to put safety first, the testing framework compared to other countries is relatively strict and extensive.
- Delivering customisation versus predictability of processes – Initiators of experiments prefer predictability and transparency, but applications for field trials are instead handled on a case-by-case basis. Because of this customisation the exact details and lead time (and associated costs) of the process of exemption is not clear in advance.

Next to the above (which concerns testing and experimenting), for deployment of autonomous vehicles, procedures, risks, and responsibilities are unclear, which hampers the realization of real-world experiments in the Netherlands. In 2022 the European Commission adopted the Automated Driving System (ADS) implementing act which provides guidelines for the type approval of automated driving systems to ensure safe and reliable implementation (Burges, 2022). This may speed up discussions in the Netherlands to come to real-world experiments and if successful, deployment. However, currently a lack of certainty regarding legislation seems to inhibit the development and preparation of these experiments. For the further development of Connected Automated Transport in the Netherlands, it is very important that experiments can be carried out in the short term. Otherwise, there is a chance that OEMs will divert to other countries for practical experiments on public roads with their (SAE Level 4) vehicles (Van Kempen & Van Meijeren, 2021).

4. Roadmap for moving Connected Automated Transport in the Netherlands forward

CATALYST developed a roadmap for moving beyond the gaps presented in the previous section to make het next steps for Connected Automated Transport in the Netherlands (Van Kempen, Gerritse, & Van Meijeren, 2022). This roadmap resulted from extensive stakeholder discussions and the *Actieagenda CAT Zeeland* as developed in the CATALYST Living Lab.

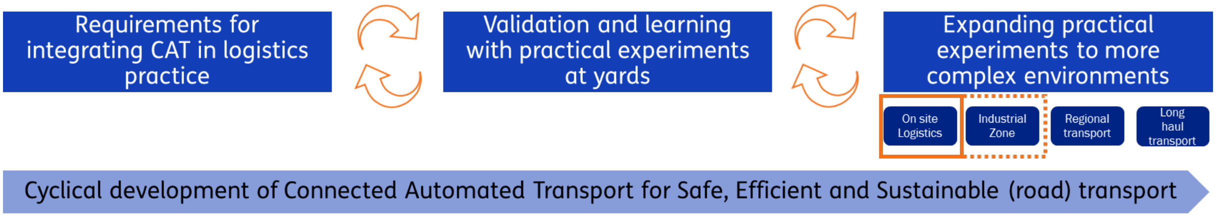

Figure 2 Roadmap for moving Connected Automated Transport in the Netherlands forward (adapted from: Van Kempen et al., 2022).

First, to bridge the gap between logistics and automotive and the gap between automotive and road infrastructure managers, there is a need for assessing the requirements for integrating Connected Automated Transport in logistics practice. The CATALYST roadmap suggests designing a method and tool in a structured way, as such that it can be applied to multiple use cases in various contexts. Practical experiments are required for quantifying costs and benefits of CAT to align models with reality. At the same time companies want to have insight in this before participating in an experiment. Therefore, this approach should allow for an ex-ante estimation which can be validated in the next step. Ultimately, logistics parties can make informed decisions about whether/where/ when to use CAT in their operation. This is not only useful for logistics companies but is also valuable for OEMs and other technology providers. By providing insights regarding efforts, requirements for implementing CAT and the associated impacts, logistics companies are much better able to state their user requirements and needs and OEMs and technology providers have a much better idea about how to bridge the gap between technology that can be supplied and the needs specified by the logistics companies.

Second, real-world testing of CAT is necessary to validate quantification of costs and benefits as often reality reveals important issues that might be overlooked in desk research or simulation studies. Experience is needed in mixed traffic situations and with real-world operations to learn about realized benefits and unexpected problems. These real-world tests should have a main focus on integration in logistics, rather than testing the technical functionalities of automated vehicles. Furthermore, it is suggested to start these practical trials at confined areas because it is a relatively simple operational domain (or it can more easily be controlled than open roads) and no approval is required from a road authority. At the same time, it is suggested to have close interaction with road infrastructure managers and approval authorities to – where possible – already consider preconditions for applications on public roads. In other words, it is important to assess what efforts and requirements are similar for CAT implementations at yards and open roads and what additional efforts and extra requirements are needed in more complex domains. On the other hand, implementation of CAT at more complex domains such as industrial zones might have impact on CAT at yards as well. In these cases, this interaction should already be considered for CAT at yards. Examples of important aspects are safety, liability, responsibility of vehicles in specific situations and control of the vehicles. As such CAT concepts for yards can be optimally aligned with open road conditions.

Lastly, expanding real-world testing of CAT from yards to more complex environments – such as industrial (port) areas, regional (hub-hub) transport and long-haul transport – is needed to step-by-step work towards an integrated and seamless logistics system. Where this discussion paper initially focuses on road transport, we do not neglect the developments in other modes of transport. So, ultimately creating synergies and integration with smart shipping, autonomous sailing, and Automatic Train Operation (ATO) is important as well. For example, SMASH is a large collaborative platform that unites the maritime sector to implement smart shipping and strengthen the Dutch international competitive position. Partnering up with these types of collaborations will contribute to taking the next steps for advancing Connected Automated Transport for safe and efficient logistics.

5. Discussion

This discussion paper describes the challenges in Dutch road transport and the potential contribution of Connected Automated Transport innovation to mitigate these. Despite the envisioned benefits, progress is not going as fast as can be expected. Based on insights from the CATALYST Living Lab we highlight several gaps between various stakeholder groups – automotive, logistics companies, road infrastructure managers and national government – that result in 'wait and see' behaviour. To overcome this, we present elements from the CATALYST roadmap that are directed at bridging these gaps and moving Connected Automated Transport developments in the Netherlands forward.

There are some key enabling factors that ensure that these next steps for Connected Automated Transport can be realized (Van Kempen et al., 2022). First, a learning by doing Living Lab approach is critical to validate and test assumptions in real world operations. It can be expected that iterative cycles (plan do check act) are needed to enhance the integration of CAT concepts in logistics. Furthermore, increased knowledge sharing in the CAT ecosystem (both national projects, a.o. LL Autonomous Transport Zeeland, CATALYST, SAVED and international projects a.o. MAGPIE, MODI) will contribute to building further on most recent insights (and prevent from reinventing the wheel). Lastly, a supportive regulatory environment will serve as a basis for trust and commitment by all stakeholders to collaboratively develop a safe, efficient, and sustainable transport system.

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